Annexe : Textes des publications

Publications scientifiques parues

Dupraz P., Latouche K. et Turpin N., 2007, Programmes agri-environnementaux en présence d'effets de seuil, *Cahiers d'Economie et de Sociologie Rurales*, n°82-83, 6-32

Publications soumises ou à paraître

Ducos, G. and Dupraz, P. (2007). The Asset Specificity Issue in the Private Provision of Environmental Services: Evidence from Agri-Environmental Contracts. *Working paper 07-02*. INRA-ESR, Rennes. En révision à *Ecological Economics*. 25 pages.

Ducos G., Dupraz P. and Bonnieux F. (2007). Agri-Environmental Contract adoption under fixed and variable costs. Article soumis à *Journal of Environmental Planning and Management*. 28 pages.

Dupraz P., Latouche K, Turpin N., 2007, Threshold effect and coordination of agri-environmental efforts. Soumis à *Journal of Environmental Planning and Management*, 16 p.

Publications prévues

Bontems P. et G. Rotillon, 2008, On social and market sanctions in deterring non compliance in environmental standards, 27 pages.

Bontems P., 2008, On the optimal design of income support and agri-environmental regulation, 38 pages.

Bontems P., 2008, Contracting with agents seeking status, 26 p.

Autres supports (Colloques, rapports)

Ducos G. and Dupraz P. (2006). Private provision of environmental services and transaction costs: Agro-environmental contracts in France. Contribution paper to the 3rd world congress of environmental and resource economists, Kyoto, Japan, July 3-7 2006. 24 pages

Arnaud S., Desjeux Y., Dupraz P., Lepage D. (2006). Facteurs déterminant l'efficacité des Programmes Agro-environnementaux : le cas de la Basse-Normandie. Rapport restituant les résultats de l'enquête auprès des acteurs institutionnels pour les mesures agri-environnementales en Basse-Normandie. INRA, UR122 Economie et Sociologie Rurales, Rennes, France. 28p.

Programmes agri-environnementaux en présence d'effets de seuils

Pierre DUPRAZ
Karine LATOUCHE
Nadine TURPIN

Cahiers d'économie et sociologie rurales, n° 82-83, 2007

Pierre DUPRAZ *, Karine LATOUCHE **, Nadine TURPIN ***

Agri-environmental schemes with threshold effect

Summary *– In this paper, we propose mechanism design for agri-environnemental schemes that ensure their environmental and social efficiency, when the biophysical processes are characterized by threshold effects. Public regulation of agri-environmental processes has to cope with two different problems: on the one side, there are asymmetric information between the regulator and the farmers on the adoption cost and the effective effort of the farmers; on the other side, the regulator and the farmers share uncertainty on the relationship between farming practices and environmental quality. These two difficulties often cumulate into the agri-environmental schemes and may lead, when threshold effects occur, to no effective environmental effects and to farmers' discouragement.*
Using a simple micro-economic model and the analysis of an example, this paper shows that a perennial and evolving management of agri-environmental schemes allows a local capitalization of competences and increase their efficiency. This management exploits economies of scale and of learning (management and technical), when the design of contracts allow to precise and quantify threshold effects, which are often badly known and have local characteristics. In some particular cases, sending a signal of a requested minimal contracting area is information that can lead to an increased participation of the farmers.

Key-words: *threshold effect, agri-environmental policy*

Programme agri-environnementaux en présence d'effets de seuil

Résumé – L'objectif de ce papier est de proposer des procédures d'élaboration et de mise en œuvre des programmes agri-environnementaux pour assurer leur efficacité environnementale et sociale, lorsque les processus biophysiques en jeu sont caractérisés par des effets de seuils.
La régulation publique est confrontée à deux problèmes bien distincts : d'une part, les asymétries d'information relevant classiquement de la théorie des contrats et des solutions qu'elle préconise et, d'autre part, une incertitude que partagent régulateur et agents sur la relation entre pratiques agricoles et état de l'environnement. Ces deux difficultés se cumulent fréquemment dans les programmes agri-environnementaux et peuvent conduire, en présence d'effets de seuils, à l'absence d'effet environnemental et au découragement des agriculteurs.
À partir d'un modèle micro-économique et de l'analyse approfondie d'un exemple, cette contribution montre qu'une gestion pérenne et évolutive des programmes permet une capitalisation locale des compétences et un gain d'efficacité. Cette gestion vise à tirer parti d'économies d'échelle et d'apprentissage tant managériales que techniques, à condition de spécifier des contrats dont la réalisation contribue à préciser et à quantifier des effets de seuil souvent mal connus et localement spécifiques. Dans certains cas, l'instauration par le régulateur d'un taux minimal de contractualisation dans une zone donnée constitue une information conduisant à accroître la probabilité de participation des agriculteurs.

Mots-clés : effet de seuil, politique agri-environnementale

* *Laboratoire d'économie et sociologie rurales (ESR), INRA, 4 allée Adolphe Bobierre, CS 61103, 35011 Rennes cedex*
e-mail : pierre.dupraz@rennes.inra.fr

** *Laboratoire d'études et de recherches en économie, INRA, rue de la Géraudière, B.P. 71627, 44316 Nantes cedex 03*
e-mail : karine.latouche@nantes.inra.fr

*** *ESR-INRA et UMR Métafort, Cemagref, 24 avenue des Landais, 63172 Aubière cedex, e-mail : nadine.turpin@cemagref.fr, nadine.turpin@rennes.inra.fr*

Ce travail a bénéficié du soutien du projet européen SSPE-CT-2003-502070, *Integrated tools to design and implement Agro Environmental Schemes* (*http//:merlin.lusignan.inra.fr/ITAES/website*). Il ne reflète cependant pas la position de l'Union européenne, ni en aucun cas la politique future de la Commission européenne dans ce domaine. La responsabilité de cet article est également partagée entre les auteurs.

LORSQUE l'état de l'environnement est la conséquence de processus caractérisés par des effets de seuil, assurer l'efficacité environnementale et sociale de programmes agri-environnementaux nécessite d'élaborer ces programmes avec un soin particulier.

Les effets de seuil, ou discontinuités écologiques, sont définis par Muradian (2001) comme une modification soudaine d'une propriété donnée d'un système écologique, à la suite de la variation lente et continue d'une variable indépendante. Les exemples sont nombreux dans la littérature écologique : accroissement de vulnérabilité à de nouvelles perturbations d'écosystèmes préalablement soumis à des pressions anthropiques (Levin, 1998), déplacements d'équilibres dans des lacs tempérés (Weisner *et al.*, 1997), colonisation par des espèces indésirables (Asner et Vitousek, 2005), fragmentation des habitats et disparition d'espèces (Kennedy *et al.*, 2002), renouvellement de ressources naturelles.

L'existence de discontinuités dans les processus écologiques, qui sous-tendent le renouvellement de ressources naturelles comme les poissons, les forêts, certaines espèces chassées ou en voie de disparition et réintroduites dans un environnement donné, génère des phénomènes de non-convexité abondamment analysés en économie des ressources naturelles (Dasgupta et Maler, 2003 ; Wirl, 2004). En présence d'effets de seuil, l'exploitation de ces ressources naturelles est caractérisée par la présence de plusieurs équilibres possibles et nécessite l'élaboration de politiques de gestion dynamiques (Maler, 2000 ; Mitra et Roy, 2006 ; Rondeau, 2001 ; Toman et Withagen, 2000).

En Europe, des politiques agri-environnementales tentent de préserver les ressources naturelles, comme la biodiversité, les paysages ruraux, les eaux superficielles et souterraines, par des programmes volontaires (OCDE, 2003) : un régulateur propose à une population d'agriculteurs d'adopter des pratiques jugées améliorantes, en échange d'une aide financière compensant les surcoûts liés à cette adoption, et sur une base volontaire. Ce régulateur a à sa disposition une littérature abondante sur les effets de seuils, leurs conséquences sur les caractéristiques souhaitables de politiques de gestion adaptées, mais généralement cette littérature ne décrit pas le problème spécifique auquel il est confronté. Faute d'information suffisamment précise, les décideurs locaux sont donc souvent amenés à élaborer les politiques locales agri-environnementales sans tenir compte de la possibilité d'effets de seuil. Ceci diminue l'efficience de ces politiques et conduit à un gaspillage de fonds publics : des études empiriques, de plus en plus nombreuses, décrivent l'adoption de bonnes pratiques au prix d'efforts d'une partie des agents et, parfois, d'importantes subventions publiques sans qu'aucune modification notable de l'environnement soit relevée (Muradian, 2001).

La probabilité d'un tel gaspillage est accrue en situation d'information imparfaite sur le comportement des agriculteurs. L'adoption de pratiques respectueuses de l'environnement dépend, au-delà du montant de la subvention associée à cette adoption, de caractéristiques individuelles de l'exploitation (Vanslembrouck *et al.*, 2002), de l'exploitant (Morris et Potter, 1995) et des réseaux dans lesquels ils sont impliqués (Bonnieux *et al.*, 2001). Lorsqu'il élabore une politique visant à améliorer l'état de l'environnement, le régulateur ne peut tenir compte des caractéristiques individuelles de chacun des agents à qui il va proposer un contrat. Ces asymétries d'information sont source d'inefficacités, inefficacités qui néanmoins peuvent être réduites (Laffont et Martimort, 2002).

Nous nous intéressons ici aux politiques agri-environnementales confrontées à deux difficultés : effets de seuils et information imparfaite. La littérature propose des solutions dans certaines situations. En présence d'effets de seuil, Wu (2004) propose de construire une politique permettant l'adoption de la mesure à un taux tel que l'effet environnemental recherché soit atteint dans chaque zone pertinente, en considérant ces zones successivement, et si possible dans l'ordre décroissant des bénéfices environnementaux associés. Cependant, en cas d'incertitude sur les seuils, et sur les effets sociaux de leur franchissement, les instruments de régulation classiques sont inappropriés et nécessitent l'ajout de critères associés à l'acceptabilité sociale d'une marge de manœuvre dans l'exploitation des ressources constituées par l'état de l'environnement (Perrings et Pearce, 1994). En présence d'asymétrie d'information, et dans le cas de régulation de pollutions diffuses, des mécanismes différenciés permettent d'inciter les agriculteurs à choisir l'effort le mieux adapté (Wu et Babcock, 1996 ; Bontems *et al.*, 2005).

Une analyse des mesures agri-environnementales proposées aux agriculteurs en France permet de mettre en évidence la dispersion des efforts environnementaux résultant des programmes élaborés ces dernières années. Cette analyse permet, en outre, de déterminer les caractéristiques principales des fonctions de bénéfice espéré que les régulateurs attendent d'une amélioration de l'état de l'environnement et qui serviront à la modélisation. Elle permet enfin de construire une typologie des situations agri-environnementales en fonction des croisements possibles entre les sources d'incertitudes : comportements cachés des agriculteurs et processus biophysiques.

Pour chaque situation de cette typologie, est proposée et discutée la possibilité de construire un mode de régulation simple, tenant compte notamment des limites imposées par les coûts de transaction. Cette modélisation montre comment on peut tirer parti de l'utilité directe dérivée par les agriculteurs de certains biens environnementaux qu'ils contribuent à produire, tout en suscitant un comportement coopératif. Par exemple, l'envoi par le régulateur d'un signal, comme l'instauration d'un taux minimal de contractualisation dans une zone donnée, constitue une information conduisant à accroître la probabilité de participation des agriculteurs sensibles à l'efficience environnementale de leurs engagements contractuels. De plus, dans le cas d'objectifs environnementaux correspondant à une forte demande sociale, mais caractérisés par des effets de seuils incertains, une gestion pérenne et évolutive des programmes permet une capitalisation locale des compétences, les premières actions intégrant dans leurs objectifs la réduction des incertitudes sur les processus biophysiques.

Nous analysons enfin un exemple pratique, dans lequel nous illustrons la présence d'effets de seuil. La possibilité concrète pour un régulateur de construire une politique évolutive en présence d'effets de seuil incertains est décrite sur un cas concret.

L'article est organisé comme suit : la première section expose le contexte et la problématique de l'adoption par les agents de mesures agri-environnementales dans le cadre de programmes nationaux et régionaux. Nous présentons une illustration du phénomène de dispersion des exploitations adhérant aux programmes agri-environnementaux à l'aide des résultats de l'évaluation à mi-parcours des mesures agri-environnementales. La deuxième section décrit un modèle de comportement des agriculteurs confrontés à des mesures agri-environnementales et analyse les propriétés des programmes agri-environnementaux lorsqu'ils sont élaborés en situation d'information complète. Dans la troisième section, nous affaiblissons l'hypothèse d'information complète et examinons comment les programmes agri-environnementaux sont modifiés lorsque le régulateur ne connaît pas le consentement à recevoir des agriculteurs. Nous proposons également des mécanismes favorisant la participation des agriculteurs pour atteindre les objectifs environnementaux fixés à une petite région et l'illustrons par un exemple. Enfin, nous examinons, principalement à partir de la littérature, les autres combinaisons d'incertitude concernant la technologie et le comportement des agriculteurs, ainsi que des extensions possibles du modèle. Puis, nous concluons.

Adhésion volontaire et dispersion des efforts environnementaux

Le plan de développement rural national (PDRN) a privilégié le contrat territorial d'exploitation (CTE) comme instrument phare d'une véritable politique agricole contractuelle, instaurée par la loi d'orientation agricole du 19 juillet 1999. L'ambition du CTE était d'intégrer une approche globale de l'exploitation agricole à un projet territorial de développement agricole, respectueux de l'environnement. Concrètement, un diagnostic économique et environnemental de l'exploitation est intégré au contrat qui permet à l'agriculteur d'accéder simultanément à des paiements agri-environnementaux et à des aides à l'investissement. La cohérence territoriale des engagements des agriculteurs est recherchée au travers de diagnostics territoriaux, départementaux ou infra départementaux et par une incitation de 20 % associée à la signature d'un contrat-type correspondant à un projet collectif. Ces contrats sont proposés par des porteurs de projets : organisation agricole, industrie agro-alimentaire, coopérative ou collectivité territoriale. Ils comprennent un ensemble de mesures, adapté aux objectifs environnementaux identifiés après un diagnostic de la zone ou du groupe d'agriculteurs concernés. Ils se distinguent des contrats individuels construits librement à partir du menu régional de mesures. Ces dispositions apparaissaient comme un progrès dans l'adaptation des programmes agri-environnementaux aux spécificités des exploitations et des territoires. Dans la pratique, le diagnostic d'exploitation a été simplifié entre 1999 et 2001. Il est devenu plus formel qu'opérationnel. De la même manière, la notion de projet collectif était suffisamment floue pour permettre une majoration des primes sans apporter nécessairement de cohérence territoriale aux engagements des contractants. Dans les faits, certains contrats dépendent de plusieurs projets collectifs. Inversement, la qualification en projet collectif supposait une subvention au porteur de projet, entraînant la nécessité d'arbitrages supplémentaires. L'Instance nationale d'évaluation du contrat territorial d'exploitation (2003) ne rapporte pas le nombre de contrats qui dépendent de projets collectifs et note que cette question n'a pas vraiment mobilisé l'attention des évaluateurs au niveau régional. Des différences marquées sont cependant relevées entre certaines stratégies départementales d'application du dispositif. Compte tenu de la flexibilité du dispositif, les actions agri-environnementales ont surtout été perçues comme un outil de soutien au revenu, aussi bien par les décideurs que par les agriculteurs. En témoigne le foisonnement des mesures proposées à la contractualisation. Si le CTE est un instrument défini au niveau national, l'élaboration et l'adaptation des mesures proposées ont été réalisées dans le cadre des commissions départementales d'orientation agricole (CDOA). Bien qu'élargies aux associations environnementales et de consommateurs par la loi de 1999, ces instances restent dominées par les organisations professionnelles agricoles (OPA), fortement structurées au niveau départemental (Dupraz et Rainelli, 2004). Pressées par le ministère de l'Agriculture de mettre en œuvre le dispositif, les directions départementales de l'agriculture se sont généralement appuyées sur les compétences techniques des chambres d'agriculture et autres OPA pour la définition des mesures. Leur multiplication s'explique par la volonté de ces organisations de rendre le CTE (et le transfert de revenu associé) accessible à toute exploitation (Arnaud, 2004).

Mis en place et adapté régionalement entre 1999 et 2001, le PDRN est caractérisé par un nombre très élevé de mesures agri-environnementales (MAE) proposées aux agriculteurs : 2 650 mesures référencées au niveau le plus fin, correspondant à 170 types de mesures différentes (Instance nationale d'évaluation du contrat territorial d'exploitation, 2003). À l'issue de l'harmonisation régionale, chaque agriculteur était confronté, selon sa région, à un nombre variant de 70 à 337 mesures offertes dont seules quelques-unes étaient éventuellement obligatoires pour accéder à un CTE. Dans la pratique, le choix du contractant potentiel était évidemment inférieur en raison de la spécificité de son système de production. De nombreux agriculteurs reconnaissant avoir choisi les mesures les moins contraignantes ou les moins éloignées de leurs pratiques antérieures, la contractualisation a sélectionné un nombre plus restreint d'actions agri-environnementales : sur 150 types de mesures surfaciques, 125 types ne représentent que 10 % de la surface contractualisée cumulée.

Malgré cette auto-sélection, l'offre plus que foisonnante de mesures a entraîné une grande dispersion des efforts environnementaux des agriculteurs contractants. D'autant plus qu'à de rares exceptions près, aucune disposition ne venait restreindre l'éligibilité d'une mesure dans les zones non pertinentes. Dans la logique du PDRN, l'incitation de 20 % associée aux projets collectifs devait assurer la coordination des efforts environnementaux des agriculteurs d'une zone donnée. Dans la Nièvre, ce bonus de 20 % était réservé aux seuls groupes d'agriculteurs, mais pas nécessairement des voisins, qui s'imposaient de contractualiser la même MAE ; cette approche reste néanmoins l'exception plutôt que la règle. De même, les MAE contractualisées dans les zones Natura 2000 bénéficiaient potentiellement d'une surprime de 20 %, rendue impossible pour des raisons de calendrier et une déconnexion des diagnostics de territoire pour les documents d'objectifs Natura 2000 les plus avancés. Dans les faits, le rapport d'évaluation des CTE insiste sur la grande absence du territoire dans la mise en œuvre des CTE (Instance nationale d'évaluation du contrat territorial d'exploitation, 2003, pp. 74-78). Les projets collectifs ont été dominés par les acteurs des filières agricoles, avec des volets environnementaux offrant un large menu de mesures, peu spécifiques au territoire des exploitations visées. En juin 2002, sur 1 129 projets collectifs recensés, plus de la moitié était initiée par des groupements de producteurs ou des coopératives associés à l'industrie agroalimentaire, un tiers par les chambres d'agriculture, 15 % par diverses associations et 10 % seulement par des collectivités territoriales, Parcs naturels régionaux inclus. La faible implication des collectivités territoriales trouve une partie de son explication dans la rigidité du système de co-financement européen, géré par le CNASEA. Il faut cependant noter que les exemples retenus dans le rapport d'évaluation pour leur impact environnemental et/ou la coordination des efforts des agriculteurs ont en commun une implication des collectivités territoriales, sans que cette implication soit une garantie de succès.

Au niveau régional, les évaluations à mi-parcours du PDRN concernant les MAE ont précisé les enjeux environnementaux des différentes mesures. Pour chaque enjeu, les surfaces contractualisées et leur localisation ont donc pu être comparées aux zones d'intérêt correspondantes. Il faut signaler que si, pour certains enjeux, les zones d'intérêt restaient mal connues ou en débat au moment de l'évaluation, elles l'étaient encore moins bien lors de l'élaboration et de la mise en œuvre des mesures. Ce fait révèle à quel point le ciblage géographique des MAE était secondaire dans la première phase de mise en œuvre du PDRN. Le cas de la Bretagne est très significatif à cet égard puisque les exploitations ayant un CTE ne représentent que 3,5 % de sa surface agricole utile, mais sont dispersées dans 625 de ses 1 268 communes. En outre, les surfaces sous contrats (60 000 ha) se répartissent entre une douzaine de mesures principales et 43 mesures secondaires, avec une moyenne de 8 mesures par contractant (Pascal Consultants et CNASEA, 2003). Avec 176 000 ha sous contrat CTE, la Basse-Normandie a un taux de contractualisation nettement plus élevé. Néanmoins, les données disponibles ne démontrent pas une pertinence géographique significativement meilleure des surfaces contractualisées (Eureval C3E, 2003). L'érosion des sols est la deuxième priorité régionale : sept mesures surfaciques sont supposées avoir un effet anti-érosif et sont contractualisées à hauteur de 51 000 ha, mais 11 000 ha seulement sont situés dans les zones de risque érosif moyen à très fort (qui représentent quelques 53 000 ha), soit un taux moyen de couverture de 2 %, n'atteignant que 7 % pour les petites zones à risque très fort. Pour la qualité de l'eau, première priorité bas-normande, 410 000 ha sont en zones vulnérables vis-à-vis des nitrates. Douze mesures représentant 90 000 ha sont supposées avoir un impact sur la réduction des apports azotés, mais 51 000 seulement sont situés en zone vulnérable, soit un taux de couverture de 12 % (en comptant la gestion extensive des surfaces en herbe, sinon 8 %).

La mise en œuvre des contrats d'agriculture durable (CAD), qui font suite aux CTE, semble avoir pris la mesure du gaspillage de moyens que représentait le saupoudrage géographique d'une multitude de MAE. Ainsi, pour chaque territoire délimité, un très petit nombre de priorités environnementales est retenu et, pour chaque priorité, un très petit nombre de mesures est offert à la contractualisation. Ce nouveau dispositif devrait donc limiter fortement la contractualisation de MAE dans les zones non pertinentes, tout en concentrant les efforts des contractants d'un même territoire sur les mêmes mesures. Ce nouveau dispositif semble néanmoins plus motivé par la réduction des coûts que par la recherche de l'efficacité environnementale, comme en témoigne le plafond de 27 000 € par contrat qui rend les CAD *a priori* moins attractifs que ne l'étaient les CTE. Sans modification des niveaux de primes par hectare, il n'est pas certain que les taux de contractualisation dans les différentes zones à enjeux soient très significativement supérieurs malgré l'absence de concurrence de mesures non pertinentes. Pour les processus agri-environnementaux caractérisés par des effets de seuils, les impacts environnementaux à venir pourraient donc se révéler aussi décevants si les surfaces ou linéaires critiques ne sont pas franchis. Pour les mesures correspondantes, nous nous interrogeons, dans la suite de l'article, sur l'opportunité pour les pouvoirs publics de ne signer les contrats d'un territoire donné que dans le cas où cette surface critique serait atteinte. Dans un contexte de rationnement des fonds publics, une telle disposition reviendrait à mettre les territoires en concurrence et, donc, à inciter les agriculteurs d'un même territoire à se coordonner pour aboutir à une offre consolidée de services agri-environnementaux. Cette disposition éviterait les paiements inutiles d'un point de vue environnemental, mais son efficacité resterait dépendante des niveaux de primes par hectare et du plafond par contrat qui nécessiteraient sans doute des ajustements.

De telles initiatives existent aux États-Unis pour la création de corridors écologiques. En présence d'effet de continuité de milieux (nécessaire à la survie d'espèces menacées, par exemple), Parkhurst *et al.* (2002) envisagent la mise en place d'un bonus incitatif pour les contrats agri-environnementaux qui coordonnent les efforts des contractants. L'idée est de pousser des contractants à associer leurs efforts agri-environnementaux en créant un territoire continu (équivalent à une réserve naturelle). Un tel comportement des contractants évite ainsi la mise en place d'un habitat fragmenté, moins favorable à la protection des espèces menacées.

En France, les évaluations des programmes agri-environnementaux mettent en lumière à la fois des incertitudes, partagées entre régulateur et agriculteurs, sur la technologie environnementale (les mesures ne sont pas ciblées dans l'espace), et une connaissance approximative de la dispersion des coûts d'adoption par le régulateur. En effet, la plupart des projets collectifs sont proposés par des groupements de producteurs ou des chambres d'agriculture, et les compensations sont basées sur les surcoûts supportés par les agriculteurs, conformément au Règlement de développement rural. En pratique, un surcoût moyen est évalué au cours de l'élaboration de chaque mesure ; la dispersion des surcoûts dans la population d'agriculteurs reste inconnue.

Agriculteurs et régulateur souhaitant coopérer pour la fourniture d'un service environnemental sont, selon les situations, confrontés à des incertitudes sur l'effet de la technologie employée pour fournir le service dans la zone considérée, mais peuvent aussi partager, ou pas, des informations privées sur le consentement à recevoir des agriculteurs dans cette zone. La section suivante propose un modèle simple décrivant le comportement d'adoption de pratiques agri-environnementales par une population d'agriculteurs, en l'absence d'incertitudes et lorsque le consentement à recevoir de ces agriculteurs est une information partagée par tous. Ensuite, nous analyserons les modifications de ce modèle lorsque les informations privées des agriculteurs sont inconnues, soit du régulateur seulement, soit du régulateur et des autres agriculteurs. Nous proposons un mode de régulation permettant, dans ces situations, de fournir le service environnemental, malgré les asymétries d'information, et analysons un exemple concret d'un tel mode de régulation. La quatrième section décrit des extensions du modèle, dans un cas d'aléa moral ou lorsqu'il existe une incertitude sur les effets de la technologie agri-environnementale.

Effets de seuil et politique en information complète

En information complète, les zones correspondant à des processus environnementaux caractérisés par des effets de seuil sont supposées connues. Conformément aux recommandations de Wu (2004), nous supposons que le régulateur s'applique à définir la politique zone par zone. Nous considérons ici l'analyse de l'une de ces zones. Une telle analyse, menée systématiquement dans toutes les zones pertinentes, permet de sélectionner les zones où il est souhaitable d'appliquer effectivement la politique. Nous nous placerons dans une approche à moyen terme, pour nous affranchir des aspects dynamiques de restauration de qualité des écosystèmes et des temps de réponse de ces écosystèmes à des modifications de pression. Supposons, comme Dupraz *et al*. (2004), que l'effet environnemental, K, dépend, à moyen terme, de la surface totale notée S, soumise à des pratiques plus favorables à l'environnement, et de l'effort environnemental constitué par ces pratiques, noté e. Nous nous donnons une technologie agri-environnementale g, représentant cette relation et telle que : $K = g(S,e)$.

Dès que la surface soumise à pratiques respectueuses de l'environnement est suffisamment importante, et que l'effort réalisé sur ces surfaces est suffisant, la fonction $g(.)$ est positive et croissante en S et e. En outre, $g(.)$ est à rendement non croissant par rapport à S. Nous nous plaçons volontairement dans le cas d'une technologie environnementale concave (Wirl, 1999) au-delà du seuil (en particulier, nous supposerons que g_{Se} est négative : l'effet marginal sur l'environnement par rapport à la surface est décroissant en fonction du service environnemental).

L'effet de seuil est représenté, avec une simplification de la formalisation habituelle des effets de seuil dynamiques (Lines, 2005), par une surface critique S_0 et/ou un effort critique e_0, en deçà desquels aucun effet environnemental n'est perceptible :

$$S \leq S_0(e) \Rightarrow \quad g(S,e) = 0,$$

$$e \leq e_0(S) \Rightarrow \quad g(S,e) = 0.$$

L'utilité de réservation de l'agriculteur i à qui l'on propose de fournir l'effort e sur une surface s est formalisée par son consentement à recevoir c^i. Ce consentement à recevoir, différent d'un agriculteur à l'autre, intègre le manque à gagner que la mise en œuvre des pratiques spécifiées lui fait supporter, puisqu'il ne peut réaliser le plan de production correspondant au profit maximum de l'exploitation, et l'utilité que l'agriculteur dérive directement, en tant que consommateur, de l'effet environnemental, K :

$$c^i = c^i(s, e, K).$$

Cette dernière hypothèse repose sur des résultats empiriques, montrant que la probabilité de contractualiser dépend positivement, et toutes choses égales par ailleurs, des préférences personnelles de l'agriculteur vis-à-vis des questions environnementales (Dupraz *et al.*, 2002). En revanche, si ces travaux empiriques mettent en évidence une relation entre la contractualisation et les préférences des agriculteurs en faveur de l'environnement pour certaines combinaisons de mesures (comme le maintien du paysage et la protection de la biodiversité, ou le maintien du paysage et la qualité de l'eau), ils montrent aussi l'absence de cette relation pour des mesures dont les effets ne sont pas directement observables (comme la protection de la biodiversité ou la qualité de l'eau non combinées à des mesures aux effets localement observables). Il semble donc que ce comportement soit lié à la protection de biens publics locaux tangibles, auxquels les agriculteurs ont de fait un accès privilégié par rapport aux autres consommateurs : leur propre effort leur importe, car ils ont un accès privilégié au bien public local.

Le consentement à recevoir de l'agriculteur i, $c^i(s, e, K)$, est croissant et convexe en s et e et non croissant en K [1]. Le territoire sur lequel l'effet environnemental est recherché est suffisamment vaste pour que cet effet ne dépende pas de l'action d'un seul agriculteur. Nous introduisons une hétérogénéité des agriculteurs en considérant qu'ils peuvent avoir une utilité de réservation individuelle, même sur un territoire *a priori* homogène. Le consentement à recevoir d'un agriculteur donné dépend du nombre d'agriculteurs qui adoptent la mesure. Cette hypothèse d'une utilité de réservation endogène au processus de contractualisation est similaire à Genicot et Ray (2006), qui montrent comment le régulateur peut arriver à ses fins dans un cadre dynamique. Ils ne considèrent cependant pas l'existence d'effet de seuil pouvant affecter les fonctions « objectifs » du régulateur et des agents que nous étudions ici.

Nous supposerons enfin que c_{sK}, la dérivée croisée du consentement à recevoir par rapport à la surface contractualisée et à l'effet environnemental, est négative : le coût marginal (par rapport à la surface) est décroissant en fonction de l'effet environnemental, ce qui est également une hypothèse classique (Genicot et Ray, 2006).

Notons $W(K)$ le consentement à payer du régulateur pour le bien K au nom de la collectivité. Cette fonction de surplus social est classiquement positive, croissante et concave en K ; nous la supposerons de plus nulle pour $K = 0$.

[1] Cette dernière hypothèse n'exclut pas que l'utilité que l'agriculteur retire de l'effet environnemental soit nulle, ou très faible, pour certains agriculteurs indifférents à l'environnement, ou passagers clandestins. Cependant, il n'y a pas de raison que les passagers clandestins contractualisent moins s'ils anticipent que les autres contractualisent plus. Cela supposerait que l'utilité croît, puis plafonne ou décroît avec K : une hypothèse qui n'est pas standard (en contradiction avec l'hypothèse de non-satiété).

Optimum social

L'optimum social est la solution du programme (1), où s^i est la surface sur laquelle l'agriculteur i fournit l'effort environnemental e. Le couple (s^i, e) constitue le service environnemental fourni par l'agriculteur i.

$$\max_{s^i,K,e}\left(W(K)-\sum_i c^i(s^i,e,K)\right) \tag{1}$$

$$\text{s.c.}\quad \begin{aligned} & K = g\left(\sum_i s^i, e\right) \\ & \forall i,\quad s^i \geq 0 \\ & e \geq e_0\left(\sum_i s^i\right) \\ & \sum_i s^i \geq S_0(e) \end{aligned}$$

Si l'une des deux dernières contraintes est saturée, la solution est évidente : toutes les variables et toutes les fonctions sont nulles.

Au-delà du seuil, la solution intérieure est caractérisée, en utilisant le théorème de l'enveloppe, par les égalités suivantes :

$$\sum_i c_e^i(s^i,e,K) = g_e\left(\sum_i s^i,e\right)\cdot\left(W'(K)-\sum_i c_k^i(s^i,e,K)\right)$$

$$s^i\left(c_s^i(s^i,e,K)-g_s\left(\sum_i s^i,e\right)\cdot\left(W'(K)-\sum_i c_k^i(s^i,e,K)\right)\right)=0;\forall i=1,\ldots,\mathrm{n}$$

La première équation définit l'effort optimal auquel est soumise chacune des surfaces s^i. Les n équations suivantes déterminent la valeur prise par chacune de ces surfaces ; certaines surfaces peuvent être nulles, si le coût marginal pour le premier hectare excède le bénéfice marginal à le soumettre à l'effort optimal. Lorsque s^i est positive, sa valeur est telle que le coût marginal (c_s^i) est égal au bénéfice marginal ($g_s.(W'-\sum c_k)$).

L'optimum social ne peut être atteint en l'absence de politique agri-environnementale puisque l'effet environnemental K ne peut être obtenu par l'action d'un agriculteur isolé. Un agriculteur souhaitant fournir un service environnemental ne peut qu'anticiper $K = 0$ et est amené à fournir un service sur une surface telle que $c_s^i(s^i, e, K) = 0$. Il ne fournira donc pas le service environnemental sur son exploitation.

Politique agri-environnementale en information complète

Le régulateur propose aux agriculteurs un contrat standard, noté (*e, p*), que nous nommerons mesure agri-environnementale, et qui associe un paiement *p* par unité de surface que l'agriculteur choisit de contractualiser impliquant le respect des pratiques décrites par *e* sur cette surface. Nous supposerons de plus que l'effort *e* est observable sans coût.

L'agriculteur à qui l'on propose le contrat (*e, p*) fait face à une incertitude concernant le comportement des autres agriculteurs. Il doit anticiper ce comportement, en fonction des informations dont il dispose. Si l'on note K^i l'anticipation de l'effet environnemental réalisée par l'agriculteur *i*, ce dernier maximise le bénéfice qu'il retire de la contractualisation : $\max_s \left(ps - c(s, e, K^i) \right)$. La solution de cette maximisation est notée $s^i(e, p, K^i)$; s^i est positive ou nulle, non décroissante en *p* et K^i et non croissante en *e*. Formellement, s_i est telle que :

$$p = c_s^i \left(s^i(e, p, K^i), e, K^i \right) \tag{2}$$

Si l'on dérive cette expression par rapport à K^i, il vient :

$$c_{ss}^i \left(s^i(e, p, K^i), e, K^i \right) \frac{\partial s^i}{\partial K^i} + c_{sK^i} \left(s^i(e, p, K^i), e, K^i \right) = 0 .$$

Avec nos hypothèses, plus l'agriculteur anticipe un bon état de l'environnement, plus il contractualise une surface importante.

En information complète, les fonctions de coût et d'utilité de chacun des agriculteurs, ainsi que les relations entre l'effort (*e*), le paiement proposé (*p*) et l'effet environnemental total (*K*) sont des connaissances communes.

Le programme du régulateur est alors de maximiser une fonction de bien-être, *U*, qui ne dépend que de la surface totale contractualisée *S* (en notant λ le coût marginal des fonds publics) :

$$U(S) = W(K) - C(S) - \lambda pS,$$

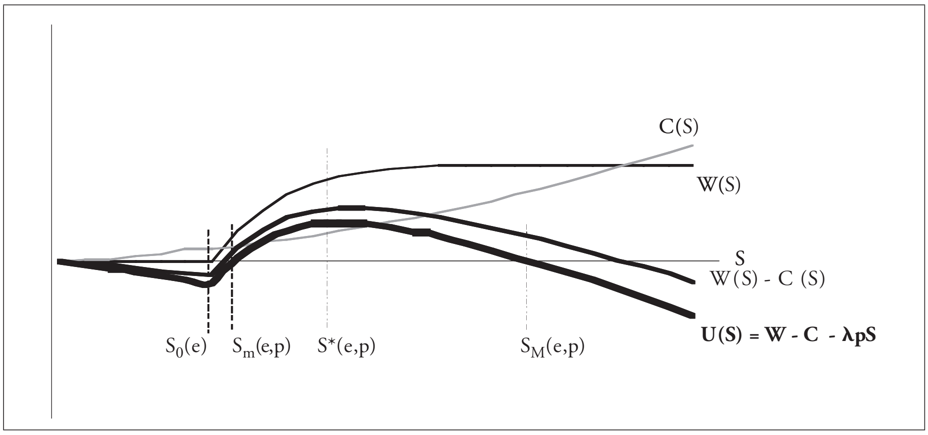
$C(S) = \sum_{i=1}^{n} c^i \left(s^i, e, K \right)$ est le consentement à recevoir de la population d'agriculteurs et la surface totale sous contrat est $S = \sum_{i=1}^{n} s^i(e, p, K)$.

La fonction $U(S)$ est très particulière en raison de l'effet de seuil (figure 1) :

– si $S < S_0(e)$, $U(S) = -C() - \lambda pS$ est négative et décroissante, minimale en S_0 ;

– si $S \geq S_0(e)$, $U(S)$ est concave, croissante à droite de $S_0(e)$, mais ne devient éventuellement positive qu'au-delà d'un seuil $S_m(e,p) > S_0(e)$. Il est enfin possible qu'au-delà d'un seuil $S_M(e,p)$, *U* devienne à nouveau négative (dans ce cas, la surface proposée à la contractualisation est si importante que les coûts engendrés par la mesure sont nettement supérieurs au gain de bien-être qui en résulte).

Figure 1. **Consentement à payer du régulateur (*W*), coût d'adoption pour les agriculteurs (*C*) et bien-être social (*U*) en information complète et à technologie connue, pour un effort *e* donné**



Si *U* reste négative, il est optimal de ne rien faire et aucun contrat n'est proposé. Dans le cas contraire, la technologie et les coûts étant connus par les uns et les autres, les agriculteurs anticipent correctement les conséquences du contrat *(e,p)* sur l'effet environnemental, *K*. Ils proposent à la contractualisation une surface $s^i(e,p,K)$ telle que :

$$p = c_s^i\left(s^i, e, K\right),$$

et le programme du régulateur devient :

$$\max_{e,p,s^i,K} U \equiv W(K) - \sum_i c^i(s^i, e, K) - \lambda p \sum_i s^i \tag{3}$$

$$\text{s.c.} \quad \begin{aligned} & K = g\left(\sum_i s^i, e\right) \\ & p = c_s^i(s^i, e, K) \\ & \forall i, \quad s^i \geq 0 \\ & e \geq e_0\left(\sum_i s^i\right) \\ & \sum_i s^i \geq S_0(e) \end{aligned}$$

Les deux dernières contraintes ne sont pas saturées puisque l'on se place au-delà du seuil (en deçà, il est optimal de ne rien faire). Les conditions de premier ordre de ce programme nous donnent le contrat optimal (e^*, p^*) permettant une contractualisation sur la surface $S^* = \sum s^i(e^*, p^*, K^*)$:

$$(1+\lambda)p = g_s(\sum_i s^i, e^*) \cdot \left(W'(K^*) - \sum_i c_K^i(s^i, e^*, K^*) \right) \quad (4)$$

$$\sum_i c_e^i(s^i, e^*, K^*) = g_e(\sum_i s^i, e^*) \cdot \left(W'(K^*) - \sum_i c_k^i(s^i, e^*, K^*) \right) \quad (5)$$

L'équation (4) nous indique que le paiement reçu par chaque unité de surface contractualisée, pondéré par le coût des fonds publics, est égal à la différence entre le consentement marginal à payer du régulateur au nom de la société (pour une variation de S^*) et le consentement marginal à recevoir des agriculteurs (pour cette même variation de S^*). L'équation (5) détermine la quantité optimale du service environnemental, qui est identique au service correspondant à l'optimum social.

Bien évidemment, l'élaboration de programmes agri-environnementaux ne s'effectue jamais en situation d'information parfaite des parties en présence. Nous allons examiner comment est modifié le contrat lorsque les informations privées des agriculteurs sont inconnues, soit du régulateur seulement, soit du régulateur et des autres agriculteurs.

Technologie connue de tous, mais information cachée

Fonction de coût inconnue du régulateur

Supposons, dans un premier temps, que les agriculteurs se connaissent suffisamment bien pour qu'ils puissent anticiper correctement l'effet environnemental associé à tout contrat *(e, p)* qui leur est proposé. Dans ce cas, l'asymétrie d'information n'existe qu'entre le régulateur et les agriculteurs, qui ont comme information privée leur fonction de coût individuelle. Cette asymétrie empêche le régulateur de spécifier le niveau de pratiques optimal e^* à respecter par unité de surface, puisque sa valeur dépend, entre autres, de c_e et de c_K. Le régulateur doit maintenant se fixer une valeur de l'effort e de façon arbitraire, par exemple en choisissant ses mesures dans un ensemble existant pour lequel l'effort demandé aux agriculteurs est prédéfini. C'est la situation dans laquelle se sont trouvés les régulateurs locaux confrontés à l'application du PDRN. Il va ensuite déterminer le paiement p_1 à associer à cet effort, en maximisant une fonction de bien-être :

$$\max_{p, s^i, K} U \equiv W(K) - \sum_i c^i(s^i, e, K) - \lambda p \sum_i s^i \quad (6)$$

sous les mêmes contraintes qu'en information complète. Au-delà du seuil, les conditions de premier ordre donnent :

$$(1+\lambda)p_1 = g_s(\sum_i s^i, e)\cdot\left(W'(K^1) - \sum_i c_K^i(s^i, e, K^1)\right) \tag{7}$$

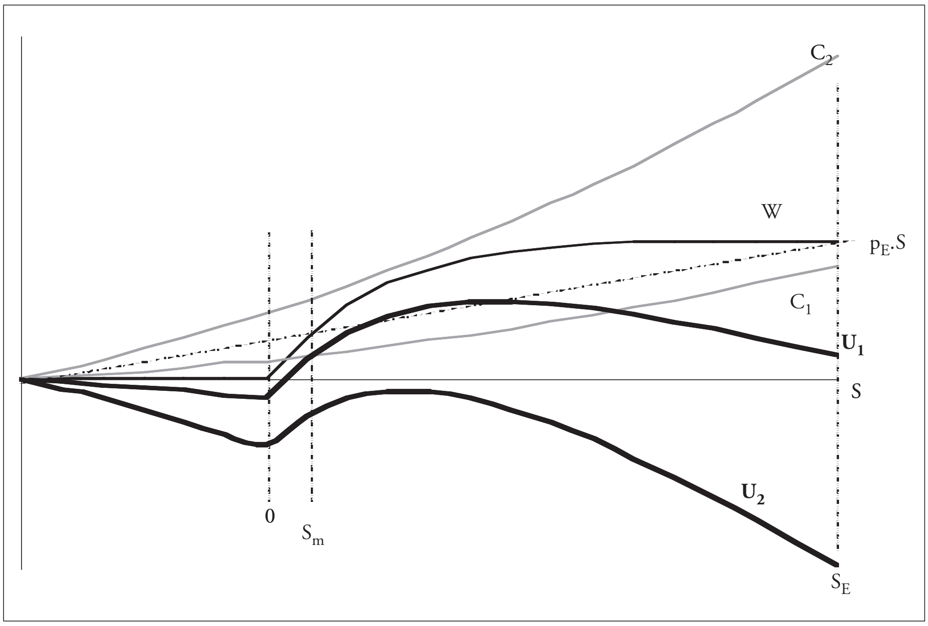
Même s'il ignore les fonctions de consentement à recevoir des agriculteurs, le régulateur doit, s'il veut déterminer p_1, faire des hypothèses sur l'utilité marginale que retirent les agriculteurs de l'effet environnemental K. En pratique, sauf à faire de telles hypothèses, très restrictives, le régulateur ne peut déterminer un optimum de second rang dans cette situation d'information incomplète.

L'étape suivante consiste pour le régulateur à éviter les gaspillages d'argent public, c'est-à-dire à éviter les situations où des paiements n'apporteraient aucun effet environnemental, ou pour lesquelles la variation de bien-être pour la société serait négative. Dans le premier cas, une façon simple de s'en sortir pour le régulateur est de fixer un seuil en deçà duquel aucun contrat n'est signé. La valeur du seuil qui semble la plus simple est $S_0(e)$ mais elle ne garantit pas que le bien-être sera positif.

Éviter les situations pour lesquelles la variation de bien-être pour la société serait négative peut se faire en construisant un programme qui ne repose que sur W (et pas sur C, inconnue du régulateur). Le régulateur peut offrir la prime la plus élevée possible qui garantit une variation de bien-être positive pour la collectivité (et qui garantisse que $W - p(1+\lambda)S \geq 0$) : si S_E est la surface maximale éligible de la zone, il peut offrir $p_E(1+\lambda) = W(g(S_E,e))/S_E$ qui épuise le consentement à payer de la collectivité si toute la surface éligible est contractualisée. Le seuil qui déclenche la signature des contrats par le régulateur (et qui élimine les situations sans effet environnemental) est alors S_m définie par $p_E(1+\lambda) = W(g(S_m,e))/S_m$. La concavité de W implique $S_m(e) > S_0(e)$ (voir figure 2).

Un tel contrat, noté (e, p_E, S_m), permet d'assurer que la variation de bien-être social du programme ne sera pas négative. La fonction de coût $C(.)$ étant incertaine, le coût total correspondant à une surface donnée S peut se situer aussi bien au-dessus (C_2, sur la figure 2), qu'au-dessous (C_1, sur la figure 2) de $W(S)$. Mais, du fait du choix de p_E et de S_m, la croissance des coûts marginaux implique que des contrats ne seront signés que si le coût total $C(.)$ est en deçà de $W(.)$ sur l'intervalle $\{S_m, S_E\}$. Sinon, le coût marginal étant supérieur à p_E, les contractants potentiels nécessaires au franchissement du seuil S_m ont un coût marginal supérieur à p_E et ne sont pas disposés à signer ; le seuil n'étant pas atteint, le régulateur ne valide donc aucun contrat, excluant les cas où le bien-être pourrait être négatif (U_2, sur la figure 2). Ce contrat (e, p_E, S_m) n'est cependant pas optimal : il exclut des situations où le bien-être pourrait être positif (U_1 positif juste en deçà de S_m) et ne garantit pas que la surface contractualisée maximisera ce bien-être, puisque le paiement unitaire choisi ne dépend pas du coût. Chaque agriculteur réalisant une anticipation correcte de l'effet environnemental associé à (e, p_E, S_m), cet effet sera inférieur à l'optimum de second

Figure 2. **Utilité du régulateur, coût de mise en place de pratiques alternatives par les agriculteurs et utilité sociale, en fonction de la surface contractualisée : détermination de la prime maximale p_E et de la surface minimale S_m garantissant une utilité sociale strictement positive (illustration pour un coût d'opportunité des fonds publics λ nul)**



rand si $p_E \sum p_1$, et supérieur sinon. Cela provient du fait que, pour chaque agriculteur, la surface sous contrat est croissante avec *p* et avec *K*.

Proposer aux agriculteurs un contrat *(e, p_E, S_m)* permet donc au régulateur de se prémunir contre les situations dégradant le bien-être social. Cette solution est *a priori* différente de celle qui serait obtenue par un mécanisme de second rang (mécanisme que le régulateur ne peut mettre en œuvre qu'au prix d'hypothèses sur la façon dont les agriculteurs valorisent l'effet environnemental). Dans la sous-section suivante, nous montrons qu'un tel contrat a un intérêt supplémentaire quand la fonction individuelle de coût de chaque agriculteur est inconnue de ses collègues.

Fonctions individuelles de coût inconnues du régulateur et des autres agriculteurs

Examinons maintenant le cas où les agriculteurs ignorent la façon dont réagiront leurs voisins. Face à un contrat *(e, p),* chaque agriculteur va effectuer ses propres anticipations sur l'effet environnemental, et son consentement à payer sera $c^i(s^i, e, K^i)$. Le régulateur éprouvera encore plus de difficultés que dans le cas précédent à calculer e^*. Il lui sera, de plus, quasiment impossible de déterminer un paiement associé à la fourniture d'un service environnemental donné puisque, pour cela, il lui faudrait connaître à la fois l'utilité que retire chaque agriculteur de l'effet environnemental, et la manière dont cet agriculteur anticipe les réactions de ces voisins.

En revanche, le régulateur peut toujours proposer le contrat (e, p_E, S_m) décrit ci-dessus. De plus, l'annonce d'un contrat (e, p_E, S_m) influence les anticipations K^i des agriculteurs. Face à un contrat (e, p), un agriculteur peut espérer réaliser un bénéfice $\pi(s^i(e,p,K^i)) = ps^i(e,p,K^i) - c^i(s^i(e,p,K^i),e,K^i)$. Cet agriculteur va réaliser *ex post* un profit, différent de $\pi(s^i(e,p,K^i))$ et que nous noterons :

$$\Pi(s^i(p, e, K^i),K) = ps^i(e,p,K^i) - c^i(s^i(e,p,K^i),e,K).$$

Si l'agriculteur avait anticipé $K^i > K$, il réaliserait *ex post* un profit inférieur à celui qu'il attendait (puisque c_K est négatif) ; en particulier, il risque d'être très déçu si $K = 0$. Au contraire, si l'état de l'environnement est meilleur que ce qu'il anticipait ($K^i < K$), l'agriculteur réaliserait un profit supérieur à celui qu'il espérait (bien que ce profit soit inférieur à celui qu'il aurait réalisé s'il avait anticipé K) :

$$\Pi(s^i(p, e, K^i),K^i) < \Pi(s^i(p, e, K^i),K) < \Pi(s^i(p, e, K),K), \text{ si } K^i < K.$$

Notons de plus que, puisque l'utilité de l'agriculteur est croissante en K^i, le profit que celui-ci réalise en anticipant K^i est, au pire, nul. Le consentement à payer de l'agriculteur pour la mise en place de mesures agri-environnementales sur sa propre exploitation lui assure une utilité totale supérieure à son utilité de réservation.

Proposer aux agriculteurs un contrat (e, p_E, S_m) revient à réduire le risque pour les agriculteurs de se voir confrontés *ex post* à une situation où K est nul : si la surface totale proposée à la contractualisation est inférieure à S_m, le régulateur ne signe pas le contrat collectif. Du coup, même s'ils ne connaissent pas les offres de leurs voisins, les agriculteurs ont intérêt à anticiper K^i au moins égal à $g(S_m, e)$. Pour optimiser leur offre personnelle s^i, ils ont même intérêt à se concerter pour anticiper correctement l'impact environnemental final.

Proposer un contrat (e, p_E, S_m) n'est *a priori* pas optimal, car e est fixé arbitrairement par le régulateur. Néanmoins, ce processus permet clairement de discriminer les zones où la mise en œuvre de contrats est souhaitable de celles où elle ne l'est pas, en permettant de révéler l'offre environnementale collective des agriculteurs de chaque zone. Cette révélation est réalisée avec un coût de transaction additionnel faible correspondant à l'annonce du seuil S_m. En revanche, ce processus suppose que le régulateur connaisse sa propre fonction d'objectif W.

Un exemple : l'élaboration de programmes itératifs d'implantation de bandes enherbées

Il est généralement accepté que les bandes enherbées permettent de limiter les écoulements superficiels et par là même protégent les cours d'eau des polluants potentiels contenus dans ces écoulements (Réal, 1998). Leur effet est maintenant relativement bien connu, grâce à de nombreux dispositifs expérimentaux. Les mécanismes qui contribuent à donner aux bandes enherbées un rôle de rétention ont été identifiés : le phénomène principal est l'infiltration dans la zone tampon, ensuite il y a la sédimentation des particules érodées et l'adsorption des molécules au contact des résidus végétaux et du sol. L'efficacité des bandes enherbées est bien documentée (Lacas *et al.*, 2005), mais sa variabilité est grande : en France, sous pluies naturelles, il apparaît, par exemple, que la variabilité de la réduction du flux de produits phytosanitaires dans le ruissellement intercepté par la bande enherbée varie entre 50 % et plus de 90 % pour la plupart des molécules. De plus, cette efficacité varie d'un site à l'autre, selon la période de l'année (en particulier, l'efficacité de la bande enherbée baisse en cas d'engorgement de la zone pendant la période hivernale), selon la largeur de la bande (aucune largeur optimale n'a été définie à l'heure actuelle) et, bien sûr, selon la proportion de berges sur lesquelles ces bandes sont implantées.

Un régulateur souhaitant proposer d'implanter des bandes enherbées pour la protection effective d'un cours d'eau se trouve dans la situation décrite dans les paragraphes précédents : il connaît la technologie, peut anticiper l'existence d'un seuil, ignore la valeur exacte de ce seuil et n'a pas de connaissance des fonctions de coût des agriculteurs pour l'implantation de ces bandes.

Le département d'Ille-et-Vilaine s'est trouvé dans cette situation et a mis en place un dispositif original permettant la coopération des agriculteurs. Le Conseil général a cherché à inciter les agriculteurs à implanter des bandes enherbées le long des berges de rivières pour protéger la qualité de l'eau et a utilisé pour cela une approche volontaire, financée par des contrats. Plusieurs étapes se sont succédé avant d'arriver à la forme actuelle du contrat (Kerhouas, 2003) :

– Les contrats initiaux ont été proposés dans le cadre des MAE pour la période 1994-1999. Sur la période 1994-1999, 536 contrats et 1 406 ha comportaient la création de bandes enherbées. Le budget total a été de 2 900 000 €.

– Un audit mené à la fin de la période sur les contrats signés sur le département a alors souligné le manque de résultats environnementaux au regard des sommes versées. Une proposition a été faite de prendre en compte dans la signature des contrats le fait que les bandes enherbées ne sont efficaces physiquement et ont un impact mesurable que si 60 % des rives d'une rivière sont sous contrat (Lancelot, 2001). La dispersion des contrats dans l'espace aurait ainsi diminué fortement l'efficacité des contrats précédents.

– Fort de cette réflexion, le Conseil général s'est lancé dans un nouveau processus d'élaboration des contrats. Un premier bassin versant a été choisi pour cette nouvelle approche. Élus et techniciens pensaient qu'annoncer, au moment de la signature des contrats, un objectif de continuité territoriale et une volonté d'obtenir un linéaire de bandes enherbées supérieur au seuil précédemment déterminé permettrait d'observer l'effet des mesures sur la faune, la flore et la qualité de l'eau, ainsi que de stimuler l'ensemble des partenaires impliqués (Lancelot, 2001).

– Après deux ans, seuls 11 exploitants de la zone concernée avaient signé un contrat. Le seuil de 60 % des rives, souhaité par le Conseil général, n'était donc pas encore atteint. Les contrats ont été payés et suivis normalement.

Une nouvelle approche a été proposée et s'est portée sur un second bassin versant. Cette fois, a été introduit, non un objectif de signature sur 60 % des berges, mais un pré-requis pour la signature des contrats. Tant que les déclarations d'intention de contracter ne concernaient pas 60 % des rives de la zone ciblée, les contrats n'étaient pas engagés. Cette nouvelle approche a conduit à la signature de 34 contrats sur la nouvelle zone concernée, dépassant ainsi le seuil des 60 % recommandé.

Les zones ciblées sont prioritairement des zones sous contrat eau-paysage-environnement (CEPE), signé avec le Conseil général. Ce type de contrat prévoit, au niveau du territoire intercommunal, la réalisation d'un diagnostic environnemental avec la définition puis la mise en œuvre d'un programme d'actions, ainsi que la coordination des programmes locaux, au niveau départemental. Le dispositif bandes enherbées est l'une des actions mises en œuvre dans le cadre de ce contrat. Ainsi, la mise en œuvre de ce dispositif est effectuée en priorité sur un territoire où la volonté de travailler à la reconquête de l'eau est déjà bien présente.

Le budget alloué à ce programme atteint 760 000 € pour la période 2001/2006. Trois types de contrats sont possibles. Le premier consiste à créer des bandes enherbées par reconversion des terres arables en herbages extensifs le long des rivières pour 375 euros/ha, si la culture initiale est céréalière. Les herbages ainsi créés ne seront fauchés qu'une fois par an, ne recevront que 70 unités d'azote et accueilleront 1,4 unité gros bovins par ha. Le second contrat prévoit également la création de bandes enherbées par reconversion des terres arables en prairies temporaires pour 259 euros/ha. Ces prairies pourront recevoir 210 unités d'azote, pourront être cultivées en trèfle, être fauchées trois fois par an, et accueillir 1,8 unité gros bovins par ha. Un désherbant sélectif pourra y être appliqué. Le dernier type de contrat est le maintien de bandes enherbées par gestion extensive de prairies pour 63,6 euros/ha.

Ces montants sont majorés de 20 % par le Conseil général si les mesures sont adoptées dans le cadre d'un CTE. Ces contrats concernent l'implantation ou la gestion de bandes enherbées de 20m de large. Les bandes enherbées doivent être implantées après un diagnostic précis des conditions territoriales. L'implantation des bandes enherbées doit se faire à des endroits précis du bassin versant afin d'avoir un impact mesurable sur la qualité de l'eau. Des conventions particulières ont été élaborées afin de mettre en œuvre ce dispositif. La responsabilité de l'instruction des dossiers est déléguée à l'ADASEA d'Ille-et-Vilaine qui assure également l'animation. Le CNASEA est l'organisme payeur.

Une convention a été signée avec la préfecture d'Ille-et-Vilaine qui engage l'État dans la mise en œuvre du dispositif. Cet engagement a évité au Conseil général d'avoir à notifier directement sa politique à la Commission européenne et a permis le co-financement des contrats par le FEOGA, section garantie.

Dans cet exemple, on constate, dans un premier temps, la capitalisation par le Conseil général d'expériences locales pour déterminer la valeur du seuil. Dans un second temps, une gestion évolutive des modalités de signature des contrats a permis d'élaborer progressivement un contrat de type (e, p_E, S_m) qui garantit un effet environnemental. Aucune étude vérifiant la qualité du cours d'eau sur le bassin versant concerné par ce contrat-type n'est disponible à ce jour. Ainsi, nous ne disposons pas d'éléments permettant de déterminer si la surface contractualisée atteint finalement la valeur S_m, ni si le bien-être social est positif.

Extensions

Aléa moral

L'autre problème classique d'asymétrie d'information concerne l'aléa moral, dans le cas où l'effort de chaque agriculteur, e^i, est difficile à contrôler. Aussi surprenant que cela puisse paraître, un certain nombre de mesures agri-environnementales existantes ont pourtant proposé de telles mesures (Instance nationale d'évaluation du contrat territorial d'exploitation, 2003).

Une politique classique est basée sur peu de contrôles, par nature coûteux dans cette situation, et des sanctions très élevées en cas de non-conformité (Holmström 1982). Dans la pratique, le contexte institutionnel ne permet pas, en général, de fixer des sanctions à un niveau tel qu'elles puissent être dissuasives.

Une solution coopérative est à nouveau envisageable si chaque agriculteur peut être aisément et fréquemment observé par ses collègues (Segerson, 1988). Segerson (1988) a repris les résultats déterminés par Holmström (1982) dans le cas de pollutions diffuses : l'ensemble des pollueurs potentiels est considéré comme une équipe, dont la production jointe est le niveau de pollution observé dans le milieu. Le régulateur ne mesure que la concentration en polluants et les paiements de taxes par les firmes. Les firmes sont soumises à une taxe individuelle (ou une subvention individuelle) lorsque le niveau de pollution dépasse (tombe sous) un niveau objectif prédéterminé. La mise en place de la taxe (différenciée selon chaque firme) permet d'atteindre un équilibre de Nash sous l'hypothèse que les fonctions de profit, d'émissions individuelles, de devenir et de transport des polluants, ainsi que toute autre information nécessaire, font partie d'un ensemble de connaissances communes.

C'est le cas, par exemple, pour la mesure imposant la fauche du centre vers la périphérie de la parcelle ; bien que des contrôles soient très difficiles à organiser par l'administration, les éleveurs sont fréquemment en mesure d'observer la manière dont leurs collègues fauchent. L'idée de base est alors un contrat entre le régulateur et un consortium d'agriculteurs d'une zone donnée. Le consortium reçoit un paiement global $P = C(p^*, e^*)$ si K^* est fourni, et sinon, rien du tout. En pratique, le consortium peut avoir à rembourser le paiement reçu *ex ante* si l'objectif n'est pas atteint, plus une pénalité éventuelle couvrant les coûts de l'administration et le coût d'opportunité des fonds publics (Falconer *et al.,* 2001). Cela signifie que la pénalité par agriculteur contractant est beaucoup plus faible que la pénalité optimale associée à des contrats individuels. Le respect de l'engagement collectif est basé sur les relations interindividuelles au sein du consortium, quelques passagers clandestins mettant en danger le paiement de tous les autres.

Incertitudes sur la technologie agri-environnementale

Nous avons jusqu'à présent supposé qu'il était possible de trouver une technologie agri-environnementale, *g*, qui relie les efforts fournis pas les agriculteurs, les surfaces contractualisées et l'effet environnemental observé. Déterminer cette technologie n'est pas toujours simple. Le cas le plus fréquent se rencontre lorsque l'effet environnemental concerne la restauration d'un biotope : les spécialistes de ce biotope ont souvent une idée très précise du résultat à rechercher, mais ne savent pas toujours traduire ce résultat escompté en effort à réaliser par les agriculteurs. Il est également possible que l'effet environnemental soit soumis à des aléas climatiques et ne reflète qu'imparfaitement les efforts des agriculteurs. Nous n'analyserons pas les modifications du mécanisme contractuel dans ces situations, car il nous faudrait pour cela ajouter des hypothèses sur l'aversion au risque des agriculteurs et du régulateur, et sur le partage du risque entre les deux. Nous considérerons par la suite que le régulateur a une représentation, même imprécise, de la forme de la technologie agri-environnementale à mettre en œuvre localement.

La plupart du temps, la technologie environnementale est connue partiellement des régulateurs et de leurs conseillers. Une difficulté fréquente provient de la possible convexité de cette technologie environnementale. La convexité de la technologie introduit un effet d'échelle : lorsque la surface totale contractualisée est relativement faible, le consentement à payer du régulateur peut être convexe. La mesure pour la couverture hivernale des sols, visant la réduction du lessivage hivernal d'azote et l'érosion, en est un exemple : la prime par hectare est modulée en fonction du pourcentage de terres arables de l'exploitation qui y sont soumises : elle est supérieure si plus de 40 % des terres arables de l'exploitation sont contractualisées.

En effet, l'on a :

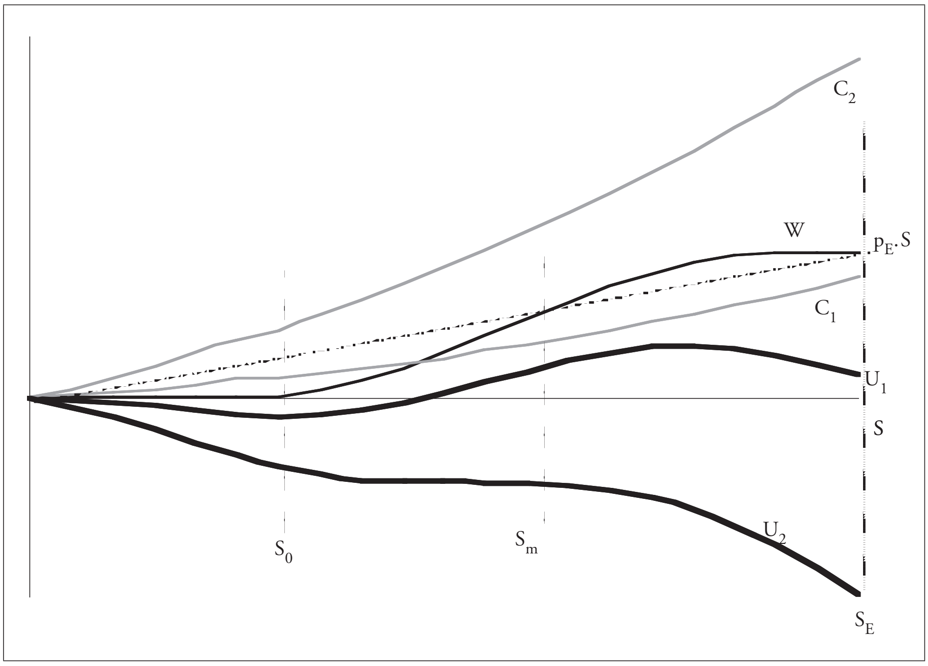
$$\frac{\partial^2}{\partial S^2}\left[W(g(S,e))\right] = W''(g_s)^2 + W'g_{ss} \qquad (8)$$

Puisque W est croissante concave en K, W' est positive et décroissante. Le $W'g_{ss}$ de l'équation (8) est positif, mais le terme W'' est négatif, on peut alors avoir plusieurs configurations. Soit W est strictement concave en S et l'on est ramené au cas étudié dans la sous-section « Fonction de coût inconnue du régulateur ». Soit W est strictement convexe en S : dans ce cas, soit W est toujours inférieur à C et il est optimal de ne rien faire, soit W est supérieur à C à partir d'une surface contractualisée donnée et il est optimal de contractualiser toute la surface potentielle. Si l'on suppose que les dérivées secondes de W et de K sont monotones, il reste un dernier cas : W est convexe, puis concave en S (figure 3). Le mécanisme proposé au paragraphe « Fonction de coût inconnue du régulateur » reste applicable, avec une surface déclenchant la signature du contrat collectif plus importante en raison du point d'inflexion.

Bien entendu, si les fonctions W'' et g_{ss} ne sont pas monotones, le signe de d^2W/dS^2 peut très bien ne pas être constant et il conviendrait alors d'élaborer une régulation dynamique (Rondeau, 2001).

Plus simplement, la présence d'effet de seuil est généralement connue et l'incertitude porte sur la valeur précise du seuil dans un contexte local. En général, les agriculteurs disposent de moins d'information que les décideurs publics sur les processus environnementaux. Dans ce cas, la difficulté est de proposer et d'assurer le suivi de contrats

Figure 3. **Utilité du régulateur (*W*), coût de mise en place de pratiques alternatives par les agriculteurs (C_1 et C_2) et utilité sociale (U_1 et U_2), en fonction de la surface contractualisée lorsque la technologie environnementale est convexe**



qui produiront une information supplémentaire sur ces processus et fourniront les valeurs des seuils. Une démarche itérative qui prévoit plusieurs étapes de contractualisation est nécessaire. Sans asymétrie d'information, des contrats standard sont offerts dans une première étape dans quelques zones représentatives délimitées selon l'objectif environnemental et les possibles effets de seuil associés. S'il existe des sites aux caractéristiques proches, différents contrats *(e,p)* peuvent être testés pour découvrir les valeurs critiques plus rapidement et avec une plus grande précision. Commencer avec des niveaux d'effort et de paiements associés élevés, offrant un profit confortable aux agriculteurs, peut avoir des avantages : la probabilité de production du bien environnemental étant plus élevée, le coût social net de la première étape de contractualisation sera probablement plus faible, même si le surplus social n'atteint pas le coût du programme. De plus, un succès environnemental encouragera les agriculteurs pour les prochaines étapes de contractualisation, alors qu'un échec les aurait découragés. À la fin du suivi du programme, le régulateur saura *ex post* si les seuils ont été atteints ou pas. Dans certains cas, il est pertinent d'offrir un paiement supplémentaire aux contractants pour qu'ils réalisent eux-mêmes une partie du suivi. Le processus itératif, dans lequel les résultats des étapes précédentes sont pris en compte, permet au régulateur d'atteindre le contrat optimal pas à pas et de le proposer à d'autres zones selon les recommandations de Wu (2004). Notons cependant la difficulté de mise en œuvre d'un tel processus dans le cas fréquent d'un temps de latence du milieu aux efforts environnementaux, qui ralentit l'acquisition de données pertinentes.

Une coopération active entre scientifiques, décideurs publics, agriculteurs et organisations environnementales devrait créer un contexte dans lequel les impacts environnementaux attendus, les procédures de suivi et les contrats sont définis à chaque étape en tenant compte des résultats précédents. Dans un tel contexte, les interrelations entre les différentes mesures décrites dans la littérature, notamment sur les programmes de conservation d'espèces menacées (Wu, 2004), pourraient également être intégrées dans l'élaboration des contrats futurs.

Lorsque, de plus, la fonction de coût des agriculteurs est partiellement inconnue par le régulateur, annoncer une surface minimale de contractualisation pour déclencher la signature par le régulateur du contrat (e, p, S_m) n'est plus utile lorsque la valeur du seuil est inconnue. L'analyse *ex post* des contrats (e, p) fournira l'information nécessaire sur la fonction de production environnementale des agriculteurs. Une fois encore, la révélation du consentement à recevoir des agriculteurs, sous différents scénarios, peut fournir des informations complémentaires intéressantes. Par exemple, l'influence de la probabilité de l'effet environnemental recherché associée à différents contrats peut être testée, avant qu'une telle probabilité soit elle-même estimée.

Le problème d'aléa moral est plus difficile à appréhender parce que l'identification de la source d'échec du programme est impossible. Pour la régulation des nuisances, plusieurs auteurs préconisent une taxe ambiante, dont le taux dépend de l'état de l'environnement, car c'est une politique qui s'appuie sur les résultats plutôt que sur des efforts difficiles à observer. C'est ainsi, par exemple, que dans la zone agricole des Everglades, les cultures sont taxées depuis 1994, selon un taux par hectare croissant avec le temps (Ribaudo, 2004). Ce mécanisme constitue un transfert progressif des droits sur l'environnement des agriculteurs vers la collectivité. Le mécanisme prévoit une réduction de taxe dès lors que la pollution agrégée diminue au-delà d'un certain seuil. On ne connaît pas encore les conséquences de ce mécanisme. Sa transposition pour la production d'aménité pourrait être envisagée sous forme de subvention ambiante. Cela donne l'opportunité et la responsabilité aux agriculteurs d'entrer dans un processus de capitalisation de connaissances sur la technologie environnementale et de décider des actions à mener ou non. Il faut cependant noter que ce type de mécanisme peut aussi permettre au régulateur de faire porter tout le risque aux agriculteurs lorsque l'effet environnemental dépend fortement d'aléas (climatiques ou biologiques). C'est pourquoi l'utilisation d'une taxe/subvention ambiante semble plus adaptée à de petites zones homogènes (Weersink *et al.*, 1998).

Lorsque des biotopes remarquables sont menacés par l'évolution économique d'une région, Perrings et Pearce (1994) montrent que l'incertitude sur les seuils est souvent associée à une incertitude et à une irréversibilité des dommages potentiels et de leurs coûts sociaux. Dans ce cas, les outils économiques conventionnels ne sont pas utilisables car aucun optimum n'est calculable : les décisions concernant la préservation de ces biotopes reposent alors sur des critères non économiques. La préservation du *statu quo* est assurée par des pénalités dont le montant doit être élevé par rapport au profit privé du non-respect des normes. De nombreux programmes agri-environnementaux sont utilisés pour préserver de l'abandon et de l'intensification agricole des sites remarquables comme certains marais, des tourbières ou des prairies sèches de montagne. L'utilisation des résultats de Perrings et Pearce (1994) justifie des paiements suffisamment élevés pour empêcher une utilisation alternative des terres dans les sites sélectionnés par les décideurs publics. Parfois, ces paiements ne correspondent à aucun effort tangible de l'agriculteur.

Conclusion

La diversité des situations agri-environnementales ne permet pas, en général, de définir des politiques efficaces à un échelon territorial élevé. Comme l'observait Mollard (2003), l'effet environnemental doit être recherché sur un territoire de taille permettant de nouer des cohérences entre les acteurs et les ressources dont ils sont dotés. Les collectivités locales apparaissent les plus légitimes pour réaliser l'animation associée à une construction évolutive visant à maintenir la motivation et la coopération entre les différents acteurs, bureaux d'étude, associations environnementales, groupements de producteurs, industries d'amont et aval, agriculteurs et leurs représentants.

Dans une région donnée, un processus itératif de capitalisation des connaissances sur des petites zones pertinentes permet de définir pas à pas un contrat optimisé, qui sera dans un second temps proposé à d'autres zones comparables. Les contraintes budgétaires, auxquelles sont soumises les collectivités, vont induire une compétition entre ces zones et une interaction avec leur développement qui doivent être intégrées dans un projet régional, précisant le consentement à payer de la collectivité zone par zone. Cet article montre l'importance de repérer les effets de seuils pouvant caractériser les processus agri-environnementaux et offre des pistes pour l'élaboration de politiques plus efficaces.

En présence d'effet de seuil, le conditionnement du paiement à une intention de contractualisation (S_m) supérieure à la surface nécessaire au franchissement du seuil (S_0) permet au régulateur de favoriser une solution coopérative, même en présence d'asymétries d'information sur le consentement à recevoir des agriculteurs. Le mécanisme proposé dans ce papier est applicable concrètement, ainsi que l'illustre le cas décrit en Ille-et-Vilaine. Un tel processus n'est pas optimal et peut être amélioré par une construction évolutive reposant sur la capitalisation des connaissances locales.

L'existence d'un consentement à payer des agriculteurs pour la mise en place sur leur propre exploitation de mesures agri-environnementales est un élément qu'un nombre croissant d'études empiriques met en évidence (Dupraz *et al.*, 2002 et 2003). Ce consentement à payer doit être pris en compte par le régulateur, dans un objectif de bonne utilisation des fonds publics en assurant une dynamique de contractualisation et une coopération des agents dans la durée. Ce consentement à payer est susceptible d'être mobilisé par une meilleure formation et information des agriculteurs sur les processus agri-environnementaux, et la proposition de mesures dont les impacts environnementaux attendus sont crédibles au regard de leurs conditions d'application.

Les nouvelles dispositions relatives à la conditionnalité des aides européennes incluent l'obligation faite aux exploitations agricoles de « *mettre en place une surface équivalente à 3 % de la surface en céréales, oléoprotéagineux et gel de l'exploitation en bandes* *enherbées ou avec un couvert à intérêt environnemental* ». Les surfaces et les linéaires en jeu sont considérables (400 000 ha de surfaces enherbées et 400 000 à 800 000 km de bandes enherbées, soient 200 000 à 400 000 km de linéaire de cours d'eau ; Gril et Lacas, 2004). Dans de nombreux cas, les cultivateurs gardent une marge de manœuvre importante quant à la localisation de ces bandes enherbées. Les implantations de bandes enherbées (différents aménagements possibles, différentes localisations possibles) devraient autant que possible être adaptées à chaque territoire sous peine d'imposer des contraintes significatives aux exploitants sans grands bénéfices environnementaux tangibles. Un diagnostic précis de ce territoire ainsi qu'une capitalisation et une diffusion des connaissances techniques locales sont donc indispensables pour une application optimale des nouvelles dispositions réglementaires.

Bibliographie

Arnaud S. (2004). Expression de la demande sociale pour les diverses fonctions de l'espace rural dans le Parc des Marais du Cotentin et du Bessin, Mémoire de DEA, Laboratoire d'économie et sociologie rurales, INRA, Rennes, Faculté des sciences économique de l'université de Montpellier 1, ENSA de Montpellier.

Asner G.P., Vitousek P.M. (2005). Remote analysis of biological invasion and biogeochemical change, *Proceedings of The National Academy of Sciences of The United States of America*, 102 (12), pp. 4383-4386. National Academy of Sciences (USA).

Bonnieux F., Dupraz P. and Retière C. (2001). Farmer's supply of environmental benefits, *in: Multifonctionality of Agriculture, Seminar Proceedings*, Erling Vardal (ed.), February 16-18, Department of Economics of the University of Bergen, Research Council of Norway, pp. 105-133.

Bontems P., Rotillon G. and Turpin N. (2005). Self-selecting agri-environmental policies with an application to the Don watershed, *Environmental and Resource Economics*, 31 (3), pp. 275-301.

Dasgupta P., Maler K.G. (2003). The economics of non-convex ecosystems: Introduction, *Environmental and Resource Economics,* 26 (4), pp. 499-525.

Dupraz P., Latouche K. and Bonnieux F. (2004). Economic implication of scale and threshold effects in agri-environmental processes, Proceedings of 90th EAAE Seminar *Multifunctional agriculture, policies and markets: Understanding the critical linkage,* INRA/AgroCampus Rennes, October 28-29, (*http://merlin.lusignan.inra.fr:8080/eaae/website/ContributedPapers*), 8 p.

Dupraz P., Rainelli P. (2004). Institutional approaches to sustain rural landscapes in France, *in: Sustaining Agriculture and the Rural Economy,* Brouwer F. (ed.), Cheltenham, Edward Elgar Publishing, pp. 162-182.

Dupraz P., Vanslembrouck I., Bonnieux F. and Van Huylenbroeck G. (2002). Farmers' participation in European agri-environmental policies, Paper presented at the Xth Congress of the European Association of Agricultural Economists*,* Zaragoza (Spain), August 28-31, 14 p.

Dupraz P., Vermersch D., Henry de Frahan B. and Delvaux L. (2003). The environmental supply of farm households: A flexible willingness to accept model, *Environmental and Resource Economics*, 25 (3), pp. 171-189.

Eureval C3E (2003). Évaluation à mi-parcours portant sur l'application en France du règlement C.E. n° 1257-1999 du Conseil, concernant le soutien au développement rural, partie sur le soutien à l'agri-environnement (chapitre VI du R.D.R.) et le contrat territorial d'exploitation en Basse-Normandie, Rapport final MAE, 15 juin, 164 p.

Falconer K., Dupraz P. and Whitby M. (2001). An investigation of policy administrative costs using panel data for the English environmentally sensitive areas, *Journal of Agricultural Economics,* 52 (1), pp. 83-103.

Genicot G., Ray D. (2006). Contracts and externalities: How things fall apart., *Journal of Economic Theory,* 131 (1), pp. 71-100.

Gril J.-J., Lacas J.-G. (2004). Intérêt des zones tampons enherbées et boisées pour limiter le transfert diffus des produits phytosanitaires vers les milieux aquatiques. De l'état des connaissances aux recommandations pratiques, Rapport d'étude, Lyon, CEMAGREF/Unité de recherche Qualité de l'eau et prévention des pollutions, 37 p.

Holmström B. (1982). Moral hazard in teams, *Bell Journal of Economics*, 13 (2), pp. 324-340.

Instance nationale d'évaluation du contrat territorial d'exploitation (2003). Le programme CTE, Rapport d'évaluation, Paris, ministère de l'Agriculture, de l'Alimentation, de la Pêche et des Affaires Rurales, décembre, 177 p.

Kennedy T.A., Naeem S., Howe K.M., Knops J.M.H., Tilman D. and Reich P. (2002). Biodiversity as a barrier to ecological invasion, *Nature,* 417 (6889), pp. 636-638.

Kerhouas Y. (2003). La mise en œuvre de mesures agro-environnementales sur le département d'Ille-et-Vilaine. Dispositif « Bandes Enherbées », Rapport du Conseil général d'Ille-et-Vilaine, Rennes (France), Conseil général d'Ille-et-Vilaine, 70 p.

Lacas J.-G., Voltz M., Gouy V., Caluer N. and Gril J.-J., (2005). Using grassed strips to limit pesticide transfer to surface water: A review, *Agronomy for Sustainable Development,* 25, pp. 253-266.

Laffont J.-J., Martimort D. (2002). *The Theory of Incentives: The Principal-Agent Model*, Princeton (NJ), Princeton University Press, 360 p.

Lancelot F. (2001). Le renouveau des bandes enherbées le long des rivières, *La Terre,* semaine du 28 février au 6 mars, pp. 2-3.

Levin S.A. (1998). Resilience in natural and socioeconomic systems, *Environment and Development Economics,* 3 (2), pp. 222-234.

Lines M. (2005). Intertemporal equilibrium dynamics with a pollution externality, *Journal of Economic Behavior and Organization,* 56 (3), pp. 349-364.

Maler K.G. (2000). Development, ecological resources and their management: A study of complex dynamic systems, *European Economic Review,* 44 (4-6), pp. 645-665.

Mitra T., Roy S. (2006). Optimal exploitation of renewable resources under uncertainty and the extinction of species, *Economic Theory,* 28, pp. 1-23.

Mollard A. (2003). Multifonctionnalité de l'agriculture et territoires : des concepts aux politiques publiques, *Cahiers d'économie et sociologie rurales,* 66, pp. 28-54.

Morris C., Potter C. (1995). Recruiting the new conservationists: Farmers' adoption of agri-environment schemes in the UK, *Journal of Rural Studies*, 11, pp. 51-63.

Muradian R. (2001). Ecological thresholds: A survey, *Ecological Economics,* 38 (1), pp. 7-24.

OCDE (2003). *Voluntary Approaches for Environmental Policy - Effectiveness, Efficiency and Usage in Policy Mixes*, Paris, OECD publishing, 144 p.

Parkhurst G.M., Shogren J., Bastian C., Kivi P., Donner J. and Smith R.B.W. (2002). Agglomeration bonus: An incentive mechanism to runite fragmented habitat for biodiversity conservation, *Ecological Economics*, 41, pp. 305-328.

Pascal Consultants-CNASEA (2003). Évaluation des MAE et CTE à mi-parcours en Bretagne, Rapport final, 25 juin, Limoges, CNASEA, 75 p.

Perrings C., Pearce D. (1994). Threshold effects and incentives for the conservation of biodiversity, *Environmental and Resource Economics*, 4, pp. 13-28.

Réal B. (1998). Étude de l'efficacité des dispositifs enherbés, ITCF et Agences de l'eau, campagnes 1993-94, 1994-95, 1995-96, Institut technique des céréales et des fourrages, Services techniques de production, Estrées Mons et La Chapelle Saint Sauveur, septembre, 30 p.

Ribaudo M.O. (2004). Policy explorations and implications for nonpoint source pollution control: Discussion, *American Journal of Agricultural Economics*, 86 (5), pp. 1220-1221.

Rondeau D. (2001). Along the way back from the brink, *Journal of Environmental Economics and Management*, 42 (2), pp. 156-182.

Segerson K. (1988). Uncertainty and incentives for nonpoint pollution control, *Journal of Environmental Economics and Management*, 15, pp. 87-98.

Toman M.A., Withagen C. (2000). Accumulative pollution, "clean technology", and policy design, *Resource and Energy Economics*, 22 (4), pp. 367-384.

Vanslembrouck I., Van Huylenbroeck G. and Verbeke W. (2002). Determinants of the willingness of Belgian farmers to participate in agri-environmental measures, *Journal of Agricultural Economics*, 53 (3), pp. 489-511.

Weersink A., Livernois J.R., Shogren J.F. and Shortle J.S. (1998). Economic instruments and environmental policy in agriculture, *Canadian Public Policy,* 24 (3), pp. 309-327.

Weisner S.E.B., Strand J.A. and Sandsten H. (1997). Mechanisms regulating abundance of submerged vegetation in shallow eutrophic lakes, *Oecologia,* 109 (4), pp. 592-599.

Wirl F. (2004). Thresholds in concave renewable resource models, *Ecological Economics*, 48 (2), pp. 259-267.

Wirl F. (1999). Complex, dynamic environmental policies, *Resource and Energy Economics*, 21 (1), pp. 19-41.

Wu J. (2004). Using sciences to improve the economic efficiency of conservation policies, *Agricultural and Resource Economics Review*, 33 (1), pp. 18-23.

Wu J., Babcock B.A. (1996). Contract design for the purchase of environmental goods from agriculture, *American Journal of Agricultural Economics,* 78, pp. 935-945.

Institut National de la recherche Agronomique

Unité d'Economie et Sociologie Rurales
4 Allée Adolphe Bobierre, CS 61103
F 35011 Rennes Cedex

Tél. (33) 02 23 48 53 82/53 88 - Fax (33) 02 23 48 53 80
http://www.rennes.inra.fr/economie/index.htm

The Asset Specificity Issue in the Private Provision of Environmental Services: Evidence from Agri-Environmental Contracts

Géraldine DUCOS and Pierre DUPRAZ

June 2007

Working Paper 07-02

The Asset Specificity Issue in the Private Provision of Environmental Services: Evidence from Agri-Environmental Contracts

Géraldine DUCOS
INRA - Unité ESR Rennes

Pierre DUPRAZ
INRA - Unité ESR Rennes

This document uses results obtained within the EU project SSPE-CT-2003-502070 on Integrated tools to design and implement Agri-Environmental Schemes (http//:merlin.lusignan.inra.fr/ITAES). It does not necessary reflect the view of the European Union and in no way anticipates the Commission's future policy in this area. This research benefits from the support of the French Ministry of Environment and Sustainable Development within the project "Implementation and Acceptability of Contractual Agri-Environmental Policies" of the S3E program.

Corresponding address:
Géraldine DUCOS
INRA – Unité ESR
4 allée Bobierre, CS 61103
35011 Rennes Cedex, France
E-mail: geraldine.ducos@rennes.inra.fr
Tel: 00 33 (0) 2 23 48 54 01
Fax: 00 33 (0) 2 23 48 53 80

The Asset Specificity Issue in the Private Provision of Environmental Services: Evidence from Agri-Environmental Contracts

Abstract

Conservation practice adoption is classically explored through the technology lens. However, by introducing the trade-off between production cost savings and higher transaction costs, involved asset specificity level should be considered too. This paper addresses this issue in the case of agri-environmental contracts, in which subscribed agri-environmental practices are freely chosen by the farmer. Several studies have examined factors influencing farmers' adoption but none have distinguished practices from their associated asset specificity level and transaction costs. We fill this gap by assuming a utility maximizing farmer who compares contract payments with compliance costs. Transaction costs being endogenous and difficult to measure, we identify conditions in which these costs vary and derive testable propositions about these conditions' effect on the choice over asset specificity level. Estimations on a sample of 328 French farmers interviewed in 2005 confirm the existence of a transaction cost barrier in agro-environmental contract adoption. They also show factors such as distrust in the Government, uncertainty stemming from the opacity of public decisions and the non-similarity of transactions have a significant negative effect on the probability farmers choose more specific practices.

Key words: Agri-environmental contract, asset specificity, endogeneity, transaction costs

JEL classification : D23, Q12, Q28

La spécificité des investissements dans la fourniture privée de services environnementaux : évidences à partir des contrats agro-environnementaux

Résumé

Le contrat agro-environnemental est un instrument de politique publique largement utilisé en Europe dédié à la production de services environnementaux en milieu rural. C'est un contrat de 5 ans entre l'Etat et l'agriculteur où l'agriculteur s'engage à adopter des pratiques respectueuses de l'environnement qu'il est libre de choisir en échange d'une compensation financière. Sachant que la spécificité des investissements a un rôle majeur dans l'obtention de résultats environnementaux, il est important d'identifier les facteurs de comportement de l'agriculteur vis-à-vis des pratiques spécifiques. Bien que le comportement d'adoption soit largement traité dans la littérature empirique, le choix de la spécificité des actifs n'a pas encore été exploré. Cet article s'intéresse à cette question en supposant que l'agriculteur maximise son utilité et qu'il compare le paiement compensatoire de la pratique avec les coûts de conformité au cahier des charges. Les coûts de transaction n'ayant pas été pris en compte dans le calcul des paiements compensatoires, nous nous attendons à ce que le choix de l'agriculteur soit affecté par leur variabilité entre pratiques. Les conditions dans lesquelles ces coûts varient sont identifiées et nous dérivons des propositions sur l'effet de ces conditions sur le choix de spécificité des actifs. L'analyse empirique est basée sur un échantillon de 328 agriculteurs français interrogés en 2005. Les estimations supportent que le manque de confiance dans l'Etat, l'incertitude provenant de l'opacité des décisions publiques et la non-similarité des transactions ont un effet négatif significatif sur la probabilité que l'agriculteur choisisse des actifs spécifiques.

Mots-clés : contrat agri-environnemental, actif spécifique, endogénéité, coût de transaction

Classification JEL : D23, Q12, Q28

The asset specificity issue in the private provision of environmental services: Evidence from agro-environmental contracts

1. Introduction

Conservation practice adoption is classically explored through the technology lens (Dupraz et al., 2002; Soule et al., 2000; Traoré et al., 1998; Gould et al., 1989; Napier and Camboni, 1993) whereas involved asset specificity level gives rise to other important issues. This characteristic has a double implication. On the one hand, asset specificity permits cost savings to be realized, in that environmental outcomes highly depend on timing or localization aspects. On the other hand, these specificities require the production system to be entirely adapted and result in non negligible risky investments. Indeed, such investments are non redeployable without sacrifice of productive value if the contract should be interrupted or prematurely terminated. These elements constituting a hold up situation from which difficulties of writing contracts contingent on all important future events and the fact that these contracts can be renegotiated lead to high transaction costs. Transaction costs enter then in the decision over what level of asset specificity to invest in.

From this observation, this paper aims at better understanding the choice over conservation practices adoption differing in their asset specificity level. We base our analysis on the study of agri-environmental contract adoption by farmers. At the present time, adoption remains low and enrolled agri-environmental practices are low asset specific. Farmers actually avoid subscribing practices such as timely and site adapted conservation practices, specialized planting equipment, or advanced agronomic skills. Most of the time, these requirements leading the farmer to fully adapt his production system, they ends up to an important and long term investment. Moreover, the Government being the only demander of environmental services in rural areas, the value of these investments relies on the Government-farmer relationship. From this hold up situation and given that environmental outcomes highly depend on involved asset specificity levels, we therefore argue the asset specificity issue deserves more attention in the analysis of agri-environmental transactions.

Several studies have examined factors influencing farmers' agri-environmental contract adoption. Four main determinants have been identified, namely (i) farmer and farm household characteristics, (ii) farm biophysical characteristics, (iii) farm financial/management characteristics, and (iv) exogenous factors such as information availability, sources of information, society social capital (Knowler and Bradshaw, 2007). However, except from Bekele and Drake (2003), none have distinguished agri-environmental practices between them and their related adoption factors. As regard to Bekele and Drake's work, they studied farmers' choice over different soil and water conservation practices but did not distinguish them from their asset specificity level. This is what this paper aims at by analysing farmers' choice over different agri-environmental practices associated to different asset specificity levels.

We base our analysis on farmers' choice modelling. Facing agri-environmental practices differing in their asset specificity level, we assume each farmer selects the practice that maximises his utility. For that, the usual operational cost based analysis, i.e. the analysis of additional costs and profit foregone resulting from the technology adaptation to the commitment made, is completed by introducing to each agri-environmental practice their involved asset specificity level and associated transaction costs. Taking into account that transaction costs and asset specificity levels are endogenous in the farmer's decision, our analysis focused on exogenous transaction costs determinants, namely trust, bounded rationality, utility in the transaction, uncertainty and the similarity of transactions. Propositions are then derived to relate estimated effects of transaction cost exogenous determinants to chosen asset specificity levels.

This case study owes its originality to the policy compensation payment calculation. Being based on the 1999-Common Agricultural Policy (CAP) regulation, it only covers operational costs. Transaction costs are thus not included. With such a payment pattern and negligible transaction costs, all proposed compensated agri-environmental practices are expected to attract a good share of farmers. However, given that the different practices are associated to different asset specificity levels, farmers' transaction costs should differ across practices and therefore should affect each practice uptake rate.

The estimation of a multinomial logit model with data collected among 328 French farmers in 2005 first shows 1999-CAP compensation payments do not incite farmers to subscribe practices involving high asset specificity. Then, they clearly support that some factors favour the adoption of more specific practices, namely to trust in the Government, uncertainty and the similarity of transactions, i.e. how similar the new transaction technology is compared to existing ones. They support that the higher the farmer trusts in the Government, the higher the probability he chooses more specific practices. They also support, but in a less rigid way, that uncertainty stemming from the opacity of public decision making reduce the probability the farmer chooses more specific practices.

The first contribution of this paper is thus to highlight and support the importance of asset specificity in the choice over conservation practice adoption. The second contribution goes beyond the environmental field. Indeed, very few studies tried to take the asset specificity endogeneity into account whereas it is asserted (Masten, 1995; Masten and Saussier, 2002) that the specificity of assets is itself a decision variable. According to Masten and Saussier (2002), "the binding constraint is not technique, but data availability". This study beneficiating from an original data base, some information constraints are lowered, which places us in a position to provide empirical evidences on determinants of the choice over the asset specificity level.

In section 2, we present the model from which we derived propositions. Section 3 first introduces survey conditions and then provides estimation results. Section 4 concludes.

2. The conceptual framework and propositions

2.1. Asset specificity: Theory and evidence

Asset specificity is the most important and most distinguishes transaction costs economics from other treatments of economic organization. Transaction specific investments result in assets that have greater value when used to service a particular transaction, than they would have if that relationship broke down. This constitutes a hold up problem in which the economic relationship is characterized by the existence of appropriable quasi-rents[1] that are available to parties to bargain over. Besides, as noted by Williamson (1985), "asset specificity only takes on importance in conjunction with bounded rationality/ opportunism and in the presence of uncertainty". Therefore, when these conditions are gathered, transacting parties should be tempted to protect their relationship. They will be willing to write a contract as complete as possible, implement enforcement and monitoring designs,… which may lead to significant problems related to *ex ante* and *ex post* negotiations and maladaptation aspects and generate important transaction costs.

[1] The quasi-rent value of an asset is the excess of its value over its salvage value, that is, its value in its next best use to another renter. The potentially appropriable specialized portion of the quasi-rent is that portion, if any, in excess of its value in its second highest-valuing user (Klein et al., 1978)

Williamson is the first to note the role quasi rents can play in causing contracting problems and incentives to vertically integrate. This idea is then popularised in Klein et al., (1978). They emphasized on the presence of appropriable specialized quasi rents as likely producing a serious threat of opportunism and litigation which may turn out to be costly and ineffectual. They then assumed "as assets become more specific and more appropriable quasi-rents are created (and therefore the possible gains from opportunistic behaviour increases), the cost of contracting will generally increase more than the costs of vertical integration".

Four types of asset specificity are usefully distinguished, namely site specificity, physical asset specificity, human asset specificity and dedicated assets (Williamson, 1985). Masten et al. (1991) add time specificity as a fifth type, which particularly fits the agri-environmental transaction. It refers to the following case: "when timely performance is critical, delay becomes a potentially effective strategy for exacting price concessions. Knowing that interruptions at one stage can reverberate throughout the rest of the project, an opportunistic supplier may be tempted to seek a larger share of the gains from trade by threatening to suspend performance at the last minute. Even though the skills and assets necessary to perform the task may be fairly common, the difficulty of identifying and arranging to have an alternative supplier in place on short notice introduces the prospect of strategic hold ups".

Even if the transaction cost economics approach is not linked with formal models, it offers an "empirical success story" in the sense that many empirical tests flourished and confirmed propositions on (i) vertical integration (Joskow, 1985; Masten et al., 1991), (ii) long term contracts (Crocker and Masten, 1988; Joskow, 1985), or (iii) price adjustments (Crocker and Masten, 1991; Joskow, 1988). As regard to the literature on environmental service transactions, the presence of transaction costs has also been widely demonstrated (Colby, 1990; Stavins, 1995; Kuperan et al., 1998; McCann and Easter, 1999; Falconer et al. 2001). However, the specificity of assets is usually treated as an exogenous variable whereas it is itself a decision variable. According to Masten and Saussier (2002), "the binding constraint is not technique, but data availability". This is what be beneficiate in this present case study. Compensation payments not covering transaction costs borne by the farmer, we are in a position to compare the costs derived from the profit function with transaction costs. Then, by identifying conditions in which transaction costs vary, we could derive testable propositions about the choice over asset specificity level.

2.2. The model

We assume the farmer decides to adopt an agri-environmental contract with given agri-environmental practices and involved asset specificity levels if the offered contract payment is higher than compliance costs. Compliance costs gather technology adaptation costs derived from additional costs (also called operational costs), income foregone resulting from the commitment made and transaction costs borne by the farmer. In line with the 1999-CAP regulation, the implemented compensation payment (or contract payment) is a per-unit payment based on average operational costs and income foregone in each region and do not include transaction costs. Given that the asset specificity level associated to an agri-environmental practice is a factor of transaction costs, the variability of transaction costs from a practice to another is thus expected to affect their respective uptake rate, *ceteris paribus*. Farmers should then choose the agri-environmental practice which involves the lowest transaction costs. In addition, we suspect some conditions to lower or increase these transaction costs and, consequently, to impact on farmers' choice.

As implied by this choice framework, we consider a utility maximizing farmer facing K agri-environmental practices, each of them being linked to an asset specificity level. The farmer selects the K-dimensional vector y of agri-environmental service units derived from each practice according to his preferences and budget constraint. The agri-environmental contract lasts five years corresponding to a medium term time horizon. Offered per-unit payments are included in the K-dimensional vector q. Utility is supposed to be non decreasing, continuous, differentiable and quasi-concave in the private consumption m and the vector y. Utility also depends on exogenous farmer's preferences. In the budget constraint, the medium term income m can not exceed the contract payment $q.y$ plus the short term profit $\pi(.)$ that depends on y and on prices of variable inputs and outputs p. The short term $\pi(p,y)$ dually represents the technology. It is assumed linearly homogenous in prices p, non increasing and quasi-concave in y (Dupraz et al., 2003). A transaction cost function, called $T(.)$, is distinguished from the profit function. This function is assumed to depend on exogenous determinants of transaction costs, t.

$$\begin{aligned} &\underset{m,y}{Max}\, U(m,y) \\ &m \leq \pi(p,y) - T(p,y,t) + qy \qquad (1) \\ &y \geq 0 \end{aligned}$$

As previously explained, the profit variation due to the farm technology adaptation is compensated by the contract payment, but it does not encompass transaction costs. Therefore, when asset specificity gets higher, we should observe effects stemming from the variability of transaction costs and utility only. Effects stemming from the profit function are thus theoretically non observable.

The solution of the maximisation programme (1) is noted (m^*, y^*), with $V(p,q,t) = U\left(m^*(p,q,t), y^*(p,q,t)\right)$ being the indirect utility function. The vector y^* is the optimal combination of agri-environmental practices, in other words, the global asset specificity level selected by the farmer. Given the very high number of practices, which leads to a large spectrum of possible practice combinations, this decision making process is difficult to estimate directly. Therefore, to derive a tractable econometric specification, we assume a two stage decision making process, based on a partition Z of all possible combinations of practices distributed into J groups of practice combinations noted Z_j. The partition includes groups of non compensated practices. These groups differ according to the asset specificity associated with the corresponding combinations of practices. Within each group, the maximal utility is:

$$V(p,q,Z_j) = \underset{m,y}{Max}\left\{U(m,y); m \leq \pi(p,y) + q.y; y \in Z_j\right\} \tag{2}$$

It follows that:

$$V(p,q) = \underset{Z_j}{Max}\left\{V(p,q,Z_j); Z_j \in Z\right\} \tag{3}$$

We consider i^{th} farmer's decision to be associated to the maximization program (3). His maximal indirect utility for the group Z_j is noted V_{ij} and is the solution of program (2). The econometric specification then relies on a random utility model:

$$V_{ij} = b_j x_i + u_{ij}$$
$$\forall j = 1,...,J \qquad (4)$$

Where x_i is the vector of explanatory variables describing the exogenous determinants of farmer *i*'s choice. Assuming p and q do not change during the contract duration and accross farmers, x_i is thus the vector of factors of transaction costs and utility (effects stemming from the profit function being theoretically non observable). b_j are the corresponding parameters to be estimated and u_{ij} a perturbation which is assumed to have a Gompertz distribution ($F(u_{ij}) = \exp(-\exp(-u_{ij}))$). Perturbations are assumed independent and identically distributed.

Let d_{ij} be the dichotomous variable describing farmer *i*'s choice over the different conservation practice combinations *j*. The decision rule is then:

$$d_{ij} = 1 \quad \textit{if} \;\; V_{ij} > V_{ij'} \quad \forall j' \neq j$$
$$d_{ij} = 0 \qquad \textit{otherwise} \qquad (5)$$

Relations (4) and (5) specify a multinomial logit model where the probability of the i^{th} farmer to select a combinations *j* is given by (6):

$$P_{ij} = \Pr\{d_{ij} = 1\} = \frac{\exp(x_i' b_j)}{\sum_{j'=1}^{J} \exp(x_i' b_{j'})} \qquad \forall j \qquad (6)$$

2.3. Conditions for choosing more specific assets

This section aims at determining factors affecting farmers' choice. From the above specified model, these factors may theoretically not only impact on farmers' transaction cost function but on his utility and profit functions too. We here present propositions about these factors effects on these two functions and on the overall probability the farmer chooses higher specific practices. The theoretical and empirical transaction cost economics literature provides us with five relevant determinants. Three of them seem to impact on the transaction cost function only and allow conclusions whereas two have more complex effects.

2.3.1. Factors impacting on the transaction cost function only

Trust

As defined in Sako and Helper (1998), trust is an expectation held by an agent that its trading partner will behave in a mutually beneficial manner. For simplification, we will consider trust as the opposite of opportunism. A lack of trust may stem from the fear the co-contracting party might try to take unfair decisions, or suspicion on his use of given information, or distrust arising from non shared goals. According to Hwang (2006), a deterioration of trust exhibits a negative relationship to the willingness to make specific investments. Trust is thus expected to reduce the hold up pressure on the transacting parties. Consequently, we expect them to be less tempted to protect their relationship and we should observe a lower magnitude of transaction costs, other things being equal. Our proposition is straight forward.

Proposition 1: The more the farmer trusts in the Government, the lower the magnitude of transaction costs and the higher the probability he chooses more specific assets, *ceteris paribus*.

Bounded rationality

According to Williamson (1985), bounded rationality is a semi-strong form of rationality in which economic actors are assumed to be "intendedly rational, but only limitedly so" (Simon, 1961, p.xxiv). Bounded rationality implies "economic agents do not know all the solutions to the problems they face, are unable to calculate the possible outcomes of these solutions, and cannot perfectly arrange these outcomes in order in their space of preferences. With regard to contracts, this means that they are unable to design the optimal solutions (behavioral rules) taking into account every relevant contingency without high, and sometimes prohibitive, costs and delays" (Brousseau and Fares, 2000). Therefore, if we assume decisions are time-consuming and costly and that agents can make mistakes, we can acknowledge more bounded rationality lead to more transaction costs, and we suggest the following proposition on the relationship between asset specificity and bounded rationality.

Proposition 2: The more the farmer has a bounded rationality, the higher the magnitude of transaction costs and the lower the probability he chooses more specific assets, *ceteris paribus*.

Uncertainty

Following Carson et al. (2006), uncertainty may be associated to disturbances from two different origins, namely volatility and ambiguity. Volatility refers to "the rate and unpredictability of change in an environment over time, which create uncertainty about future conditions". This conceptualization of uncertainty follows Williamson's (1985) one. Ambiguity refers to the metering problem, i.e. "the degree of uncertainty inherent in perceptions of the environmental state irrespective of its change over time". Here, we associate uncertainty to volatility aspects. Saussier's 2000 study then gives insight into the relationship between uncertainty and transaction costs, namely "the greater the uncertainty level of the transaction, the more difficult, expensive, and risky it will be to establish a contract that aims for completeness". Therefore, our proposition about the relationship between asset specificity and uncertainty is as follow.

Proposition 3: The more uncertainty surrounds the agri-environmental transaction, the higher the magnitude of transaction costs and the lower the probability the farmer chooses more specific assets, *ceteris paribus.*

2.3.2. Factors with more complex effects

Utility in the transaction

In the case of public good transactions, non rivalry makes it possible for the farmer to derive utility from both the service he produces and the payment he receives accordingly. Utility in the transaction thus refers to the total value the farmer gives to environmental services he produces from the investments he decides to make. We argue this utility has two consequences. First, it may lead the farmer to have a positive willingness to pay for environmental services. An increased utility due, for instance, to environmental awareness or the presence of children, should thus reduce the compensation payment necessary to incite the farmer to enrol (Dupraz et al., 2003). Second, from the asset specificity perspective, it provides an alternative value to specific investments outside the transaction with the Government and, consequently, should reduce the appropriable quasi-rent. Therefore, the hold-up pressure should be reduced and transaction costs dedicated to protect the relationship should be lower. From this second observation, we derive the following proposition:

Proposition 4: The more utility the farmer gets from environmental services he produces through the agri-environmental contract, the lower the magnitude of transaction costs and the higher his willingness to pay for environmental services. Since both effects are non distinguishable, it is not possible to conclude on the effect of utility in the transaction on the probability the farmer chooses more specific assets.

Similarity of transactions

The similarity of transactions can be defined as "those transactions that are similar to ones in which the firm is already engaged" (Masten et al., 1991). This characteristic has a double impact. On transaction costs through internal organization costs, and, on the profit function through economies of scale and scope. Internal organization costs are the costs of organizing and losses through management decision mistake. Coase (1937) and Masten et al. (1991) assert that internal organization costs increase with an increase in the dissimilarity of transactions. Therefore, the costs related to efforts to adapt the farming production technology and management decisions with the agri-environmental transaction will be higher when the farmer is unfamiliar with what he commits. Masten et al.'s study then set a relationship between the similarity of transactions and the specificity of involved investments by observing that "workers with more specific skills are less costly to manage". They went to the conclusion that human specific assets were reducing internal organization costs. The objective of reducing internal organization costs may therefore be a reason for choosing more specific assets. By impacting on internal organization costs, the similarity of transaction may thus be a determinant of the choice over asset specificity. As regard to the similarity effect on the profit function, we argue that an activity the farmer is familiar with is technically close to other activities he is already having or used to have and should therefore produce economies of scale and/or scope[2]. However, the compensation payment being calculated on technology adaptation costs and thus taking economies of scale and scope into account[3], estimations are expected not to capture the economy of scale and scope effect but the effect of internal organization costs only.

---

[2] In other respects, Lyons (1995) observed a relationship between asset specificity and economies of scale and scope. He showed that "economies of scale and scope are a significant motivation behind the decision to buy-in, but only in the absence of specific assets", and that "specific assets are the overriding influence when scale or scope economies exist".
[3] Compensation payments are per-region calculated.

Proposition 5: The more the agri-environmental transaction is similar to ones he is already engaged, the lower the internal organization costs and the higher the probability the farmer chooses more specific assets, *ceteris paribus*.

3. Agri-environmental contracts: an empirical test

Propositions were tested using data from a 2005 survey covering the Basse-Normandie region in France. Within the survey area, 328 farmers were face to face interviewed. Among them, 171 are contracting farmers and 157 are non contracting ones. The sample is quite representative although contracting farmers are over represented on purpose in order to get better information on contracts. This section first gives insight into the characterization of practice asset specificity levels. Then, after having presented explanatory variables, estimation results are provided.

3.1. Characterizing practice asset specificity levels

In the agri-environmental transaction asset specificity may appear in three contexts. First, for environmental outcomes to be gained, most agri-environmental practices must be operated on proper periods as a function of meteorological conditions and natural cycles. In the same line, Allen and Lueck (1998) and many agricultural economists (for example, Brewster, 1950; Castle and Becker, 1962) argue "seasonality is the main feature that distinguishes farm organization from "industrial" organization". Even if skills and assets necessary to perform these tasks are common, it is very difficult for the Government to turn to an alternative supplier in place on short notice, which may introduce strategic hold up. In addition of being dependant on time aspects, environmental outcomes depend on agri-environmental practice localization too, which constitutes a second source of asset specificity. As for time specificity, skills and investments are easily redeployable, but environmental goals can't be reached if these tasks are implemented elsewhere. This is thus another opportunity for hold up.

It is important to note both hold up cases mostly concern the Government in that he should not be bargaining from a position of strength. However, these time and site requirements bring the farmer to fully adapt his farming production system and may lead him to be required to improve his agronomic knowledge and his material park. This new production system management is an important investment for the farmer, which has currently no other uses outside the agri-environmental contract with the Government. The farmer thus becomes taken in a hold up position too. Finally, the third origin of asset specificity stems from human skills. Practices aiming at biodiversity or extensive management goals such as low pesticide inputs require advanced agronomic and ecological knowledge which does not find other valuable uses outside the transaction with the Government. This constitutes another hold up case as regard to the farmer point of view.

In our case study, farmers willing to subscribe an agri-environmental contract had the possibility to choose one or more agri-environmental practices among a set of about 170 different practices. Our sample of contracting farmers accounts for 45 different practices and thus includes a high number of practice combinations. For simplification, we distributed these combinations into five practice combination groups[4]. These groups were created with a classification method. The hypothesis under this classification is that choices are mutually exclusive. Table 1 presents these practice combination groups.

Table 1: Description of practice combination groups

Practice combination groups	**Nb. of farmers**	**Description**
A1	68	Important changes on meadows and landscape
A2	20	Fauna protection
B	43	Changes on arable lands and meadows
C1	28	Practice maintenance on meadows
C2	12	Changes on arable lands
D1	76	More than 4 non paid actions
D2	81	Less than 3 non paid actions

From these practice combination groups, we distinguished three asset specificity levels.

Practice combination group A call for assets which we consider as highly specific. A1 refers to constraining commitments such as production system reconversion towards grazing systems, extensive management of meadows and landscape maintenance. These practices lead the farmer to rethink his whole farming system so as to be able to honour his commitment in terms of dates, input quantities and practice localization. In addition, practices concerning landscape maintenance such as hedgerows or ponds, require a certain level of agronomical and botanical expertise, which involves the farmer to get advanced knowledge in these fields. These different investments do not have any value outside the agri-environmental contract. This is why A1 is assumed to be a highly specific practice combination group. A2 group focuses on fauna protection. This entails timing restrictions for certain operational tasks, such

[4] These practice combination groups are specified by j in the econometric model.

as mowing or ploughing, depending on natural cycles and ecological expertise. As for A1 group, these investments do not have any value outside the agri-environmental contract.

Practice combination group C calls for low asset specificity. C1 group only concerns extensive management of meadow practices. It does not entail constraining requirements in terms of date, input quantities and practice localization, which does not lead the farmer to entirely change his farming system and thus to invest in a new production system management. C2 group is different from C1. C2 group entails changes on arable lands, such as covering bare lands in winter, and restrictions on pesticide and fertilizer input management, which lead the farmer to entirely revise his production system. This involves the farmer to highly invest in order to commit with his contract. However, contrarily to A groups, these investments are redeployable on other transactions, namely quality labels and the new orientation of the Common Agricultural Policy. Indeed, the last CAP regulation calls for ecoconditionality requirements, among which, winter bare lands management, pesticide and fertilizer inputs requirements are included.

Practice combination group B calls for average specificity. It is similar to C1 group but requirements are more numerous and lead to higher investments. Some of them, such as covering bare lands in winter are redeployable, as referred to the new CAP regulation, but others are not.

Moreover, given that non contracting farmers may implement non compensated conservation practices, we added up two non compensated practice combination groups, namely D1 and D2. D1 includes combinations of more than 4 non compensated conservation practices, and D2 includes combinations of less than 3 specified practices, including none. In both groups, involved assets are assumed not to show any specificity.

It is finally necessary to stress that the gradient of specificity levels among enrolled practices is narrower than the 170 initially proposed practices' one. To be more precise, farmers have chosen the less specific practices whereas proposed practices encompassed a whole gradient of practices from very specific ones, such as converting arable lands into meadows, to non specific ones such as winter covering of arable lands. This will have to be taken into account in the interpretation of the results.

3.2. Explanatory variables

In order to capture the notion of previously described determinants, several types of variables were collected. They concern the farmer (education level, environmental awareness…), his production system (farm legal status, number of Full Time Equivalent workers…), his professional environment (involvement in agricultural organizations, administrative and technical external services,…) and his relationship with the Government (trust in administrations, …). From these raw data, we created variables providing a measure of asset specificity determinants as presented in table 2.

Table 2: Determinants of asset specificity and their respective explanatory variables

Determinants of asset specificity	Related constructed explanatory variables	Variable values
Bounded rationality	Agricultural education (***AGRI EDUC***) General education	6 classes 7 classes
Trust	To trust the implementation process of agri-environmental contracts (***TRUST IMPL***) Strong belief in the Government goodwill (***GOODWILL***)	Continuous variable [-1;1] Continuous variable [-1;1]
Uncertainty	To regularly receive technical and administrative advices (***ADVICES***) To be involved in an agricultural organization (***ORGA***)	Continuous variables [-1;1] Continuous variable [-1;1]
Similarity of transaction	Grassland share (***GRASSLAND***) Farm land area (***UAA***) Arable land share Labor (***FTE***) Animal population Milk quota Production system type (organic or conventional)	Continuous variable (%) Continuous variable (hectares) Continuous variable (%) 5 classes Continuous variable (Livestock units) Continuous variable (litre) 0=organic; 1=conventional
Utility	Environmental awareness (***ENV AW***) Children Free time dedicated in nature related hobbies	Continuous variable [-1;1] 3 classes Continuous variable [-1;1]
Control variables		
Changes in the production system in the last 5 years (***CHANGES***) To have already enrolled an agri-environmental contract (***EXPERIENCE***) Age (***AGE***) NUT region Machinery ownership Land share in ownership Land share in long term tenant tenure Land share in short term tenant tenure Farm legal status		Continuous variable [-1;1] 0=no; 1=yes 3 classes 0=Calvados;1=Manche; 2=Orne Continuous variable [-1;1] Continuous variable (%) Continuous variable (%) Continuous variable (%) 5 classes

Trust variables were created with a Multiple Correspondence Analysis from farmers' opinions (strongly disagree; somewhat disagree; somewhat agree; strongly agree; do not know) on statements such as "the eligibility rules are fair", or "the sanctions for not carrying out the contract are reasonable". These statements tend to describe farmers' expectation that the Government will behave in a mutually beneficial manner (cf. section 2.3.1). Then, for each created variable, we assumed a positive TRUST IMPL, for instance, indicates the farmer trusts in the Government, and that the higher it gets, the more the farmer trusts in the Government. The same method was used for uncertainty and utility variables.

Bounded rationality was measured with qualitative variables by creating classes of variables. Variables describing farmers' education were assumed to measure their rationality since education is expected to provide solutions to problems and unable farmers to calculate the possible outcomes to these solutions. It was than assumed that the higher the education level, the less bounded the farmer's rationality.

We measured the similarity of transactions in the same way as Masten et al. did in their 1991 article. They compared the initial low-technology and labor intensive tasks with the integration of high engineering-intensive tasks. Here, the similarity of transaction is measured from the characteristics of the farm production technology (continuous variables) and the technology required by the different conservation practices. For instance, the practice "extensive management of meadows", will be qualified as similar to extensive grazing production systems whereas it will be different from a maize oriented production system.

3.3. Estimation results

Parameter estimates are gathered in table 3. Significant variables are presented only. The model has kept all observations. The reference contract is D2, which is the category of farmers implementing less than 3 non compensated conservation practices. The reference farmer has an agricultural education level superior than the primary level[5] and has not subscribed an agri-environmental contract in the past. As regard to continuous variables, we took average values (grassland share is 53.65%, farm land area is 93.69ha. The model adjustment quality is medium as the Mc Fadden R^2 is 33.55.

[5] Certificat d'Aptitude Professionnelle

Table 3: Logit multinomial estimations

Variable	A1	A2	B	C1	C2	D1
Constant	**-1,91**** ***(0,87)***	**-6,15***** ***(2,07)***	**-2,30***** ***(0,91)***	**-6,17***** ***(1,75)***	-1,31$^{/}$ *(1,97)*	-0,24$^{/}$ *(0,55)*
UNCERTAINTY						
ADVICES	0,28$^{/}$ *(0,29)*	-0,13$^{/}$ *(0,56)*	0,18$^{/}$ *(0,29)*	**0,98**** ***(0,48)***	**1,40**** ***(0,76)***	0,001$^{/}$ *(0,22)*
ORGA	**0,49**** ***(0,25)***	0,22$^{/}$ *(0,50)*	0,38$^{/}$ *(0,29)*	-0,05/ *(0,39)*	0,62$^{/}$ *(0,44)*	0,10$^{/}$ *(0,23)*
SIMILARITY						
UAA	**0,01**** ***(0,005)***	0,01/ *(0,009)*	**0,008*** ***(0,005)***	**0,01**** ***(0,008)***	0,006$^{/}$ *(0,01)*	**0,007*** ***(0,003)***
GRASSLAND	**0,01**** ***(0,008)***	0,02$^{/}$ *(0,02)*	0,01$^{/}$ *(0,01)*	**0,05***** ***(0,02)***	-0,15$^{/}$ *(0,11)*	-0,005$^{/}$ *(0,006)*
TRUST						
TRUST IMPL	**1,61***** ***(0,31)***	**2,17***** ***(0,68)***	**1,26***** ***(0,31)***	**1,59***** ***(0,38)***	**2,20**** ***(1,06)***	0,22$^{/}$ *(0,22)*
GOODWILL	**0,41*** ***(0,24)***	**0,62*** ***(0,41)***	**0,44*** ***(0,27)***	0,45$^{/}$ *(0,38)*	-0,18$^{/}$ *(0,79)*	-0,06$^{/}$ *(0,22)*
UTILITY						
ENV AW	-0,23$^{/}$ *(0,21)*	**-1,10*** ***(0,69)***	-0,48$^{/}$ *(0,46)*	-0,24$^{/}$ *(0,34)*	-2,74$^{/}$ *(2,14)*	0,22$^{/}$ *(0,19)*
BOUNDED RATIONALITY						
LOW AGRI EDUC	**0,67*** ***(0,48)***	**2,06**** ***(0,91)***	**0,86*** ***(0,55)***	0,19$^{/}$ *(0,72)*	1,66$^{/}$ *(1,59)*	0,29$^{/}$ *(0,42)*
CONTROL VARIABLES						
CHANGES	**0,52*** ***(0,30)***	**1,60*** ***(0,93)***	**1,12***** ***(0,33)***	-0,04$^{/}$ *(0,45)*	-0,39$^{/}$ *(1,31)*	**0,39*** ***(0,22)***
EXPERIENCE	**-1,69***** ***(0,72)***	**1,89***** ***(0,83)***	**-1,84*** ***(1,10)***	-0,27$^{/}$ *(0,63)*	1,99$^{/}$ *(1,96)*	-0,65$^{/}$ *(0,47)*

In the light of our propositions, six variables have expected signs. They describe uncertainty ("to regularly receive technical and administrative advices" and "to be involved in an agricultural organization"), trust ("to trust the implementation process of agri-environmental contracts" and "strong belief in the Government goodwill") and the similarity of transactions ("grassland share" and "farm land area"). Among them, variables describing trust clearly distinguish contractors from non contractors and let us think that trust has an important role in farmers' decision to enroll and invest in the production of environmental services. This result highly supports the existence of a transaction costs barrier in the adoption of agri-environmental contracts. This may explain why farmers enrolled practices associated to rather low specificity levels compared to what was initially possible to choose.

The variability of parameters is presented in table 4.

Table 4: Marginal effects (%)

Variables	A1	A2	B	C1	C2	D1	D2
UNCERTAINTY							
ADVICES	0,50 *(2,70)*	-1,59 *(1,49)*	-0,43 *(2,41)*	**5,17** ***(1,68)***	2,48 *(1,93)*	-3,09 *(2,88)*	-3,06 *(2,83)*
ORGA	**4,34** ***(2,22)***	-0,06 *(1,51)*	1,34 *(1,94)*	-1,91 *(1,99)*	0,78 *(1,39)*	-1,42 *(2,95)*	-3,06 *(2,72)*
SIMILARITY							
UAA	0,03 *(0,04)*	0,01 *(0,02)*	0,01 *(0,04)*	0,05 *(0,03)*	0,00 *(0,02)*	0,02 *(0,05)*	**-0,12** ***(0,05)***
GRASSLAND	0,12 *(0,09)*	0,03 *(0,05)*	0,06 *(0,08)*	**0,26** ***(0,07)***	-0,30 *(0,29)*	-0,12 *(0,13)*	-0,06 *(0,1)*
TRUST							
TRUST IMPL	2,43 *(2,99)*	1,27 *(1,29)*	2,16 *(2,34)*	1,12 *(1,78)*	-0,66 *(2,14)*	**-3,94** ***(2,66)***	-2,39 *(2,48)*
GOODWILL	**9,50** ***(2,47)***	**4,06** ***(1,33)***	2,15 *(2,62)*	**3,43** ***(1,69)***	2,85 *(1,60)*	**-9,27** ***(2,57)***	**-12,72** ***(2,55)***
UTILITY							
ENV AW	0,97 *(5,78)*	-3,28 *(4,62)*	-2,68 *(4,49)*	0,01 *(2,85)*	-5,12 *(3,40)*	**7,96** ***(3,98)***	2,15 *(3,98)*
BOUNDED RATIONALITY							
LOW AGRI EDUC	0,75 *(5,56)*	**6,85** ***(1,92)***	3,03 *(4,58)*	-2,66 *(2,76)*	2,50 *(2,13)*	-2,86 *(4,27)*	**-7,62** ***(3,91)***
CONTROL VARIABLES							
CHANGES	-0,17 *(2,68)*	**4,34** ***(1,79)***	**7,18** ***(2,67)***	**-3,64** ***(1,72)***	-1,60 *(1,95)*	0,73 *(3,02)*	**-6,84** ***(2,05)***
EXPERIENCE	**-16,15** ***(4,07)***	**18,98** ***(5,13)***	**-10,62** ***(3,60)***	1,86 *(4,18)*	-2,31 *(1,98)*	-3,23 *(6,73)*	**11,46** ***(5,85)***

From the six expected variables, “goodwill trust in the Government” and “to be involved in an agricultural organization” show higher coefficients for combination group A. They thus support that, first, the higher the farmer trusts in the Government, the higher the probability he chooses specific assets, second, the less uncertainty surrounds the agri-environmental transaction, the higher the probability the farmer chooses specific assets. In addition, the similarity of transactions has a significant positive impact on farmers’ choice towards specific practices by reducing internal organization costs, but coefficients across practices do not allow to confirm our proposition. On the other hand, these coefficients being very low, they show technology characteristics have nearly no effect on farmers’ choice. This last observation supporting contract payments do compensate farmers for technology linked costs but do not for asset specificity linked costs.

Beyond these observations, how to explain these six variables have “discontinuous” effect? For instance, “to be involved in agricultural organizations” has a higher and significant effect on the specific combination group A1 but has a non significant and negative effect on A2. The significancy effect is easily explained from the number of observations in group A1 (68 observations) and A2 (20 observations) (cf. table 1). The coefficient difference may come from the fact that contracts in the same asset specificity level category are not homogenous on other significant aspects.

Another discontinuous effect regards the variable “to receive regularly technical and administrative advices”. It only impacts on the non specific combination group C1. This isolated effect may come from the fact that C1 requirements corresponds to the CAP orientation for the next coming years whereas the future of other contract types is far more uncertain. It is thus normal to observe that well informed farmers will prefer to enroll conservation practices whose payment is less uncertain for a longer period.

Concerning variables describing the similarity of transactions and more particularly “grassland share”, whose effect is observable for the non specific combination group C1 only, the explanation is certainly to be found in the compensation payment. Indeed, since it is calculated on average operational costs and profit foregone per region, the economy of scale and scope effect may be captured too in estimations. Following this reasoning, we should observe similar effects of the “grassland share” variable on both C1 and C2 groups, but, this is not the case. This may come from the number of observations and the fact that combination groups C differ in the technology they call. It is thus non surprising to observe that C2, which calls for non grassland farm technology, is not chosen by farmers with a high grassland share.

As regard to non expected variables in table 3, “environmental awareness”, which has a non expected effect in table 3, has an expected effect in table 4 since it increases the probability the farmer implements non compensated conservation practices. This effect may be explained from the fact that environmental awareness is an overriding factor for non-contracting farmers to implement environmental friendly actions, whereas it is “competing” with other significant factors, such as the compensation payment, for contracting farmers. The other non expected variables find explanations from missing characteristics describing whether the farmer or the combination group.

To have a lower agricultural education has no effect on contracting farmers and a positive one on A2 contractors. This is explained from the characteristics of the agricultural education which used to be oriented towards productivity and did not give much attention to “green” production technologies.

Evolving production systems, observable through “changes in the production system in the last five years”, have a lower probability to enrol combination group C1. The explanation has to be found in the contract technology requirements which correspond to farm production systems already existing: farms with high a grassland share. The variable "grassland share" supports this observation showing these farms have a higher probability to enrol combination group C1. It is thus expected these farms are not in a dynamic of change since what C1 group requires is what they are already doing.

Finally, the negative effect of the variable "to have already enrolled an agri-environmental contract" is easily explained from contract implementation dates. Indeed, except from combination group A2, which originated in the 1992-reform of the Common Agricultural Policy, they all stem from the 1999-reform. Therefore, farmers with combination group A2 could commit on a longer period than others. We also observe this variable to have a non expected effect on D2. There are two possible explanations. Whether D2 farmers did enrolled an agri-environmental contract and remain disappointed, or, they were not eligible anymore.

4. Conclusion

The purpose of this paper was to identify conditions favouring farmers' choice towards specific assets and to test propositions on these determinants. Results led to the conclusion that farmers' trust in the Government appears to be the most robust determinant of the choice toward more specific practices. First, it distinguishes contracting farmers from non contracting farmers whereas variables describing the technology were expected to explain farmers' behaviours but did not. Second, it highly supports the existence of a transaction costs barrier in the adoption of agri-environmental contracts, which may explain why farmers enrolled practices associated to rather low specificity levels. Finally, coefficients across practices allow to support that the higher the farmer trusts in the Government, the higher the probability he chooses specific assets. In addition to trust, the effect of uncertainty was also observed to negatively impact on farmers' choice towards more specific practices.

Keeping as an objective the production of environmental services in rural areas and low production costs, i.e. to enhance the adoption of agri-environmental practices involving specific assets, this study provides new outcomes for policy design. It particularly highlights the role of asset specificity and implied transaction costs in the choice over different conservation practices. In addition, by identifying factors favouring the adoption of specific investments, recommendations are derivable to direct the Government towards actions on these factors. For instance, knowing that farmers' trust in the implementation process has a major role, the Government may work on the clarity of contract requirements so as to narrow its implementation interpretation spectrum. Trust may also be restored by balancing the Government and the farmers' rights when a case is brought to private negotiation or to court. Finally, as regard to the uncertainty aspect, the Government could improve its communication policy in order to reduce the opacity of its political actions. In practice, a better communication may go through an improved coordination between Government agencies or a merging of agencies responsible for writing contracts, signing and paying.

References

Allen, D.W., Lueck, D. (1998). The Nature of the Farm. *Journal of Law and Economics*, 41(2): 343-386.

Bekele, W., Drake, L., (2003). Soil and water conservation decision behaviour of subsistence farmers in the Eastern Highlands of Ethiopia: a case study of the Hunde-Lafto area. *Ecological Economics*, 46: 437-451.

Brewster, J.M. (1950). The Machine Process in Agriculture and Industry. *Journal of Farm Economics*, 32: 69-81.

Brousseau, E., Fares, M. (2000). Incomplete Contracts and Governance Structures: Are incomplete Contract Theory and New-Institutional Economics Substitutes or Complements?. In: C. Ménard (Ed), *Institutions, Contracts and Organizations, Perspectives from New-Institutional Economics*. Edward Elgar Pub.

Carson, S. J., Madhok, A., Wu, T. (2006). Uncertainty, Opportunism, and Governance: the Effects of Volatility and Ambiguity on Formal and Relational Contracting. *Academy of Management Journal*, 49(5): 1058-1077.

Castle, E.N., Becker M.H. (Ed), (1962). *Farm Business Management*. MacMillan, New York.

Coase, R.H., (1937). The Nature of the Firm. *Economica*, 4: 386-405.

Colby, B., (1990). Transaction costs and efficiency in western water allocation. American *Journal of Agricultural Economics*, 72: 1184-92.

Crocker, K.J., Masten S.E. (1988). Mitigating Contractual Hazards: Unilateral Options and Contract Length. *Rand Journal of Economics*, 19: 327-343.

Crocker, K.J., Masten, S.E. (1991). Pretia ex Machina? Prices and Process in Long-Term Contracts. *Journal of Law and Economics*, 34: 69-99.

Dupraz, P., Vanslembrouck, I., Bonnieux, F., Van Huylenbroeck, G. (2002). *Farmers' participation in european agri-environmental policies*. Presented at X Congress of EAAE, August 28th – 31st 2002, Zaragoza

Dupraz, P., Vermersch, D., Henry de Fraham, B., Delvaux, L. (2003). The environmental supply of farm households: A flexible willingness to accept model. *Environmental and Resource Economics*, 25(3): 171-189.

Falconer, K., Dupraz, P., Whitby, M. (2001). An investigation of policy administrative costs using panel data for the English environmentally sensitive areas. *Journal of Agricultural Economics,* 52 (1): 103-883.

Gould, B.W., Saupe, W.E, Klemme, R.M. (1989). Conservation tillage: the role of farm and operator characteristics and the perception of soil erosion. *Land Economics*, 65(2): 167-182.

Hwang, P. (2006). Asset specificity and the fear of exploitation. *Journal of Economic Behavior and Organization*, 60: 423-438.

Joskow, P.L. (1985). Vertical Integration and Long-Term Contracts: The case of Coal-Burning Electric Generating Plants. *Journal of Law, Economics and Organization*, 1: 33-80.

Joskow, P.L. (1988). Price Adjustment in Long-Term Contracts: The Case of Coal. *Journal of Law and Economics*, 31: 47-83.

Klein, B., Crawford, R.A., Alchian, A.A. (1978). Vertical integration, appropriable rents, and the competitive contracting process. *Journal of Law and Economics*, 21: 297-326.

Knowler, D., Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research. *Food Policy*, 32: 25-48.

Kuperan, K., Abdullah, N. M. R., Pomeroy, R.S., Genio, E.L., Salamanca, A.M. (1998). *Measuring transaction costs of fisheries co-management. Marine Resource Economics*, 13, 103–114

Masten, S.E. (1995). Empirical research in transaction costs economics: challenges, progress, directions. In: Groenewegen, J. (Ed), *Transaction Cost Economics and beyond*. Kluwer, Amsterdam.

Masten, S.E., Meehan, J. W., Snyder, E. A. (1991). The Costs of Organization. *Journal of Law, Economics and Organization*, 7: 1-27.

Masten, S.E., Saussier, S. (2002). Econometrics of contracts: an assessment of developments in the empirical litterature of contracting. In: E. Brousseau and J.M. Glachant (Ed), *The Economics of Contracts: Theories and Applications*. Cambridge University Press, Cambridge, pp 273–292.

McCann, L., Easter, K.W. (1999). Evaluating transaction costs of nonpoint source pollution policies. *Land Economics*, 75 (3): 402-414.

Napier, T.L., Camboni S.M. (1993). Use of conventional and conservation practices among farmers in the Scioto River basin of Ohio. *Journal Soil and Water Conservation*, 48(3): 231-237.

Sako, M., Helper, S. (1998). Determinants of trust in supplier relations: evidence from the automotive industry in Japan and the United States. *Journal of Economic Behavior and Organization,* 34: 387-417.

Saussier, S. (2000). Transaction costs and contractual completeness. *Journal of Economic Behavior and Organization*, 42: 189–206.

Simon, H.A. (1961). *Administrative behaviour. 2d ed.* Macmillan, New York. Original publication: 1947.

Soule, M.J., Tegene, A., Wiebe, K.D. (2000). Land tenure and the adoption of conservation practices. *American Journal of Agricultural Economics*, 82(4): 993-1005.

Stavins, R.N. (1995). Transaction costs and tradable permits. *Journal of Environmental Economics and Management*, 29 (2): 133-148.

Traoré, N., Landry, R., Amara, N. (1998). On-farm adoption of conservation practices : the role of farm and farmer characteristics, perceptions, and health hazards. *Land Economics*, 74(1): 114-127.

Williamson, O.E. (1985). *The Economic Institution of Capitalism- Firms, Markets and Relational Contracts*. The Free Press, New York.

Working Papers INRA – Unité ESR Rennes

WP02-01 Tariff protection elimination and Common Agricultural Policy reform: Implications of changes in methods of import demand modelling. Alexandre GOHIN, Hervé GUYOMARD, Chantal LE MOUËL (March 2002)

WP02-02 Reducing farm credit rationing: An assessment of the relative effectiveness of two government intervention schemes. Laure LATRUFFE, Rob FRASER (April 2002)

WP02-03 Farm credit rationing and government intervention in Poland. Laure LATRUFFE, Rob FRASER (May 2002)

WP02-04 The New Banana Import Regime in the European Union: A Quantitative Assessment. Hervé GUYOMARD, Chantal LE MOUËL (July 2002)

WP02-05 Determinants of technical efficiency of crop and livestock farms in Poland. Laure LATRUFFE, Kelvin BALCOMBE, Sophia DAVIDOVA, Katarzyna ZAWALINSKA (August 2002)

WP02-06 Technical and scale efficiency of crop and livestock farms in Poland: Does specialisation matter? Laure LATRUFFE, Kelvin BALCOMBE, Sophia DAVIDOVA, Katarzyna ZAWALINSKA (October 2002)

WP03-01 La mesure du pouvoir de vote. Nicolas-Gabriel ANDJIGA, Frédéric CHANTREUIL, Dominique LEPELLEY (January 2003)

WP03-02 Les exploitations agricoles polonaises à la veille de l'élargissement : structure économique et financière. Laure LATRUFFE (March 2003)

WP03-03 The Specification of Price and Income Elasticities in Computable General Equilibrium Models: An Application of Latent Separability. Alexandre GOHIN (April 2003)

WP03-04 Mesures agro-environnementales et demande de travail agricole. Pierre DUPRAZ (May 2003)

WP03-05 The Fischler's Proposals for the Common Agricultural Policy: Paving the Way for the Future? Hervé GUYOMARD, Katell LE BRIS (June 2003)

WP03-06 The phasing out of EU agricultural export subsidies: Impacts of two management schemes. Alexandre GOHIN, Patrice GAUTIER (June 2003)

WP03-07 Une politique agricole commune au service de l'emploi ? Analyse économique du modèle de l'agriculture paysanne de la Confédération paysanne. Alexandre GOHIN, Hervé GUYOMARD (June 2003)

WP03-08 Farm credit and investment in Poland: A case study. Laure LATRUFFE (July 2003)

WP03-09 La réforme de la PAC de 2003, le principe du découplage des aides directes et la régionalisation : Quels impacts sur le secteur européen de la pomme de terre ? Alexandre GOHIN (November 2003)

WP03-10 Technical efficiency and farm financial management in countries in transition. Sophia DAVIDOVA, Laure LATRUFFE (December 2003)

WP04-01 Investment and financial constraints of Polish farmers. Laure LATRUFFE (February 2004)

WP04-02 Self selecting agri-environmental policies with an application to the Don watershed. Philippe BONTEMPS, Gilles ROTILLON, Nadine TURPIN (December 2004)

WP05-01 Effets de seuils et coordination des efforts agri-environnementaux. Pierre DUPRAZ, Karine LATOUCHE, Nadine TURPIN (April 2005)

WP05-02 Assessing the cost, effectiveness and acceptability of best management farming practices: a pluridisciplinary approach. Nadine TURPIN, Ramon LAPLANA, Peter STRAUSS, Minna KALJIONEN, Frédéric ZAHM, Véronique BEGUE (July 2005)

WP05-03 Application of a double bootstrap to investigation of determinants of technical efficiency of farms in Central Europe. Kelvin BALCOMBE, Sophia DAVIDOVA, Laure LATRUFFE (December 2005)

WP06-01 Is remoteness a locational disadvantage? Kristian BEHRENS, Carl GAIGNE, Gianmarco OTTAVIANO, Jacques-François THISSE (January 2006)

WP06-02 Trade integration and the destination of public expenditures. Nelly EXBRAYAT, Carl GAIGNE, Stéphane RIOU (February 2006)

WP06-03 Marchés avec coûts d'information sur la qualité des biens : Une application aux produits écolabellisés. Douadia BOUGHERARA, Virginie PIGUET (October 2006)

WP06-04 Comparer les politiques agricoles américaines et européennes : Les indicateurs ESP sont-ils bien utiles ? Alexandre GOHIN, Fabrice LEVERT (December 2006)

WP07-01 Estimating price elasticities of food trade functions: How relevant is the gravity approach? Fabienne FEMENIA, Alexandre GOHIN (March 2007)

Research Reports INRA – Unité ESR Rennes

RR02-01 Les propositions de révision à mi-parcours de la Politique Agricole Commune: Evaluation des impacts sur l'agriculture française à partir du modèle MEGAAF. Alexandre GOHIN (December 2002)

RR03-01 OLEOSIM : Modélisation du marché mondial des oléagineux. Yves DRONNE, Patrice GAUTHIER, Alexandre GOHIN, Fabrice LEVERT (September 2003)

Journées INRA-SFER de recherché en Sciences Sociales, 13-14 décembre 2007, AgroParisTech

CONSERVATION CONTRACT ADOPTION UNDER FIXED AND VARIBLE COSTS

Géraldine DUCOS* and Pierre DUPRAZ*

*French National Institute for Agricultural Research (INRA), Department of Economics, Rennes, FRANCE

Corresponding author:
Géraldine DUCOS
INRA-ESR
4 allée Adolphe Bobierre
35011 Rennes Cedex
Tel: (33) 2 23 48 54 01
Fax : (33) 2 23 48 53 80
e-mail : geraldine.ducos@rennes.inra.fr

Abstract: Farmers' conservation contract adoption is usually explained through the technology lens, i.e. with operational costs depending on the subscribed area and environmental efforts. In their 2003 article, Dupraz et al. analysed this issue by introducing utility farmers directly derive from contract environmental outcomes. They specified farmers' willingness to accept, which is the minimum compensation payment the farmer accepts to enrol and produce environmental services on a given area. Here, we deepen this analysis at two levels. First, at the theoretical one, by introducing fixed compliance costs in the willingness to accept approach. Secondly, we empirically show that among fixed compliance costs, fixed transaction costs are a significant contracting barrier. It explains why smallest farms have a reduced probability to contract.

Key words: agro-environmental contract; willingness to accept; fixed compliance costs;

JEL Classification: *D23, Q12, Q28*

Acknowledgement: This document presents results obtained within the EU project SSPE-CT-2003-502070 on Integrated tools to design and implement Agro Environmental Schemes (http//:merlin.lusignan.inra.fr/ITAES). It does not necessary reflect the view of the European Union and in no way anticipates the commission's future policy in this area.
This research also benefited from a grant under the S3E program (Ministère de l'Ecologie, du Développement et de l'Aménagement Durable).

I) INTRODUCTION

The degradation of environmental quality and rural landscape has induced a strong demand of rural amenities in European countries. This led to a significant increase of agro-environmental schemes in Europe from the 90's. The trend was confirmed with the 1999-Common Agricultural Policy (CAP) reform and the implementation of "agro-environmental contracts". In this policy framework, farmer's voluntary participation is compensated if he adopts more environmental friendly practices than what is mandatory. First appraisals show the adoption rate remains globally low (about 25% of EU farms) and smallest farms are not involved. From this situation, displayed environmental objectives are expected not to be reached. The overall aim of this study is threfore to improve the understanding of farmers' adoption behaviour.

Several studies have examined factors influencing farmers' adoption. Four main determinants have been identified, namely (i) farmer and farm household characteristics, (ii) farm biophysical characteristics, (iii) farm financial/management characteristics, and (iv) exogenous factors such as information availability, sources of information, society social capital (Knowler and Bradshaw, 2007). Even if they give an important insight on the overall adoption behaviour, a sharper analysis is obviously required. In particular, a first distinction between fixed and variable compliance costs should provide some useful explanations. Indeed, while compensation payment are on a per-hectare basis calculation, technology related fixed costs (a hedge cutter or an adapted seeder for instance) and fixed transaction costs (the costs of gathering information on contracts or writing the contract) amount to total significant levels.

This paper thus first seeks to know if fixed compliance costs are a significant adoption barrier. This should explain why smallest farms or farms having a small eligible area are not involved in agro-environmental contracts. The second research question is whether, among fixed compliance costs, transaction costs are a significant adoption barrier. We particularly think of transaction costs as an adoption barrier since we suspect agro-environmental contract to require specific investments. Indeed, contract requirements lead the farmer to entirely modify his production system, which ends up to a non negligible total investment. Most of the time, these investments being non redeployable outside the agro-environmental contract, they are threfore transaction specific and produce transaction costs.

As Dupraz et al. (2003), we base our analysis on a farm household model so that we incorporate the farmer's producer and consumer behavior. The household willingness to accept (WTA) is the minimum per-hectare compensation payment the farmer accepts to adopt an agro-environmental contract on a given area instead of not to adopt while his initial utility level remains the same (eq. Hicksian optimization). Besides, considering the presence of fixed compliance costs, we work the minimal per-hectare payment out from the average WTA and get a minimum compensation payment and a minimum necessary area. Finally, when the per-unit payment is higher, farmers with a higher eligible area will be able to choose over the area to subscribe, this choice being derived from his Marshallian behavior. Therefore, as long as his marginal WTA is lower than the per-hectare payment, they will accept to subscribe an additional hectare.

The empirical analysis is based on a European sample made of 2262 farmers interviewed in 2005. It aims at highlighting the impact of fixed compliance costs on adoption behavior, and transaction cost one in particular. These last costs being not included in the calculation of compensation payments, it is therefore statistically possible to distinguish their effect from other costs. However, transaction costs being difficult to measure and endogenous to the decision to adopt, their effect is thus indirectly identified through their determinants. It is important to note that some of these determinants impact on transaction costs only whereas others have more complex effects, i.e. they impact on transaction costs, farmer's utility or operational costs too. These multiple effects will complicate the estimation interpretation.

We use the two-stage Heckman method to shed light on whether and to what extent variations in fixed compliance costs are responsible for observed adoption rates. In the first step, the most influential factors on participation are the type of farming system, past experience in agro-environmental contracts and farmer's trust in the implementation process. In the second step, the area under contract is the dependant variable. The disappearance of significant transaction cost determinants from the first step in the second step reveals the presence of fixed transaction costs and their significant effect on adoption behavior. As regard to fixed compliance costs, given that none of variables describing the production system disappear in the second step, we may say that, whether the compensation payment do include fixed operational costs, or, they have no significant effect on adoption behavior. Concerning variables with more complex effects and that are present in both estimations, the interpretation is harder. Whether variable transaction costs exist and their effect is mixed with other variable operational costs, or, they do not exist and we may conclude fixed transaction cost effect on adoption is lower than utility or operational cost effects. Finally, variables appearing in the second step purely highlight the effect of the production system characteristics on the farmer's choice over area to subscribe.

This paper has a double contribution. First, by introducing fixed compliance costs in the usual adoption model, we improve the understanding of farmers' conservation practice adoption behavior. Second, by empirically showing that among fixed compliance costs, fixed transaction costs are a significant contracting barrier, we support the idea fixed compliance costs and transaction costs in particular should be taken into account in participation constraints.

The paper is organized as follows. Section 2 presents the conceptual framework from which we derived propositions. Section 3 describes the transaction cost issue in AEC and the data set on which the empirical analysis is based on. Section 4 provides estimation results and section 5 concludes.

II) SPECIFYING FARMERS' WILLINGNESS TO ACCEPT

II.1) Model settings

As Dupraz et al. (2003), we consider a utility maximizing farmer with an income constraint depending on farm profit. The restricted profit function, or short-term profit function, π^R, enables to derive the income from the on-farm activity with an agro-environmental contract that is attached to an area *v*.

.

$$\underset{m,v}{Max}\, U(m,v,Z)$$

$$m = \pi^R(p,v,Z) + \rho.v + e_0 \qquad (1)$$

$$v \geq 0$$

The variables of the utility function are the farmer's income m, expressed in monetary value, the quantity v of an environmental service co-produced by farming activities (the number of hectares submitted to environmentally friendly practices for instance) and other relevant utility characteristics Z. This function is supposed to be increasing, concave and differentiable in m and v.
The farmer's restricted profit function π^R represents the agro-environmental technology using the dual approach by a short-term optimization of products and production factor variables of prices p. Z represents other relevant profit characteristics. π^R is linearly homogenous in prices p. It is assumed to be non increasing and convex in v. The e_0 scalar represents off-farm incomes that are assumed to be exogenous.
The contract payment is based on a positive per-unit premium ρ. The budget constraint always binds. In this model, the farmer is assumed to enroll when the premium is higher than ρ_0, the farmer's marginal willingness to accept (WTA) for the first unit of co-produced environmental service. It is defined in (2), which provides the corner solution of (1), noted (m^*, v^*), when the positivity constraint regarding v binds, meaning the contract is rejected.

$$v^* = 0 \quad \Leftrightarrow \quad \rho \le \rho_0 = -\frac{\partial U(m^*, 0, Z)/\partial v}{\partial U(m^*, 0, Z)/\partial m} - \partial \pi^R(p, 0, Z)/\partial v \qquad (2)$$

When $\rho > \rho_0$, the marginal WTA, noted $\rho^m(p, v_m, Z)$, is then defined by (3).

$$\begin{aligned} &\underset{m,v}{Max}\, U(m, v, Z) \\ &m = \pi^R(p, v, Z) + e_0 \qquad (3) \\ &v \ge v_m \end{aligned}$$

First order conditions bring:

$$\rho_m = -\frac{\partial U(m^*, v^*, Z)/\partial v}{\partial U(m^*, v^*, Z)/\partial m} - \partial \pi^R(p, v^*, Z)/\partial v \qquad (4)$$

Where ρ^m is the shadow value, i.e. the lagrangian multiplicator, of the minimal area v_m submitted to environmental friendly practices. ρ^m is increasing and convex with v_m. From this specification, when v_m is nil, ρ^m corresponds to the minimum premium ρ_0.

Let's go back to program (1) and distinguish a fixed cost function $F(.)$ associated with strictly positive v. Fixed costs may come from physical or immaterial investments which are needed to conclude or implement the contract. The optimization programme becomes:

$$\begin{aligned} &\underset{m,v}{Max}\, U(m, v, Z) \\ &m = \pi^R(p, v, Z) - F(p, v, Z) + \rho.v + e_0 \qquad (5) \\ &v \ge 0 \end{aligned}$$

It depends on Z describing the technology and the transaction environment such as the governance structure type or the asset specificity level. Following is a detailed specification of

$F(.)$. It does not depend on v for strictly positive values. We also assume that this fixed cost deters smallest contracted areas (6).

$$F(p,0,Z)=0 \quad and \quad \frac{\partial F(p,v,Z)}{\partial v}=0 \qquad (6)$$
$$\exists \tilde{v}>0; \qquad 0<v\leq \tilde{v} \Rightarrow F(p,v,Z)>\rho$$

Finally, we specify $C(.)$ the cost function of contracting:

$$C(p,v,Z)=\pi^R(p,0,Z)-\pi^R(p,v,Z)+F(p,v,Z) \qquad (7)$$

It is positive, continuous, increasing and concave with all strictly positive v. Under the preceding assumptions, the average cost function is U-shaped. As usual, the profit maximizing farmer will sign a contract if the per-unit payment exceeds the minimal average cost.

Next section is the analysis of the willingness to accept function that we associate to ρ_0.

II.2) Specifying the farmer's willingness to accept

Under the preceding assumptions, especially those regarding the fixed compliance costs, the farmer will not produce the environmental service without payment. In this case, the solution of (5) is:

$$U_0=U(m_0,0,Z), \qquad m_0=\pi^R(p,0,Z)+e_0, \qquad v=0 \qquad (8)$$

The farmer's willingness to accept (WTA) an agro-environmental contract is the minimum compensation payment ρ_0 the farmer accepts to enroll and produce a fixed amount of environmental services v instead of not to produce those services (eq. $v=0$) while his initial utility level, U_0, remains the same. It is specified in two steps (Dupraz et al., 2003).

First, the restricted expenditure function, called e^R, is minimized in *m*. e^R is continuous, increasing and concave with all strictly positive *v*. We get the Hicksian optimal consumption $m^*(p,v,Z,U_0)$:

$$e^R(p,v,Z,U_0)=\underset{m}{Min}\left(m-\pi^R(p,v,Z)+F(p,v,Z)\right)$$
$$U_0\leq U(m,v,Z) \qquad (9)$$
$$v\geq 0$$

The corner solution described in (8) is also a solution for (9). Then, having assumed a utility maximizing farmer, the utility constraint always binds.

Second, the farmer's WTA is obtained by deriving the surplus variation:

$$WTA(p,v,Z,U_0) = e^R(p,v,Z,U_0) - e^R(p,0,Z,U_0)$$
$$= \pi^R(p,0,Z) - \pi^R(p,v,Z) + F(p,v,Z) - \{m*(p,0,Z,U_0) - m*(p,v,Z,U_0)\} \quad (10)$$
$$= C(p,v,Z) - WTP(p,v,Z,U_0)$$

The first term is the farm profit loss or the cost function of contracting (cf. equation 7). The second term is the farmer's willingness to pay (WTP) for an increase in the environmental service on his farm site. Therefore, when the farmer's utility from environmental services he produces is negligible, his WTA equals the profit loss. Otherwise, the profit loss overestimates the farmer's WTA. With convex preferences, the WTP is positive, increasing and concave with *v*. Under our preceding assumptions, there is no production of environmental service without strictly positive payment. It means that the WTP is always lower than the cost of contracting for strictly positive *v*. Hence, the WTA function is positive, continuous, increasing and concave with all strictly positive *v*. Next section considers the actual policy context in which the farmer chooses the subscribed area.

II.3) Introducing the choice over the subscribed area

II.3.1) Specifying the minimum per-unit payment

The cost function including fixed compliance costs, the minimum per-unit payment $\rho*$ that triggers the contract is therefore the minimum of the average WTA:

$$\rho* = WTA^M(v*) = \underset{v}{Min}\frac{WTA(v)}{v} \quad (11)$$

The first order condition provides (12) and $v*(p,m*,Z,U_0)$ the minimum contractible area:

$$-\frac{WTA(v*)}{v*^2} + \frac{1}{v*}\left(-\frac{\partial\pi^R(p,v*,Z)}{\partial v} + \frac{\partial m*(p,v*,Z,U_0)}{\partial v}\right) = 0 \quad (12)$$

Since the WTA refers to a minimal utility, we set $U_0 = U(m*,v*,Z)$ from (9) with $m*(p,v*,Z,U_0)$. The total differentiation of the utility function thus gives:

$$\frac{\partial m*(p,v*,Z,U_0)}{\partial v} = -\frac{\partial U(m*,v*,Z)/\partial v}{\partial U(m*,v*,Z)/\partial m}$$

The right part being the marginal rate of substitution between *m* and *v*, i.e. the farmer's WTP for environmental services.

We finally get (13) for specifying the minimal per-unit payment:

$$\rho* = WTA^M(v*) = -\frac{\partial\pi^R(p,v*,Z)}{\partial v} - \frac{\partial U(m*,v*,Z)/\partial v}{\partial U(m*,v*,Z)/\partial m} \quad (13)$$

And, we get (14) from (10) and (11):

$$m^* = \pi^R(p,v^*,Z) - F(p,v^*,Z) + \rho^* v^* + e_0 \qquad (14)$$

II.3.1) Specifying the optimal subscribed area

The farmer's choice over the area to enroll is derived from his Marshallian behavior with an unchanged exogenous income e_0. His Marshallian optimal contracted area $v^{**}(p,m,Z)$ is given by program (5).

The farmer's decision depends on ρ:

$$\begin{array}{lll} when\ \rho < \rho^* & \Rightarrow & v^{**} = 0 \\ when\ \rho = \rho^* & \Rightarrow & v^{**} = v^* \\ when\ \rho > \rho^* & \Rightarrow & v^{**} > v^* \end{array} \qquad (16)$$

With $\rho = \rho^m(p,v^{**},Z)$ the marginal WTA.

II.4) Utility maximizing behaviour with fixed costs

In order to show the contracting decision based on the minimal average WTA is compatible with a utility maximizing behaviour, we shall now prove that $U_0 = U(m^*,v^*,Z)$ is also a solution of program (5) for $\rho = \rho^*$.

Let $(\overline{m},\overline{v})$ be a solution of program (5) for $\overline{\rho} = \rho^*$, with $\overline{v} > 0$. Next, we show $(\overline{m},\overline{v})$ can not be different from (m^*,v^*).

First order conditions of (5) bring:

$$\rho^* = -\pi_v^R(\overline{v}) - \frac{U_v(\overline{m},\overline{v})}{U_m(\overline{m},\overline{v})} \qquad (17)$$

The budget constraint, which is binding, brings :

$$\overline{m} = \pi^R(p,\overline{v},Z) - F(p,\overline{v},Z) + \rho^*.\overline{v} + e_0 \qquad (18)$$

i) First we suppose that $\overline{v} > v^*$. As the marginal cost of contracting is increasing with *v*, (13) and (17) imply that the marginal rate of substitution (MRS) for (m^*,v^*) is lower than the MRS for $(\overline{m},\overline{v})$.

$$\begin{array}{l} \overline{v} > v^* \Rightarrow -\dfrac{\partial \pi^R(p,v^*,Z)}{\partial v} < -\dfrac{\partial \pi^R(p,\overline{v},Z)}{\partial v} \\ (13) \quad and \quad (17) \Rightarrow \quad \dfrac{U_v(m^*,v^*)}{U_m(m^*,v^*)} < \dfrac{U_v(\overline{m},\overline{v})}{U_m(\overline{m},\overline{v})} \end{array} \qquad (19)$$

As the MRS is decreasing with *v* when m is constant, it implies that $\overline{m} > m^*$ must hold, and is compatible with a maximized utility. However, by using (14) and (18) this inequality contradicts our basic assumption of a positive MRS:

$$\overline{m} - m^* > 0 \Rightarrow \pi^R(p,\overline{v},Z) - \pi^R(p,v^*,Z) + F(p,v^*,Z) - F(p,\overline{v},Z) + \rho^*(\overline{v} - v^*) > 0$$

$$F(p,v^*,Z) = F(p,v^*,Z) \qquad \Rightarrow \int_{v^*}^{\overline{v}} \left(\pi_v^R(p,v,Z) + \rho^*\right) dv > 0 \Rightarrow \pi_v^R(p,v,Z) + \rho^* > 0 \qquad (20)$$

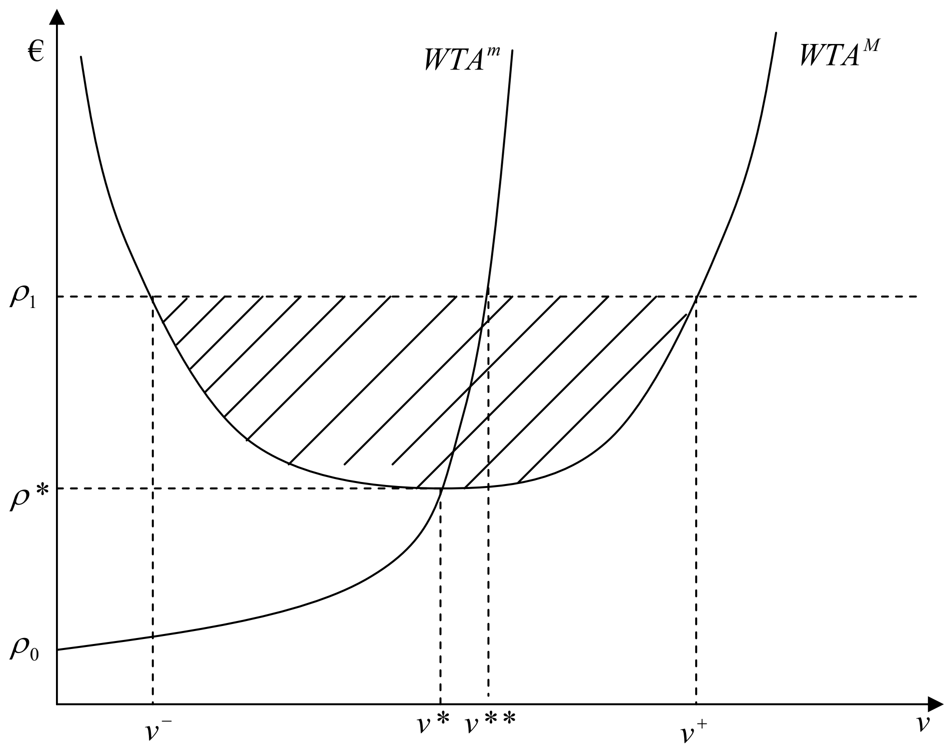
This result contradicts both (13) and (17) where the marginal willingness to pay is positive. Therefore $\overline{v} > v^*$ can not hold.

ii) Secondly, we suppose that $\overline{v} < v^*$. As the marginal cost of contracting is increasing with *v*, (13) and (17) imply that the MRS for (m^*,v^*) is higher than the MRS for $(\overline{m},\overline{v})$. As the MRS is decreasing with *v* when m is constant, it implies that $\overline{m} < m^*$ must hold. It implies $U(\overline{m},\overline{v},Z) < U(m^*,v^*,Z) = U_0$. This inequality contradicts the optimization program (5). Indeed, the relationships (13) and (14) shows that (m^*,v^*) respects the necessary conditions of this program, as stated in (17) and (18), and provides an higher utility than $(\overline{m},\overline{v})$. Therefore $(\overline{m},\overline{v})$ can not be a solution of (5) if $\overline{v} < v^*$.

From i) and ii) we can conclude $(\overline{m},\overline{v}) = (m^*,v^*)$.

<u>II.5) Synthesis</u>

We can observe from graph (1), the marginal WTA curve (WTA^m) where, in the absence of fixed compliance costs, the minimum WTA is ρ_0.
In the presence of fixed compliance costs, we can observe the U-shaped average WTA curve (WTA^M) whose minimum is located in v^* and the associated minimum per-unit payment for contracting is ρ^*.



Graph 1: Average WTA and marginal WTA with the number of hectare under contract

When the per-unit payment is higher than ρ^*, ρ_1 for instance, as long as $WTA^M \leq \rho_1$, farmers respecting the area condition enroll. This corresponds to the hachured area between v^-, the minimal necessary area to enrol, and v^+, the maximal possible area to enrol, without utility loss. Farmers with an eligible area higher than v^* will prefer to subscribe the optimal area v^{**}. If the eligible area of their farm is lower than v^{**}, they will enter 100% of this available suboptimal area.

III) FIXED AND VARIABLE COMPLIANCE COSTS: APPLICATION TO AGRO-ENVIRONMENTAL CONTRACTS

We here seek to observe the impact of fixed compliance costs on adoption behavior, and fixed transaction costs in particular. The empirical analysis is based on a European sample made of 2262 farmers interviewed in 2005. They come from 10 different regions spread among 9 EU countries, namely France, the Netherlands, Belgium, England, Germany, Italy (two regions: Emilia Romagna and Veneto), Ireland, Finland and Czech Republic. 55% of interviewed farmers have subscribed an agro-environmental contract and the proportion of contractors is quite similar in every region except for Finland where only 32% of farmers are considered as contractors. Next table presents an overview of the origin population.

Table 1: Overview of the origin population

Sub-samples	Farmer population	Participation rate	Farm production system
France	34000	7%	Predominance of dairy farms
Netherlands	6000	11%	Predominance of dairy farms
Belgium	20667	15%	Mixed farming
England	5690	33%	Mainly cattle and sheep farms
Germany	1054	10%	?
Italy Em. Rom.	34919	40%	?
Italy Ven.	?	2.5%	Arable farms and dairy farms
Ireland	13233	26%	Mainly cattle farming
Finland	4600	15%	Mainly grain crops
Czech Republic	46400	26.5%	Combined production

This table highlights an over-coverage of contractors. Indeed, 60% of surveyed farms are contractors while they represent only 25% of farms on average. It also shows an over-coverage of some types of farming systems, namely breeding systems (82%) and dairy systems (38%) . This makes a high proportion of grassland in total farmland (52%).

The questionnaire addresses issues concerning farmers' socio-demographic and cultural characteristics, their farm, their professional environment, their perceptions on agro-environmental contract and their income. The sample is quite representative although contracting farmers are over represented on purpose in order to get better information on contracts.

III.1) The empirical methodology

Agro-environmental contracts (AEC) involve various compliance costs we can present as follows. Fixed compliance costs do not vary with the enrolled area. Fixed transaction costs are information gathering before contracting, contract writing, or bureaucratic costs for the contract follow-up. Variable compliance costs are varying with the enrolled area. Variable transaction costs are maladaptation costs and the costs of contract renegotiations. Indeed, we assume that the more the farmer has hectares under AEC, the more hazards may appear and lead him to be trapped in contracts commitments.

From this observation, taking back our theoretical model, fixed compliance costs $F(.)$ encompasses fixed costs of production and fixed transaction costs, whereas the variable compliance cost function $\pi^R(.)$ gathers variable production costs and variable transaction costs. Equations (?) give the new specification, where Z^T are determinants of fixed and variable transaction costs.

$$\pi^R(p,0,z^\pi,z^T) - \pi^R(p,v,z^\pi,z^T) = y(p,v,z^\pi) + t(p,v,z^T)$$
$$F(p,v,Z^\pi,Z^T) = Y(p,v,Z^\pi) + T(p,v,Z^T)$$

It is important to remind that farmer's characteristics, Z^U, determine neo-classical preferences, variables describing the technology, Z^π, determine the profit according to the duality theory, and, variables describing the transaction environment, Z^T, determine transaction costs according to the transaction cost theory. Some of these determinants being common to the utility function, the profit function and the transaction cost function, we clarify these relationships in table 2 in order to simplify our estimation interpretations. This table is based on the previous work of Ducos and Dupraz (2007) analyzing determinants of the choice over asset specificity level in agro-environmental contracts. It provides determinants expected effects on each component of farmers' *WTA*, namely the production cost variation, the transaction cost variation and the *WTP*, other things being equal.

Table 2: Synthesis of the WTA determinant expected effects

Determinants of *WTA*	ΔY or Δy	ΔT or Δt	*WTP*
Trust		-	
Uncertainty		+	
Bounded rationality		+	
Utility		-	+
Technology/ Similarity	-	-	
- means a reduced variation + means an increased variation			

Among these five determinants, three have an impact on the transaction cost function only and two impact on other components of the WTA too. Before providing propositions about the relationship between these determinants and the choice over contracting and the area to subscribe, some assumptions are to be set. First, agro-environmental contracts are centrally designed, i.e. the European commission has specified agro-environmental contract provisions (duration, flexibility[1], eligibility and compensation payment calculation). Consequently, contract design is assumed to be the same whatever the EU state. Second, we assume agro-environmental contracts involve non negligible investments and their magnitude is similar across contractors. Third, we assume agro-environmental contract involve specific investments, such investments being non redeployable without sacrifice of productive value (Ducos and Dupraz, 2007). More precisely, we assume contracting farmers got engaged in the same specificity level of investments. This is a reasonable assumption since they subscribed for the least specific suggested environmental friendly practices such as "extensive management of grassland, "extensive management of arable land" or "landscape maintenance". We thus consider the asset specificity level does not vary from a contractor to an other.

In other respects, in line with the 1999-CAP regulation, the implemented compensation payment is a per-unit payment based on average operational costs and income foregone in each region and do not include transaction costs. We therefore expect transaction costs originating from involved investment specificity to affect agro-environmental contract uptake rate, *ceteris paribus*.

[1] A contract is said to be flexible when some terms are left open to ex post renegotiation.

From this last observation, we set the following testable propositions[2] on the relationship between transaction characteristics and farmers' choice to enroll an agro-environmental contract:

Proposition 1: The more the farmer trusts in the State, the lower the transaction cost variation, the lower his WTA and the higher the probability he enrolls, *ceteris paribus*.

We argue the same effects for less uncertainty and less bounded rationality.

Proposition 2: The more the agro-environmental transaction is similar to ones the farmer is already engaged, the lower the transaction cost variation and the profit loss. The probability to enroll is thus higher and because of the compensation payment calculation, we may argue this is due to transaction cost effect, *ceteris paribus*.

Proposition 3: The more utility the farmer gets from environmental services he produces through the agro-environmental contract, the lower the transaction cost variation and the greater his WTP. The probability to enroll is thus higher but it is not possible to distinguish both effects, *ceteris paribus*.

By introducing the prospect of estimating the structural relationships underlying the adoption decision, the application of the two-stage Heckman method stands to shed light on the issue of whether and to what extent variations in fixed costs (fixed transaction costs) are responsible for observed adoption rate.

The econometric specification is based on the optimal area the farmer would contract if he were obliged to contract: this is the notional area v^n where the marginal WTA equals the per hectare premium (). It does not depend on fixed costs. So contracting this area may entail a utility loss under a threshold area because of fixed costs. Or this optimal area is negative if the premium do not reach the marginal WTA for any positive contracted area. In fact, the farmer refuses the contract in these both cases.

$$\rho = \rho^m(p, v^n, z^\pi, z^T) \Rightarrow v^n = v^n(p, \rho, z^\pi, z^T)$$

The first step of the Heckman method analyses the decision to contract or not, using a probit model. It is based on the probability that the premium exceeds the minimal average WTA, which depends on fixed costs according to (14), or ρ_0 in the absence of fixed costs. Alternatively this is the probability that the notional area v^n exceeds v^* or zero. The latent variable of the probit model is the difference b between v^n and v^*. This first step enable the calculation of the inverse Mills ratio to be used in the second step.

$$b = v^n - v^* \Rightarrow b = b(p, \rho, Z^\pi, Z^T)$$

The second step analyses the contracted area with a least square regression. The contracted area is the optimal area, knowing that the contract is accepted. Hence the regression is augmented with the inverse Mills ratio to take into account the outcomes of the first step.

Accordingly, the econometric specification assumes that the pair (v^n, b) has a bivariate normal distribution:

$$E(v^n / x) = x'\alpha \qquad Var(v^n) = \sigma_1^2$$
$$E(b / X) = X'\beta \qquad Var(b) = \sigma_2^2 \quad Cov(v^n, b) = \theta.\sigma_1.\sigma_2$$

[2] These propositions are derived from Ducos and Dupraz (2007).

The probability of contracting is $P(b \geq 0) = \Phi(X'(\beta / \sigma_2))$ with Φ the cumulative function of the normal distribution. The parameter (β / σ_2) is estimated by the maximum likelihood estimator in the probit model.

The area under contract is
$$E(v^n / b \geq 0, x) = x'\alpha + (\theta.\sigma_1).\lambda$$
$$\lambda = \varphi(X'(\beta / \sigma_2)) / \Phi(X'(\beta / \sigma_2))$$

We use the same linear specification, with the same explanatory variables, to model the expected optimal area. If there were no fixed costs both steps would bring more or less the same results, scaled by the estimated parameter of the inverse Mills ratio. With fixed costs, the results will diverge if the determinants of fixed costs are different from the determinants of the marginal WTA. These determinants will more affect the first step than the second, possibly in opposite directions.

III.2) Explanatory variables

Several types of variables were collected so as to capture the notion of the determinants previously described. They describe the farmer (education level, environmental awareness…), his production system (farm legal status, number of Full Time Equivalent workers…), his professional environment (involvement in agricultural organizations, administrative and technical external services,…) and his relationship with the State (trust in administrations, …). From these raw data, we created variables providing a measure of the determinants of the WTA as presented in table 3.

Table 3: Determinants of the WTA and their respective explanatory variables

Determinants of asset specificity	Related constructed explanatory variables	Variable values[3]
Bounded rationality	Agricultural education (***AGRI EDUC***) General education	6 classes 7 classes
Trust	To trust the implementation process of agro-environmental contracts (***TRUST IMPL***) Strong belief in the Government goodwill (***GOODWILL***)	Continuous variable [-1;1] Continuous variable [-1;1]
Uncertainty	To regularly receive technical and administrative advices (***ADVICES***) To be involved in an agricultural organization (***ORGA***)	Continuous variables [-1;1] Continuous variable [-1;1]
Similarity of transaction	Grassland share (***GRASSLAND***) Farm land area (***UAA***) Arable land share Labor (***FTE***) Animal population Milk quota Production system type (organic or conventional)	Continuous variable (%) Continuous variable (hectares) Continuous variable (%) 5 classes Continuous variable (Livestock units) Continuous variable (litre) 0=organic; 1=conventional
Utility	Environmental awareness (***ENV AW***) Children Free time dedicated in nature related hobbies	Continuous variable [-1;1] 3 classes Continuous variable [-1;1]
Control variables		
Changes in the production system in the last 5 years (***CHANGES***)		Continuous variable [-1;1]

[3] See the annex for a more detailed description of how explanatory variables measure determinants of the *WTA*.

To have already enrolled an agro-environmental contract (***EXPERIENCE***)	0=no; 1=yes
Age (***AGE***)	3 classes
NUT region	0=Calvados; 1=Manche; 2=Orne
Machinery ownership	Continuous variable [-1;1]
Land share in ownership	Continuous variable (%)
Land share in long term tenant tenure	Continuous variable (%)
Land share in short term tenant tenure	Continuous variable (%)
Farm legal status	5 classes

Next table provides average annual payment per hectare of enrolled area.

Table 4: Average annual payment per hectare of contracted area

	France	Netherlands	Belgium	England	Germany	Ireland	Finland	Czech Republic	Italy_ Em. R.	Italy_ Veneto
Mean (€/ha)	119.7	168.4	455.6	389.1	163.4	164.7	124.1	90.8	317.4	334.4
Median (€/ha)	109.4	137.1	180.9	76.9	129.9	169.2	105.8	90.9	277.8	183.6

The lowest payments per hectare are in France, Netherlands, Germany, Ireland, Finland, and Czech Republic. The highest are in Belgium, England, Italy Emilia Romania and Italy Veneto.

IV) RESULTS

This section provides estimation results. Probit estimates allow to distinguish factors of transaction cost variation from those of the profit ones. Heckman estimates allow to distinguish factors of fixed transaction cost from those of variable ones;

IV.1) Probit estimations

The reference choice is not to enroll. The reference farmer is high agricultural education, intermediate general education, no experience in previous AEC, no children under 6 years-old, his production system is conventional and dairy farming oriented, and, for other variables, average values of continuous explanatory variables have been taken. Country specificities, including characteristics of sampling in each case study, are taken into account through country dummies, which are introduced as control variables. France is the reference.
The different parameter estimations are gathered in table 7. Significant variables are presented only. The model has kept every observations.

Table 5. Model of participation (pooled sample with country dummies)

PARAMETERS (Mac Fadden R^2 = 30.01%)		**Estimation**	**Standard error**	**Pr > Khi 2**
Intercept		-0.7666	0.1268	<.0001
TRUST				
TRUST IMPL		0.6756	0.0393	<.0001
TRUST INST		0.1802	0.0376	<.0001
BOUNDED RATIO				
GEN EDUC	Non response	-0.1714	0.1508	0.2557

	None	0.3177	0.1351	0.0187
	Low	0.0872	0.0830	0.2935
	High	0.1683	0.1133	0.1375
UTILITY				
NAT HOBBIES		-0.1735	0.0432	<.0001
ENV AW		0.2423	0.0471	<.0001
CHILDREN		0.3659	0.0892	<.0001
SIMILARITY				
PROD	Non response	1.1070	0.5030	0.0278
	Organic	0.8475	0.1389	<.0001
GRASSLAND		0.8191	0.1123	<.0001
CONTROL VARIABLES				
EXPERIENCE		0.9820	0.0754	<.0001
COUNTRY	Netherlands	-0.2252	0.1766	0.2023
	Belgium	0.4276	0.1297	0.0010
	United Kingdom	0.2569	0.1332	0.0538
	Germany	-0.0672	0.1508	0.6560
	Ireland	-0.6353	0.1442	<.0001
	Finland	-0.9524	0.1734	<.0001
	Czech Republic	0.0769	0.1404	0.5837
	Italy E. Romagna	-0.5395	0.1674	0.0013
	Italy Veneto	0.2729	0.1604	0.0888

Looking at variable signs, we observe seven expected factors, namely trust factors ("to trust in the implementation process of AEC", "to trust in institutions"), bounded rationality factor ("to have a high general education"), similarity factors ("environmental awareness", "to have children under 6 years-old"), and similarity factors ("organic production system", "grassland share"). Trust and bounded rationality factors thus support the proposition 1 whereas similarity and utility factors support propositions 2 and 3.
Non expected variables are "to have no or a low general education" and "Free time dedicated to nature related hobbies.

Instead of looking at estimation coefficient magnitude, we observe marginal effects on the probability to enrol an AEC in table 6. They are calculated for the reference farmer whose probability to participate is 0.41. Only significant effects are indicated.

Table 6: Marginal effects (pooled sample with country dummies)

Variable	Marginal effect
TRUST	
TRUST IMPL	0.25
TRUST INST	0.07
BOUNDED RATIONALITY	
GEN EDUC	0.12
UTILITY	
CHILDREN	0.14

NAT HOBBIES	-0.06
ENV AW	0.09
SIMILARITY	
PROD	0.33
GRASSLAND	0.31
CONTROL VARIABLES	
EXPERIENCE	0.37
BE	0.17
UK	0.10
IRL	-0.20
FIN	-0.27
IT-R	-0.18
IT-V	NS

Marginal effects allow ranking variables according to their estimated effect on participation. The most influential factors are the type of farming, past experience in AEC and farmer's trust in the implementation process.

IV.2) Heckman estimations

Table 7 provides the estimation with the Heckman procedure. The inverse Mills ratio, λ, is calculated in the first step and used in the second one to correct data. This specific parameter accounts for differences between participants and non-participants that are captured by the error term. λ being non-significantly different from zero, it may be considered that omitted factors do not account for differences between the two categories. In other words, explanatory variables are enough to discriminate farmers and to estimate the share of area entering AECs.

Table 7: Estimation of the proportion of Farmland which is enrolled (Heckman model)

PARAMETERS		Estimate	Std Error	Pr > |t|
Intercept		-.8727	0.1674	<.0001
λ		-.0439	0.1041	0.6736
UTILITY				
ENV AW	Environmental awareness	0.0807	0.0344	0.0192
SIMILARITY				
PROD	Non response	0.2143	0.4045	0.5964
	Organic	0.2723	0.1192	0.0225
GRASSLAND	Share of grassland	0.8977	0.1316	<.0001
DAIRY	No	0.2394	0.0940	0.0110
UAA	Surface	-.00164	0.0004	<.0001
UAA²	Square-surface	0.0001	0.0001	<.0001
CONTROL VARIABLES				
CHANGE	Past change	0.0856	0.0457	0.0616
COUNTRY	Netherlands	-.9754	0.1404	<.0001
	Belgium	-.9450	0.1274	<.0001

	United Kingdom	-.3397	0.1659	0.0408
	Germany	0.0818	0.1913	0.6690
	Ireland	0.3155	0.3239	0.3302
	Finland	0.5412	0.2114	0.0106
	Czech Republic	-.1289	0.1401	0.3576
	Italy E. Romagna	0.2997	0.1833	0.1024
	Italy Veneto	-.3639	0.1706	0.0332
R^2 = 23.17%. Number of observations= 1996. Number of participants = 981				

Three additional explanatory variables appear and describe the similarity of transactions, namely “to have a dairy production system”, “farm land area”, and “square farm land share”. An other one appear and is a control variable “changes in the production system in the last five years”. On the other hand, variables describing trust and bounded rationality disappeared and a utility variable (“to have children under six years-old”) too. From this observation, and concentrating on trust and bounded rationality variables, which impact on transaction cost only, we can argue the presence of fixed transaction costs as a barrier of contracting AEC.

Two variables describing the similarity of transaction (“production system type”, “grassland share”) and the utility in the transaction (“environmental awareness”) positively influence the relative area under AEC. They support the presence of variable costs but, since they impact on the profit loss and the WTP respectively, it is not possible to disentangle their effect on transaction costs. An additional explanatory variable (“changes in the production system in the last five years”) whose effect is positive is also considered. As expected, farmers who made significant changes over the last five years enter a larger area than the others.

In addition, there is a significant effect of farm size on the contracted surface. This effect has been modelled using two components, a linear one and a quadratic one. Based on the estimation of the coefficient of the surface and square surface, a threshold (around 2 600 ha) has been calculated. There is a negative effect under the threshold and a positive one over, this threshold.

Finally there is a specific country effect which is mainly due to the difference of Schemes proposed to farmers.

V) CONCLUSION

Estimation results support the presence of fixed transaction costs among fixed compliance costs and their significant negative effect on participation. The policy implications of this case study are straight forward. In order to increase farmers’ adoption, the State seems to have two possibilities, whether to compensate farmers’ transaction costs with a higher subsidy, or to reduce farmers’ transaction costs. The first option requires an evaluation of the magnitude of transaction costs borne by the farmer, which is not an easy operation. The second option is to act on transaction cost significant determinants, namely trust and bounded rationality. For instance, knowing that farmers’ trust in the implementation process has a major role, the State may work on the clarity of contract requirements so as to narrow its implementation interpretation spectrum. Trust may also be restored by balancing the State and the farmers’ rights when a case is brought to private negotiation or to court. Finally, it is important to remind that this study focuses on transaction costs borne by the farmer only, whereas the agro-environmental transaction generates transaction costs borne by the State too. Consequently, reducing farmers' transaction costs may increase the State's one. This relation remains unknown and provides interesting future researches.

REFERENCES

Brousseau E. and Fares M., 2000. Incomplete Contracts and Governance Structures: Are incomplete Contract Theory and New-Institutional Economics Substitutes or Complements?, In: C. Ménard, (ed), Institutions, Contracts and Organizations, Perspectives from New-Institutional Economics, Edward Elgar Pub.

Ducos G., Dupraz P., 2007. The asset specificity issue in the private provision of environmental services: Evidence from agro-environmental contracts, Working Paper.

Dupraz P., D. Vermersch, B. Henry de Frahan, L. Delvaux, 2003. The Environmental Supply of Farm Households, a Flexible Willingness to Accept Model, *Environmental and Resource Economics*, N°25, pp 171-189

Knowler D., Bradshaw B., 2007. Farmers' adoption of conservation agriculture: A review and synthesis of recent research, *Food Policy*, 32, pp 25-48.

Mahul O., 2002. Les outils de gestion des risques de marché, étude commandité par le Ministère de l'Agriculture, de l'alimentation, de la pêche et des affaires rurales (ref. MAAPAR 00.G3.01.01).

Masten S.E., Meehan J.W., Snyder E.A., 1991. The Costs of Organization, *Journal of Law, Economics and Organization*, Vol 7, pp 1-27.

Sako M. and Helper S., 1998. Determinants of trust in supplier relations: evidence from the automotive industry in Japan and the United States, *Journal of Economic Behavior and Organization*, 34, pp 387-417.

Williamson O.E., 1985. The Economic Institution of Capitalism- Firms, Markets and Relational Contracts. The Free Press, New York.

ANNEX : Measure of the WTA determinants

Determinants of transaction costs, which we identified and defined in the previous section, are notions that do not allow any direct measurement. When available, previous studies characterizing conditions in which these determinants may increase or decrease helped us to build a measurement framework.

<u>Explanatory variables measuring "Trust"</u>
Trust is an expectation held by an agent that its trading partner will behave in a mutually beneficial manner (Sako and Helper, 1998).
Conditions favouring trust (Sako and Helper, 1998) :

- "Long-term trading and future expectations of customer commitment": (i) the longer the informal commitment made by the customer to continue trading with the supplier, the higher is the supplier's trust for its customer; (ii) the longer the duration of past trading, the higher is the supplier's trust of its customer.
- "Reciprocity in information exchange": the more a supplier's disclosure of information to its customer is matched by the customer's provision of information to the supplier, the higher the supplier's trust for its customer.
- "Technical assistance": the more technical assistance is provided by the customer, the higher the supplier's trust in the customer

TRUST IMPL
This variable encompasses farmers' opinions (strongly disagree; somewhat disagree; somewhat agree; strongly agree; do not know) on the following statements:

- "The eligibility rules are fair"
- "The financial compensation is sufficient to cover the extra costs incurred by the farmer"
- "Compensation payments are always made on time"
- "The rules and requirements are easy to understand"
- "The measures can easily be implemented on my farm"
- "The intended environmental benefits are clear and easy to understand"
- "The current policy rules and regulations will remain constant over a longer period"
- "There is a lot of control when implementing measures"
- "The sanctions for not carrying out the contract are reasonable"

These statements were chosen because they tend to describe farmers' expectation that the State will behave in a mutually beneficial manner. The global variable *TRUST IMPL* was created from these primary data using a Multiple Correspondence Analysis.
A positive *TRUST IMPL* is assumed to indicate the farmer trusts in the State. The higher it gets, the more the farmer trusts in the State.

TRUST INST
In addition of *TRUST IMPL*'s statements, this variable encompasses:

- "The local government can be trusted"
- "Our government can be trusted for their commitments"
- "The agricultural administration can be trusted"
- "The European Union can be trusted"
- "Generally speaking, other farmers' can be trusted"
- "Generally speaking, most people can be trusted"

As for *TRUST IMPL*, a positive *TRUST INST* is assumed to indicate the farmer trusts in the State. The higher it gets, the more the farmer trusts in the State.

GOODWILL

Similarly, *GOODWILL* gathers the following statements:

- "The procedures for contract applications are easy"
- "The rules and requirements are easy to understand"
- "It is easy to find the right person to contact in the administration when there are problems"
- "Regarding agro-environmental schemes, administration behaviour is fair and responsible"

A positive *GOODWILL* indicates the farmer trusts in the State. The higher it gets, the more the farmer trusts in the State.

<u>Explanatory variables measuring "Bounded Rationality"</u>

Same definition as Williamson (1985). Bounded rationality implies "economic agents do not know all the solutions to the problems they face, are unable to calculate the possible outcomes of these solutions, and cannot perfectly arrange these outcomes in order in their space of preferences. With regard to contracts, this means that they are unable to design the optimal solutions (behavioral rules) taking into account every relevant contingency without high, and sometimes prohibitive, costs and delays" (Brousseau and Fares, 2000).

Conditions favouring bounded rationality:

We argue initial education and any form of improved knowledge reduce each individual rationality.

GEN EDUC + AGRI EDUC

Bounded rationality is characterized with qualitative variables by creating classes of variables. Variables describing farmers' education were assumed to measure their rationality since education is expected to provide solutions to problems and unable farmers to calculate the possible outcomes to these solutions (cf. section II.3.1).

The higher the education level, the less bounded the farmer's rationality.

<u>Explanatory variables measuring "Uncertainty"</u>

Conditions favouring uncertainty (Mahul, 2002):

The agricultural production is subject to various risk sources. A classification of those risks is provided in numerous studies (see for instance USDA 1999) and is provided bellow:

- "Production risks" from climatic uncertainties (drought, flooding,…), technological uncertainties, sanitary conditions and epidemics.
- "Market or price risks" characterizes price production factor changes.
- "Institutional risk" created by policy or regulation changes.
- "Financial risks" includes interest rate variation uncertainties or those of exchange rate, non-payment risk,…
- "Human and personal risks" are common to any individual. They are related to illness, accidents,…

ORGA

This variable reports farmers' membership and participation frequency in agricultural organizations. It was created using a Multiple Correspondence Analysis.

We assumed a farmer regularly meeting other farmers and people from the profession or involved in professional organizations better feel what is going on and what are policy orientations. This refers to the volatility aspect of uncertainty.

A positive *ORGA* indicates the farmer's perception about future conditions is rather clear and thus shows low uncertainty. The higher it gets, the less uncertain the farmer perceives future conditions.

ADVICES

This variable gathers information on organizations or persons farmers get technical, financial or administrative advices from. It was created using a Multiple Correspondence Analysis.
ADVICES follows the same logic as *ORGA*, namely a positive *ADVICES* indicates the farmer beneficiate from conditions lowering uncertainty about future conditions. The higher it gets, the less uncertain the farmer perceives future conditions.

<u>Explanatory variables measuring the "Similarity of Transactions"</u>

Except from the production system type which is a qualitative variable, every variables describing the similarity of transactions are continuous.
As Masten et al. (1991), the similarity of transactions is measured by comparing the initial technology with the technology required by enrolled environmental friendly practices. Therefore, from what we know about farm technology dedicated to the production of environmental services, the similarity of transactions is characterized as follows:

- the higher the grassland share, the more similar the transactions;
- the higher the farms land area, the more similar the transactions;
- the lower the arable land share, the more similar the transactions;
- the more labour force, the more similar the transactions;
- the bigger the animal population, the less similar the transactions;
- the bigger the milk quota, the less similar the transactions;
- An organic production system indicates similar transactions.

<u>Explanatory variables measuring " Utility"</u>

Conditions favouring utility in the transaction:
We argue any form of interest for environmental or nature issues is an indicator of farmers' utility in environmental services he may produce through an AEC.

ENV AW

This variable contains information on farmers' hobbies, readings and involvement in environmental associations. It was created using a Multiple Correspondence Analysis.
We assumed a positive SENSI indicates farmers' environmental awareness and thus derive utility from environmental services. The higher SENSI gets, the more the farmer derives utility from environmental services.

We follow the same logic for the variable "free time dedicated in nature related hobbies".
As regard to children, which gives the number and age of farmers's children, we assumed a farmer with young children will be more aware of environmental issues than farmers with no child.

Threshold effect and coordination of agri-environmental efforts

Pierre Dupraz[a*], Karine Latouche[b] and Nadine Turpin[c]

[a]INRA, UMR 1302, SMART, 35000 Rennes, France

[b]INRA, UR 1134, LERECO, 44000 Nantes, France

[c]CEMAGREF, UMR Métafort AgroParisTech-Cemagref-ENITA-INRA, 63000 AUBIERE, FRANCE

No senior authorship is involved

* Corresponding author: Pierre Dupraz, INRA-SMART, CS 61103, 35011 Rennes Cedex, France. Tel : +33223485606, Fax :+33223485380, e-mail : pierre.dupraz@rennes.inra.fr

Title:

Threshold effect and coordination of agri-environmental efforts

Threshold effect and coordination of agri-environmental efforts

Abstract

This paper deals with policy mechanism designs for agri-environnemental schemes when the bio-physical processes are characterized by threshold effects. There is a threshold effect when specified farming practices must be applied on a minimal share of an area of interest to trigger perceptible changes of the state of the natural environment. Schemes result in a pure economic loss if the induced agro-environmental efforts are not sufficient. Different situations are considered including the lack of information on farmers' characteristics or actions, uncertainty on the relationship between farming practices and environmental quality, and combined difficulties of scheme design.

Keywords: threshold effect, agri-environmental policy

JEL: Q28, Q57

Threshold effect and coordination of agri-environmental efforts

1. Introduction

When threshold effects characterise the processes involved in the environmental quality on a given area, the regulators need specific skills to ensure that the environmental effectiveness of the policy design. We deal with a simple case of threshold effect: no perceptible change in the environmental state occurs unless a specified farming practice is applied with a minimal intensity and on a minimal area in the zone of interest. The efficiency of agri-environmental schemes is particularly vulnerable to threshold effects because farmers' participation is voluntary and contractors may adjust their enrolled area in most cases. The analysis of the environmental performance of agri-environmental schemes, realised in the ITAES project in 9 case study regions, show that participation is the performance factor that most impedes scheme efficiency. In three regions, participation rate and geographical targeting are the two factors that limit environmental performance most (Finn et al., 2007). Although threshold effects are not always involved in analysed schemes, these results illustrate the importance of this issue.

Threshold effects on ecological discontinuities have been defined by Muradian (2001) as sudden modifications of a given system property, resulting from the soft and continuous variation of an independent variable. The examples for such discontinuities are numerous in the ecological literature: increase of the vulnerability to additional perturbations for ecosystems that have been previously submitted to strong anthropogenic pressure (Levin 1998), modifications in the equilibrium of temperate lakes (Weisner *et al.* 1997), colonisation by undesired species (Asner et Vitousek 2005), habitat fragmentation and disappearance of species (Kennedy *et al.* 2002), management of renewable resources.

The existence of discontinuities in the ecological processes that underline the renewing of natural resources like fishes, forests, soils, hunted animals or newly introduced species, induce strong nonlinearities that are largely addressed in management of renewable resources (Dasgupta et Maler 2003; Wirl 2004). The management of such resources, when thresholds occur, is characterised by the existence of multiple equilibriums, and thus the design of management policies needs to be dynamic (Maler 2000; Mitra et Roy 2006; Rondeau 2001; Toman et Withagen 2000).

In Europe, agri-environmental policies aim at preserving natural and semi-natural resources like biodiversity, rural landscapes, surface and groundwater quality, mostly using voluntary agreements (OCDE 2003) : a regulator proposes to a population of farmers to voluntarily adopt management practices that are supposed to be better than the current ones, against financial support for over costs. This regulator can base her policy on a large literature on thresholds effects, on their consequences upon the requested properties for accurate regulation policies, but generally this literature does not address the specific problem that this regulator faces. Because the available information is generally not precise enough for each regulated area, local regulators are often bounded to design policies without considering thresholds effects, which decreases strongly the efficiency of the regulation and leads to a waste of public fund: more and more empirical studies describe the adoption of good management practices, with important efforts from the population and sometimes with large public subsidies, with no noticeable modification of the environmental quality (Muradian, 2001).

The probability of wasting public funds is increased when asymmetric information occurs between the regulator and the farmers. Uptake mainly depends on the economic incentive offered to eligible farmers. However, the success of such schemes also depends on the individual characteristics of the eligible farms (Vanslembrouck *et al.,* 2002), on the social context (Morris et Potter, 1995) on the different farm and extension networks (Bonnieux *et al.,* 2001). When she designs a policy, the regulator cannot consider individual characteristics of all the eligible farms. These asymmetries of information create inefficiencies, that can however be reduced (Laffont et Martimort, 2002).

We focus on the paper on agri-environmental schemes that address two difficulties: threshold effects and asymmetries of information. Literature provides mechanism design in some situations. For threshold effects a two stage allocation of conservation funds has been proposed to optimally target conservation efforts: in the first stage, the allocation across the eligible sites ensures that thresholds are met in every selected site while within site fund allocation only needs to be based on a physical criterion of environmental effectiveness (Wu, 2004). An important issue related to threshold effects is the uncertainty with which they are associated. Perrings and Pearce (2004) provided a general framework to design the optimal mandatory policy dealing with certain and uncertain ecological thresholds. When asymmetries of information occur, and for non-point source pollutions only, optimally differentiated mechanisms ensure that each producer chooses the instruments (effort or practice) that have been designed for him (Wu et Babcock, 1996 ; Bontems *et al.,* 2005).

Starting from an analysis of particular agri-environmental schemes and EU wide sample, this paper highlights the scattering of agri-environmental efforts that result from the different schemes designed last years. This analysis also depicts the main characteristics of the benefit functions for the regulators when they expect an improvement of the environment. Last, the analysis enables the elaboration of a typology for the agri-environmental situations; this typology relies on the different uncertainties occurring from hidden farmers' behavior or bio-physical processes.

For each situation in this typology, we propose and discuss the possibility to design simple contracts. Simple standard contracts are considered regarding the high transaction costs involved in the management of differentiated contracts. The modelling suggests that the regulator can make of the direct utility that farmers derive from specific environmental goods they contribute to supply, and arouse cooperation behaviour. For example, when the regulator sends a signal, like the institution of a minimal rate of contracting intentions before signing any contract, this signal can easily consist in information that contributes to increase the probability of commitment by farmers that have a positive attitude towards the environment. Moreover, when the environmental objective matches a strong social demand, but is characterised by uncertain threshold effects, a perennial and progressive management of the scheme allows capitalising the local competences as the first implemented measures include the reduction of the uncertainties in their objectives.

In this paper, we finally analyse a concrete example that illustrates the existence of threshold effect. The practical possibility for a regulator to design a progressive scheme is described.

The paper is organised as follows: Section 2 describes the context of agri-environmental measures adoption with national or regional programmes. This description illustrates the phenomenon of scattering of committing farms. Section 3 designs a behaviour model for farmers who face agri-environmental measures and analyses the proprieties of such schemes when they are design in complete information situations. In the Section 4, this assumption of complete information is weakened: we examine here how the agri-environmental schemes are modified when the regulator cannot observe the farmers' willingness to accept. The Section 5 focuses, mostly through literature, the other combinations of uncertainties that a regulator may face. The last Section concludes.

2. Voluntary adoption and scattering of agri-environmental efforts

At the farm level, attempts to take into account scale and threshold effects may be limited by the Commission degressive rules, introduced and enforced with 1257/99 AESs, as a new component in the budget management. The average payment per hectare decreases according to the area under contract, the mix of area based measures being the same (punctual or linear elements/measures are not concerned by such rules). The payment calculation is done as follows:

- Sum of the different measure committed areas, each committed area being multiplied by the corresponding payment per hectare(= theoretical aid amount);
- this amount is then divided by the total enrolled area (= average amount/ha);
- the actual payment is then calculated by intervals of committed area, with per hectare payment equalling 100% under 2 SMIs, 60% between 2 and 4 SMIs and 30% above 4 SMIs. Defined in article L312-6 of the Rural Code, the SMI is presented as the minimum farm area from which a standard household is supposed to get enough income for a basic living. The value of the SMI is set at the NUTS 3 level according to farm types. Regularly revised, the SMI cannot, in any case, be less than 30% of the national SMI and is revised every 5 years.

Thus in the French case, the degressive rule can be in contradiction with some AES environmental objectives because it discourages large farm to enrol large areas. Scale and threshold are taken into account in very few French measures: the grassland premium must be applied on the whole farm, the payment for winter coverage or arable land depend on the share of eligible land which is enrolled.

Coordination between farms at a higher territorial level is usually not enforced. Contract applications and conclusions are considered by the administration on an individual basis. The territorial approach presented in section 4.3 remains an exceptional procedure. Yet a CNASEA report published in 1996 (CNASEA, 1996) dealing with the results of a French survey on 1183 farmers under contracts 2078/92 highlighted the willing of farmers to avoid dispersion in contracts signed. They insisted on the importance of reaching a minimum area under contract in a precise area. 51% of interviewees proposed to enhance efficiency of agro-environmental contracts through a minimum rate of adoption. 48 % of interviewees also proposed that contracts should be applied on the whole farm instead of just a part of the farm. All this recommendations and farmers' advice were not taken into account in the French application of the regulation 1257/99

The low rate of compliance is a real problem in France.

In Basse-Normandie it indeed appeared that some 40% of the farmers faced some difficulties to enforce the 1257/99 contracts (Eureval-C3E, 2003) – mainly its environmental part – mainly due to the framework planning and to the technical respect of some of the prescriptions.

Hence even in a ideal case of collective contracts signed only if the minimal targeted area is concerned, the provision of the environmental good can fail because the global effort of production (individual respect of contract commitments) is not effective.

The same holds in Brittany. The compliance controls lead nearly to the same results. The compliance with commitments failed in 84 % of CTE controlled. In 65 % the gap noticed between commitments and reality was major, in 12 % it was significant, and in 23% it was low.

3. Threshold effect and regulation for complete information situations

In a complete information situation, the sites where environmental processes involve threshold effects are common knowledge. According to Wu (2004) recommendations, we assume that the regulator designs her scheme on a per-site basis and we focus on policy design for a given site. Last, we consider medium-term environmental effects.

Let us consider, as Dupraz *et al.* (2004), that the environmental effect, K, depends on the total area S involved in the agri-environmental scheme and on the environmental effort e that the farmers provide. The agro-environmental technology is denoted $K=g(S,e)$.

As soon as the area cropped with agri-environmental practices is wide enough, and when the environmental effort on this area is important enough, the function *g(.)* is positive and increasing in *S* and *e*. Moreover, we assume that $\delta g/\delta S \leq 0$: we deliberately consider a concave environmental technology (Wirl, 1999) beyond the threshold. Last let us assume that g_{Se}, is negative: the marginal effect on the environment, with respect to the area, is decreasing on the environmental effort.

The threshold effect is formalised, with a simplification of usual characterisation of dynamic threshold effects (Lines, 2005), with the critical area S_0 and the critical effort e_0 below which no environmental effect is noticeable:

$$S \leq S_0(e) \Rightarrow \quad g(S,e) = 0,$$

$$e \leq e_0(S) \Rightarrow \quad g(S,e) = 0.$$

The farmer's reservation utility, when he is proposed to supply the effort *e* on an area *s*, is formalised by his willingness to accept c^i. This willingness to accept differs from one farmer to the other and includes both the losses due to the adoption of the specific practices, which prevents the farmer to apply the production plan that corresponds to the higher profit for his farm, and the utility that the farmer directly derives, as a consumer, from the environmental effect *K*:

$$c^i = c^i(s, e, K).$$

This last assumption relies on several empirical studies regarding particular schemes and EU wide sample: evidence shows that farm households derive a direct satisfaction from their production of environmental services (Dupraz *et al.*, 2002). On the other hand, if these empirical studies highlight a positive relationship between environmental practices adoption and the farmer's personal preferences for environment for some combinations of practices (like maintenance of landscape associated with biodiversity protection, or maintenance of landscape associated with water quality), these studies also point out that this relationship does not exist when the measures aim at non directly observable effects (for example protection of biodiversity, when the measure is not associated measures with locally evident effects). The specific behaviour of farmers who adopt costly practices because they value their environmental effect seems to be related to the production of tangible local public goods: the farmers have a special access to this local public good and thus their own effort if of importance for them.

The farmer's willingness to accept, $c^i(s, e, K)$, is increasing and convex in s and e but non-increasing in K. The environmental effect is striven on an area large enough for one farmer not being able to provide alone this effect and the willingness to accept for the i^{th} farmer depends on the number of farmers who adopt the measure in the area (Genicot et Ray, 2006).

Last, we assume that c_{sK} the marginal willingness to accept (relative to the area) is decreasing in the environmental effect.

Let us denote $W(K)$ the regulator's willingness to pay for the environmental good K, reflecting the social surplus function. This function is classically increasing and concave in K. We normalise this function and assume that W is null when $K = 0$.

3.1. Social optimum

The social optimum is the solution of program (1) where s_i is the area on which the i^{th} farmer supplies the environmental effort e. The pair (s_i, e) forms the environmental service supplied by the i^{th} farmer.

$$\max_{s^i, K, e}\left(W(K) - \sum_i c^i(s^i, e, K)\right) \tag{1}$$

$$
\text{s.c.}\quad
\begin{aligned}
&K = g\left(\sum_i s^i, e\right)\\
&\forall i,\quad s^i \geq 0\\
&\mathrm{e} \geq \mathrm{e}_0\left(\sum_i s^i\right)\\
&\sum_i s^i \geq S_0(e)
\end{aligned}
$$

As soon as one of the last two constraints is binding, the solution of this program is evident: all the variables and all the functions are null.

Beyond the threshold, the interior solution is characterised, using the envelop theorem, by the following equations:

$$
\begin{aligned}
&\sum_i c_e^i(s^i, e, K) = g_e(\sum_i s^i, e)\cdot\left(W'(K) - \sum_i c_k^i(s^i, e, K)\right)\\
&s_i\left(c_s^i(s^i, e, K) - g_s(\sum_i s^i, e)\cdot\left(W'(K) - \sum_i c_k^i(s^i, e, K)\right)\right) = 0; \forall i = 1,\ldots,n
\end{aligned}
$$

The first equation defines the optimal effort to which the areas s^i are submitted. The n following equations determine the level of each of theses areas; the contracted areas for some farms can be null when the marginal cost for the first hectare exceeds the marginal benefit that the farmers realises when he applies the effort *e* on this area. When s^i is positive, its value is determined such that the marginal costs (c_s^i) equals the marginal benefit ($g_s.(W'-\sum c_k)$).

The social optimum cannot be reached without any regulation because the environmental effect *K* cannot be realised under the action of one farmer only. If a farmer wishes to provide an environmental service, he can only anticipate $K = 0$ and thus provides the effort *e* on an area such that $c_s^i(s^i, e, 0) = 0$. Even if this farmer has a positive attitude towards the environment, economic considerations lead him not to provide the service on his own farm.

3.2 Agri-environmental regulation for complete information

The regulator proposes to the farmers a standard contract, denoted (*e, p*), that we will call agri-environmental measure. This contract, as many standard contract used in EU agri-environmental policies, combines a per-hectare payment *p* to the adoption by the farmer of agri-environmental practices on the contracted area. The agri-environmental practices result in an effort *e* for the farmer. We assume here, because of complete information, that the effort can be observed without any additional cost.

In a complete information situation, the cost and utility functions for all the farmers, and the relationships between the effort (*e*), the proposed payment (*p*) and the expected environmental effect (*K*) are common knowledge.

The farmers who face the (*e, p*) contract also faces uncertainties on the behaviour of the other farmers. They must anticipate this behaviour, with the information they have. Let us denote K^i the anticipation that the i^{th} farmers realises. This farmer maximises the expected benefit he can gain from contracting: $\max_s \left(ps - c(s, eK^i)\right)$. The solution of this maximisation is denoted $s^i(e, p, K^i)$; s^i is positive or nul, non decreasing in *p* et K^i and non increasing in *e*. Formally, s_i is such that :

$$p = c_s^i\left(s^i(e, p, K^i), e, K^i\right) \tag{2}$$

Differentiating this expression according to K^i, we obtain the following expression for the increase rate of the area:

$$c^i{}_{ss}\left(s^i(e, p, K^i), e, K^i\right)\frac{\partial s^i}{\partial K^i} + c_{sK^i}\left(s^i(e, p, K^i), e, K^i\right) = 0$$

With our assumptions (c_{ss}>0 and c_{sK}<0), a farmer who anticipates a better environmental effect contracts on a larger area.

The regulator program consists in maximising a global welfare function, *U,* depending on the total contracted area *S* only. Denoting λ the marginal cost of public funds, this function can be expressed as:

$$U(S) = W(K) – C(S) - \lambda pS$$

$C(S)=\sum_{i=1}^{n} c^i\left(s^i, e, K^i\right)$ is the total willingness to accept of the farmers and the total contracted area is $S=\sum_{i=1}^{n} s^i(e, p, K^i)$.

The fonction *U(S)* has a very specific form because of the threshold effect (*Figure 1*) :

- If $S < S_0(e)$, $U(S) = -C() - \lambda pS$ is negative and decreasing, with a minimum for S_0.

- If $S \geq S_0(e)$, *U(S)* is concave, increasing on the right hand side of $S_0(e)$, but becomes eventually positive only after a second threshold $S_m(e,p) > S_0(e)$. Last, it is also possible that beyond a threshold $S_M(e,p)$ *U* becomes again negative (in this case, the area that the farmers propose for contracting is so large that the total costs involved by the scheme are far higher than the benefits of the measure.

Figure 1

If *U* stays negative, it is optimal not to do anything and no contract is proposed to the farmers. In the other case, because the environmental technology is known and the adoption cost are common knowledge, the farmers correctly anticipate the consequences of the *(e,p)* contract on the environmental effect, *K*. The i^{th} farmers proposes to contract on the area $s^i(e,p,K)$ such that:

$$p = c_s^i\left(s^i, e, K\right)$$

and the regulator's program becomes:

$$\max_{e,p,s^i,K} U \cong W(K) - \sum_i c^i(s^i, e, K) - \lambda p \sum_i s^i \quad (3)$$

with.
$$K = g\left(\sum_i s^i, e\right)$$
$$p = c_s^i(s^i, e, K)$$
$$\forall i, \quad s^i \geq 0$$
$$\mathrm{e} \geq \mathrm{e}_0\left(\sum_i s^i\right)$$
$$\sum_i s^i \geq S_0(e)$$

The last two constraints are not binding because we consider situations beyond the threshold (below the threshold, it is optimal for the regulator to propose no contract at all). The first order conditions for this program provide the optimal contract (e^*, p^*) that leads to a total contracted area $S^* = \sum s^i(e^*, p^*, K^*)$:

$$(1+\lambda)p = g_s(\sum_i s^i, e^*) \cdot \left(W'(K^*) - \sum_i c_K^i(s^i, e^*, K^*) \right) \quad (4)$$

$$\sum_i c_e^i(s^i, e^*, K^*) = g_e(\sum_i s^i, e^*) \cdot \left(W'(K^*) - \sum_i c_k^i(s^i, e^*, K^*) \right) \quad (5)$$

Equation (4) indicates that the payment provided per unit of contracted area, weighted by the total cost of public funds, equals the difference between the regulator's marginal willingness to pay (for a variation of S^*) and the farmers' marginal willingness to accept (for the same variation of S^*). Equation (5) determines the optimal amount of effort, which is the same as for the social optimum.

It is clear that the design of agri-environmental schemes is never performed in complete information situations. We shall examine how the contracts are modified when the farmers' private information is imperfectly known, first from the regulator only and second from both th regulators and the neighbouring farmers.

4. Consequences of asymmetric information

4.1. Adoption cost unknown from the regulator only

Let us assume, as a first stage, that the farmers on the regulated site have a common knowledge of their respective willingness to accept. In this case, they are able to correctly anticipate the environmental effect associated with any *(e, p)* that is proposed to them. The asymmetry of information only occurs between the regulator and the farmers.

Of course, this asymmetry prevents the regulator from estimating the optimal effort e^* that the farmers have to respect per unit of area, because its value depends, among other things, of the farmer's marginal willingness to accept c_e and c_K. Now, the regulator has to fix arbitrarily an effort level e (for example, she can rely on literature for comparable sites). This is the situation to which the local regulators dealing with the application of the second CAP pillar have been confronted. The regulator could still determine the associated payment p while maximising a welfare function:

$$\max_{p,s^i,K} U \cong W(K) - \sum_i c^i(s^i, e, K) - \lambda p \sum_i s^i \tag{5}$$

subject to the same constraints as for the complete information case. Beyond the threshold, the first order conditions provide:

$$(1+\lambda)p_1 = g_s(\sum_i s^i, e) \cdot \left(W'(K^1) - \sum_i c_K^i(s^i, e, K^1) \right) \tag{6}$$

Even if she has no idea of the farmers' willingness to pay functions, the regulator has to rely on assumptions on the marginal utility that the farmers' derive from the environmental effect *K* if she wants to be able to design a payment p_1.

The following step for the regulator consists in reducing wastes of public funds, i.e. avoids the situations where the payments induce no environmental effect or where U is negative. In the first case, a simple solution for the regulator is to fix a threshold below which no contract is signed. The simpler level of this signal is $S_0(e)$ but this level does not warrant that the total welfare will be positive.

It is possible to avoid the situations where the welfare variation for the society is negative: the regulator can design a scheme that relies only on W (and not on C, unknown from the regulator). The regulator can offer the higher possible payment that warrants a positive variation of welfare for the society (and that warrants that $W - pS \geq 0$): with S_E being the maximal eligible area in the regulated site, the regulator can offer the payment $p_E = W(g(S_E,e))/S_E$ that dries up the community willingness to pay if all the eligible area is contracted. The threshold that activates the contracting procedure (and that avoids situations with no environmental effect) is then defined by $p_E = W(g(S_m,e))/S_m$. The concavity of W implies $S_m(e) > S_0(e)$ (see *Figure 2*).

Figure 2

Such a contract, denoted (e, p_E, S_m), ensures that the social welfare variation is not negative. As the cost function C(.) is uncertain for the regulator, the aggregated cost can be either over (C_2 on *Figure 2*) or below $W(S)$ (C_1 on *Figure 2*). But the design of p_E and S_m, along with the growth of marginal costs ensure that contracts will be signed only when the total cost $C(.)$ is below $W(.)$ on the interval $[S_m, S_E]$. Otherwise, as the marginal cost is over p_E, the potentially contracting farmers who are necessary for getting over the threshold have a marginal cost greater than p_E and are not willing to contract; as the threshold is not reached, the regulator does not validate any contract, which excludes the situations where the social welfare is negative (U_2 on *Figure 2*).

This kind of contract is not optimal because it excludes situations where the social welfare could be positive (note that U_1 is positive juste below S_m) and does not warrant that the contracted area maximises the social welfare because the payment does not depend on the farmers'willingness to accept.

The welfare function for a regulator proposing the (e, p_E) contract is:

$$U(p_E) = W\left(g(\sum_i s^i(p_E), e) \right) - \sum_i c^i(s^i(p_E), e, K_2) - \lambda p_E \sum_i s^i(p_E)$$

Derivating this expression with respect to s^i provides:

$$\frac{\partial}{\partial s^i} U(p_E) = W'(K_2) g_s \left(\sum_i s^i(p_E), e \right) - c_s^i \left(s^i(p_E), e, K_2 \right) - \lambda p_E$$

We can simplify the notations. Because we have $p_E = c_s$), this expression can be written: $\frac{\partial}{\partial s^i} U(p_E) = W' g_s - (1+\lambda) p_E$. Now, with our assumptions we have $p_E \leq W' g_S$. Thus, if the marginal cost of public funds is not too high, we also $\frac{\partial}{\partial s^i} U(p_E) \leq 0$ and we can deduct from this expression that $p_E \leq p_1$. In other words, when the regulator proposes a contract (e, p_E, S_m) to the farmers, this contract leads to a sub-optimal area contracted.

4.2 Individual willingness to accept unknown from both the regulator and the neighbouring farmers

Let us examine now the case where the farmers do not know the way their neighbours are liable to act when facing a gri-environmental scheme. Facing a *(e, p)* contract proposition, a farmer will individually anticipate the resulting environmental effect, K^i and his own willingness to accept will be $c^i(s^i, e, K^i)$. It will be even more difficult for the regulator than on the previous case to calculate e^*. It will be nearly impossible to assess a payment for the supply of this effort, because for doing so, the regulator would need to know both the individual utilities that each farmers gains from the environmental effect and the way each farmer anticipates his neighbours reactions to the *(e, p)* contract.

But the regulator still has the possibility to propose the contract (e, p_E, S_m) described above. Moreover, announcing such a contract would act upon the K^i anticipations of the farmers. Let us examine how. When facing a (e, p_E, S_m) contract, the i^{th} farmer can expect realising a benefit $\pi(s^i(e,p,K^i)) = ps^i(e,p,K^i) - c^i(s^i(e,p,K^i),e,K^i)$. This farmer will realise ex-post a profit (different from his expected benefit) denoted:

$$\Pi(s^i(p, e, K^i),K) = ps^i(e,p,K^i) - c^i(s^i(e,p,K^i),e,K).$$

In the case where the farmer anticipates $K^i > K$, this farmer would have ex post a profit less high than the expected benefit (because c_K is negative). On the contrary, when the environmental effect is greater than expected by the farmer ($K^i < K$), this farmer realises ex post a profit greater than his expected benefit:

$$\Pi(s^i(p, e, K^i),K^i) < \Pi(s^i(p, e, K^i),K) < \Pi(s^i(p, e, K),K) \quad \text{si } K^i < K \quad (6)$$

Proposing to the farmers a contrac t (e, p_E, S_m) comes down reducing the risk for these farmers to face *ex post* a situation where K is null: if the total proposed area is below S_m, the regulator does not sign any contract. Thus, even when they ignore their neighbours' offers, it's the farmers' interest to anticipate K^i at least equal to $g(S_m, e)$. When they want to optimise their individual offers s^i, it is even their interest to consult each other to correctly anticipate the final environmental effect (because their profit is greater when K is positive).

Such a contract (e, p_E, S_m) is not optimal because e is arbitrarily fixed by the regulator. Nevertheless, this mechanism allows distinguishing the sites where the implementation of agri-environmental contracts is desirable from those where it is optimal to do nothing. This distinction is performed through the revelation of the collective environmental offer from the farmers in each site. The associated transaction cost is very low because the regulator only needs to send the signal S_m. Of course, this mechanism assumes that the regulator is able to determine her own willingness to pay, W.

4.3 An example

A first example found in Brittany can be presented. It is the implementation by the *"Conseil général d'Ille et vilaine"* (NUTS3 regional council) of particular contracts.

The regional authorities successively offered several contractual arrangement to favour the conversion of arable land in grassland buffer zone in areas along the river (Kerhouas, 2003).

The buffer zone aim at:

- catching and filtering ground flow
- slowing the streaming and avoiding soil erosion
- filtering streaming water fixing the solved substances
- avoiding river contamination which can occur after plant-care product spraying

Environmental impacts of buffer zones are well known. The installation of a buffer zone of 6m leads to the catchment of nearly 70% of plant-care products streaming. For a buffer zone of 18m, 90 % of plant-care products are caught.

The budget allocated to this program reaches 760 000 Euro for 2001-2006period. Three types of contracts exist. The first one deals with implementation of grasslands long the river for 375 Euro/ha if the implantation of buffer zone concern crops. The second one deals with implantation of buffer zones on temporary grassland for 259 Euro/ha. The last one is extensive management of grassland for 63,6 Euro/ha.

These amount are increased of 20% if the measures are adopted in a CTE *"Contrat Territorial d'Exploitation"*

The agreement concerns the installation of maintenance of grassland buffer zone of 20 m large. These agreements aims at protecting the rivers.

Their installation must be based on a precise diagnostic of the territorial conditions. Buffer zones have to be implemented on relevant positions on the watersheds.

This offer was contingent and would have been effective only if at least 60% of river bank of the targeted area was under contract. The eligible parcels were those described at 1/25000th from IGN (*Institut Géographique National*).

To gather 60% of river bank of a targeted zone under contract was first an objective of the NUTS3 policy. This threshold of 60 % was chosen according to an audit led on the previous 1994-1999 AES contracts aiming at creating grassland buffer zone. The conclusions of this audit showed that a minimum rate of 60% of conversion was needed to lead to efficient environmental impact on a catchment area. During 1994-1999, 536 contracts concerning 1,406 ha with creation of grassland buffer zones were signed. The total budget was 2 900 000 Euro and spent for nothing. The spatial dispersion of contracts signed did not permit any measured significant environmental impact. No consistent reasoning regarding catchment areas was initiated. It illustrates our situation S2.

After 1999, the "*conseil général"* contracts were proposed on a particular catchment area to test farmer reactions. After two years, the balance was disappointing because only 11 farmers had contracted and the parcels under contracts did not represent the 60% of the targeted area.

On the second chosen area, the threshold of 60 % of the targeted area became not only an objective, but a necessary condition to engage contracts. Hence, this necessary condition aimed at reaching a minimal impact on environment and avoiding to give money without any results guarantee. Farmers, gathered around a project leader, signed a declaration of intent. They finally signed contracts once the area under contract reached the threshold. 34 contracts were signed on a particular watershed following an territorial approach. The chosen watershed was preferentially belonging to a *"Contrat Eau paysage Environnement"* (water landscape environment contract) signed with the *"conseil général"*. The story of this particular example illustrates how the procedure using (e, p, S_m) contracts initiate a cooperative behaviour of the farmers, at first to reach the threshold.

At a national level, the National Rural Development Program proposes measures to farmers in which threshold effects at the farm level are taken into account. For example, the sub-measure 8.1 "Introduction of integrated crop protection" is paid only if a precise part of the farm area is concerned by the decrease in the use of pesticides. The minimum part of the farm which has to be under contract is defined at the NUTS3 level to fit local conditions.

Scale effects are considered at the farm level in measures such as " Winter covering of arable land with intermediary culture". If the farm area committed in this measure reaches 40 % of the farm area, then the paid amount is increased by 20% and if the area committed is less than 10% of the farm area, then the amount paid is decreased by 20 %.

The involvement of local and regional councils must be emphasised. Although scale and threshold effects are considered at the farm level by nationally designed measures, it seems that higher level threshold effects and the necessary coordination farmers' environmental efforts are only considered where local authorities are involved (Instance nationale d'évaluation du contrat territorial d'exploitation, 2003). In the few success stories which are reported they take advantage of successive experiences despite the deep changes that have affected the French agro-environmental policy framework. In contrast the schemes that are managed by the usual agricultural networks clearly privilege the access of all farmers to the wider range of contractual measures, without any knowledge accumulation strategy at the local level.

5. Extensions

5.1. Moral hazard

The other usual problem with information asymmetries is moral hazard, which occurs when the individual effort of each farmer, e^i is difficult to observe and monitor. How surprising it looks, there are numerous examples of agri-environmental contracts with uncontrollable prescriptions (Instance Nationale d'Evaluation du Contrat Territorial d'Exploitation, 2003).

The classical second order solution is based on the risk aversion of the agents: the regulator performs costly controls on limited samples and applies very strong sanctions when the non compliance happens to be proved, in order to reduce the rate of non compliance (Holmström 1982). However the design of an appropriate control and sanction system is often limited by laws and pre-existing procedures that determine the maximum penalties in accordance with other references.

Once again a cooperative approach might be proposed if the effort e^i of a particular farmer is easily observable by his/her neighbours. An example of such effort is the mowing of meadows from their centre to their periphery. This practice is recognised to be very efficient to preserve certain wildlife species. Although official controls are very difficult to organise, farmers frequently and easily and observe the way their neighbours perform. The basic idea is to design a contract between the regulator and a consortium of farmers of a designated area (see Segerson, 1988 mechanisme designed, which is based on Holmström, 1982, one). The consortium receive a global payment P=C(p*,e*) for the provision of K* and nothing if the environmental objective is not reached. Practically this means that the consortium has to reimburse the global payment, possibly with an additional penalty to cover administration cost and the opportunity cost of public funds. However the financial penalty per farmer would be much lower than the optimal sanction associated with individual contracts. As the consortium members are collectively committed and know each other, the enforcement of the contract makes use of social pressures based on personal relationships since few free riders endanger the payment of all the others.

5.2 Uncertainty on agri-environmental technology

The environmental technology is never totally unknown. In most cases, environmentalists have an idea of the underlying technology process and especially know if it exhibits threshold effects or doesn't. Under locally specific conditions, the exact threshold critical values are usually unknown. At least policy makers may use existing scientific references or similar experience to be aware of threshold effect and possibly get a hazy idea of these critical values. It must be emphasised that the farmer themselves often have less information about the agri-environmental processes than policy makers.

The challenge of the scheme design is to offer and monitor contracts that will produce additional information on the agri-environmental processes, and particularly the threshold critical values. An iterative process that includes successive contractual rounds is needed.

Without any hidden information by the farmers, standard contracts are first offered in few selected representative zones which are delimited according to the targeted environmental output and the suspected scale and threshold effects which are associated. If similar sites are available, different contracts *(e,p)* may be tested in order to discover the critical values more rapidly and more precisely. Starting with rather high effort and payment, and providing a comfortable profit to farmers may provide advantages: the probability of the environmental good production being higher, the net social cost of the first contractual round will probably be lower, even if the social surplus does not reach the costs of the scheme. Moreover, a success will encourage the farmers for future contractual rounds while a failure might discourage them. Out of the monitoring of the scheme, the regulator will know ex-post if the thresholds have been reached or not. If it is relevant, an extra payment may be offered to associate the contractors to monitoring tasks. In the iterative process, where previous results are taken into account, the regulator can step by step reach the optimal contract and offer it in additional zones according to the recommendations of Wu (2004). A big difficult is the common case of the delayed response of the environmental efforts which slows down the production of knowledge.

Consultations between scientists, decision makers, farmers and environmental organisations should create a dynamic and trustful context where the targeted level of environmental impacts, the monitoring procedures and the contract are step by step redefined taking into account previous results . In such a context, interrelations between different measures described in literature regarding conservation programmes for instance (Wu, 2004) could also be analysed and taken into account in future design of contracts.

When the farmers' cost function are partly unknown by the regulator, setting a minimal aggregated area to trigger the State signature of (e, p, S_m) contracts is no more useful in the context of uncertain threshold critical values. The ex post analysis of *(e,p)* contracts will also provide the required information on the farmers' environmental supply function. Once again the elicitation of the farmers' willingness to accept under different scenarios may provide interesting complementary information. For instance the influence of the probability of the environmental production associated with different contracts may be tested, before such probability is eventually approximated.

The moral hazard problem characterised by hidden efforts of the contractors is more difficult to deal with because the identification of the source of scheme failure is itself unknown. Still, the preceding proposal of a collective contract with a consortium of farmers may be preferred if the consortium is truly interested in the process of knowledge capitalisation about the agri-environmental technology. Obviously, the farmers won't accept their payment is entirely conditioned by the observation of an environmental output that does not entirely depend on their efforts. Some kind of risk sharing system between the regulator and the consortium must be negotiated.

When remarkable biotopes are endangered by the trend of economic changes, Perrings and Pearce (1994) pointed out that the uncertainty about thresholds is often associated with the uncertainty and irreversibility of potential damages and of their social costs. They show that these cases resist conventional applied economics because no optimum is calculable. Therefore decision making about preservation must rely on non economic criteria. Hence the preservation of the status quo is enforced with strong penalties compared to the private profit of trespassing the conservative standards. Many agro-environmental schemes are used to preserve remarkable sites like marshes, peat land or mountainous dried meadows, from land abandonment or agricultural intensification. Using Perrings and Pearce results justify payments high enough to deter alternative use of land in the sites which are selected by policy makers. Sometimes such payments do not correspond to any tangible effort of the farmer.

5. Conclusion

The large variety of agri-environmental situation does not generally allow designing efficient schemes at a high territorial level. As observed by Mollard (2003), in France, the environmental effect has to be sought on regions small enough to allow tying consistency between actors and the resources they manage. Local communities appear to have a legitimate role to play in leading a progressive design of agri-environmental schemes that maintain motivation and cooperation between the different actors.

For a given region, an iterative process of knowledge capitalisation on small pertinent sites allows the iterative design of an optimised but standard contract that can be in a second step proposed on other comparable sites. The budget constraints the local communities have to bear will induce a competition between the different sites and an interaction with their own development plans. These plans can be considered at the regional level, given that the social willingness to pay for the community can be assessed per site. This paper highlights the importance to pinpoint the threshold effects that can occur in the environmental processes and suggests avenues to design more efficient policies.

When threshold effects occur, conditioning the payment to an intention of contracting (S_m) greater than the area needed to pass the threshold (S_0) lets the regulator to favour a cooperative solution, even when asymmetric information occurs on the farmers' willingness to accept. The scheme designed in this paper can be implemented in real case situations, as illustrated by the Ille-et-Vilaine example. Such a mechanism is not optimal but can be improved through a progressive design relying on the capitalisation of local knowledge.

In several empirical studies regarding particular schemes and EU wide examples, evidence shows that farm households derive a direct satisfaction from their production of environmental services (Dupraz, *et al.,* 2002, 2003). This willingness to pay has to be considered by the regulator who wants to efficiently make use of public funds and ensure that the contracting process and the cooperation of actors can last along years. This willingness to pay can be mobilised through a better formation of farmers on agri-environmental processes and through the design of measures with credible expected environmental impacts.

The new dispositions regarding cross-compliance for European agricultural subsidies include commitment to reserve 3 % of the area cropped with cereals, oilseeds and set-aside for grass strips. The areas involved are considerable and the potentially protected banks also: grass strips should reach 400,000 ha and 200 to 400,000 km of banks should be protected (Gril *et al.* 2004). In many cases, the farmers keep a leeway for the location of these grass strips. The conditions for implanting grass strips (including the different potential fixings and locations) should be adapted to each site, otherwise unacceptable constraints can be imposed to the farmers with no tangible environmental benefits occurring. A precise diagnosis of the whole area along with a capitalisation and a diffusion of the local knowledge acquired are thus essential for an optimal allocation of these new regulatory arrangements.

Acknowledgements

This document presents results obtained within the EU project SSPE-CT-2003-502070 on Integrated tools to design and implemented Agro Environmental Schemes (http//:merlin.lusignan.inra.fr/ITAES). It does not necessary reflect the view of the European Union and in no way anticipates the commission's future policy in this area.

It also benefits from the financial support of the S3E program of the French Ministry of Ecology and Sustainable Development: Project entitled "efficacité et acceptabilité des mesures agro-environnementales".

References :

Arnaud S. (2004). Expression de la demande sociale pour les diverses fonctions de l'espace rural dans le Parc des Marais du Cotentin et du Bessin, Mémoire de DAA, INRA-ESR, Rennes, Faculté des sciences économique de Université de Montpellier 1, ENSA de Montpellier.

Asner G. P. et Vitousek P. M. (2005). Remote analysis of biological invasion and biogeochemical change." *Proceedings Of The National Academy Of Sciences Of The United States Of America*, 102 (12), 4383-4386.

Bonnieux F., Dupraz P., Retière C. (2001). Farmer's supply of environmental benefits » in Erling Vardal (Ed.) *"Multifonctionality of Agriculture", Seminar Proceedings*, February 16-18, Department of Economics of the University of Bergen- Research Council of Norway, 105-133.

Bontems P., Rotillon G., et Turpin N. (2005). Self-selecting agri-environmental policies with an application to the Don watershed, ***Environemental and Resource Economics, 31, 275-301***.

Dasgupta P., et Maler K.G. (2003). The Economics of Non-convex Ecosystems: Introduction, ***Environmental and Resource Economics, 26 (4), 499-525.***

Dupraz P., Vanslembrouck I., Bonnieux F. et Van Huylenbroeck (2002). Farmers' participation in european agri-environmental policies, *X^{th} congress of the European Association of Agricultural Economists,* Zaragoza (Spain), 28-31 août 2002, 14 pages.

Dupraz P., Vermersch D., Henry de Fraham B. et Delvaux L. (2003). The environmental supply of farm households : A flexible willingness to accept model, ***Environmental and Resource Economics, 25 (3)3, 171-189.***

Dupraz P. et Rainelli P. (2004). Institutional approaches to sustain rural landscapes in France, in Brouwer F.(ed.) *"Sustaining Agriculture and the Rural Economy",* Edward Elgar Publishing, 162-182.

Dupraz P., Latouche K. et Bonnieux F. (2004). Economic implication of scale and threshold effects in agri-environmental processes, in *Proceedings of 90th EAAE Seminar: Multifunctional agriculture, policies and markets: understanding the critical linkage,* Rennes, October 28-29, 2004).

Eureval C3E (2003). Evaluation à mi-parcours portant sur l'application en France du règlement C.E n°1257-1999 du Conseil, concernant le soutien au développement rural, partie sur le soutien à l'agro-environnement (chapitre VI du R.D.R.) et le contrat territorial d'exploitation en Basse-Normandie, Rapport final MAE, 15 juin 2003, 164 pages.

Falconer K., Dupraz P. et Whitby M. (2001). An Investigation of Policy Administrative Costs Using Panel Data for the English Environmentally Sensitive Areas, ***Journal of Agricultural Economics, 52 (1), 83-103.***

Finn, J.A.; Bourke, D.; Kurz, I. and Dunne, L. (2007). Estimating the environmental performance of agri-environmental schemes via use of expert consultations: ITAES WP5 Final report. 133p.

Genicot G. et Ray D. (2006). Contracts and externalities: How things fall apart. *Journal of Economic Theory,* 131(1), 71-100.

Gril J.J. et Lacas J.G. (2004). Intérêt des zones tampons enherbées et boisées pour limiter le transfert diffus des produits phytosanitaires vers les milieux aquatiques. De l'état des connaissances aux recommandations pratiques. Rapport d'étude, 37pages

Holmström B. (1982). Moral Hazard in Teams, ***Bell Journal of Economics, 13(2), 324-340.***

Instance Nationale d'Evaluation du Contrat Territorial d'Exploitation (2003). Le programme CTE, Rapport d'évaluation. Décembre 2003, 177 pages.

ITCF et Agences de l'eau (1998). Etude de l'efficacité des dispositifs enherbés, 30 Pages, Septembre

Kennedy T. A., Naeem S., Howe K. M., Knops J. M. H., Tilman D., et Reich P. (2002). Biodiversity as a barrier to ecological invasion, ***Nature, 417(6889), 636-638.***

Kerhouas Y. (2003). La mise en œuvre de mesures Agro-environnementales sur le département d'Ille et Vilaine. Dispositif "Bandes Enherbées, rapport du conseil général d'Ille et Vilaine. 70 p.

Laffont J.-J. et Martimort D. (2002). The Theory of Incentives: The Principal-Agent Model, Princeton University Press, 360 p.

Lancelot F. (2001). Le renouveau des bandes enherbées le long des rivières, ***La Terre, semaine du 28 Février au 6 Mars 2001.***

Levin S. A. (1998). Resilience in Natural and Socioeconomic Systems, ***Environment and Development Economics, 3(2), 222-234.***

Lines M. (2005). Intertemporal Equilibrium Dynamics with a Pollution Externality, ***Journal of Economic Behavior and Organization, 56(3), 349-364.***

Maler K.G. (2000). Development, Ecological Resources and Their Management: A Study of Complex Dynamic Systems, ***European Economic Review, 44(4-6), 645-665.***

Mitra T., et Roy, S. (2006). Optimal exploitation of renewable resources under uncertainty and the extinction of species, ***Economic Theory, 28, 1-23***.

Mollard A. (2003). Multifonctionnalité de l'agriculture et territoires : des concepts aux politiques publiques. ***Cahiers d'économie et sociologie rurales, 66, 28-54***.

Morris C. et Potter, C. (1995). Recruiting the new conservationists: farmers' adoption of agri-environment schemes in the UK, ***Journal of Rural Studies 11: 51-63.***

Muradian R. (2001). Ecological thresholds: a survey, ***Ecological Economics, 38 (1),7-24.***

OCDE (2003). Voluntary Approaches for Environmental Policy - Effectiveness, Efficiency and Usage in Policy Mixes, Paris.

Parkhurst G.M., Shogren J., Bastian C., Kivi P., Donner J., smith R. B.W. (2002), Agglomeration bonus: an incentive mechanism to runite fragmented habitat for biodiversity conservation, ***Ecological Economics, 41, 305-328.***

Pascal Consultants - CNASEA (2003). Evaluation des MAE et CTE à mi-parcours en Bretagne. Rapport final provisoire, Juin 2003, 75 pages.

Perrings C. et Pearce D. (1994). Threshold effects and Incentives for the Conservation of Biodiversity, ***Environmental and Resource Economics 4, 13-28.***

Ribaudo M.O. (2004). Policy Explorations and Implications for Nonpoint Source Pollution Control: Discussion. ***American Journal of Agricultural Economics 86(5), 1220-1221***

Rondeau D. (2001). Along the Way Back from the Brink, ***Journal of Environmental Economics and Management, 42(2), 156-182.***

Segerson K. (1988). Uncertainty and incentives for nonpoint pollution control, ***Journal of Environmental Economics and Management, 15, 87-98.***

Toman M. A., et Withagen C. (2000). Accumulative Pollution, "Clean Technology," and Policy Design, ***Resource and Energy Economics, 22(4), 367-384.***

Vanslembrouck I., Van Huylenbroeck G., et Verbeke W. (2002). Determinants of the willingness of Belgian farmers to participate in Agri-environmental measures, ***Journal of Agricultural Economics, 53 (3), 489-511.***

Weersink A et al. (1998). Economic Instruments and Environmental Policy in Agriculture. ***Canadian Public Policy, 24(3), 309-327.***

Weisner S. E. B., Strand J. A., et Sandsten H. (1997). Mechanisms regulating abundance of submerged vegetation in shallow eutrophic lakes, ***Oecologia, 109(4), 592 - 599.***

Wirl F. (1999). Complex, Dynamic Environmental Policies, ***Resource and Energy Economics, 21(1), 19-41.***

Wirl F. (2004). Thresholds in Concave Renewable Resource Models, ***Ecological Economics, 48(2), 259-267.***

Wu J. (2004). Using Sciences to improve the economic efficiency of conservation policies, ***Agricultural and Resource Economics Review, 33(1), 18-23.***

Wu J. et Babcock BA (1996). Contract design for the purchase of environmental goods from agriculture, ***American Journal of Agricultural Economics, 78, 935-945.***

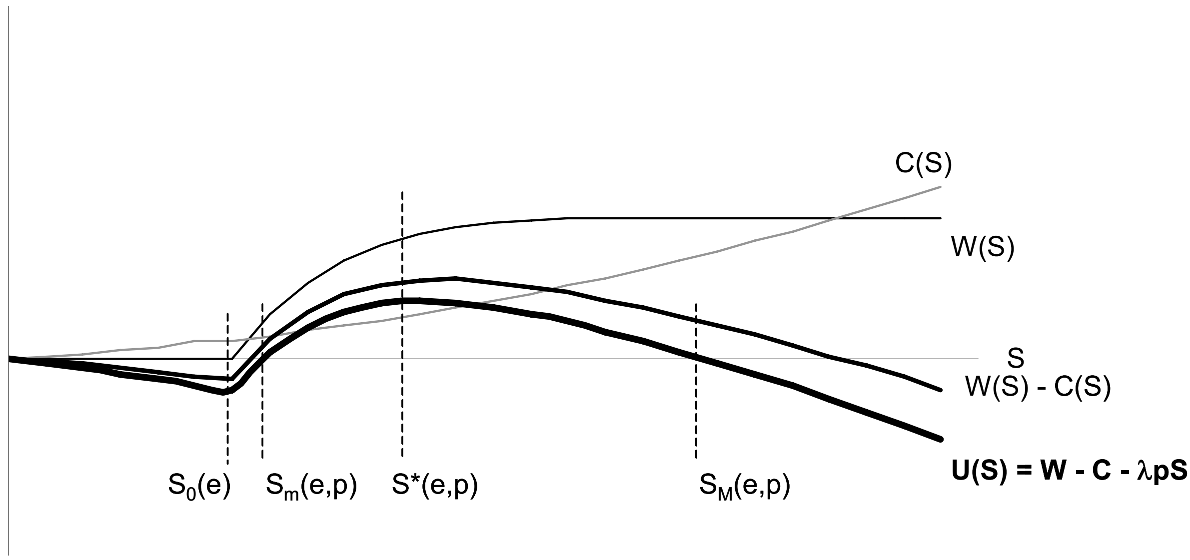


Figure 1 regulator willingness to pay (W), adoption cost for the farmers (C) and social welfare (U) for a given effort (e), in a complete information situation where the environmental technology is known

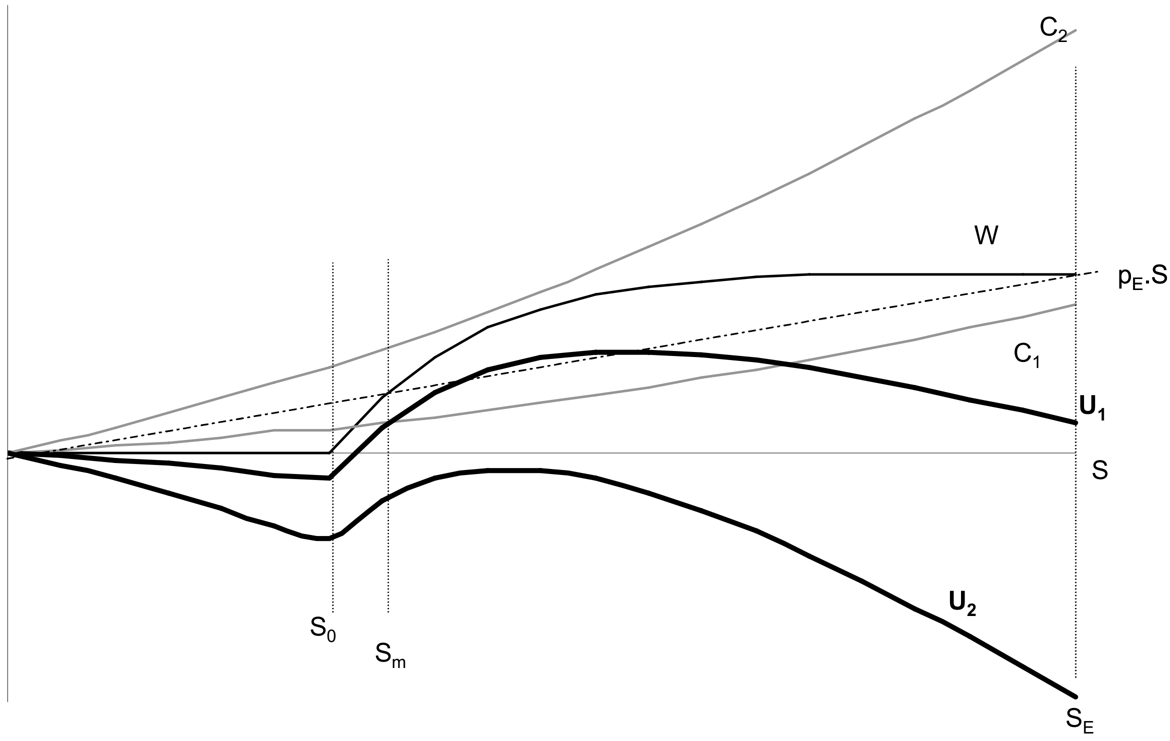


Figure 2 : regulator's utility, adoption cost and social welfare, depending on the total contracted area

On social and market sanctions in deterring illegal behavior*

Philippe Bontems† Gilles Rotillon‡

February 2008

Abstract

In this paper, we theoretically explore the implications of social norms in deterring pollution standard fraud along with economic incentives provided both by markets and regulatory activities. The model assumes that a large number of risk-averse individuals differ not only in their private cost of compliance with the environmental standard but also in their individual aversion to fraud. The aversion of fraud is influenced by the extent of social norms. We show that there may be multiple equilibrium rates of compliance for a given enforcement policy. We also show that under risk aversion the potential loss in market revenues has an ambiguous effect on the equilibrium rates of compliance. Similarly, increasing the probability of audit may decrease the equilibrium rate of compliance when stochastic events make involuntary non compliance possible. Last, we show that the information brought to the market is crucial for polluters' behavior. For this, we explore the impact of self-reporting procedures and public disclosure of criminal records.

JEL : Q50, Z13.

Key-words: social norms, asymmetric information, audit, pollution.

* *Corresponding author* : Philippe Bontems, INRA, Université des Sciences Sociales de Toulouse, 21 Allée de Brienne, F-31000 Toulouse. Email: bontems@toulouse.inra.fr. Phone: (33) 561 128 522. Fax : (33) 561 128 520. Financial support from the S3E program (Ministère de l'Ecologie, du Développement et de l'Aménagement Durables) is gratefully acknowledged.

†Toulouse School of Economics (INRA, GREMAQ, IDEI); UMR 1291, 21 Allée de Brienne, F-31000 Toulouse.

‡Université de Paris-X Nanterre, EconomiX.

1 Introduction

Human behavior seems to be influenced both by economic incentives and social norms. While economists have largely emphasized economic incentives, social norms have been largely neglected although this is a major topic in other social sciences like sociology (Ellickson 1998, Elster 1989, Posner 1997). It is only recently that some economists have analyzed the economic consequences of social norms and status seeking in societies (see e.g. Akerlof 1980 for a seminal paper and more recently Lindbeck et al. 1999). The basic idea is that individuals when considering decisions not only take into account the private economic incentives (for example, the expected penalty when being non compliant with respect to an environmental standard) but also the intensity of social norms against certain actions. In other words, individual decisions can be influenced by the aggregate behavior observed in the population.

Recently, Lai et al. (2003) have suggested that the presence of social norms may explain why one observes that a surprisingly large number of firms comply with pollution standards even though expected penalties for non compliance are low (see Russell, Harrington and Vaughan, 1986, for evidence in the US and Livernois and McKenna, 1999, for the Canadian case). Cropper and Oates (1992) suggest that "perhaps public opprobrium is a stronger disciplinary force than economists are typically inclined to believe". Hatcher et al. (2000) have empirically explored social norms in the context of compliance in fisheries. Various papers have analyzed the role of non-economic motivations for being compliant with pollution standards: both Bontems and Rotillon (2000) and Heyes (2001) assume the existence of an *exogenous* proportion of firms that always comply and show that increasing this proportion may have adverse impacts on welfare.

The purpose of the paper proposed here is to theoretically explore the implications of social norms in deterring pollution standard fraud along with economic incentives. The model assumes that a large number of risk-averse individuals differ not only in their private cost of compliance with the environmental standard but also in their individual aversion to fraud. The aversion of fraud is influenced by the extent of social norms: if the rate of fraud is rationally expected to be high then the individual cost of being caught while being non compliant is low ceteris paribus. And conversely. This contrasts with Bontems and Rotillon (2000) and Heyes (2001) by endogenizing the compliance decisions not only through the economic incentives provided both by regulatory activities and by markets, but also through the presence of social norms against frauding behavior.

Besides penalties and social norms influence, non compliant individuals may also suffer from market sanctions. The model assumes that consumers are ready to pay a premium to obtain unobservable environmental attributes. Imperfectly informed consumers on the "green" market are able to form rational expectations regarding the extent of illicit activities. Importantly, we also depart from the existing literature by assuming that there are some stochastic events that make involuntary non compliance possible (that is even if the polluter has sunk the cost of compliance).

The analysis yields to multiple instable or stable equilibria for a given enforcement policy (i.e. for a given penalty and rate of inspection). This explains why some gradual change in policy may cause a sudden and drastic move in the value that individuals attach to the norm. We also show that under risk aversion the potential loss in market revenues has an ambiguous effect on the equilibrium rates of compliance. Similarly, increasing the probability of audit may decrease the equilibrium rate of compliance when stochastic events make involuntary non compliance possible.

The analysis yields to several other interesting results. First, it is necessary for the regulator to distinguish voluntary from involuntary non compliance in order to save incentives to comply. Second, the amount of information provided to the market by the regulator (through identifying non compliant products) is crucial and we show indeed that under risk neutrality that providing information to the market through public disclosure of criminal records allows to increase the equilibrium rate of compliance. Last, incorporating the possibility for non compliant firms to self-report their status before any inspection allows to save audit costs but also modify the rational expectations of consumers in a sense which is not always desired by a welfare-maximizing regulator.

2 The model

We consider a continuum population of risk-averse individuals, where each individual faces a binary choice: whether or not to engage into compliance with regards to an (exogenous) clearly defined environmental law (or standard). The cost of compliance is c but we assume that compliance is stochastic from the individual's point of view. Actually with probability μ, the individual that has spent the compliance cost c will be non compliant in the end due to some external circumstances. Also, we assume that there is no chance that an individual that has chosen not to spend c will be found compliant. If we denote p the probability of being audited and convicted, then the probability of being found non compliant while having spent the cost c is μp.

In order to induce individuals to conform to the standard, the regulator imposes a penalty upon non-compliant agents. With probability p, the individual who has not spent c has to pay a fine F through random audits. However, we allow the regulator to distinguish between involuntary non compliance from voluntary non compliance by imposing a fine $f \leq F$ to the formers.[1] Such a fine might be needed in practice in cases where a compensation is to be paid to the victims of violation even in case of involuntary non compliance.

We denote λ the expected (and actual) rate of compliance in the population. Besides the incentives brought by the regulator, we introduce also the possibility that individuals may suffer from a loss in market revenue if found non compliant. Assume that an individual who is found non compliant and convicted gets a market revenue equal to $V = r - \delta$ where $r \geq 0$ is the potential maximal revenue and $\delta \leq r$ is the loss of revenue due to non compliance. We assume that the market faces incomplete information on the true status of any individual but

[1] For this, we assume that the regulator is supposed to observe whether c has been spent or not at no cost. We later examine the consequence of not being able to distinguish between voluntary and involuntary non compliance.

observes convictions. Hence, if the market anticipates a compliance rate λ, then the revenue R that any non convicted individual gets is given by

$$\begin{aligned} R &= (r-\delta)\Pr(\text{not compliant} \mid \text{not convicted}) + r\Pr(\text{compliant} \mid \text{not convicted}) \\ &= \frac{(1-\lambda)(1-p)+\mu\lambda(1-p)}{(1-p)(1-\lambda)+\lambda(1-\mu)+\lambda\mu(1-p)}(r-\delta) \\ &\quad + \frac{\lambda(1-\mu)}{(1-p)(1-\lambda)+\lambda(1-\mu)+\lambda\mu(1-p)} r \\ &= r - \frac{(1-\lambda+\mu\lambda)(1-p)}{1-p+\lambda p(1-\mu)}\delta \in (r-\delta, r). \end{aligned}$$

Note that R is increasing in λ (with $\lim_{\lambda\to 1} R = r - \mu(1-p)/(1-\mu p)$), is decreasing in μ (with $\lim_{\mu\to 1} R = r-\delta$) and is increasing in p (with $\lim_{p\to 1} R = r$).

Besides market sanctions, the non compliant individual also suffers from a psychic cost or social sanction due to illegal behavior equal to $\theta\psi(\lambda)$ where $\theta \geq 0$ denotes the individual adherence to the norm and where $\psi(.)$ is increasing in the rate of compliance. An extreme case is where $\theta = 0$ so that such an individual does not suffer at all from social sanctions in case of compliance. The higher θ is, the more reluctant to non compliance the agent is. This phenomenon is reinforced by the presence of a positive externality of λ through the function ψ on the social sanction. The social sanction is higher when the compliance rate is large in the population. We assume that this social sanction appears only in cases where non compliance is voluntary.

We are now in a position to derive the expected payoffs relative to a compliance or non compliance decision. The decision tree with monetary payoffs is depicted in Figure 1. A type-(θ, c) individual who chooses compliance gets an expected payoff equal to

$$(1-\mu p)U(R-c) + \mu p U(V-f-c)$$

where $U(.)$ is an increasing utility function of net monetary income.[2] Similarly, a type-(θ, c) who chooses non compliance gets

$$pU(V-F) + (1-p)U(R) - \theta\psi(\lambda).$$

[2]If one were unable to distinguish voluntary from involuntary non compliance, then the expected payoff of a compliant agent may depend on the extent of social norms. See section 4 below.

3 The equilibrium rate of compliance

If each individual chooses the alternative with the highest expected utility, then compliance is optimal for a type-(θ, c) individual if and only if:

$$(1-\mu p)U(R-c)+\mu pU(V-f-c)>pU(V-F)+(1-p)U(R)-\theta\psi(\lambda),$$

or equivalently

$$\theta>\tilde{\theta}(c,\lambda)\equiv\frac{\Delta W}{\psi(\lambda)}$$

where

$$\Delta W=pU(V-F)+(1-p)U(R)-(1-\mu p)U(R-c)-\mu pU(V-f-c) \quad (1)$$

is the expected utility gain from being non compliant as compared with compliance.

The following lemma indicates the basic properties of the minimal adherence to the norm $\tilde{\theta}(c,\lambda)$, needed for compliance to be optimal.

Lemma 1 *The minimal adherence to the norm $\tilde{\theta}(c,\lambda)$ is continuous, decreasing in the compliance rate λ and increasing in the compliance cost c.*

Proof: Indeed, we get

$$sign\frac{\partial\tilde{\theta}}{\partial\lambda}=sign\left\{\frac{\partial\Delta W}{\partial\lambda}\psi-\psi'\Delta W\right\}$$

Recall that ψ is increasing in λ while ΔW is decreasing in λ as shown below:

$$\frac{\partial\Delta W}{\partial\lambda}=\left[(1-p)U'(R)-(1-\mu p)U'(R-c)\right]\frac{\partial R}{\partial\lambda}<0$$

because $1-\mu p\geq 1-p$ and $U'(R-c)>U'(R)$ as U is concave.

Moreover, we have $sign\frac{\partial\tilde{\theta}}{\partial c}=sign\left\{\frac{\partial\Delta W}{\partial c}\right\}=sign\left\{(1-\mu p)U'(R-c)+\mu pU'(V-f-c)\right\}=$ $+$. This concludes the proof. ■

Intuitively, the minimal adherence to the norm for compliance to be chosen must be higher when the compliance cost c increases. Furthermore, this threshold level decreases with the rate of compliance λ as an increase in the compliance rate increases both the social norm and the market revenue effects. Indeed, the expected utility gain of non compliance $\Delta W(c, \lambda)$ decreases in λ because of the market revenue effect. The following lemma indicates some further comparative results for ΔW.

Lemma 2 *The expected utility gain of non compliance* ΔW

(i) *is increasing in the penalty* f *for involuntary non compliance and the probability* μ *of involuntary non compliance,*

(ii) *is decreasing in the penalty* F *for voluntary non compliance,*

(iii) *varies ambiguously with the loss* δ *in market revenue if non compliant, under the assumption of risk aversion*

(iv) *varies ambiguously with the probability* p *of being inspected, as long as the probability of involuntary non compliance* μ *is strictly positive.*

Proof: First, we have

$$\frac{\partial \Delta W}{\partial f} = \mu p U'(V - f - c) > 0$$

and

$$\frac{\partial \Delta W}{\partial \mu} = \frac{\partial \Delta W}{\partial R}\frac{\partial R}{\partial \mu} + p\left[U(R-c) - U(V-f-c)\right] > 0$$

because $\frac{\partial \Delta W}{\partial R} < 0$, $\frac{\partial R}{\partial \mu} < 0$ as shown above and $R > V$. This proves (i).

Next, we have

$$\frac{\partial \Delta W}{\partial F} = -pU'(V - F) < 0$$

which proves (ii). Considering the impact of δ, we have

$$\begin{aligned}\frac{\partial \Delta W}{\partial \delta} &= \frac{\partial \Delta W}{\partial V}\frac{\partial V}{\partial \delta} + \frac{\partial \Delta W}{\partial R}\frac{\partial R}{\partial \delta} \\ &= \left[pU'(V-F) - \mu p U'(V-f-c)\right]\frac{\partial V}{\partial \delta} + \left[(1-p)U'(R) - (1-\mu p)U'(R-c)\right]\frac{\partial R}{\partial \delta}\end{aligned}$$

Recalling that both V and R decrease in δ, we still have that $\frac{\partial \Delta W}{\partial R} < 0$ while $\frac{\partial \Delta W}{\partial V}$ is ambiguous in general. In the special case where $\mu = 0$, then $\frac{\partial \Delta W}{\partial V} > 0$ and the sign of $\frac{\partial \Delta W}{\partial \delta}$ is *a priori* ambiguous. We now prove that the ambiguity disappears if one makes the risk-neutrality assumption (as in Rasmussen 1996). Indeed, under risk neutrality, we have

$$\begin{aligned}\frac{\partial \Delta W}{\partial \delta} &= [p - \mu p] \frac{\partial V}{\partial \delta} + [(1-p) - (1-\mu p)] \frac{\partial R}{\partial \delta} \\ &= p(1-\mu)\left(\frac{\partial V}{\partial \delta} - \frac{\partial R}{\partial \delta}\right) \\ &= p(1-\mu)\left(-1 - \frac{\partial R}{\partial \delta}\right) < 0\end{aligned}$$

as $\frac{\partial V}{\partial \delta} = -1 \leq \frac{\partial R}{\partial \delta} \leq 0$. This proves (iii).

Finally, with regards to p, we get

$$\frac{\partial \Delta W}{\partial p} = U(V-F) - U(R) + \frac{\partial \Delta W}{\partial R}\frac{\partial R}{\partial p} + \mu\left[U(R-c) - U(V-f-c)\right]$$

The two first terms are non positive because $R > V$ and $\frac{\partial R}{\partial p} > 0$ together with $\frac{\partial \Delta W}{\partial R} < 0$. In the last term, the expression between the brackets is positive as $R > V$. This proves the ambiguity of the sign of $\frac{\partial \Delta W}{\partial p}$ and thereby part (iv). ■

Parts (i) and (ii) of Lemma 2 yield to expected results. If the probability and the penalty for involuntary non compliance increase then non compliance appears to be increasingly a better strategy than compliance. On the contrary, an increase in the penalty for voluntary non compliance reduces the utility gain of non compliance. More surprising are the last two results (parts (iii) and (iv)). Part (iii) suggests that the market loss δ has an ambiguous effect on ΔW and hence on $\tilde{\theta}$. Indeed, it is easy to construct examples where $\frac{\partial \Delta W}{\partial \delta} > 0$ that is where the gain to be non compliant increases with the market loss. In turn, the threshold $\tilde{\theta}$ increases too. As shown by Lemma 2 this result comes from the non linearity of the utility function under the assumption of risk aversion. Last, part (iv) indicates that an increase in the inspection probability p may yield to an increase in the utility gain of non compliance and hence a similar pattern for the threshold $\tilde{\theta}(c, \lambda)$. As shown in the proof of Lemma 2, this phenomenon is purely due to the fact that $\mu > 0$ and expresses the fact that when compliance is stochastic and μ sufficiently large *ceteris paribus* then an increase in p may actually favor the non compliance strategy.

Having characterized the basic properties of the crucial variables $\tilde{\theta}$ and ΔW, we now turn to the determination of the equilibrium rate of compliance. We denote $G(\theta, c)$ the joint distribution of the adherence to the norm and the compliance cost, on the product of their respective supports. We assume that all individuals simultaneously choose between compliance and non compliance for given parameters $(p, \mu, f, F, r, \delta)$. If all individuals expect a compliance rate equal to λ, then λ must be equal to the population share $H(\lambda)$ that finds compliance as being optimal. We thus obtain the following result.

Proposition 3 *An equilibrium rate of compliance exists and is defined by a fixed point of:*

$$\lambda = H(\lambda) \equiv \int_{\underline{c}}^{\overline{c}} \int_{\tilde{\theta}(c,\lambda)}^{\overline{\theta}} dG(\theta, c) \tag{2}$$

From Lemma 1, it follows that $H(.)$ is a continuous non decreasing function of λ, mapping the interval $[0, 1]$ into itself. Hence, there exists at least one compliance rate satisfying equation (2) for any policy (p, f, F). This follows from the intermediate value theorem applied to $f(\lambda) = \lambda - H(\lambda)$ which is a continuous function with $f(0) \leq 0$ and $f(1) \geq 0$. However, multiplicity of equilibria is possible and it is actually a general feature of this class of models with aggregate externality (see e.g. Weibull and Villa 2005 or Lindbeck et al., 1999). Equilibria may be stable or unstable.

Given the results contained in Lemma 2, it is not surprising that it is easy to find examples where an increase in the audit probability p or in the market loss δ nevertheless induce a decrease in equilibrium rate of compliance. We indeed prove this using simulations. All simulations are done using a utility function with constant relative risk aversion (CRRA) with parameter γ, a logistic function ψ, an exponential distribution for θ and assuming that all polluters have the same value for c.

Figure 2 depicts the equilibrium rate correspondence in function of p for a low value of the probability of involuntary non compliance ($\mu = 0.2$) and for a value $\gamma = 1.1$ for the degree of relative risk aversion. As long as the probability of inspection and conviction is lower than 0.5 then the only equilibrium is a situation where nobody conforms. Then, as soon as p reaches 0.5, a new equilibrium with intermediate rate of compliance (around 60%) also appears. When increasing p, the increasing branch of the correspondence corresponds to a stable equilibrium with an increasing rate of conformity while the decreasing branch corresponds to an unstable equilibrium. Note that once the increasing branch reaches $\lambda = 1$ when increasing p, then the stable equilibrium with full compliance remains an equilibrium for any larger probability p.

From this simulation, one can see that the multiplicity of equilibria implies that it is possible to get simultaneously stable equilibria with very opposite rates of compliance for a given and same regulatory activity in terms of penalties and rate of inspection. Secondly, there might be large change in the rate of compliance when one modify only slightly the rate of inspection.

Figure 3 and 4 depict the equilibrium rate of compliance for $\gamma = 2$ and successively for $\mu = 0.2$ and $\mu = 0.4$. Note that the increase in the probability of involuntary non compliance may have unattended consequences for the stable equilibrium with a high rate of conformity. When μ is low, then the equilibrium rate of compliance increases with p (upper branch of the correspondence). On the contrary, when μ is larger, then the equilibrium rate of compliance decreases with p. This confirms that the role of μ is crucial in determining the motivation to conform or not. It implies also that it might be of utmost importance from the regulator's perspective to consider standards that do not imply a too large probability of failure.

4 When involuntary and voluntary non compliance are not distinguishable

Up to now, we have supposed that the regulator is able to observe precisely using the audit whether the cost of compliance has been spent. If this is not the case, then the regulator is unable to distinguish voluntary from involuntary non compliance. In such a situation, it is interesting to separate the consideration to the guilt feeling from the shame feeling in the psychic cost $\theta\psi(\lambda)$. Following Weibull and Villa (2005), let us assume that

$$\theta = \alpha + \beta p$$

where $\alpha > 0$ represents the intensity of feeling guilty while being non compliant and $\beta > 0$ represents the intensity of being ashamed as the individual is convicted publicly.

The expected payoff of a compliant agent would then write

$$(1 - \mu p)U(R - c) + \mu p U(V - F - c) - \mu\beta p\psi(\lambda)$$

which means that the compliant agent would now suffer from being publicly convicted in case of involuntary non compliance (but not from feeling guilty). In addition, the involuntarily non compliant individual would pay the fine F just like any voluntarily non compliant individual.

It is immediate to see that a comparison with the preceding situation where the audit reveals whether c has been spent reveal that the inability to distinguish involuntary from voluntary non compliance is detrimental for compliance incentives. First, the fact that the penalty cannot be sized according to the voluntary/non voluntary individual behavior clearly undermines the willingness to comply. Indeed, if we denote

$$\Delta W(F, F) = pU(V - F) + (1 - p)U(R) - (1 - \mu p)U(R - c) - \mu p U(V - F - c)$$

we have

$$\Delta W(F, F) > \Delta W(f, F)$$

where $\Delta W(f, F)$ is the expected utility gain of non compliance given by (1). This means that non compliance becomes more attractive if one has to pay F instead of f in case of involuntary non compliance. Second, the social pressure now plays a role on the expected gain when compliance is chosen. Once again, this undermines the willingness to comply because of the additional risk of being ashamed in case of involuntary non compliance.

Finally, note that in the particular situation where social norms are absent ($\theta = 0$ or equivalently $\alpha = \beta = 0$), then there exists a unique value $\tilde{c}(\lambda)$ such that if $c \leq \tilde{c}(\lambda)$ then a type-c firm chooses to be compliant. The threshold value $\tilde{c}(\lambda)$ is increasing in λ and is defined implicitly by

$$(1-\mu p)U(R-\tilde{c}(\lambda))+\mu pU(V-f-\tilde{c}(\lambda))=pU(V-F)+(1-p)U(R) \tag{3}$$

and consequently the equilibrium compliance rate is defined by

$$\lambda=\int_{\underline{c}}^{\tilde{c}(\lambda)}dG(0,c).$$

Obviously, compliance is possible only if $f<F$. Otherwise, no individual would find an interest in being compliant. Hence, it is necessary for the regulator to observe whether c has been spent in order to provide incentives in the absence of social pressure.

5 The role of the information publicly provided to the market

In this section, we examine the crucial role of information provided to the market. We successively analyze the impact of self-reporting and public disclosure of information.

5.1 The impact of self-reporting

For simplicity, we concentrate first on the case where social norms are absent. If one allows self-reporting as part of the mechanism, then an individual has always the option to declare his status (compliant/non compliant) before being inspected at random. If he declares to be non compliant, we assume that the individual will pay a sanction $s\leq f$ with probability one if c has been spent and $S\leq F$ if c has not been spent. The decision tree is depicted in Figure 5. If an individual is non compliant because he has not spent c, he declares his status if and only if

$$U(V-S)>pU(V-F)+(1-p)U(R). \tag{4}$$

Obviously, this inequality does not depend on the cost of compliance, c. This means that all individuals voluntarily non compliant and sharing the same preferences $U(.)$ will take the same decision whatever their private cost of compliance.

Suppose for the moment that $\mu = 0$ so that involuntary non compliance does not exist. Then, the situation where self-reporting appears at the equilibrium is such that all non compliant individuals declare their status. Otherwise, we would be back to the case in which there is no self-reporting. Consequently, a type-c individual chooses to comply if and only if,

$$U(R - c) > U(V - S)$$

where $R = r$ and $V = r - \delta$. Indeed, the direct consequence of truthtelling by all non compliant individuals is that the market faces no asymmetric information. The threshold level is given by $R - c = V - S$ or equivalently by $\tilde{c} = \delta + S$ and consequently, there exists an unique equilibrium compliance rate give by $\lambda = G(0, \delta + S)$. We thus obtain the following result.

Proposition 4 *Assume that non compliance can only be voluntary, i.e.* $\mu = 0$. *Whenever self-reporting appears at the equilibrium, it implies complete information for the market and thereby selects an unique equilibrium compliance rate. Consequently, introducing the possibility of self-reporting yields ambiguous welfare results.*

Indeed, introducing self-reporting is ambiguous from a welfare point of view as we may select a unique equilibrium with a lower compliance rate than the one we get before. And conversely.

Now consider the situation where involuntary non compliance exists, i.e. $\mu > 0$. An individual who is involuntarily non compliant chooses to declare his status if and only if

$$U(V - s - c) \geq pU(V - f - c) + (1 - p)U(R - c). \tag{5}$$

Note first that if $f = s$, ie there is no rebate for truthtelling, then the inequality simply becomes

$$U(V - f - c) \geq U(R - c)$$

and the decision is now independent of c. Moreover as $V < R$ then nobody will declare his status. Hence we obtain the following result.

Proposition 5 *A rebate for truthtelling is necessary for involuntary non compliance to be self-reported, i.e.* $s < f$.

Let us examine the inequality (5) more closely:

$$U(V - s - c) \geq pU(V - f - c) + (1 - p)U(R - c)$$

Both sides of this inequality are decreasing in c so that the set of values for c such that the inequality is satisfied is ambiguous and difficult to describe at this level of generality. To pursue further the analysis, we assume risk neutrality. An individual who has spent c and is finally non compliant due to external reasons will self-report its status if and only if

$$V - s - c \geq p(V - f - c) + (1 - p)(R - c)$$

or rearranging

$$s + R - V \leq pf + p(R - V)$$

that is when the monetary loss in case of self-report is lower than the expected monetary loss when not reporting his status. This condition does not depend on c, so that all individuals will take the same decision whatever their compliance cost. It follows that if the following condition holds

$$s + \delta \leq pf + p\delta$$

then there is complete information on the market because all non compliant polluters, whether voluntarily or involuntarily, self-report their status to the regulator. The set of compliant polluters is given by the following inequality indicating when it is optimal to spend c :

$$\mu(V - s - c) + (1 - \mu)(R - c) > V - S$$

which is equivalent to

$$c < \mu(V - s) + (1 - \mu)R - (V - S) = \delta + S - \mu(\delta + s)$$

given complete information on the market which implies $R = r$. We thus obtain that the equilibrium rate of compliance is unique and equal to

$$\lambda = G(0, \delta + S - \mu(\delta + s))$$

We sum up our results in the following proposition.

Proposition 6 *When compliance is stochastic ($\mu > 0$) and assuming risk neutrality, if the following condition holds*

$$s + \delta \leq pf + p\delta$$

then the introduction of self-reporting implies complete information to the market. Thereby, there is an unique equilibrium compliance rate and consequently, introducing the possibility of self-reporting yields ambiguous welfare results.

Once again, introducing the possibility of self-reporting allows to reduce drastically here the multiplicity of equilibria by selecting a unique equilibrium. By contrast, under risk neutrality and no possibility of self-reporting, multiplicity of equilibria appears in general.

Last, it is interesting to note that the presence of social norms makes self-reporting of status more difficult and this implies that the regulator has to offer a larger rebate on penalties. To see this, consider that $\theta = \alpha + \beta p$ where α represents guilt while β represents shame. In that case, a voluntarily non compliant polluter declares his status if and only if

$$U(V - S) - (\alpha + \beta)\psi(\lambda) > pU(V - F) + (1 - p)U(R) - (\alpha + \beta p)\psi(\lambda)$$

or equivalently

$$U(V - S) > pU(V - F) + (1 - p)U(R) + \beta(1 - p)\psi(\lambda) \quad (6)$$

which has to be compared to equation (4). There is one additional term $\beta(1 - p)\psi(\lambda)$ which makes self-reporting a less interesting option when social norms are present. We thus have the following result.

Proposition 7 *In the presence of social norms, the regulator has to offer larger rebate on penalties to induce self-reporting of non compliance.*

Note finally, that when $\mu = 0$, then the decision to self-report or not only concerns agents that do not spend c. As suggested above, there is self-report of non compliance if and only if (6) holds. In other words, an equilibrium with self-reporting only appears when the expected rate of compliance is low and/or β (shame) is low *ceteris paribus*. Hence it is possible to have simultaneously equilibria with self-reporting (with low rate of compliance) and without self-reporting (with higher rate of compliance) for a given economic environment in terms of penalties F and S and inspection probability p.

5.2 The impact of public disclosure of criminal records

Up to now, we have assumed implicitly that the regulator publicly announces the outcome of the audit procedure. We now examine the impact of not disclosing publicly the criminal records to the market. In the absence of public information on criminal records, the market forms beliefs so that the expected revenue for any individual is given by

$$\begin{aligned} R^{NPI} &= \lambda(1-\mu)r + (1-\lambda+\lambda\mu)(r-\delta) \\ &= r - (1-\lambda(1-\mu))\delta \end{aligned}$$

where NPI stands for non public information. Note that $R^{NPI} \geq V = r - \delta$. Also, as expected, R^{NPI} does not depend on the probability of inspection p. Moreover, one can easily check that $R^{NPI} \leq R$. Indeed,

$$\begin{aligned} R - R^{NPI} &= r - \frac{(1-\lambda+\mu\lambda)(1-p)}{1-p+\lambda p(1-\mu)}\delta - r + (1-\lambda(1-\mu))\delta \\ &= \left(1-\lambda(1-\mu) - \frac{(1-\lambda+\mu\lambda)(1-p)}{1-p+\lambda p(1-\mu)}\right)\delta \\ &= \lambda p(1-\mu)\left(\frac{1-\lambda(1-\mu)}{1-p+\lambda p(1-\mu)}\right)\delta \geq 0. \end{aligned}$$

Hence, if criminal records are non public, the expected market revenue is lower than the expected market revenue R under public criminal records and non conviction, but greater than the expected market revenue V under public criminal records and conviction.

In such a situation, the decision of being compliant is taken if and only if

$$(1-\mu p)U(R^{NPI}-c)+\mu pU(R^{NPI}-f-c) > pU(R^{NPI}-F)+(1-p)U(R^{NPI})-\theta\psi(\lambda)$$

or equivalently

$$\theta > \tilde{\theta}^{NPI}(c,\lambda) \equiv \frac{\Delta W^{NPI}}{\psi(\lambda)}$$

where

$$\Delta W^{NPI} = pU(R^{NPI}-F)+(1-p)U(R^{NPI})-(1-\mu p)U(R^{NPI}-c)-\mu pU(R^{NPI}-f-c) \quad (7)$$

is the expected utility gain from being non compliant as compared with compliance, in the absence of public information on convictions.[3] We denote $H^{NPI}(\lambda)$ the rate of compliance given by

$$H^{NPI}(\lambda) = \int_{\underline{c}}^{\overline{c}} \int_{\tilde{\theta}^{NPI}(c,\lambda)}^{\overline{\theta}} dG(\theta, c)$$

It is interesting to compare H^{NPI} (or equivalently ΔW^{NPI}) with its corresponding expression under public information H given by (2). We first consider the simplifying case of risk neutrality. Under risk neutrality, we obtain from (7):

$$\begin{aligned}\Delta W^{NPI} &= p(R^{NPI}-F)+(1-p)R^{NPI}-(1-\mu p)(R^{NPI}-c)-\mu p(R^{NPI}-f-c)\\ &= c-p(F-\mu f)\end{aligned}$$

while from (1), we get

$$\begin{aligned}\Delta W &= p(V-F)+(1-p)R-(1-\mu p)(R-c)-\mu p(V-f-c)\\ &= c-p(F-\mu f)-p(1-\mu)(R-V).\end{aligned}$$

Comparing these expressions, it follows that $\Delta W \leq \Delta W^{NPI}$ with equality when $\lambda = 0$ (as $R = V = r - \delta$ in that situation). Hence, we have $H^{NPI}(\lambda) \leq H(\lambda)$ with equality in $\lambda = 0$. This implies that for any stable equilibrium, the situation without public information entails

[3]Note that here if we distinguish between the components of θ, the term β reflecting "shame" is present when criminal records are not public. Hence, only the term α reflecting guilt remains.

a lower rate of compliance than under the situation of public disclosure of criminal record.[4] This underlines the positive side of public disclosure of criminal records in the presence of social norms.

Proposition 8 *Under risk neutrality, disclosing publicly the criminal records allows to reach a higher rate of compliance at a stable equilibrium.*

Figure 6 depicts the equilibrium correspondence depending on the probability of inspection p for risk neutral agents. On the upper increasing branch of this correspondence (which corresponds to stable equilibria), the curve with public disclosure always entails a higher rate of compliance than under non public disclosure. Under risk aversion, using simulations, it seems that the same qualitative result holds but it cannot be guaranteed in general because it is not possible to directly sign the difference between ΔW^{NPI} and ΔW.

6 Concluding remarks

In this paper, we have theoretically explored the implications of social norms in deterring pollution standard fraud along with economic incentives provided both by markets and regulatory activities. The model assumes that a large number of risk-averse individuals differ not only in their private cost of compliance with the environmental standard but also in their individual aversion to fraud. The aversion of fraud is influenced by the extent of social norms. We show that there may be multiple equilibrium rates of compliance for a given enforcement policy. We also show that under risk aversion the potential loss in market revenues has an ambiguous effect on the equilibrium rates of compliance. Similarly, increasing the probability of audit may decrease the equilibrium rate of compliance when stochastic events make involuntary non compliance possible. Last, we show that the information brought to the market is crucial for polluters' behavior. For this, we explore the impact of self-reporting procedures and public disclosure of criminal records.

[4] Conversely, for any unstable equilibrium the rate of compliance is higher under the situation where criminal records are not public.

An interesting and natural extension of this framework would be to consider the dynamics of social norms and the influence of the regulatory activities on it. The issue would be to understand how the regulator's policy (inspection rate, penalties) should evolve over time to increase the rate of compliance in the population by taking into account the formation of social norms.

References

[1] Akerlof G.A. (1980), "A theory of social custom, of which unemployment may be one consequence", *Quaterly Journal of Economics*, 94(4):749-775.

[2] Cropper M. and W. Oates (1992), "Environmental Economics: a survey", *Journal of Economic Literature*, 30:675-740.

[3] Bontems P. and Rotillon G. (2000), "Honesty in environmental compliance games", *European Journal of Law and Economics*, 10(1):31-41.

[4] Ellickson R.C. (1998), "Law and Economics discovers social norms", *Journal of Legal Studies*, 27(2):537-552.

[5] Elster J. (1989), "Social norms and economic theory", *Journal of Economic Perspectives*, 3(4):99-117.

[6] Hatcher A., Jaffry S., Thebaud O. and E. Bennett (2000), "Normative and social influences affecting compliance with fishery regulations", *Land Economics*, 76(3):448-461.

[7] Heyes A. (2001), "Honesty in a regulatory context - Good thing or bad?", *European Economic Review*, 45:215-232.

[8] Lai C.C., Yang C-Y. and J-J Chang (2003), "Environmental regulations and social norms", *International Tax and Public Finance*, 10:63-75.

[9] Lindbeck A., Nyberg S. and J.W. Weibull (1999), "Social norms and economic incentives in the welfare state", *Quaterly Journal of Economics*, 114(1):1-35.

[10] Livernois J. and J. McKenna (1999), "Truth or consequences: enforcing pollution standards with self-reporting", *Journal of Public Economics*, 71:415-440.

[11] Posner R.A. (1997), "Social norms and the law: an economic approach", *American Economic Review*, 87(2):365-369.

[12] Russell C.S., Harrington W. and W.J. Vaughan (1986), *Enforcing Pollution Control Laws*. Washington D.C.: Resource for the Future.

[13] Weibull J.W. and E. Villa (2005), "Crime, punishment and social norms", mimeo.

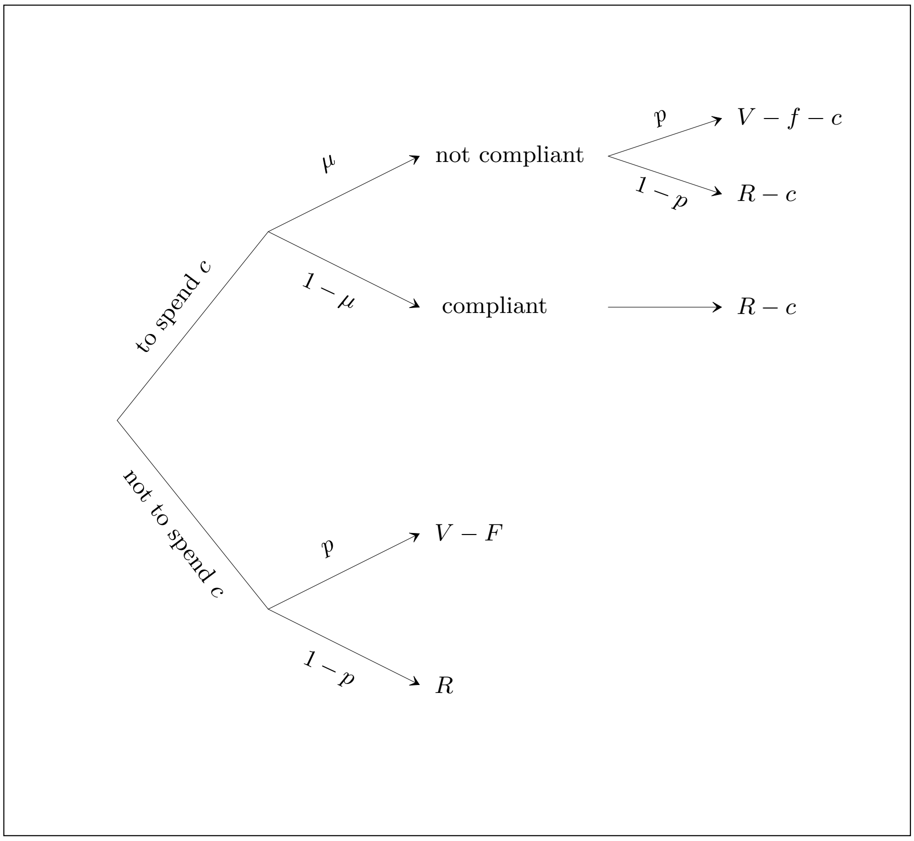


Figure 1: Decision tree.

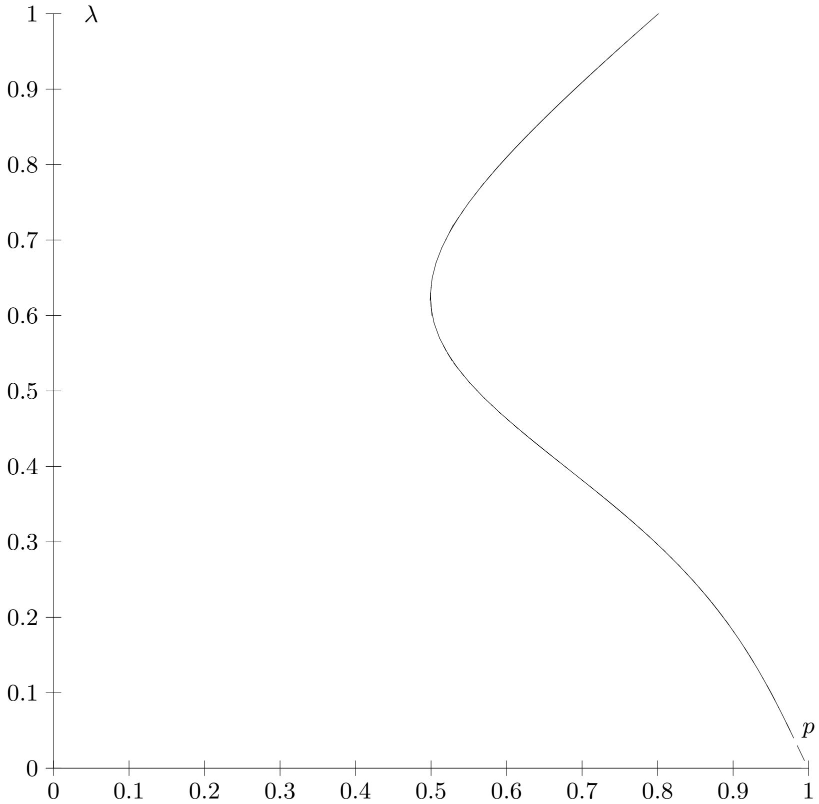


Figure 2: The equilibrium compliance rate correspondance for $\gamma = 1.1$ and $\mu = 20\%$.

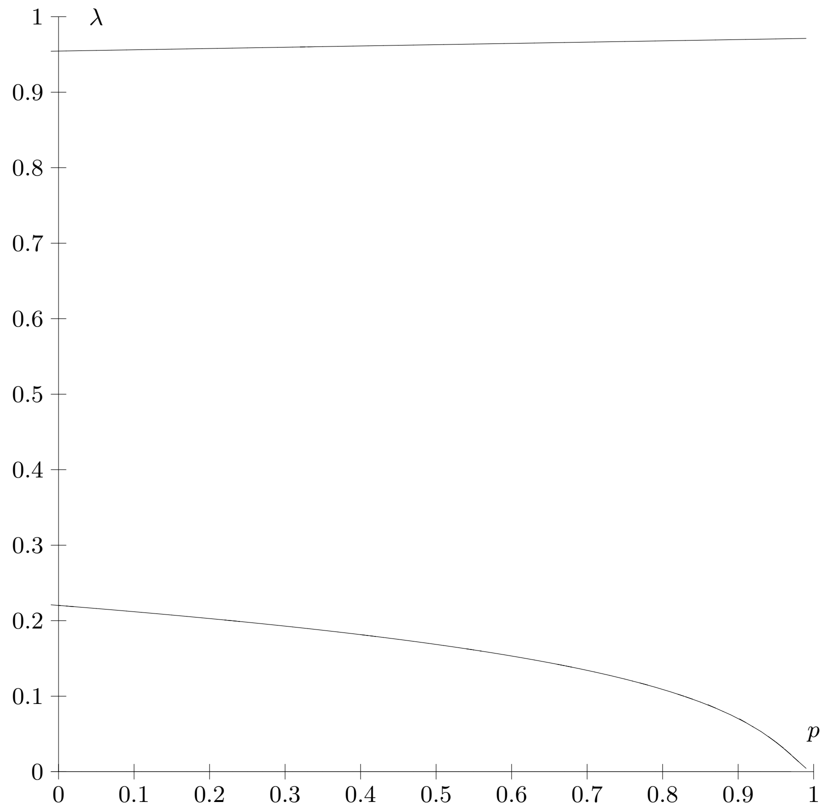


Figure 3: The equilibrium compliance rate correspondance for $\gamma = 2$ and $\mu = 20\%$.

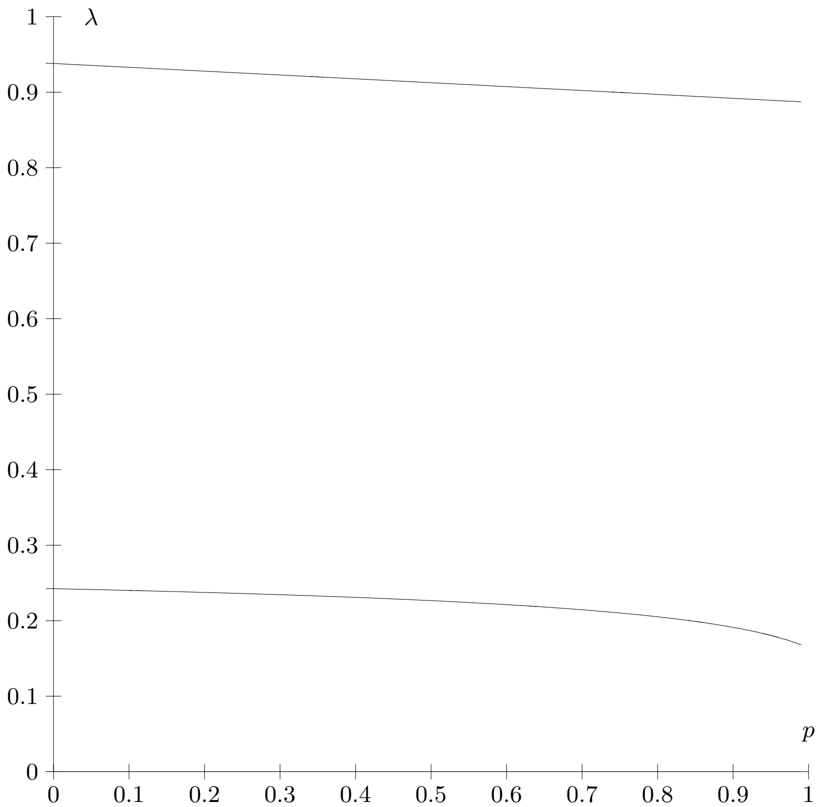


Figure 4: The equilibrium compliance rate correspondance for $\gamma = 2$ and $\mu = 40\%$.

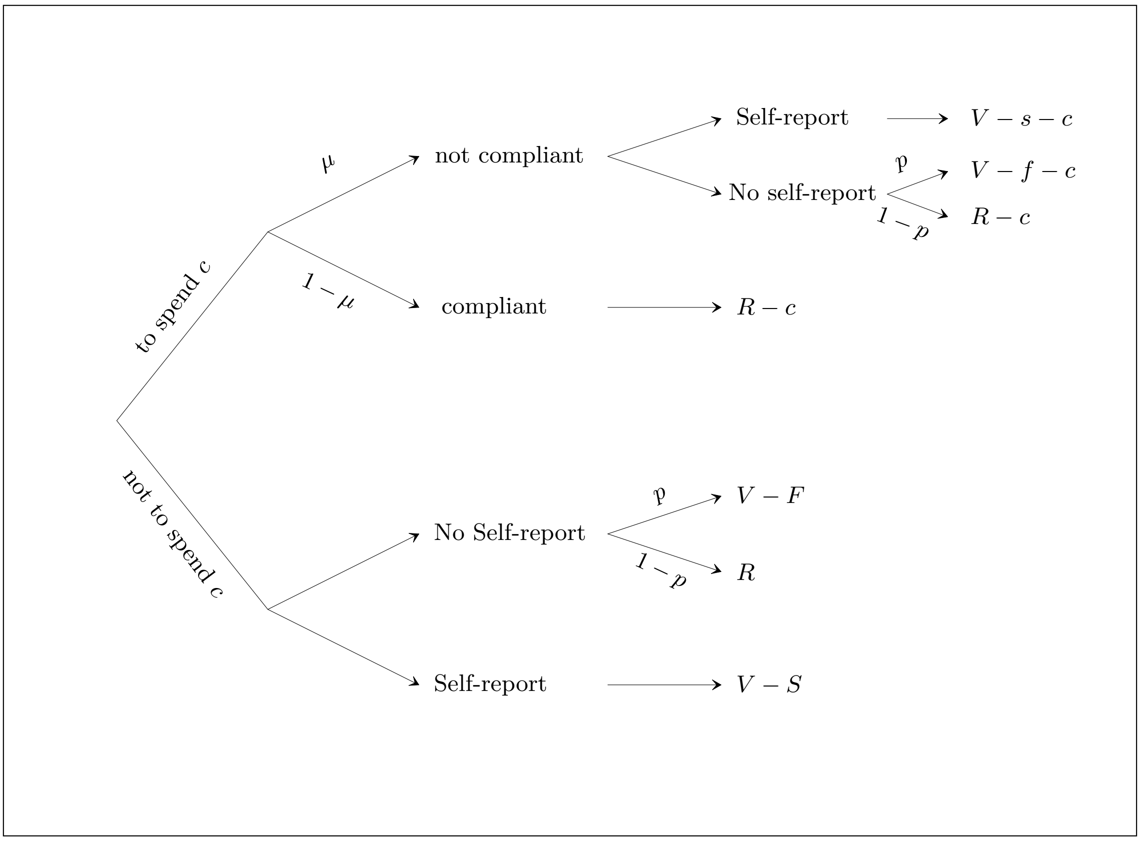


Figure 5: Decision tree under the self-reporting option.

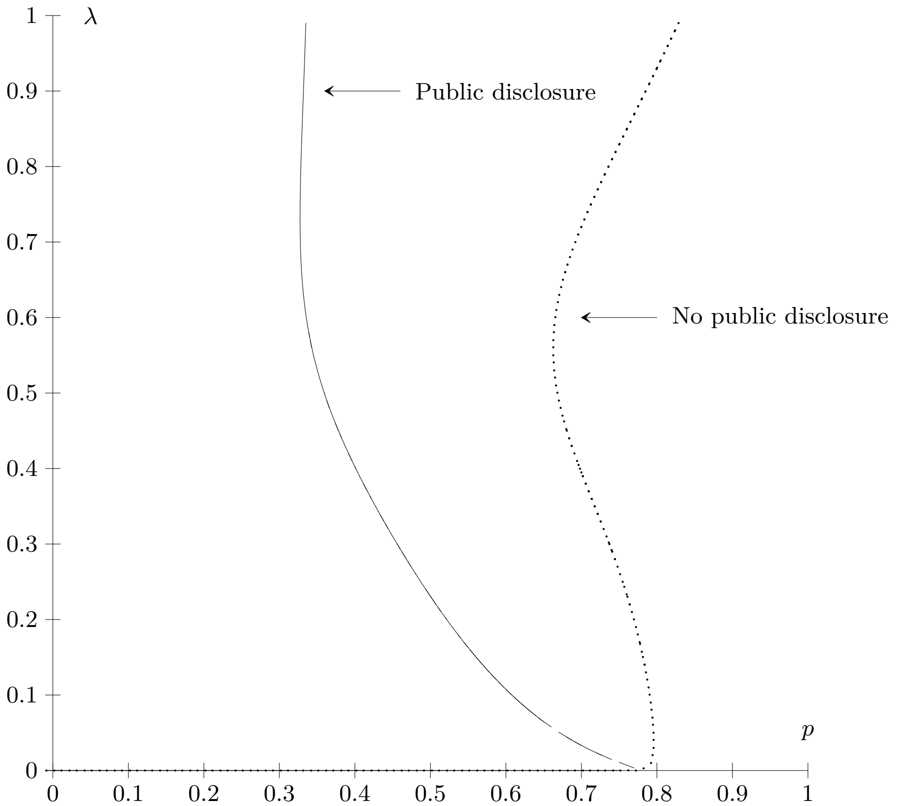


Figure 6: The equilibrium compliance rate correspondance for $\gamma = 0$ and $\mu = 40\%$.

On the optimal design of income support and agri-environmental regulation*

Philippe Bontems†

February 2008

Abstract

In this paper, we develop a model of regulation for a set of heterogenous farmers whose production yields to environmental externalities. The goal of the regulator is first to offer some income support depending on collective preferences towards income redistribution and second to internalize externalities. The optimal policy is constrained by the information available. We first consider the second best where the regulator is able to observe all individuals decisions in terms of inputs and individual profit, but not the individual farming labor supply. We characterized the generalized transfer in function of the desire to redistribute and the underlying characteristics of the production process. In a second step, we assume that the regulator has only information on aggregate consumption of inputs and hence can only tax/subsidy linearly inputs and output. However, because the accounting profit remains observable, a non linear transfer of profit is still part of the optimal policy. In the last part of the paper, we endogenize the market price of land and examine how the optimal policy should be modified.

JEL : Q18, Q12, Q58

Key-words: asymmetric information, agricultural policy, agri-environmental policy, income support

*This research has been financially supported by the French Ministry of the Environment under a grant from S3E program. *Address* : Philippe Bontems, GREMAQ-INRA, Université des Sciences Sociales de Toulouse, 21 Allée de Brienne, 31000 Toulouse, France. Email: bontems@toulouse.inra.fr. Phone: (33) 561 128 522. Fax: (33) 561 128 520.

†Toulouse School of Economics (GREMAQ, INRA, IDEI).

1 Introduction

Government intervention remains pervasive in agriculture, at least for two reasons. One is to provide some income support to farmers and the second one is to promote positive externalities and to reduce negative externalities arising from agricultural production. It often appears that agricultural policies in developed countries are often characterized by apparently countervailing provisions. Indeed, income support motivated subsidies may have undesired environmental consequences. As noted by Bourgeon and Chambers (2000), production subsidies are granted but at the same time farmers are paid to reduce their acreage. Finally, the different ways governments intervene to achieve several objectives are not equivalent as some measures are less production and trade distorting than others. These issues and therefore the design of efficient governmental intervention in agriculture have raised a considerable concern in the literature.

For instance, Guyomard et al. (2004) (see also Leathers (1992) for an earlier reference) compare four agricultural income support programs (output subsidy, land subsidy, a decoupled payment with or without mandatory production) according to achieve four goals (income support, reduction of negative externalities, maintenance of a maximum number of farmers and effects on trade). It is shown that no program uniformly dominates others. While these kind of results are of importance, it might be needed to go further by using a more normative approach in order to better understand the determinants of optimal governmental intervention and in particular to understand how to combine efficiently the different available instruments.

This is precisely such an approach that Bourgeon and Chambers (2000) have used to study the optimal design of income support in agriculture (as well as public investment) in a context of imperfect discrimination due to asymmetric information between farmers and the regulator.[1] There, in order to insure all farmers a minimum parity income, there is a

[1] See also Lewis, Ware and Feenstra (1989), Chambers (1992) and Hueth (2000).

need to transfer money to high-cost and low income farmers. But these transfers can be claimed by high income farmers as well and hence an optimal policy deters these claims by tying income support programs to production or acreage limits that are more costly to the high-income farmers. Innes (2003) pursues this line of research by showing that it is also important to incorporate the effects of the policy on all market prices and in particular on farmland prices. It is shown that it may be optimal to implement some compensated acreage limitations for high-cost farmers together with low-cost farmers cultivating more acreage than they otherwise would.

Besides, the optimal design of environmental regulation in agriculture has been extensively studied. For instance, Bontems, Turpin and Rotillon (2005, 2007) study an output regulation aimed at reducing negative externalities and that takes into account the political power of farmers and the pre-intervention distribution of farming incomes. More recently, Sheriff (2008) analyzes the optimal design of environmental regulation taking into account the need to support income and the existence of price uncertainty while Feng (2007) looks at a model of optimal green payments for conservation and income support goals, where farmers are heterogeneous along two dimensions (farm size and conservation efficiency).[2]

Despite the interesting results gathered by the literature, it is fair to observe that many of these normative models typically rely on a rather crude modelling of farmer's behavior with often only one decision to be taken (production or land cultivated). Hence, the regulation is optimally designed on a exogenously and very limited set of variables in order to achieve several goals simultaneously. The purpose of the paper is to theoretically explore the optimal design of both income support and agri-environmental regulation in a more general model where farmer's decisions cover several variable inputs such as fertilizer, land cultivated and labor devoted to production. Given the existing policies, another important decision for a farmer is whether to stay as an active farmer or to give up production and lease out all his land endowment and allocating his labour to the next best alternative in terms of wages. In

[2] See also Wu and Babcock (1995) for an earlier analysis.

other words, the size of the agricultural sector is endogenous in the analysis. The goal of the government is to redistribute income among a population of heterogenous farmers taking into account the potential negative externalities of production and its budget constraint. The intensity of redistribution depends on the social preferences towards redistribution through the degree of social aversion to inequality. The amount of damage caused by production depends on all polluting inputs used and also of the size of land cultivated. For instance, if environmental damage is primarily driven by intensification then increasing the land used reduces damages holding the level of polluting inputs constant.

Importantly, the policies that the government can implement are constrained by the information available. First, we assume that farmers are heterogenous according to their ability in the production process which is private information. In addition, the effort (or labour) devoted to production constitutes a private decision of farmers and hence is non observable to the regulator. However, we assume that the regulator is able to observe the accounting profit (profit gross of the disutility of labor) at the individual level. In addition, the status of agent (active farmer or not) is observable so that the regulator can implement a poll subsidy/tax on all non active farmers that lease out their lands.

We derive the optimal regulation policy in two different settings. First, we assume in addition that a very powerful regulator is able to gather observations of all relevant farmer's individual decisions (production, inputs). We show that unless some separability conditions hold for the production function, it is generally optimal to distort the taxation of polluting inputs like fertilizers from the traditional pigovian rule for redistributive purposes. We also study the shape of the optimal transfer and its progressive/regressive feature depending on the social preferences towards redistribution and the respective political weights of different types of farmers. Second, we consider a more realistic setting where the regulator has only access to aggregate decisions and hence cannot do better than employing linear tax/subsidy when regulating the output or the variable inputs. In this setting, the optimal policy is a combination of linear tax/subsidy on output and inputs and a non linear transfer based on the observation of accounting profit. Here, the Principle of Targeting breaks down as the income subsidy based on the observed accounting profit is influenced by the negative externality.

We hence obtain results that are related to the ones obtained by Cremer et al. (1998) in the context of income non linear taxation and commodities taxes for the consumer case. Our model differs in that it is first in a context of production, also because the political or social weights of individuals appear in the analysis and finally because individuals may opt to quit the production sector making the size of the agricultural sector endogenous. Last, another difference lies into the fact that we endogenize the price of some good (namely the farmland price) which then depends on the policy implemented. There, the objective of the government now also takes into account the opportunity cost of land devoted to agriculture and the rents for landowners. We study the influence of income support and environmental policies on the equilibrium price of farmland.

The paper is organized as follows. The next section is devoted to assumptions and notations. Sections 3 and 4 are devoted to benchmark cases, the laissez-faire equilibrium and the first best. We analyze the second best regulation in section 5 and the optimal regulation under observable aggregate variables in section 6. Section 7 is devoted to the endogeneization of farmland price. Section 8 concludes.

2 Assumptions and notations

Consider a farmer with the following production technology:

$$q = f(l, z, e, \theta)$$

where q denotes the agricultural production, l is the land used, z is a variable marketed input (say chemical fertilizers, pesticides, energy...), e is the production-enhancing effort supplied by the farmer and θ is a one-dimensional productivity parameter.[3] We assume that land l is essential to production, i.e. $f(0, z, e, \theta) = 0$. We assume that f is smooth and is increasing

[3]The extension of the model to more than two inputs is straightforward.

in all its arguments, i.e. $f_i > 0$, $\forall i = l, z, e, \theta$.[4] Parameter θ can be interpreted as a value characterizing the farmer himself in terms of ability to produce or some fixed characteristics of the production process. Here, a larger θ means a more efficient production process. We assume that θ belongs to a compact set $\Theta = [\underline{\theta}, \overline{\theta}]$ with distribution $K(\theta)$ and a positive density $k(\theta)$ on Θ.

The effort e can be interpreted as the quantity of effective labor devoted to production or even as the (continuous) choice of technology intensity employed on the farm. More effort which is costly in time or a more intensive technology allows to increase production.

In addition, we also assume that f is supermodular in (l, z, e, θ), that is, $f_{ij} \geq 0$, $\forall i \neq j$ with $(i, j) \in \{l, z, e, \theta\}$. This amounts to suppose that the technology is normal in all inputs in the sense of Rader (1968) and hence exhibits some complementarity between the variables.

The agricultural accounting profit absent any governmental intervention is given by the restricted profit function π defined as follows:

$$\pi(e; p, r, w, \theta, l^{\circ}) = \max_{l,z} \left\{ pq - r(l - l^{\circ}) - wz \text{ s.t. } q \leq f(l, z, e, \theta),\ l \geq 0,\ z \geq 0 \right\}$$

where l° is the initial endowment in land and r the market price of land. Also, p and w are respectively the market price of output and polluting input which are assumed to be constant. We denote $z(\theta)$ and $l(\theta)$ the optimal (interior) allocation of polluting input and land from the perspective of a type-θ farmer.

Each farmer has a utility function $U(I, e)$ where I is the net income. We assume that U takes the following quasi-linear form $U = I - \psi(e)$ where ψ is the (monetary) cost of effort with $\psi' > 0$ and $\psi'' > 0$.

The farmer can quit the agricultural sector and obtain an outside wage v together with the returns from renting his land endowment. Hence, in the laissez-faire situation, a farmer is actually active and produces if and only if

$$\pi(e; p, r, w; \theta, l^{\circ}) - \psi(e) \geq v + rl^{\circ}. \tag{1}$$

[4] We denote $f_x = \frac{\partial f}{\partial x}$ as the partial derivate of f with respect to x.

Note that this free entry/exit condition (1) does not depend on l° as the optimal allocation $z(\theta)$ and $l(\theta)$ do not depend on l° as well. But the distribution of income obviously depends on the distribution of land endowment. We assume that the outside wage is constant (otherwise, we would have to model a second sector of production where workers are employed).

We assume that producing entails an environmental damage x which is related to the intensity of input usage

$$x = x(z, l)$$

and we assume that $x(.,.)$ is increasing in the first argument z. Concerning the land use, if the environmental damage is primarily caused by the intensification of production process then it is natural to assume that $x(.,.)$ is decreasing in l. In that case, obviously the intervention of the regulator would call a for land subsidy. Conversely, if damage is instead driven by excessive use of marginal land, then it would be natural to assume that $x(.,.)$ is increasing in l.

3 Laissez-faire equilibrium with free entry/exit

In the absence of governmental support, the farmer has to take four decisions: first whether to stay active or to leave the sector, if active how much land, fertilizer and effort to put in the production process. Note that the entry condition only depends on θ, hence it follows that a farmer with type $\hat{\theta}$ decides to stay then any farmer with type $\theta > \hat{\theta}$ stays active as well. This implies that the set of active farmers is only determined by the ability θ and is $[\theta_s, \overline{\theta}]$.

The equilibrium is characterized by the following conditions:

$$\begin{aligned} pf_l(l, z, e, \theta) &= r \\ pf_z(l, z, e, \theta) &= w \\ pf_e(l, z, e, \theta) &= \psi' \end{aligned}$$

which gives the equilibrium allocation for an active θ-type farmer, $l(\theta)$, $z(\theta)$ and $e(\theta)$. Also, the (interior) marginal farmer θ_s who is indifferent between producing and leaving the agricultural sector is such that:

$$U(\theta_s) = pf(l(\theta_s), z(\theta_s), e(\theta_s), \theta_s) - wz(\theta_s) - r(l(\theta_s) - l^{\circ}) - \psi(e(\theta_s)) = v + rl^{\circ}$$

or equivalently

$$pf(l(\theta_s), z(\theta_s), e(\theta_s), \theta_s) - wz(\theta_s) - rl(\theta_s) - \psi(e(\theta_s)) = v.$$

This condition means that the return of production must be at least superior to the next best alternative v. Note that this condition is independent of the land endowment l°.

4 The First Best

We now examine the benchmark situation where the regulator intervenes without informational constraints. Indeed, we assume that the regulator can observe costlessly the status of agents (farmer or not), the individual decisions over l, z, q and the accounting profit π. In addition, we assume in this section that the regulator is able to observe the effort e and the type θ. The objective of the regulator is to maximize a weighted sum of social value of utilities. The social value of utility U is denoted $\mathcal{W}(U)$ where $\mathcal{W}(.)$ is increasing, concave, reflecting the desire to redistribute income from the richer to the poorer farmers. The social (or political) weight in the welfare function is denoted $\alpha(\theta)$ for a type-θ farmer. If this weight function is increasing in θ then the basic desire to redistribute ($\mathcal{W}(U)$ is concave) is counterbalanced by the fact that richer farmers have also a higher weight in the welfare function. A transfer $T(\theta)$ is paid to any type-θ active farmer and a transfer τ is paid to any non active farmer. The budget devoted to the agricultural sector is denoted B while the maximal environmental damage which is sustainable is given by X.

The program of the regulator can thus be written as follows:

$$\max \int_{\theta_s}^{\overline{\theta}} \alpha(\theta)\mathcal{W}(U(\theta))dK(\theta) + \int_{\underline{\theta}}^{\theta_s} \alpha(\theta)\mathcal{W}(v + rl^{\circ} + \tau)dK(\theta)$$

s.t.

$$\int_{\underline{\theta}}^{\theta_s} \tau dK(\theta) + \int_{\theta_s}^{\overline{\theta}} T(\theta)dK(\theta) \leq B \tag{2}$$

$$\int_{\theta_s}^{\overline{\theta}} x(z(\theta), l(\theta))dK(\theta) \leq X \tag{3}$$

$$U(\theta) \geq v + rl^{\circ} + \tau \text{ for any } \theta \geq \theta_s$$

$$U(\theta) = \pi(\theta) + T(\theta) - \psi(e(\theta))$$

where $\pi(\theta) = pf(l(\theta), z(\theta), e(\theta), \theta) - r(l(\theta) - l^{\circ}) - wz(\theta)$. Also $\alpha(\theta)$ is a positive function of θ with the normalization $\int_{\underline{\theta}}^{\overline{\theta}} \alpha(\theta)d\theta = 1$ which represents as indicated above the social (or political) weight of type-θ farmers in the welfare function.

Let us denote by μ the Lagrange multiplier of the environmental constraint (3) and by ν the Lagrange multiplier of the budget constraint (2). Solving the regulator's program, we obtain the following result.

Proposition 1 *At the first best, the optimal allocation devoted to a type-θ farmer is such that*

$$\begin{aligned} pf_l(l, z, e, \theta) &= r + \frac{\mu}{\nu}x_l(z, l) \\ pf_z(l, z, e, \theta) &= w + \frac{\mu}{\nu}x_z(z, l) \\ pf_e(l, z, e, \theta) &= \psi'(e) \end{aligned}$$

and the (interior) marginal farmer is such that

$$pf(l(\theta_s), z(\theta_s), e(\theta_s), \theta_s) - rl(\theta_s) - wz(\theta_s) - \psi(e(\theta_s)) - \frac{\mu}{\nu}x(z(\theta_s), l(\theta_s)) = v$$

Last, the first best is characterized by the equality between marginal social value of utility across types:

$$\alpha(\theta)\mathcal{W}'(U(\theta)) = \alpha_0\mathcal{W}'(v + rl^{\circ} + \tau) = \nu.$$

for any $\theta \geq \theta_s$ *and where* $\alpha_0 = \frac{1}{K(\theta_s)} \int_{\underline{\theta}}^{\theta_s} \alpha(\theta) dK(\theta)$.

Proof: See appendix A. ■

As can be seen from the Proposition, the First Best allocation entails a Pigovian tax/subsidy on both z and l. More precisely, if the optimal allocation is $l^*(\theta)$ and $z^*(\theta)$, then the regulator can decentralize the first best allocation by implementing a personalized tax per unit of land equal to $\frac{\mu}{\nu} x_l(z^*(\theta), l^*(\theta))$ and a personalized tax per unit of fertilizer equal to $\frac{\mu}{\nu} x_z(z^*(\theta), l^*(\theta))$.[5] Note that in the case of land, it can be a subsidy if damage is primarily driven by intensification ($x_l < 0$). In addition, the optimal distribution of incomes is obtained through personalized transfers $T(\theta)$ for active farmers and a uniform transfer τ for inactive agents. Note also that there is no need to regulate the effort once z and l are driven to their efficient levels.

Last, the identity of the marginal farmer is such that the return of production from the marginal farmer net of the social damage weighted by the shadow price of public funds should be equal to the outside wage. It follows that the intervention tends to reduce the size of the agricultural sector by taking into account the social cost of production in terms of environmental damages.

5 The second best with observable individual decisions

We now suppose that the regulator can always observe the accounting profit π and the status of any agent (being an active farmer or not). In addition, we will assume that the regulator may observe individual decisions like the land used, the quantity of fertilizer used and the production level. However, the effort level and the productivity parameter are unobservable to the regulator.

Given its information set, the regulator is able to consider a general policy of the form $\{\tau, \hat{t}(\pi, z, l, q)\}$ where τ is the transfer paid to any farmer stopping his activity and t is

[5] The tax would have been uniform if we had instead assumed that the aggregate pollution level is a function $\tilde{X}(Z, L)$ where Z is the aggregate consumption of polluting input z and L the aggregate use of farmland. The constraint would then write $\tilde{X}(Z, L) \leq X$.

the transfer paid to each active farmer as a function of observable variables. Note that actually a transfer $t(\pi, z, l)$ is equivalent to the transfer $\hat{t}(\pi, z, l, q)$, because we have $q = (\pi + wz + r(l - l^{\circ}))/p$ and (z, l, l°) are observable.

5.1 Analysis

From the Revelation Principle, any mechanism $\{\tau, t(\pi, z, l)\}$ is equivalent to a direct revelation mechanism $\{\tau, \pi(\theta), z(\theta), l(\theta), T(\theta)\}$ where $T(.)$ is the transfer paid by the regulator to a producing agent and in which truthtelling is an optimal strategy for each farmer. For simplicity, we assume the differentiability of the policy.[6] The program of the regulator can be written as follows:

$$\max_{e,l,z,\theta_s,\tau,U} \int_{\theta_s}^{\overline{\theta}} \alpha(\theta)\mathcal{W}(U(\theta))dK(\theta) + \int_{\underline{\theta}}^{\theta_s} \alpha(\theta)\mathcal{W}(v + rl^{\circ} + \tau)dK(\theta)$$

s.t.

$$\int_{\underline{\theta}}^{\theta_s} \tau dK(\theta) + \int_{\theta_s}^{\overline{\theta}} T(\theta)dK(\theta) \leq B$$

$$\int_{\theta_s}^{\overline{\theta}} x(z(\theta), l(\theta))dK(\theta) \leq X$$

$$U(\theta_s) = v + rl^{\circ} + \tau$$

$$U(\theta) \geq U(\theta, \tilde{\theta}) \text{ for any } \theta, \tilde{\theta}$$

$$U(\theta) = \pi(\theta, l(\theta), z(\theta), e(\theta)) + T(\theta) - \psi(e(\theta))$$

$$\pi(\theta, l(\theta), z(\theta), e(\theta)) = pf(l(\theta), z(\theta), e(\theta), \theta) - wz(\theta) - r(l(\theta) - l^{\circ})$$

Given that the regulator observes π together with l and z, it is interesting to denote the effort $E(\theta, l, z, \pi)$ needed to generate a profit π using l and z for a type-θ farmer. As $f_e > 0$, the equation $\pi = \pi(\theta, l, z, e) = pf(l, z, e, \theta) - wz - r(l - l^{\circ})$ defines implicitly the function $E(\theta, l, z, \pi)$. Note that we easily get:

$$E_\theta = -\frac{f_\theta}{f_e} < 0,\ E_\pi = \frac{1}{pf_e} > 0,\ E_l = -\frac{pf_l - r}{pf_e},\ E_z = -\frac{pf_z - w}{pf_e}.$$

Hence, the effort needed decreases with ability and increase with the profit goal. Whether E

[6] Standard arguments allow to prove the differentiability almost everywhere.

increases or not with l or z depends on whether the optimum involves under-use (compared to the private optimum) of land or fertilizer or not.

Proposition 2 *At a separating optimum, the allocation devoted to a type-θ active farmer is characterized by:*

$$\begin{aligned} pf_l(l(\theta), z(\theta), e(\theta), \theta) &= r + \frac{\mu}{\nu} x_l(z(\theta), l(\theta)) + \frac{\lambda(\theta)}{\nu k(\theta)} \psi'(e(\theta)) \frac{d(E_\theta)}{dl} \\ pf_z(l(\theta), z(\theta), e(\theta), \theta) &= w + \frac{\mu}{\nu} x_z(z(\theta), l(\theta)) + \frac{\lambda(\theta)}{\nu k(\theta)} \psi'(e(\theta)) \frac{d(E_\theta)}{dz} \\ pf_e(l(\theta), z(\theta), e(\theta), \theta) &= \psi'(e(\theta)) + \frac{\lambda(\theta)}{\nu k(\theta)} \frac{d(\psi' E_\theta)}{de} \end{aligned}$$

where

$$\lambda(\theta) = -\nu(1 - K(\theta)) + \int_{\theta}^{\overline{\theta}} \alpha(\theta) \mathcal{W}'(U(\theta)) dK(\theta)$$

and

$$\nu = \int_{\theta_s}^{\overline{\theta}} \alpha(\theta) \mathcal{W}'(U(\theta)) dK(\theta) + \alpha_0 \mathcal{W}'(v + r\overset{\circ}{l} + \tau) K(\theta_s) > 0.$$

Also the marginal farmer has identity θ_s given by:

$$pf(l(\theta_s), z(\theta_s), e(\theta_s), \theta_s) - rl(\theta_s) - wz(\theta_s) - \psi(e(\theta_s)) - \frac{\mu}{\nu} x(z(\theta_s), l(\theta_s)) - \frac{\lambda(\theta_s)}{\nu k(\theta_s)} \psi'(e(\theta_s)) \left. E_\theta \right|_{\theta = \theta_s} = v$$

Proof: See appendix B. ■

A direct comparison between the first best and the second best suggests that the first-order conditions for l, z and e are now corrected by a new term due to incentive compatibility. Let us consider for instance the condition for land use:[7]

$$pf_l(l(\theta), z(\theta), e(\theta), \theta) = r + \frac{\mu}{\nu} x_l(z(\theta), l(\theta)) + \frac{\lambda(\theta)}{\nu k(\theta)} \psi'(e(\theta)) \frac{d(E_\theta)}{dl}$$

This equation can be interpreted as follows: in the absence of asymmetric information on θ (first best) then $\lambda(\theta) = 0$ so that we recover the first-best rule described before. Under asymmetric information, there is a need to introduce an incentive distortion due to the fact that by distorting l it is possible to extract rents in order to redistribute income across

[7] The interpretation of the condition for z is similar.

farmers. Note that we get the usual result of no distortion at the top as $\lambda(\overline{\theta}) = 0$ which means no distortion for the highest type of farmers. Actually, $\frac{d(E_\theta)}{dl}$ measures how much land use l affects the potential effort savings ($E_\theta < 0$) associated with an increase in efficiency. It also measures how the rent $U'(\theta)$ evolves with l. Note that we have:

$$\frac{d(E_\theta)}{dl} = \frac{\partial}{\partial l}\left(-\frac{f_\theta}{f_e}\right) = -\frac{f_{\theta l}f_e - f_\theta f_{el}}{(f_e)^2} > 0$$

if and only if

$$\frac{f_{el}}{f_e} > \frac{f_{\theta l}}{f_\theta}(> 0).$$

which means in terms of elasticity that the elasticity of marginal productivity of ability with respect to land use is lower than the elasticity of marginal productivity of effort with respect to land use. In other words, land use has a more (positive) influence on the marginal productivity of effort than on the marginal productivity of ability.

It follows that by increasing the land use of a type-θ farmer, one also decreases the (positive) rate of growth $U'(\theta) = -\psi' E_\theta$ of the rent devoted to this farmer and hence the rents to all more efficient farmers (between θ and $\overline{\theta}$). The social cost of this decrease is $\lambda(\theta)\frac{d(U'(\theta))}{dl}$. On the other hand, the distortion in l for type θ relative to the first best level $\left(pf_l - r - \frac{\mu}{\nu}x_l\right)$ has social cost $\nu\left(pf_l - r - \frac{\mu}{\nu}x_l\right)$ and occurs with probability $k(\theta)$. The trade-off between redistribution and efficiency thus yields to the condition in the Proposition. Finally, for the highest type, there is no more efficient farmers on which one would want to extract rents and this calls for efficiency at the top, i.e. $\lambda(\overline{\theta}) = 0$.

Now it is possible to obtain a result in the spirit of Laffont-Tirole (1991) on the dichotomy between the tasks of redistributing income among farmers and the tasks of correctly pricing land and fertilizer by taking into account externalities.

Proposition 3 *The tasks of distributing income support among farmers and the tasks of correctly pricing land and fertilizer by taking into account externalities are disconnected if* $f(l, z, e, \theta) = f(l, z, h(e, \theta))$. *Under this assumption, we obtain the first-best rules for land*

and fertilizer (for a given effort)

$$\begin{aligned} pf_l(l(\theta), z(\theta), e(\theta), \theta) &= r + \frac{\mu}{\nu} x_l(z(\theta), l(\theta)) \\ pf_z(l(\theta), z(\theta), e(\theta), \theta) &= w + \frac{\mu}{\nu} x_z(z(\theta), l(\theta)) \end{aligned}$$

while the effort remains distorted for redistributive purposes

$$pf_e(l(\theta), z(\theta), e(\theta), \theta) = \psi'(e(\theta)) + \frac{\lambda(\theta)}{\nu k(\theta)} \frac{d(\psi' E_\theta)}{de}.$$

Proof: If $f(l, z, e, \theta) = f(l, z, h(e, \theta))$ (Aggregation theorem of Leontieff (1947)), then

$$\begin{aligned} \frac{f_{el}}{f_e} &= \frac{f_{\theta l}}{f_\theta} \\ \frac{f_{ez}}{f_e} &= \frac{f_{\theta z}}{f_\theta} \end{aligned}$$

which implies that $\frac{d(E_\theta)}{dl} = \frac{d(E_\theta)}{dz} = 0$. ■

This Proposition applies for instance if f is a Cobb-Douglas function, i.e. $f = \theta e^{\alpha_1} z^{\alpha_2} l^{\alpha_3}$. Proposition 3 implies that the second best can be decentralized through a pure pigouvian regulation of x and l together with a non linear subsidy t as a function of π alone for redistributive purposes.

Concerning the effort decision, we have

$$pf_e(l(\theta), z(\theta), e(\theta), \theta) = \psi'(e(\theta)) + \frac{\lambda(\theta)}{\nu k(\theta)} \frac{d(\psi' E_\theta)}{de} \tag{4}$$

with

$$\begin{aligned} \frac{d(\psi' E_\theta)}{de} &= \psi' \frac{d(E_\theta)}{de} + \psi'' E_\theta \\ &= \psi' \left[\frac{\partial(-f_\theta / f_e)}{\partial e} \right] - \psi'' \frac{f_\theta}{f_e} \\ &= -\psi' \left[\frac{f_{\theta e} f_e - f_{ee} f_\theta}{(f_e)^2} \right] - \psi'' \frac{f_\theta}{f_e} < 0 \end{aligned}$$

as $f_{ee} \leq 0$ and $f_{\theta e} \geq 0$. This means that increasing the effort allows to increase the rate $U'(\theta)$ of growth of rents. This means that if the objective is to redistribute income towards the poorer farmers (i.e. if $\lambda(\theta) < 0$), it might be optimal to reduce the incentives to exert effort.

This is because increasing the effort amounts to finally get a more unequal distribution of incomes in the population. This expresses the conflict between the search for more equity between heterogenous farmers and efficiency. On the contrary, when $\lambda(\theta) > 0$, it is optimal to give incentives for effort in order to generate more incomes to the more efficient farmers.

It then appears that it is crucial to understand how the nature of objective (the desire to redistribute and the presence of social weights for different types of farmers) will generate the direction of the distortions under second best and this is precisely the role of $\lambda(\theta)$.

5.2 Implementation

Before looking at the sign of $\lambda(\theta)$, it is interesting to go back to the way the optimal policy can be implemented through the generalized transfer $t(\pi, z, l)$ intented for active farmers.[8] Facing such a transfer, the type-θ farmer maximizes his utility by choosing the land l, the fertilizer level z and the effort e (or equivalently the profit level π):

$$\max_{\pi,z,l} U = \pi + t(\pi, z, l) - \psi(E(\theta, l, z, \pi))$$

The corresponding first-order conditions for an interior solution are as follows:

$$\begin{aligned}
\frac{\partial U}{\partial \pi} &= 1 + \frac{\partial t}{\partial \pi} - \psi' E_\pi = 0 \\
\frac{\partial U}{\partial z} &= \frac{\partial t}{\partial z} - \psi' E_z = 0 \\
\frac{\partial U}{\partial l} &= \frac{\partial t}{\partial l} - \psi' E_l = 0
\end{aligned}$$

Recalling that $E_\pi = 1/pf_e$, we first get for the effort:

$$\frac{\partial t}{\partial \pi} = \frac{\psi' - pf_e}{pf_e} = -\frac{\lambda(\theta)}{\nu k(\theta) pf_e} \frac{d(\psi' E_\theta)}{de} \tag{5}$$

using (4). This means that whenever $\lambda(\theta) > (<) 0$, then the transfer t increases (decreases) in the observed level of profit. Intuitively, when $\lambda(\theta) > 0$, such a pattern gives incentives to the farmer to exert more effort. Conversely, when $\lambda(\theta) < 0$, it is optimal to reduce the incentives to exert effort as this goes against the search for a more equal distribution of

[8] Recall that non active farmers receive the uniform transfer τ.

incomes. Furthermore, at the top ($\theta = \overline{\theta}$), the marginal rate of subsidy is $\frac{\partial t}{\partial \pi} = 0$ because $\lambda(\overline{\theta}) = 0$.

Concerning the fertilizer level, we have

$$\begin{aligned} \frac{\partial t}{\partial z} &= \psi' E_z = -\psi' \frac{pf_z - w}{pf_e} \\ &= -\frac{\psi'}{pf_e} \left[\frac{\mu}{\nu} x_z(z(\theta), l(\theta)) + \frac{\lambda(\theta)}{\nu k(\theta)} \psi'(e(\theta)) \frac{d(E_\theta)}{dz} \right] \end{aligned}$$

It follows that the transfer should decrease with the fertilizer use due to the damage impact but this implicit tax also depends on the redistributive concern through the incentive distortion. If

$$(0 <) \frac{f_{ez}}{f_e} < \frac{f_{\theta z}}{f_\theta}$$

which once again means in terms of elasticity that the elasticity of marginal productivity of ability with respect to fertilizer use is larger than the elasticity of marginal productivity of effort with respect to fertilizer use, then $\frac{d(E_\theta)}{dz} < 0$. This means that if $\lambda(\theta) < 0$ then it is optimal to increase the implicit taxation of fertilizer for redistributive issues.[9]

In other words, if $\frac{d(E_\theta)}{dz} < 0$ then ceteris paribus the taxation on fertilizer is heavier than under the first best. In that case, if one increases the fertilizer use of a type-θ farmer, one also increases the rent of all more efficient farmers which goes against inequality preferences. Hence, the tax on fertilizer cannot escape from redistribution considerations except under the pricing-dichotomy assumption. The intuition goes as follows: when $\frac{dU'(\theta)}{dz} = -\psi' \frac{d(f_\theta / f_e)}{dz} \geq 0$, then more fertilizer makes it easier for the farmers to convert a superior ability into less effort. A farmer who wants to mimic the profit of a lower ability farmer uses more fertilizer than the farmer being mimicked. Finally, there is no reason to overtax the more able because there is nobody more able than him, hence first best taxation rule occurs.[10]

[9] Obviously, we would have the same situation but for opposite reasons when $\lambda(\theta) > 0$ and $\frac{d(E_\theta)}{dz} > 0$.
[10] A similar interpretation holds for the land use as well.

5.3 The direction of distortions

As suggested above, of utmost importance for the direction of the incentive distortions is the sign of the marginal cost of incentive compatibility $\lambda(\theta)$. For instance, from (4), we know that if $\lambda(\theta)$ is negative for all θ in $\left[\theta_s, \overline{\theta}\right]$ then it is optimal to distort downward the effort provided by all active farmers (except at the top). On the contrary, each times $\lambda(\theta)$ is positive this entails that distorting upwards the effort is optimal.

First, we know that there is no distortion at the top ($\lambda(\overline{\theta}) = 0$). Second, we also know that

$$\lambda(\theta_s) = \left[\nu - \alpha_0 \mathcal{W}'(U(\theta_s))\right] K(\theta_s) \tag{6}$$

Third, derivating the expression of $\lambda(\theta)$, we get

$$\lambda'(\theta) = \left[\nu - \alpha(\theta)\mathcal{W}'(U(\theta))\right] k(\theta). \tag{7}$$

It follows that a priori there are many possibilities for the pattern of $\lambda(\theta)$ over the set $\left[\theta_s, \overline{\theta}\right]$ depending in particular on the social weight function $\alpha(\theta)$. The following lemma is useful to obtain further results concerning the sign of $\lambda(\theta)$.

Lemma 4 *The marginal weighted social utility of income $\alpha(\theta)\mathcal{W}'(U(\theta))$ is increasing in θ if and only if the elasticity $\chi(\theta) = \theta\alpha'(\theta)/\alpha(\theta)$ of the social weight function is greater than $\rho(\theta) = -\theta\mathcal{W}''(U(\theta))U'(\theta)/\mathcal{W}'(U(\theta))$, the absolute value of the elasticity of the marginal social utility function $\mathcal{W}'(U(\theta))$ with respect to θ.*

Proof: We have

$$\begin{aligned} \frac{d}{d\theta}\left[\alpha(\theta)\mathcal{W}'(U(\theta))\right] &= \alpha'(\theta)\mathcal{W}'(U(\theta)) + \alpha(\theta)\mathcal{W}''(U(\theta))U'(\theta) \\ &= \alpha(\theta)\mathcal{W}'(U(\theta))\left[\frac{\alpha'(\theta)}{\alpha(\theta)} + \frac{\mathcal{W}''(U(\theta))U'(\theta)}{\mathcal{W}'(U(\theta))}\right]. \end{aligned}$$

Let us denote $\chi(\theta) = \theta\alpha'(\theta)/\alpha(\theta)$ the elasticity of the political weight function $\alpha(.)$ w.r.t θ. Also let us define $\rho(\theta) = -\frac{\theta\mathcal{W}''(U(\theta))U'(\theta)}{\mathcal{W}'(U(\theta))}$ as the absolute value of the elasticity of $\mathcal{W}'(U(\theta))$

with respect to θ (recall that $\mathcal{W}$ is concave and that $U' > 0$). Hence, $\alpha(\theta)\mathcal{W}'(U(\theta)) > 0$ if and only if $\chi(\theta) \geq \rho(\theta)$. ■

Hence the social weight function $\alpha(\theta)$ has to be sufficiently increasing in θ in order to counterbalance the desire to redistribute which is expressed by the concavity of $\mathcal{W}$. In the following, we describe the situations where the function $\alpha(\theta)\mathcal{W}'(U(\theta))$ is assumed to be monotone in θ, either increasing or decreasing.

We now introduce the following condition.

Condition 5 *The marginal weighted social utility of the income of the mean non active farmer, $\alpha_0\mathcal{W}'(U(\theta_s))$, is greater or equal to the average marginal weighted social utility of income for all agents, ν.*

From (6), this condition is equivalent to $\lambda(\theta_s) < 0$. This essentially means that the social weight of the poorest agents is rather high compared to the total population of farmers. In particular, Condition 5 holds in the particular case of equal social weights ($\alpha(\theta) = 1$ for any θ). We are now able to establish the following Proposition.

Proposition 6 *Assume that the marginal weighted social utility of income $\alpha(\theta)\mathcal{W}'(U(\theta))$ is decreasing in θ or equivalently that $\chi(\theta) \leq \rho(\theta)$. Then,*

(i) *the transfer $t(\pi, l, z)$ decreases in π if and only if Condition 5 holds,*

(ii) *the transfer $t(\pi, l, z)$ is first increasing and second decreasing in π if and only if Condition 5 does not hold.*

Proof: See appendix C. ■

The context described by Proposition 6 is one where the priority in terms of income support is directed towards the less efficient farmers, including those who are not active. This is because the marginal weighted social utility of income is decreasing in θ. We would then expect that the transfer should optimally decrease with the observed level of profit π as this is the way to reduce incentives to exert effort which entails a more equal distribution of incomes in the population. This intuitive result holds but only under Condition 1. Actually, as suggested by part (ii), it is possible for the optimal policy to gives incentives for effort for the less efficient active farmers by making t an increasing function of observed π.

Consider for instance the particular case where $\alpha(\theta) = 1$ for any θ (equal social weight situation). Here the only task of the government is to redistribute from the rich to the poor as $\mathcal{W}$ is concave. One can check that $\lambda(\theta)$ is negative, first decreasing then increasing. This means that the point where there is the highest decrease in the transfer when π increases lies somewhere between θ_s and $\overline{\theta}$.

Note finally that because of the no distortion at the top result, the transfer is always locally convex in the neighborhood of $\pi(\overline{\theta})$ which means that the rate of decrease in the transfer is lower when approaching the highest level of profit.

Examining the opposite situation where $\alpha(\theta)\mathcal{W}'(U(\theta))$ is an increasing function of θ, we obtain the following proposition.

Proposition 7 *Assume that the marginal weighted social utility of income $\alpha(\theta)\mathcal{W}'(U(\theta))$ is increasing in θ or equivalently that $\chi(\theta) \geq \rho(\theta)$. Then, the transfer $t(\pi, l, z)$ is increasing in π.*

Proof: See appendix D. ■

From Proposition 7, we deduce that it is optimal to make the transfer an increasing function of π in order to give incentives to exert effort. Nevertheless, from the no distortion at the top result, t is locally concave around $\pi(\overline{\theta})$. The highest marginal rate of subsidy is hence interior or in θ_s.

6 Observable aggregate variables

In this section, we discuss the optimal design of the income support and environmental policy when the regulator cannot observe the individual variables like the output level, the use of variable input like fertilizers or the amount of land involved in production. Hence, the policy can only rely on the observation of the status of each agent and their accounting profit. However, as the regulator can observe the aggregate consumption of fertilizer or land and the aggregate level of output, linear taxes are available. The taxes on output, land and fertilizer are denoted respectively t^q, t^l and t^z. In that case, we have to compute the optimal reaction of a farmer to these linear taxes.

The problem of the regulator is now to find the optimal uniform transfer τ for non active farmers, the optimal non linear transfer t as a function of observed π together with the linear taxes t^q, t^l and t^z in order to maximize the social welfare subject to the budget constraint and the environmental constraint. Hence, the utility of the type-θ farmer who is active writes as follows:

$$\max_{z,l,e} U = (p+t^q)f(l,z,e,\theta) - (w+t^z)z - (r+t^l)(l-l^{\circ}) + t(\pi) - \psi(e)$$

where $\pi = (p+t^q)f(l,z,e,\theta) - (w+t^z)z - (r+t^l)(l-l^{\circ})$. We denote z^*, l^* and e^* the optimal decisions for this farmer given the existing policy $\left\{t^q, t^l, t^z, t(\pi), \tau\right\}$.

Solving the regulator's problem, we establish the following Proposition.

Proposition 8 *At an optimal separating policy, the non linear transfer $t(\pi)$ depends on the presence of environmental externalities. The optimal effort of a type-θ farmer is given by*

$$pf_e = \psi' + \frac{\lambda(\theta)}{\nu k(\theta)} \frac{d(\psi' E_\theta)}{de} - (pf_l - r - \frac{\mu}{\nu} x_l) l_e^* - (pf_z - w - \frac{\mu}{\nu} x_z) z_e^* \tag{8}$$

Proof: See appendix E. ■

Comparing with Proposition 2, we now have two additional terms in determining the incentives to exert effort and thereby the way the non linear transfer $t(\pi)$ evolves. The last two terms of (8) correspond to the marginal impact of the effort on the profit net of the environmental damage. This is due to the fact that with only one non linear instrument, the regulator has to take into account the redistributive concern (through the term $\frac{\lambda(\theta)}{\nu k(\theta)} \frac{d(\psi' E_\theta)}{de}$) but also the influence of $t(\pi)$ on the decisions over land and fertilizer taken by the farmer. In other words, the income support policy must now take into account the presence of externalities contrary to the preceding section.

Intuitively, suppose for instance that $pf_z - w - \frac{\mu}{\nu} x_z < 0$ which means that at the optimum the type-θ farmer over-uses land compared to the first best. If increasing the effort also contributes to increase the fertilizer use, then the last term is positive and this means that it is optimal to reduce the transfer $t(\pi)$ at the margin because of the negative externalities due to z.

The linear taxes are designed optimally by taking account all their effects on incentives. Consider for instance the case of the optimal linear tax on fertilizer. From the appendix E we have the following condition:

$$\nu \int_{\theta_s}^{\overline{\theta}} \left[(pf_l - r) \, l^*_{t^z} + (pf_z - w) \, z^*_{t^z} \right] dK(\theta) - \mu \int_{\theta_s}^{\overline{\theta}} \left[x_z z^*_{t^z} + x_l l^*_{t^z} \right] dK(\theta)$$
$$- \int_{\theta_s}^{\overline{\theta}} \lambda(\theta) \frac{d(\psi' E_\theta)}{dt^z} d\theta = 0.$$

Rearranging, we have

$$\int_{\theta_s}^{\overline{\theta}} \left[\left(pf_l - r - \frac{\mu}{\nu} x_l \right) l^*_{t^z} + \left(pf_z - w - \frac{\mu}{\nu} x_z \right) z^*_{t^z} \right] dK(\theta) = \int_{\theta_s}^{\overline{\theta}} \frac{\lambda(\theta)}{\nu} \frac{d(\psi' E_\theta)}{dt^z} d\theta$$

Hence, the tax t^z is set such that the total marginal impact on profit net of damage is equal to the total marginal impact on the informational rents left to all active farmers. In other words, when manipulating the tax rate t^z the regulator will modify the decisions taken with respect to fertilizer and also land use. This will impact the social surplus of production $\pi - \frac{\mu}{\nu} x$. The other impact is that this tax influences the distribution of incomes in the population (which is reflected by the term . We have a similar interpretation for the tax t^l on land and the subsidy t^q on production.

7 Introducing an endogenous market price for lands

In this section, we go back to the second best analysis of section 5 but we also introduce the possibility of having an endogenous market price for land. For simplicity, we consider only the case where the social weights are equal ($\alpha(\theta) = 1$ for any θ).

Let L the total amount of land used in the agricultural sector and $V(L)$ the value (or opportunity cost) of land in other sectors, that is increasing and concave. The market value of land per acre is then given by

$$r(L) = -V'(L)$$

where $r'(L) > 0$ because of diminishing returns to land use in other sectors.

Following Innes (2003), suppose that we have the endowment for agricultural usage denoted $L^{\circ} = N\int_{\Theta} l^{\circ} dK(\theta)$ and we denote also L the total land used for agriculture. N represents the number of farmers that is hereafter normalized to equal one, $N = 1$. Similarly, for non agriculture usage, we have L°_{NA} and L_{NA}. We have

$$V(L) = \max_{L_T \geq L^{\circ} + L^{\circ}_{NA}} B(L_T - L) - c(L_T - L^{\circ} - L^{\circ}_{NA})$$

where $L_T = L + L_{NA}$ is the aggregate land use and $c(.)$ is the increasing, convex cost of developing new lands. We also have

$$\max_{L_{NA}} B(L_{NA}) - rL_{NA} \Leftrightarrow B'(L_{NA}) = r = -V'(L)$$

It follows that the associated supply function is $L^S(r)$ and it is given implicitly by $r = r(L - L^{\circ})$. And the equilibrium on the market of land is described by

$$L^S(r^*) + L^{\circ} = \int_{\Theta} l^*(r^*;\theta)dK(\theta)$$

where we denote the demand for land from a type-θ farmer by $l^*(r^*;\theta)$. The model encompasses the limit cases where the supply of land is either fixed (perfectly inelastic) as in Guyomard et al. (2005) or perfectly elastic (which means that r is constant) as in Bourgeon and Chambers (2000).

The objective of the regulator is written as the sum of social utility of profits plus the value of land use and the land rents of the landowners. However, because the social utility $\mathcal{W}$ is only defined up to an increasing transformation, we normalize the problem by aggregating the certainty equivalent:

$$CE(U) = \mathcal{W}^{-1}\left(\int_{\underline{\theta}}^{\overline{\theta}} \mathcal{W}(U(\theta))dK(\theta)\right)$$

with the opportunity cost of land use and the rents of landowners which can be written as

$$\begin{aligned} & B(L_{NA}) - r(L_{NA} - L_{NA}^{\circ}) + r(L_{NA} + L - L^{\circ} - L_{NA}^{\circ}) - c(L_T - L^{\circ} - L_{NA}^{\circ}) \\ = \;& B(L_{NA}) + r(L - L^{\circ}) - c(L_T - L^{\circ} - L_{NA}^{\circ}) \\ = \;& V(L) + r(L - L^{\circ}) \end{aligned}$$

Hence, the objective of the regulator sums up to maximize

$$CE(U) + V(L) + r(L - L^{\circ})$$

under the budget constraint, the environmental constraint and the incentive compatibility constraints as written in section 5. Solving this program, we establish the following proposition.

Proposition 9 *Assuming a separating optimal policy, the optimal allocation of land use with endogenous market price for land is given by*

$$pf_l(l(\theta), z(\theta), e(\theta), \theta) = r + \frac{\delta}{\nu} + \frac{\mu}{\nu} x_l(z(\theta), l(\theta)) + \frac{\lambda(\theta)}{\nu k(\theta)} \psi'(e(\theta)) \frac{d(E_\theta)}{dl} \qquad (9)$$

where

$$\lambda(\theta) = -\nu(1 - K(\theta)) + \int_{\theta}^{\overline{\theta}} \frac{\mathcal{W}'(U(u))}{\mathcal{W}'(CE(U))} k(u)du$$

and

$$\delta = r'(L)\left[(\nu - 1)L - \nu K(\theta_s) l^{\circ}\right].$$

Proof: See appendix F. ■

Proposition 9 suggests that when the market price is endogenous, the optimal policy now takes into account the shadow price δ of the aggregate land demand L from the agricultural sector. Obviously, if the market price r is constant ($r'(L) = 0$) then we are back to Proposition

5, with the only minor difference in the evolution of $\lambda(\theta)$ due to the normalization through the certainty equivalent $CE(U)$ in the objective in place of $\mathbb{E}_\theta \mathcal{W}(U)$.

The intuition of the expression of δ goes as follows. As $r'(L) > 0$, due to diminishing returns to land use in other sectors, each time we increase marginally the land use $l(\theta)$ for a type-θ farmer, this has also some consequences for the rest of the economy. Indeed, as the price r increases, this induces a marginal loss to all active farmers who have to pay a larger price for land and this needs a compensation in terms of income support which costs ν times L. But on the other hand, we also increase the rents of landowners marginally over L units. Last, we also increase the income of non active farmers (in proportion $K(\theta_s)$) who rent their endowment l° and hence are less needed to get socially costly income support.

Consequently, if the drawback for active farmers outweighs the advantage for landowners' rents and non active farmers' income, then at the optimum, we have $\delta > 0$. Hence, if we assume for simplicity the absence of asymmetric information ($\lambda(\theta) = 0$) and the absence of land impact on the environmental constraint ($x_l = 0$), then the optimal land use of a type-θ farmer should be set such that the private marginal return should be equal to the social price which is equal to r plus the *positive* shadow price δ weighted by the shadow cost ν of the budget constraint. In other words, it is optimal ceteris paribus to induce an under-use of land compared to the first best with constant market price given by $pf_l = r$.

8 Conclusions

In this paper, we have developed a model of regulation for a set of heterogenous farmers whose production yields to environmental externalities. The goal of the regulator is first to offer some income support depending on collective preferences towards income redistribution and second to internalize externalities. The optimal policy is constrained by the information available. We first considered the second best where the regulator is able to observe all individuals decisions in terms of inputs and individual profit, but not the individual farming labor supply. We characterized the generalized transfer in function of the desire to redistribute and the underlying characteristics of the production process. In a second step, we assumed that the regulator has only information on aggregate consumption of inputs and hence can only tax/subsidy linearly inputs and output. However, because the accounting profit remains observable, a non linear transfer of profit is still part of the optimal policy. In the last part of the paper, we have endogenized the market price of land and examine how the optimal policy should be modified.

Obviously, the limit of such an approach of income support and agri-environmental regulation lies in its static character. Also a natural extension would consider a model where farmers are heterogenous along other dimensions, for instance the endowment in land l° or the disutility of effort. Finally, it would be interesting to introduce price and production uncertainty (see Sheriff 2008 for a first approach) to better understand the insurance role of regulation in agriculture. All these interesting extensions are devoted to further research.

References

[1] Bontems P., Turpin N. and G. Rotillon (2005), "Self-selecting agri-environmental policies with an application to the Don watershed",*Environmental and Resource Economics*, 31:275-301.

[2] Bontems P., Turpin N. and G. Rotillon (2007), "Acceptable reforms of agri-environmental policies", mimeo.

[3] Bourgeon J.M. and R. Chambers (2000), "Stop and Go Agricultural Policies", *American Journal of Agricultural Economics*, 82:1-13.

[4] Cremer H., Ghavari F. and N. Ladoux (1998), "Externalities and optimal taxation", *Journal of Public Economics*, 70:343-364.

[5] Feng H. (2007), "Green Payments and Dual Policy Goals", *Journal of Environmental and Economics Management*, 54:323-335.

[6] Guyomard H., Le Mouël C. and A. Gohin (2004), "Impacts of alternative agricultural income support schemes on multiple policy goals", *European Review of Agricultural Economics*, 31(2):125-148.

[7] Hueth B. (2000), "The goal of US agricultural policy: a mechanism design approach", *American Journal of Agricultural Economics*, 82(1):14-24.

[8] Innes R. (2003), "Stop and Go Agricultural Policies with a Land Market", *American Journal of Agricultural Economics*, 85(1):198-215.

[9] Leathers H. (1992), "The market for land and the impact of farm programs on farm numbers", *American Journal of Agricultural Economics*, 74(2):291-298.

[10] Lewis T., Feenstra R. and R. Ware (1989), "Eliminating price supports", *Journal of Public Economics*, 40:159-185.

[11] Sheriff G. (2008), "Optimal environmental regulation of politically influential sectors with asymmetric information", *Journal of Environmental and Economics Management*, 55:72-89.

[12] Wu J. and B.A. Babcock (1995), "Optimal design of a voluntary green payment program under asymmetric information", *Journal of Agricultural and Resource Economics*, 20(2):316-327.

Appendix

A Proof of proposition 1

The Lagrangean writes as follows:

$$\begin{aligned}\mathcal{L} &= \int_{\theta_s}^{\overline{\theta}} \alpha(\theta)\mathcal{W}(\pi(\theta)+T(\theta)-\psi(e(\theta)))dK(\theta) + \int_{\underline{\theta}}^{\theta_s} \alpha(\theta)\mathcal{W}(v+rl^{\circ}+\tau)dK(\theta) \\ &\quad +\nu\left(B-\int_{\underline{\theta}}^{\theta_s}\tau dK(\theta)-\int_{\theta_s}^{\overline{\theta}}T(\theta)dK(\theta)\right)+\mu\left(X-\int_{\theta_s}^{\overline{\theta}}x(z(\theta),l(\theta))dK(\theta)\right)\end{aligned}$$

Pointwise maximization gives us the following first-order conditions:

$$\begin{aligned}\alpha(\theta)\mathcal{W}'(U(\theta))\left[pf_l-r\right] &= \mu x_l \\ \alpha(\theta)\mathcal{W}'(U(\theta))\left[pf_z-r\right] &= \mu x_z \\ \alpha(\theta)\mathcal{W}'(U(\theta))\left[pf_e-\psi'\right] &= 0\end{aligned}$$

together with

$$\alpha(\theta)\mathcal{W}'(U(\theta))=\nu$$

for any $\theta \geq \theta_s$. Also, derivating with respect to τ, we get

$$\alpha_0\mathcal{W}'(v+rl^{\circ}+\tau)=\nu$$

where we denote $\alpha_0=\frac{1}{K(\theta_s)}\int_{\underline{\theta}}^{\theta_s}\alpha(\theta)dK(\theta)$. Finally we also have (assuming an interior solution)

$$\frac{\partial\mathcal{L}}{\partial\theta_s}=-\mu x(z(\theta_s),l(\theta_s))-\nu(\tau-T(\theta_s))=0$$

which gives the identity of the marginal farmer. This concludes the proof.

B Proof of Proposition 2

A type-θ farmer solves the following program:

$$\max_{e,\tilde{\theta}} \pi(\tilde{\theta})+T(\tilde{\theta})-\psi(e)$$

s.t.

$$\pi(\tilde{\theta})=pf(l(\tilde{\theta}),z(\tilde{\theta}),e,\theta)-wz(\tilde{\theta})-r(l(\tilde{\theta})-l^{\circ})$$

Hence the farmer's program can be rewritten as follows:

$$\max_{\tilde{\theta}} \pi(\tilde{\theta}) + T(\tilde{\theta}) - \psi(E(\theta, l(\tilde{\theta}), z(\tilde{\theta}), \pi(\tilde{\theta})))$$

and we denote $U(\theta, \tilde{\theta}) = \pi(\tilde{\theta}) + T(\tilde{\theta}) - \psi(E(\theta, l(\tilde{\theta}), z(\tilde{\theta}), \pi(\tilde{\theta})))$ the utility of a type-θ farmer announcing to be of type $\tilde{\theta}$. Incentive compatibility requires that:

$$\left.\frac{\partial U}{\partial \tilde{\theta}}\right|_{\tilde{\theta}=\theta} = 0 \text{ and } \left.\frac{\partial^2 U}{\partial \tilde{\theta} \partial \theta}\right|_{\tilde{\theta}=\theta} \geq 0$$

that is

$$\left.\frac{\partial U}{\partial \tilde{\theta}}\right|_{\tilde{\theta}=\theta} = \pi'(\theta) + T'(\theta) - \psi' \left[E_l l'(\theta) + E_z z'(\theta) + E_\pi \pi'(\theta)\right] = 0$$

and

$$\begin{aligned} \left.\frac{\partial^2 U}{\partial \tilde{\theta} \partial \theta}\right|_{\tilde{\theta}=\theta} &= -\psi'' E_\theta \left[E_l l'(\theta) + E_z z'(\theta) + E_\pi \pi'(\theta)\right] - \psi' \left[E_{l\theta} l'(\theta) + E_{z\theta} z'(\theta) + E_{\pi\theta} \pi'(\theta)\right] \\ &= l'(\theta) \left[\psi'' E_\theta E_l + \psi' E_{l\theta}\right] + z'(\theta) \left[\psi'' E_\theta E_z + \psi' E_{z\theta}\right] + \pi'(\theta) \left[\psi'' E_\theta E_\pi + \psi' E_{\pi\theta}\right] \leq 0 \end{aligned}$$

which will be checked ex-post.

If we denote $U(\theta) = U(\theta, \theta)$ then we have

$$U'(\theta) = -\psi'(e) E_\theta(\theta, l, z, \pi(\theta, l, z, e)) > 0$$

so that the rent is increasing in θ.

Hence the program to be solved (ignoring the second order constraint) is

$$\max_{e,l,z,\theta_s,\tau,U} \int_{\theta_s}^{\overline{\theta}} \alpha(\theta) \mathcal{W}(U(\theta)) dK(\theta) + \int_{\underline{\theta}}^{\theta_s} \alpha(\theta) \mathcal{W}(v + r l^\circ + \tau) dK(\theta)$$

s.t.

$$\int_{\underline{\theta}}^{\theta_s} \tau dK(\theta) + \int_{\theta_s}^{\overline{\theta}} \left[U(\theta) - \pi(\theta, l(\theta), z(\theta), e(\theta)) + \psi(e(\theta))\right] dK(\theta) \leq B$$

$$\int_{\theta_s}^{\overline{\theta}} x(z(\theta), l(\theta)) dK(\theta) \leq X$$

$$U(\theta_s) = v + r l^\circ + \tau$$

$$U'(\theta) = -\psi'(e(\theta)) E_\theta(\theta, l(\theta), z(\theta), \pi(\theta, l(\theta), z(\theta), e(\theta)))$$

$$\pi(\theta, l(\theta), z(\theta), e(\theta)) = p f(l(\theta), z(\theta), e(\theta), \theta) - w z(\theta) - r(l(\theta) - l^\circ)$$

or equivalently

$$\max \int_{\theta_s}^{\overline{\theta}} \alpha(\theta)\mathcal{W}(U(\theta))dK(\theta) + \alpha_0\mathcal{W}(v + rl^{\circ} + \tau)K(\theta_s)$$

s.t.

$$\tau K(\theta_s) + \int_{\theta_s}^{\overline{\theta}} \left[U(\theta) - \pi(\theta, l(\theta), z(\theta), e(\theta)) + \psi(e(\theta))\right] dK(\theta) \leq B$$

$$\int_{\theta_s}^{\overline{\theta}} x(z(\theta), l(\theta))dK(\theta) \leq X$$

$$U(\theta_s) = v + rl^{\circ} + \tau$$

$$U'(\theta) = -\psi'(e(\theta))E_{\theta}(\theta, l(\theta), z(\theta), \pi(\theta, l(\theta), z(\theta), e(\theta)))$$

$$\pi(\theta, l(\theta), z(\theta), e(\theta)) = pf(l(\theta), z(\theta), e(\theta), \theta) - wz(\theta) - r(l(\theta) - l^{\circ})$$

The Lagrangean writes as follows:

$$\begin{aligned}
\mathcal{L} \quad = \quad & \int_{\theta_s}^{\overline{\theta}} \alpha(\theta)\mathcal{W}(U(\theta))dK(\theta) + \alpha_0\mathcal{W}(v + rl^{\circ} + \tau)K(\theta_s) \\
& +\nu \left(B - \tau K(\theta_s) - \int_{\theta_s}^{\overline{\theta}} \Big[U(\theta) - pf(l(\theta), z(\theta), e(\theta), \theta) + wz(\theta) + r(l(\theta) - l^{\circ}) + \psi(e(\theta))\Big] dK(\theta) \right) \\
& +\mu \left(X - \int_{\theta_s}^{\overline{\theta}} x(z(\theta), l(\theta))dK(\theta) \right) + \int_{\theta_s}^{\overline{\theta}} \lambda(\theta) \big(-\psi' E_{\theta} - U'(\theta)\big) d\theta
\end{aligned}$$

Integrating by parts the last term containing $U'(\theta)$ we get

$$\begin{aligned}
\int_{\theta_s}^{\overline{\theta}} \lambda(\theta)U'(\theta)d\theta \quad &= \quad [\lambda(\theta)U(\theta)]_{\theta_s}^{\overline{\theta}} - \int_{\theta_s}^{\overline{\theta}} \lambda'(\theta)U(\theta)d\theta \\
&= \quad -\lambda(\theta_s)U(\theta_s) - \int_{\theta_s}^{\overline{\theta}} \lambda'(\theta)U(\theta)d\theta
\end{aligned}$$

as $\lambda(\overline{\theta}) = 0$ because the value of U at $\overline{\theta}$ is free. Replacing in the Lagrangean (and recall that $U(\theta_s) = v + rl^{\circ} + \tau$), we obtain:

$$\begin{aligned}
\mathcal{L} \quad = \quad & \int_{\theta_s}^{\overline{\theta}} \alpha(\theta)\mathcal{W}(U(\theta))dK(\theta) + \alpha_0\mathcal{W}(v + rl^{\circ} + \tau)K(\theta_s) \\
& +\nu \left(B - \tau K(\theta_s) - \int_{\theta_s}^{\overline{\theta}} \Big[U(\theta) - pf(l(\theta), z(\theta), e(\theta), \theta) + wz(\theta) + r(l(\theta) - l^{\circ}) + \psi(e(\theta))\Big] dK(\theta) \right) \\
& +\mu \left(X - \int_{\theta_s}^{\overline{\theta}} x(z(\theta), l(\theta))dK(\theta) \right) + \lambda(\theta_s) \Big[v + rl^{\circ} + \tau\Big] + \int_{\theta_s}^{\overline{\theta}} \Big\{\lambda'(\theta)U(\theta) - \lambda(\theta)\psi' E_{\theta}\Big\} d\theta
\end{aligned}$$

Derivating, we get the following necessary conditions (for $\theta \in [\theta_s, \overline{\theta}]$):

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial \tau} &= \alpha_0 \mathcal{W}'(v + rl^{\circ} + \tau)K(\theta_s) - \nu K(\theta_s) + \lambda(\theta_s) = 0 \qquad (10)\\
\frac{\partial \mathcal{L}}{\partial l(\theta)} &= \nu(pf_l - r)k(\theta) - \mu x_l k(\theta) - \lambda(\theta)\psi' \frac{d(E_\theta)}{dl} = 0\\
\frac{\partial \mathcal{L}}{\partial z(\theta)} &= \nu(pf_z - w)k(\theta) - \mu x_z k(\theta) - \lambda(\theta)\psi' \frac{d(E_\theta)}{dz} = 0\\
\frac{\partial \mathcal{L}}{\partial e(\theta)} &= \nu(pf_e - \psi')k(\theta) - \lambda(\theta)\frac{d(\psi' E_\theta)}{de} = 0\\
\frac{\partial \mathcal{L}}{\partial U(\theta)} &= \alpha(\theta)\mathcal{W}'(U(\theta))k(\theta) - \nu k(\theta) + \lambda'(\theta) = 0
\end{aligned}$$

and $\frac{\partial \mathcal{L}}{\partial \theta_s} = 0$ which implies:

$$pf(l(\theta_s), z(\theta_s), e(\theta_s), \theta_s) - rl(\theta_s) - wz(\theta_s) - \psi(e(\theta_s)) - \frac{\mu}{\nu}x(z(\theta_s), l(\theta_s)) - \frac{\lambda(\theta_s)}{\nu k(\theta_s)}\psi'(e(\theta_s))\ E_\theta|_{\theta=\theta_s} = v.$$

Integrating $\lambda'(\theta)$, we get

$$\begin{aligned}
\int_\theta^{\overline{\theta}} \lambda'(\theta)d\theta &= \int_\theta^{\overline{\theta}} \{\nu - \alpha(\theta)\mathcal{W}'(U(\theta))\}\, k(\theta)d\theta\\
\lambda(\theta) &= -\nu(1 - K(\theta)) + \int_\theta^{\overline{\theta}} \alpha(\theta)\mathcal{W}'(U(\theta))dK(\theta)
\end{aligned}$$

so that the (positive) shadow cost of the budget constraint writes (using (10)):

$$\nu = \int_{\theta_s}^{\overline{\theta}} \alpha(\theta)\mathcal{W}'(U(\theta))dK(\theta) + \alpha_0\mathcal{W}'(v + rl^{\circ} + \tau)K(\theta_s) > 0$$

which represents the sum of all marginal (weighted) social utilities. And we also obtain that

$$\begin{aligned}
\lambda(\theta_s) &= \left[\nu - \alpha_0\mathcal{W}'(v + rl^{\circ} + \tau)\right] K(\theta_s)\\
&= K(\theta_s)\left[\int_{\theta_s}^{\overline{\theta}} \left\{\alpha(\theta)\mathcal{W}'(U(\theta)) - \alpha_0\mathcal{W}'(v + rl^{\circ} + \tau)\right\} dK(\theta)\right]
\end{aligned}$$

This concludes the proof.

C Proof of Proposition 6

Assume that the function $\alpha(\theta)\mathcal{W}'(U(\theta))$ is decreasing in θ. Part (i): from equation (5), $\frac{\partial t}{\partial \pi} < 0$ everywhere if and only if $\lambda(\theta)$ is non positive everywhere. As the function $\alpha(\theta)\mathcal{W}'(U(\theta))$ is decreasing in θ, there two possible situations. Either $\alpha(\theta)\mathcal{W}'(U(\theta))$ is lower than ν for any θ and consequently $\lambda'(\theta) > 0$ everywhere.[11] As $\lambda(\theta)$ is increasing and because $\lambda(\overline{\theta}) = 0$, it must be that Condition 5 $\lambda(\theta_s) < 0$ holds. Or $\alpha(\theta)\mathcal{W}'(U(\theta))$ intersects once ν for an intermediate value of θ and consequently $\lambda'(\theta)$ is first negative then positive. Once again, for $\lambda(\theta)$ to be non positive everywhere, Condition 5 must hold. Conversely, if Condition 5 holds then $\lambda(\theta)$ is non positive everywhere. Otherwise, the assumption that $\alpha(\theta)\mathcal{W}'(U(\theta))$ is decreasing in θ would be violated.

Part (ii): from equation (5), $\frac{\partial t}{\partial \pi}$ is first positive then negative if and only if $\lambda(\theta)$ is first positive then negative. For $\lambda(\theta_s)$ to be positive, obviously Condition 5 must not hold. This amounts to

$$\begin{aligned}\lambda(\theta_s) &= \left[\nu - \alpha_0\mathcal{W}'(U(\theta_s))\right] K(\theta_s) \\ &= \left[\int_{\theta_s}^{\overline{\theta}} \left[\alpha(\theta)\mathcal{W}'(U(\theta)) - \alpha_0\mathcal{W}'(U(\theta_s))\right] dK(\theta)\right] K(\theta_s) > 0\end{aligned}$$

which is possible if $\alpha(\theta)$ increases sufficiently in θ.

Note also that $\lambda(\theta)$ cannot be positive for any θ. Indeed, for $\lambda(\theta)$ to be positive everywhere, we would have $\lambda'(\overline{\theta}) < 0$ or equivalently

$$\begin{aligned}\alpha(\overline{\theta})\mathcal{W}'(U(\overline{\theta})) &> \nu \\ \alpha(\overline{\theta})\mathcal{W}'(U(\overline{\theta})) &> \int_{\theta_s}^{\overline{\theta}} \alpha(\theta)\mathcal{W}'(U(\theta))dK(\theta) + \alpha_0\mathcal{W}'(U(\theta_s))K(\theta_s)\end{aligned}$$

which is impossible as $\int_{\theta_s}^{\overline{\theta}} \alpha(\theta)\mathcal{W}'(U(\theta))dK(\theta) > \alpha(\overline{\theta})\mathcal{W}'(U(\overline{\theta}))$.

Conversely, if Conditions 5 does not hold then $\lambda(\theta_s)$ is positive and $\lambda(\theta)$ is necessarily negative in the neighborhood of $\overline{\theta}$. Hence, $\frac{\partial t}{\partial \pi}$ is first positive then negative.This concludes the proof.

[11] For this case to be possible, a sufficient condition is that $\alpha(\theta)$ decreases in θ. Indeed, $\alpha(\theta)\mathcal{W}'(U(\theta))$ is lower than ν everywhere if and only if $\alpha(\theta_s)\mathcal{W}'(U(\theta_s)) < \nu$ which is equivalent to

$$\int_{\theta_s}^{\overline{\theta}} \alpha(\theta)\mathcal{W}'(U(\theta))dK(\theta) + \left[\alpha_0 K(\theta_s) - \alpha(\theta_s)\right]\mathcal{W}'(U(\theta_s)) > 0.$$

A sufficient condition is $\alpha_0 K(\theta_s) > \alpha(\theta_s)$ which is guaranteed when $\alpha(\theta)$ decreases in θ.

D Proof of Proposition 7

Assume that the function $\alpha(\theta)\mathcal{W}'(U(\theta))$ is increasing in θ. We have several possibilities for the pattern of $\alpha(\theta)\mathcal{W}'(U(\theta))$ compared to the constant ν. First consider the case where $\alpha(\theta)\mathcal{W}'(U(\theta))$ is greater than ν for any θ. This implies that $\lambda'(\theta) < 0$ and hence it must be that $\lambda(\theta)$ is positive everywhere so that t is increasing in π. Second consider the situation where $\alpha(\theta)\mathcal{W}'(U(\theta))$ intersects once ν. It follows that $\lambda(\theta)$ is first increasing then decreasing. However, it is impossible to have $\lambda(\theta_s) < 0$. Indeed,

$$\begin{aligned} \lambda(\theta_s) &= \left[\nu - \alpha_0 \mathcal{W}'(U(\theta_s))\right] K(\theta_s) \\ &= \left[\int_{\theta_s}^{\overline{\theta}} \left[\alpha(\theta)\mathcal{W}'(U(\theta)) - \alpha_0 \mathcal{W}'(U(\theta_s))\right] dK(\theta)\right] K(\theta_s) > 0 \end{aligned}$$

as $\alpha(\theta)\mathcal{W}'(U(\theta))$ is increasing in θ. It follows that $\lambda(\theta)$ is positive everywhere. Last, it is easy to check that the case where $\alpha(\theta)\mathcal{W}'(U(\theta))$ is lower than ν for any θ cannot appear. Indeed, In such a case, we would have $\lambda'(\theta) > 0$ and hence it must be that $\lambda(\theta) < 0$ everywhere which contradicts the fact that $\lambda(\theta_s) > 0$. This concludes the proof.

E Proof of Proposition 8

A type-θ farmer solves the following program:

$$\max_{e,l,z,\tilde{\theta}} \pi(\tilde{\theta}) + T(\tilde{\theta}) - \psi(e)$$

s.t.

$$\pi(\tilde{\theta}) = (p + t^q) f(l, z, e, \theta) - (w + t^z) z - (r + t^l)(l - l^\circ)$$

Once again, by defining the effort function $E(\theta, l, z, \pi)$, we can transform the program as follows:

$$\max_{l,z,\tilde{\theta}} \pi(\tilde{\theta}) + T(\tilde{\theta}) - \psi(E(\theta, l, z, \pi(\tilde{\theta}))).$$

Given $\tilde{\theta}$, the optimal solution for l and z is defined by minimizing $\psi(E(\theta, l, z, \pi(\tilde{\theta})))$, i.e.:

$$\begin{aligned} (p + t^q) f_l(l, z, E(\theta, l, z, \pi(\tilde{\theta})), \theta) &= r + t^l \quad \text{(i.e. } E_l = 0) \\ (p + t^q) f_z(l, z, E(\theta, l, z, \pi(\tilde{\theta})), \theta) &= w + t^z \quad \text{(i.e. } E_z = 0). \end{aligned}$$

This system implicitly defines the functions $l^*(\theta, \tilde{\theta})$ and $z^*(\theta, \tilde{\theta})$. Then the farmer's program becomes:

$$\max_{\tilde{\theta}} U(\theta, \tilde{\theta}) = \pi(\tilde{\theta}) + t(\tilde{\theta}) - \psi(E(\theta, l^*(\theta, \tilde{\theta}), z^*(\theta, \tilde{\theta}), \pi(\tilde{\theta}))).$$

Incentive compatibility requires that:

$$\left.\frac{\partial U}{\partial \tilde{\theta}}\right|_{\tilde{\theta}=\theta} = 0 \text{ and } \left.\frac{\partial^2 U}{\partial \tilde{\theta} \partial \theta}\right|_{\tilde{\theta}=\theta} \geq 0$$

We have (using the envelop theorem, i.e.$E_l = E_z = 0$)

$$\left.\frac{\partial U}{\partial \tilde{\theta}}\right|_{\tilde{\theta}=\theta} = \pi'(\theta) + T'(\theta) - \psi' E_\pi \pi'(\theta) = 0$$

or equivalently

$$U'(\theta) = -\psi' E_\theta \geq 0$$

Also, we get:

$$\left.\frac{\partial^2 U}{\partial \tilde{\theta} \partial \theta}\right|_{\tilde{\theta}=\theta} = -\psi'' E_\pi \pi'(\theta) \left[E_\theta + E_l l_\theta^* + E_z z_\theta^*\right] - \psi' \pi'(\theta) \left[E_{\theta\pi} + E_{\pi z} z_\theta^* + E_{\pi l} l_\theta^*\right] \geq 0$$

Applying again the envelop theorem, we get

$$\left.\frac{\partial^2 U}{\partial \tilde{\theta} \partial \theta}\right|_{\tilde{\theta}=\theta} = \pi'(\theta) \left[-\psi'' E_\pi E_\theta - \psi' \left[E_{\theta\pi} + E_{\pi z} z_\theta^* + E_{\pi l} l_\theta^*\right]\right] \geq 0$$

As $E_\theta < 0$, $E_\pi = 1/f_e > 0$ and

$$\begin{aligned}
\frac{\partial^2 E}{\partial \pi \partial z} &= \frac{\partial}{\partial z}\left(\frac{1}{f_e}\right) = -\frac{f_{ez}}{(f_e)^2} \leq 0 \\
\frac{\partial^2 E}{\partial \pi \partial \theta} &= \frac{\partial}{\partial \theta}\left(\frac{1}{f_e}\right) = -\frac{f_{e\theta}}{(f_e)^2} \leq 0 \\
\frac{\partial^2 E}{\partial \pi \partial l} &= \frac{\partial}{\partial l}\left(\frac{1}{f_e}\right) = -\frac{f_{el}}{(f_e)^2} \leq 0
\end{aligned}$$

together with $z_\theta > 0$ and $l_\theta > 0$, then

$$\left.\frac{\partial^2 U}{\partial \tilde{\theta} \partial \theta}\right|_{\tilde{\theta}=\theta} \geq 0 \Leftrightarrow \pi'(\theta) \geq 0$$

The program of the regulator is thus

$$\max \int_{\theta_s}^{\overline{\theta}} \alpha(\theta) \mathcal{W}(U(\theta)) dK(\theta) + \int_{\underline{\theta}}^{\theta_s} \alpha(\theta) \mathcal{W}(v + r l^{\circ} + \tau) dK(\theta)$$

under the budget constraint, the environmental constraint and the incentive compatibility constraint (ignoring the second order conditions) $U'(\theta) = -\psi' E_\theta \geq 0$.

The budget constraint writes

$$\int_{\underline{\theta}}^{\theta_s} \tau dK(\theta) + t^q \int_{\theta_s}^{\overline{\theta}} f(l^*, z^*, e, \theta) dK(\theta) - t^z \int_{\theta_s}^{\overline{\theta}} z^* dK(\theta)$$
$$-t^l \int_{\theta_s}^{\overline{\theta}} l^* dK(\theta) + \int_{\theta_s}^{\overline{\theta}} \left[U(\theta) - \pi(\theta, l^*, z^*, e) + \psi(e)\right] dK(\theta) \leq B$$

which simplifies into

$$\int_{\underline{\theta}}^{\theta_s} \tau dK(\theta) + \int_{\theta_s}^{\overline{\theta}} \left[U(\theta) - pf(l^*, z^*, e, \theta) + wz^* + r(l^* - l^{\circ}) + \psi(e)\right] dK(\theta) \leq B$$

The Lagrangean writes

$$\begin{aligned}
\mathcal{L} &= \int_{\theta_s}^{\overline{\theta}} \alpha(\theta) \mathcal{W}(U(\theta)) dK(\theta) + \alpha_0 \mathcal{W}(v + rl^{\circ} + \tau) K(\theta_s) \\
&\quad + \nu \left(B - \tau K(\theta_s) - \int_{\theta_s}^{\overline{\theta}} \left[U(\theta) - pf(l^*, z^*, e, \theta) + wz^* + r(l^* - l^{\circ}) + \psi(e)\right] dK(\theta) \right) \\
&\quad + \mu \left(X - \int_{\theta_s}^{\overline{\theta}} x(z^*, l^*) dK(\theta) \right) + \lambda(\theta_s) \left[v + rl^{\circ} + \tau\right] + \int_{\theta_s}^{\overline{\theta}} \left\{\lambda'(\theta) U(\theta) - \lambda(\theta) \psi' E_\theta\right\} d\theta
\end{aligned}$$

Derivating, we get the following necessary conditions (for $\theta \in \left[\theta_s, \overline{\theta}\right]$):

$$\frac{\partial \mathcal{L}}{\partial \tau} = \alpha_0 \mathcal{W}'(U(\theta_s)) K(\theta_s) - \nu K(\theta_s) + \lambda(\theta_s) = 0 \tag{11}$$

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial e} &= \nu (pf_e - \psi') k(\theta) + \nu \left[p \left(f_l l_e^* + f_z z_e^*\right) - wz_e^* - rl_e^*\right] k(\theta) \\
&\quad - \mu \left[x_z z_e^* + x_l l_e^*\right] k(\theta) - \lambda(\theta) \frac{d(\psi' E_\theta)}{de} = 0
\end{aligned}$$

$$\frac{\partial \mathcal{L}}{\partial U(\theta)} = \alpha(\theta) \mathcal{W}'(U(\theta)) k(\theta) - \nu k(\theta) + \lambda'(\theta) = 0$$

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial t^q} &= \nu \int_{\theta_s}^{\overline{\theta}} \left[(pf_l - r) l_{t^q}^* + (pf_z - w) z_{t^q}^*\right] dK(\theta) - \mu \int_{\theta_s}^{\overline{\theta}} \left[x_z z_{t^q}^* + x_l l_{t^q}^*\right] dK(\theta) \\
&\quad - \int_{\theta_s}^{\overline{\theta}} \lambda(\theta) \frac{d(\psi' E_\theta)}{dt^q} d\theta = 0
\end{aligned}$$

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial t^z} &= \nu \int_{\theta_s}^{\overline{\theta}} \left[(pf_l - r) l_{t^z}^* + (pf_z - w) z_{t^z}^*\right] dK(\theta) - \mu \int_{\theta_s}^{\overline{\theta}} \left[x_z z_{t^z}^* + x_l l_{t^z}^*\right] dK(\theta) \\
&\quad - \int_{\theta_s}^{\overline{\theta}} \lambda(\theta) \frac{d(\psi' E_\theta)}{dt^z} d\theta = 0
\end{aligned}$$

$$\frac{\partial \mathcal{L}}{\partial t^l} = \nu \int_{\theta_s}^{\overline{\theta}} \left[(pf_l - r)\, l_{t^l}^* + (pf_z - w)\, z_{t^l}^*\right] dK(\theta)$$

$$-\mu \int_{\theta_s}^{\overline{\theta}} \left[x_z z_{t^l}^* + x_l l_{t^l}^*\right] dK(\theta) - \int_{\theta_s}^{\overline{\theta}} \lambda(\theta) \frac{d(\psi' E_\theta)}{dt^l} d\theta = 0$$

Once again, we obtain for $\lambda(\theta)$ and ν the following similar expressions:

$$\lambda(\theta) = -\nu(1 - K(\theta)) + \int_{\theta}^{\overline{\theta}} \alpha(\theta)\mathcal{W}'(U(\theta))dK(\theta)$$

and

$$\nu = \int_{\theta_s}^{\overline{\theta}} \alpha(\theta)\mathcal{W}'(U(\theta))dK(\theta) + \alpha_0 \mathcal{W}'(v + rl^{\circ} + \tau)K(\theta_s) > 0$$

This concludes the proof.

F Proof of Proposition 9

The program of the regulator can be written as

$$\max CE(U) + V(L) + r(L)(L - L^{\circ})$$

s.t.

$$CE(U) = \mathcal{W}^{-1}\left[\int_{\theta_s}^{\overline{\theta}} \mathcal{W}(U(\theta))dK(\theta) + \mathcal{W}(v + rl^{\circ} + \tau)K(\theta_s)\right]$$

$$\tau K(\theta_s) + \int_{\theta_s}^{\overline{\theta}} \left[U(\theta) - \pi(\theta, l(\theta), z(\theta), e(\theta)) + \psi(e(\theta))\right] dK(\theta) \leq B$$

$$\int_{\theta_s}^{\overline{\theta}} x(z(\theta), l(\theta))dK(\theta) \leq X$$

$$U(\theta_s) = v + rl^{\circ} + \tau$$

$$U'(\theta) = -\psi'(e(\theta))E_\theta(\theta, l(\theta), z(\theta), \pi(\theta, l(\theta), z(\theta), e(\theta)))$$

$$\pi(\theta, l(\theta), z(\theta), e(\theta)) = pf(l(\theta), z(\theta), e(\theta), \theta) - wz(\theta) - r(l(\theta) - l^{\circ})$$

$$L = \int_{\theta_s}^{\overline{\theta}} l(\theta)dK(\theta)$$

We denote by δ the multiplier of the last constraint determining the aggregate land use by the agricultural sector. Following the preceding analysis, we can write directly the Lagrangean as follows

$$\begin{aligned}
\mathcal{L} &= CE(U) + V(L) + r(L)(L - L^{\circ}) \\
&\quad + \nu\left(B - \tau K(\theta_s) - \int_{\theta_s}^{\overline{\theta}} \left[U(\theta) - pf(l(\theta), z(\theta), e(\theta), \theta) + wz(\theta) + r(l(\theta) - l^{\circ}) + \psi(e(\theta))\right] dK(\theta)\right) \\
&\quad + \mu\left(X - \int_{\theta_s}^{\overline{\theta}} x(z(\theta), l(\theta)) dK(\theta)\right) + \lambda(\theta_s)\left[v + rl^{\circ} + \tau\right] \\
&\quad + \int_{\theta_s}^{\overline{\theta}} \left\{\lambda'(\theta)U(\theta) - \lambda(\theta)\psi' E_\theta\right\} d\theta + \delta\left(L - \int_{\theta_s}^{\overline{\theta}} l(\theta) dK(\theta)\right)
\end{aligned}$$

The first-order conditions are

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial l(\theta)} &= \nu(pf_l - r)k(\theta) - \mu x_l k(\theta) - \lambda(\theta)\psi' \frac{d(E_\theta)}{dl} - \delta k(\theta) = 0 \\
\frac{\partial \mathcal{L}}{\partial z(\theta)} &= \nu(pf_z - w)k(\theta) - \mu x_z k(\theta) - \lambda(\theta)\psi' \frac{d(E_\theta)}{dz} = 0 \\
\frac{\partial \mathcal{L}}{\partial e(\theta)} &= \nu(pf_e - \psi')k(\theta) - \lambda(\theta) \frac{d(\psi' E_\theta)}{de} = 0 \\
\frac{\partial \mathcal{L}}{\partial L} &= V'(L) + r'(L)L + r(L) - \nu r'(L)L + \delta + \lambda(\theta_s)r'(L)l^{\circ} + \frac{dCE(U)}{dr} r'(L) = 0 \quad (12) \\
\frac{\partial \mathcal{L}}{\partial \tau} &= \frac{dCE(U)}{d\tau} - \nu K(\theta_s) + \lambda(\theta_s) = 0 \quad (13)
\end{aligned}$$

Note that

$$\begin{aligned}
\frac{dCE(U)}{dr} &= \frac{d}{dr}\left(\mathcal{W}^{-1}\left[\int_{\theta_s}^{\overline{\theta}} \mathcal{W}(U(\theta))dK(\theta) + \mathcal{W}(v + rl^{\circ} + \tau)K(\theta_s)\right]\right) \\
&= \frac{\mathcal{W}'(U(\theta_s))K(\theta_s)}{\mathcal{W}'(CE(U))} l^{\circ}
\end{aligned}$$

and

$$\frac{dCE(U)}{d\tau} = \frac{\mathcal{W}'(U(\theta_s))K(\theta_s)}{\mathcal{W}'(CE(U))}$$

Hence, from (12) and (13) we deduce that

$$\begin{aligned}
r'(L)L - \nu r'(L)L + \delta + (\nu K(\theta_s) - \frac{dCE(U)}{d\tau})r'(L)l^{\circ} + \frac{dCE(U)}{dr} r'(L) &= 0 \\
r'(L)L - \nu r'(L)L + \delta + \nu K(\theta_s)r'(L)l^{\circ} &= 0
\end{aligned}$$

so that

$$\delta = r'(L)\left[(\nu - 1)L - \nu K(\theta_s)l^{\circ}\right]$$

With respect to $U(\theta)$, we have

$$\frac{\partial \mathcal{L}}{\partial U(\theta)} = \frac{dCE(U)}{dU(\theta)} - \nu k(\theta) + \lambda'(\theta) = 0$$

which is equivalent to

$$\frac{\mathcal{W}'(U(\theta))k(\theta)}{\mathcal{W}'(CE(U))} - \nu k(\theta) + \lambda'(\theta) = 0$$

Hence, we obtain that

$$\begin{aligned} \int_{\theta}^{\overline{\theta}} \lambda'(u)du &= \int_{\theta}^{\overline{\theta}} \left\{ \nu - \frac{\mathcal{W}'(U(u))}{\mathcal{W}'(CE(U))} \right\} k(u)du \\ \lambda(\theta) &= -\nu(1 - K(\theta)) + \int_{\theta}^{\overline{\theta}} \frac{\mathcal{W}'(U(u))}{\mathcal{W}'(CE(U))} k(u)du \end{aligned}$$

As

$$\begin{aligned} \lambda(\theta_s) &= \nu K(\theta_s) - \frac{dCE(U)}{d\tau} \\ &= \nu K(\theta_s) - \frac{\mathcal{W}'(U(\theta_s))K(\theta_s)}{\mathcal{W}'(CE(U))} \end{aligned}$$

we also have that

$$\nu = \int_{\theta_s}^{\overline{\theta}} \frac{\mathcal{W}'(U(\theta))}{\mathcal{W}'(CE(U))} dK(\theta) + \frac{\mathcal{W}'(U(\theta_s))K(\theta_s)}{\mathcal{W}'(CE(U))}.$$

This concludes the proof.

Contracting with agents seeking status*

Philippe Bontems†

February 2008

Abstract

We explore in this paper the consequences of status seeking preferences among agents contracting with a principal in the context of production. We examine in particular the case of envy and we show that in general envy entails augmented distortions due to asymmetric information in optimal contracts. Furthermore if the principal neglects the preferences of the agents with respect to status, then potentially there is under-participation to the contract. We also show that if the principal is free to choose who can participate to the contract, then under some conditions the principal may prefer to contract with only a subset of potentially "profitable" agents (that is where his utility is strictly positive). We then ask whether contracting with agents seeking status would yield to more incentives to exert unobservable effort. We actually show that the principal has incentives to discourage effort. In the last part of the paper, we consider the case of a public principal that seeks to reduce negative externalities from production under a budget constraint.

JEL : D6, H0, D86.

Key-words: status, adverse selection, contracts, envy, externalities

* *Corresponding author* : Philippe Bontems, GREMAQ-INRA, Université des Sciences Sociales de Toulouse, 21 Allée de Brienne, 31000 Toulouse, France. Email: bontems@toulouse.inra.fr. Phone: (33) 561 128 522. Fax: (33) 561 128 520. This work has benefited from a grant under the S3E program (Ministère de l'Ecologie, du Développement et de l'Aménagement Durables).

†Toulouse School of Economics (GREMAQ, INRA, IDEI).

1 Introduction

It has long been recognized that individuals are probably motivated at least partly by a concern about their relative position in the population, in particular relative to income. For instance John Stuart Mills has observed that "men do not desire to be rich but richer than other men" (cited by Luttmer 2005). The effects of social comparisons on consumption has been analyzed in the classic work of Veblen (1899). Recently, Samuelson (2004) and Rayo and Becker (2004) have offered evolutionary explanations of relative consumption effects while Luttmer (2005) provides some empirical evidence on individual-level data.[1]

However, the standard modelling of preferences would rather state that individuals derive utility $U(C)$ from their own consumption level instead of a combination of own and relative consumption $U(C, C_{others})$ or $U(C, C/C_{others})$ where C_{others} is a measure of the consumption of relevant others (for instance the mean consumption in the population or the consumption of the richest people...). As suggested by Luttmer (2005), in general both formulations are isomorphic and hence unless an individual can affect C_{others}, they cannot be distinguished on the basis of individual behavior. This would explain why most economists would favor the standard formulation.

Nevertheless, policies will in general affect C_{others} and hence the formulation with relative concern will generate different conclusions compared to the standard formulation of utility. This problem has been analyzed by Boskin and Sheshinski (1978), Oswald (1983) and Ireland (1998) in the context of income taxation. Also, Dupor and Liu (2003) have shown that if the consumption of others affects marginal utility rather than the level of own utility, then the consumption of others will affect all kind of decisions a consumer can take, work effort, job search, risk takings and savings....

In this paper, we want to explore the consequences of retaining the idea of people taking decisions while being sensitive to relative consumption in the context of production and

[1] There is even some evidence that this pattern of behavior emerges among animals like capucin monkeys as shown by the work of Frans de Waal. Some studies have shown that these monkeys can exhibit some aversion to inequity in some experiments.

contracts. We model a principal-agent relationship where agents have preferences toward the allocations of others. The relationship is subject to adverse selection with respect to individual productivity. We first consider the case of a private principal that seeks to maximize her surplus net of the transfers to be paid to agents while taking care of participation and incentive compatibility constraints. We show that under perfect information in general the presence of preferences with relative consumption yields to a distortion in the optimal allocation in order to internalize the externality each individual exerts on the others. This distortion however disappears when the marginal rate of substitution between money and production is the same at the utility level and at the externality level. This assumption is satisfied for instance if we suppose that agents have a utility function of the form $v(\pi, \overline{\pi})$ where π is his profit and $\overline{\pi}$ a weighted mean of profits in participating agents.

Under asymmetric information, the usual distortion due to the rent-extraction-efficiency trade-of depends on the presence of the externality generated by the assumption of relative consumption preferences. Suppose that there is envy (or jealousy) then individual would gain from having a profit larger than say the average profit in the population but they would experience an additional disutility if they earn less than the average profit. We then show that it is optimal for the principal to impose an augmented downward distortion to production in general. The intuition goes as follows: here leaving informational rents to the agents will have the additional effect of tightening the participation constraint of the least efficient type because this agent will earn less than the others and hence is jealous. It is therefore necessary to extract rents more than in the absence of jealousy, by decreasing production. To sum up, jealousy amounts to a more discriminating production schedule, although one can show that the gap between the highest and the lowest profits decreases (less inequality in terms of monetary payoffs). In a sense, the introduction of envy yields to some implicit redistribution between agents towards a more equal income distribution.[2]

[2] It is interesting to note that Cornéo and Grüner (2002) in an empirical analysis suggest the "social rivalry effect" as one of the possible explanations that drive people's support of governmental reduction of income inequality.

Furthermore, if the principal neglects the preferences of the agent with respect to relative income or consumption, then potentially a subset of agents among the less efficient will be reluctant to participate. There is thus potentially under-participation to the contract. We also show that if the principal is free to choose who can participate to the contract, then under some conditions the principal may prefer to contract with only a subset of potentially "profitable" agents (that is where his utility is strictly positive). This implies that there is under-participation because expanding the set of participating agents amounts to increase downward distortion on production levels which is inefficient.

We then ask whether contracting with agents seeking status would yield to more incentives to exert unobservable effort. We actually show that for a given production level, the presence of status seeking preferences induces more effort as the marginal benefit of production is expanded. But at the same time it also contributes positively to the size of the negative externality when there is envy. The principal hence designs a contract that reduces the production level in order to internalize the impact of envy over effort.

In the last part of the paper, we consider the case of a public principal (a regulator) that seeks to reduce negative externalities from production under a budget constraint. We obtain similar conclusions with regards to the consequences of status seeking preferences among agents.

The paper is organized as follows. The next section is devoted to a general model of contracting between a principal and agents with status seeking preferences. In section 3, we develop a particular specification with more details. Section 4 is devoted to the model with unobservable effort while section 5 is devoted to the model of public regulation. Section 6 concludes.

2 The private principal case

2.1 Assumptions and notations

Consider an economy populated by a continuum of individuals indexed by θ. Each individual takes a decision q (production) and receives a transfer t from the principal. The utility of the principal is $S(q) - t$. The utility of the type-θ individual is $u(q, t, \theta, \alpha)$ where α is a weighted sum of a function $H(q(\theta), t(\theta), \theta)$ of q and t accross the population

$$\alpha = \int_{\Theta} \omega(\theta) H(q(\theta), t(\theta), \theta) dF(\theta)$$

where $\omega(.)$ is the weight function and F is the distribution function of θ. We normalize the set of types such that $u_\theta < 0$. We also assume that $u_t > 0$ and that the Spence-Mirrlees property holds:

$$\frac{\partial}{\partial \theta} \left(\frac{u_q}{u_t} \right) < 0.$$

A possible interpretation of the model in the context of environmental could go like this. The quantity q can be interpreted as the environmental service provided privately by the individual and subject to some compensation t paid by the environmental agency considered as the Principal.

This model can be viewed as an extension of Oswald (1983) to the private principal case. We also slightly generalizes his analysis by considering a general formulation for α. The role of α is precisely to incorporate any externality from an aggregate value of decisions and transfers in the individual utility. For exemple, if we denote $\pi(\theta) = t(\theta) - c(q(\theta), \theta)$ the profit get by the individual by taking the decision $q(\theta)$, then a possible specification for H is

$$H(q(\theta), t(\theta), \theta) = \pi(\theta).$$

Then if $u_\alpha > 0$ then the individual is altruistic in the sense that an increase in the average profit in the population raises the utility. Conversely, if $u_\alpha < 0$ then there is envy or jealousy as an increase in the average profit yiels to decrease utility. In that case, a more specific model of interest could be written such that $u(q, t, \theta, \alpha) = v(\pi(\theta), \alpha) = \pi(\theta) + \rho(\pi(\theta) - \alpha)$ where

$\alpha = \int_\Theta \omega(\theta)\pi(\theta)dF(\theta)$ and $\rho \geq 0$ is a parameter that represents the (common) intensity of envy. If the individual earns more than α then the utility is increased. Conversely, if the individual earns less than α then the utility is decreased. There are many interpretations of α: it could be an exogenous poverty line for instance, or it could be simply the non weighted mean of profits. It could also be the profit of the less favored individual.

2.2 Analysis

The problem of the principal is to choose an allocation $(q(\theta), t(\theta))$ for each individual subject to incentive compatibility and participation constraints.[3] The program of the principal writes as follows

$$\max_{q(.),t(.)} \int_\Theta [S(q(\theta)) - t(\theta)]\, dF(\theta)$$

$$\text{s.t.}$$

$$U(\theta) = u(q(\theta), t(\theta), \theta, \alpha) \geq 0$$

$$U(\theta) \geq U(\theta, \tilde{\theta}) \text{ for any } \theta, \tilde{\theta}$$

$$\alpha = \int_\Theta \omega(\theta) H(q(\theta), t(\theta), \theta) dF(\theta)$$

This corresponds to a standard principal-agent model except for the presence of an externality effect due to α. The following proposition establishes the properties of the optimal allocation of decisions. For this, we denote $\lambda(\theta)$ as the multiplier of the incentive compatibility constraint and ϕ as the multiplier of the externality constraint.

Proposition 1 *Assuming a separating equilibrium, the optimal decision for a type-θ individual is given by:*

$$S'(q) + \frac{u_q}{u_t} = \frac{\lambda(\theta)}{f(\theta)} \left[u_{\theta q} - \frac{u_q}{u_t} u_{\theta t} \right] + \phi\omega(\theta) \left[H_q - H_t \frac{u_q}{u_t} \right] \tag{1}$$

Proof: See appendix A. ■

[3] We normalize the reservation utility level to 0 for any type-θ individual.

At the first best, the optimal decision for a type-θ individual is given by the equality between the marginal benefit S' and the marginal rate of substitution $-\frac{u_q}{u_t}$ between the decision and money. In the absence of externality ($\phi = 0$), asymmetric information imposes a distortion given by the first term of the RHS of equation (1). In the presence of the externality, not only the incentive distortion depends on ϕ through the value of $\lambda(\theta)$, but there is also a second term which appears independantly of the presence of asymmetric information. Intuitively, the presence of the externality imposes a distortion to the optimal allocation of decision which depends on the specification of H. Indeed, the principal takes into account the marginal impact of the decision allocated to θ on his contribution H to the aggregate externality α. In the presence of asymmetric information, the externality has also an impact on the cost of incentive compatibility.

Corollary 2 *Under perfect information, if the marginal rate of substitution between the decision q and the money is the same at the utility level and at the externality level, namely $H_q - H_t \frac{u_q}{u_t} = 0$ then there is no reason for the principal to distort the allocation rule compared to the situation where the externality is absent.*

The latter rule implies that the marginal rate of substitution between q and t should be equalized between the principal and the agent: $S' = -\frac{u_q}{u_t}$. If $H_q - H_t \frac{u_q}{u_t} = 0$ then the principal has no incentives to distort the allocation rule (except that the value of $\frac{u_q}{u_t}$ depends itself on α). It suffices that there exists a function $\pi(q, t, \theta)$ such that $u(q, t, \theta, \alpha) = v(\pi, \alpha)$ and $H(q, t, \theta) = \tilde{H}(\pi)$ then we obtain that $H_q - H_t \frac{u_q}{u_t} = 0$ and there is no reason to control for the externality. Hence, the principal has to distort the allocation rule only if there is a difference between the marginal rate of substitution between q and t at the individual utility level and the individual contribution H to the externality level.

At the top, there is no incentive distortion as $\lambda(\underline{\theta}) = 0$, but obviously the correction due to the presence of externality subsists whenever $H_q - H_t \frac{u_q}{u_t} \neq 0$ and $\omega \neq 0$.

2.3 The optimal uniform allocation

Suppose that the principal restricts herself to the choice of an unique allocation whatever the type of individual. This may happen if the good under scrutiny or the environmental services are transferable between individuals. Alternatively, we obtain such a situation if for some institutional reasons the principal is forbidden to price discriminate between agents. The program of the principal now reduces to

$$\max_{q,t} S(q) - t$$

$$\text{s.t.}$$

$$U(\theta) = u(q, t, \theta, \alpha) \geq 0$$

$$\alpha = \int_{\Theta} \omega(\theta) H(q, t, \theta) dF(\theta)$$

Computing the rate of growth of rents, we have that $U'(\theta) = u_\theta < 0$, so that the individual rationality constraints reduce to $U(\overline{\theta}) \geq 0$. The Lagrangean is thus given by

$$\mathcal{L} = S(q) - t + \tau u(q, t, \overline{\theta}, \alpha) + \phi(\alpha - \int_{\Theta} \omega(\theta) H(q, t, \theta) dF(\theta))$$

The necessary conditions are

$$\frac{\partial \mathcal{L}}{\partial q} = S' + \tau \overline{u}_q - \phi \int_{\Theta} \omega H_q dF(\theta) = 0 \qquad (2)$$

$$\frac{\partial \mathcal{L}}{\partial t} = -1 + \tau \overline{u}_t - \phi \int_{\Theta} \omega H_t dF(\theta) = 0 \qquad (3)$$

$$\frac{\partial \mathcal{L}}{\partial \alpha} = \tau \overline{u}_\alpha + \phi = 0 \qquad (4)$$

Hence, we have $\tau = -\phi/\overline{u}_\alpha$. Hence, either we have $\overline{u}_\alpha < 0$ and $\phi > 0$ or $\overline{u}_\alpha > 0$ and $\phi < 0$. Eliminating ϕ, we obtain that

$$S'(q) = -\frac{\overline{u}_q + \overline{u}_\alpha \int_{\Theta} \omega H_q dF(\theta)}{\overline{u}_t + \overline{u}_\alpha \int_{\Theta} \omega H_t dF(\theta)} \qquad (5)$$

This equation together with $u(q, t, \overline{\theta}, \alpha) = 0$ gives us the optimal allocation (q, t).Note that in the absence of externality ($u_\alpha = 0$), we would obtain the optimal decision as

$$S'(q) = -\frac{\overline{u}_q}{\overline{u}_t}$$

that is by equalizing the marginal rate of substitution between q and t for the highest type which is the marginal type from the principal's point of view. In the presence of the externality, the marginal individual utility of q should be corrected for its impact on the aggregate externality α. And the same for t.

In the special case where $H = \pi = t - c(q,\theta)$ and where $u(q,t,\theta,\alpha) = v(\pi,\alpha)$, then we obtain

$$S'(q) = \frac{\overline{v}_\pi c_q(q,\overline{\theta}) + \overline{v}_\alpha \int_\Theta \omega c_q dF(\theta)}{\overline{v}_\pi + \overline{v}_\alpha \int_\Theta \omega dF(\theta)}$$

If furthermore $\omega = 1$ and $v(\pi,\alpha) = (1+\rho)\pi - \rho\alpha$ then we get

$$S'(q) = c_q(q,\overline{\theta}) + \rho \left[c_q(q,\overline{\theta}) - \int_\Theta c_q(q,\theta) dF(\theta) \right]$$

As $c_{\theta q} > 0$, then the second term of the RHS is positive and there is a downward distortion to production due to the impact of ρ. At the first best, we would have $S'(q) = c_q(q,\overline{\theta})$, that is the optimal production level is the one which is optimal for the least efficient agent. The downward distortion comes from the fact that the participation constraint imposes that $u(q,t,\overline{\theta},\alpha) = (1+\rho)\overline{\pi} - \rho\alpha = 0$. Hence, the minimum level of profit devoted to the least efficient agent is equal to $\rho\alpha/(1+\rho) > 0$. Participation is hence more and more costly as ρ increases and this calls for an increasing downward distortion in order to decrease the rents left to agents. Here, the presence of ρ induces a lower production and thereby hurts welfare.

3 A special case with discriminating contracts

Back to the case of second best price discrimination, we adopt in this section the following specification.

Definition 3 (Specification) **(i)** *The utility $u(q,t,\theta,\alpha)$ of the agent is a function of his monetary payoff $\pi(q,t,\theta) = t - c(q,\theta)$ where c is the cost of producing q and θ an index of productivity. We assume that $c_\theta > 0$ and $c_{\theta q} > 0$ (Spence-Mirrlees property). We have*

$$u(q,t,\theta,\alpha) = v(\pi(q,t,\theta),\alpha)$$

where $v_\pi > 0$ *and* $v_{\pi\pi} \leq 0$.

(ii) *The aggregate externality* α *is defined as a weighted sum of monetary payoffs so that* $H(q,t,\theta) = \pi(q,t,\theta)$*:*

$$\alpha = \int_\Theta \omega(\theta)\pi(\theta)dF(\theta).$$

This specification has the particularity that there is no reason for the principal to distort production allocations under perfect information even if the agent's utility depends on the aggregate externality α as shown by Corollary 2. Indeed, we have

$$H_q - H_t\frac{u_q}{u_t} = -c_q - \frac{v_\pi(-c_q)}{v_\pi} = 0.$$

Hence, distorting production allocations across types compared to first-best only becomes optimal under imperfect information.

3.1 Analysis

Using this specification and the results contained in Proposition 1, we obtain that:

$$S'(q(\theta)) = c_q(q(\theta),\theta) + \frac{\lambda(\theta)}{f(\theta)}\left[v_\pi\left(-c_{\theta q}\right)\right] \tag{6}$$

with

$$\lambda(\theta) = \frac{\int_{\underline{\theta}}^{\theta}(1+\phi\omega(x))dF(x)}{v_\pi}$$

and

$$\phi = -\frac{v_\alpha(\pi(\overline{\theta}),\alpha)}{v_\pi(\pi(\overline{\theta}),\alpha) + v_\alpha(\pi(\overline{\theta}),\alpha)\int_{\underline{\theta}}^{\overline{\theta}}\omega(\theta)dF(\theta)}$$

where $\pi(\overline{\theta}) = \pi(q(\overline{\theta}),t(\overline{\theta}),\alpha)$ is such that $v(\pi(\overline{\theta}),\alpha) = 0$.

Replacing in (6), we have

$$S'(q(\theta)) = c_q(q(\theta),\theta) + \frac{F(\theta) + \phi\int_{\underline{\theta}}^{\theta}\omega(x)dF(x)}{f(\theta)}c_{\theta q}(q(\theta),\theta) \tag{7}$$

which shows that there is a distortion of production for any type except for the most efficient one ($\underline{\theta}$).

By contrast, note that the standard model of procurement is obtained when $v_\alpha = 0$ so that $\phi = 0$. Indeed, we get the familiar condition:

$$S'(q^s(\theta)) = c_q(q^s(\theta), \theta) + \frac{F(\theta)}{f(\theta)} c_{\theta q}(\theta, q^s(\theta)). \tag{8}$$

The sign of the distortion in (7) depends on the sign of ϕ and on the weight function $\omega(.)$. Let us assume that $\omega(\theta) \geq 0$ for any type. Suppose further that $v_\alpha > 0$ for the least efficient agent, then ϕ is clearly negative. This implies that if the least efficient agent is altruistic then the downward distortion due to the efficiency-rent extraction trade-off is reduced compared to the standard model and may even turn to an upward distortion for some types. The intuition goes as follows: it is less necessary to extract rents as giving rents will increase α and thereby will relax the participation constraint of the least efficient type. In the case where $\omega(\theta) = 1$ for any type, then $0 < \phi < 1$ and consequently the principal imposes a reduced downward distortion everywhere on production except at the top.

Suppose on the contrary that $u_\alpha < 0$ for the least efficient type, then ϕ is positive if and only if $v_\pi(\pi(\overline{\theta}), \alpha) > -v_\alpha(\pi(\overline{\theta}), \alpha) \int_{\underline{\theta}}^{\overline{\theta}} \omega(\theta) dF(\theta)$ which means that the direct effect of profit on utility must outweigh the impact of α sufficiently. In that case, the principal imposes an augmented downward distortion to production except at the top. The intuition goes as follows: here leaving informational rents to the agents will have the additional effect of tightening the participation constraint of the least efficient type because this agent is jealous. It is therefore necessary to extract rents more than in the absence of jealousy, by decreasing production. In a sense, jealousy amounts to a more discriminating production schedule, although one can show that the gap between the highest and the lowest profits decreases (less inequality in terms of monetary payoffs).

Suppose that the principal neglects the preferences of the agent with respect to α. In that case, it is optimal to offer the standard production schedule defined in (8). However, the least efficient agent will get $\pi^s(\overline{\theta}) = 0$ such that his utility is $v(0, \alpha^s)$ where $\alpha^s = \int_{\underline{\theta}}^{\overline{\theta}} \omega(\theta) \pi^s(\theta) dF(\theta)$. This utility level might be negative so that he is not willing to participate and this is also true for a subset of the less efficient types. There is thus potentially under-participation to the contract.

3.2 Optimal shutdown

In this section, we analyze the optimal shutdown policy for the principal, that is the identity of the marginal individual who is indifferent between partipating and not as part of the optimal policy. If the principal is free to choose who should enter into the mechanism, her expected utility is

$$\max_{\theta^*} W = \int_{\underline{\theta}}^{\theta^*} \left\{ S(q(\theta)) - \pi(\theta) - c(q(\theta), \theta) \right\} dF(\theta)$$

where $\pi(\theta)$ and $q(\theta)$ depend on θ^*. Hence, the first-order condition is

$$\frac{dW}{d\theta^*} = \left[S(q(\theta^*)) - \pi(\theta^*) - c(q(\theta^*), \theta^*) \right] f(\theta^*) + \int_{\underline{\theta}}^{\theta^*} \left\{ \left[S'(q(\theta)) - c_q(q(\theta), \theta) \right] \frac{dq(\theta)}{d\theta^*} - \frac{d\pi(\theta)}{d\theta^*} \right\} dF(\theta)$$

This is difficult to evaluate because both production and profit depend on θ^* in a complex way. In particular, $q(\theta)$ depends on θ^* through ϕ when $\omega(\theta)$ is not constant. Moreover

$$\pi(\theta) = \pi(\theta^*) + \int_{\theta}^{\theta^*} c_\theta(q(x), x) dx$$

and

$$\begin{aligned} \frac{d\pi(\theta)}{d\theta^*} &= \dot{\pi}(\theta^*) + c_\theta(q(\theta^*), \theta^*) + \int_{\theta}^{\theta^*} c_{\theta q}(q(x), x) \frac{dq(x)}{d\theta^*} dx \\ &= \int_{\theta}^{\theta^*} c_{\theta q}(q(x), x) \frac{dq(x)}{d\theta^*} dx \end{aligned}$$

The rule becomes

$$\begin{aligned} \frac{dW}{d\theta^*} &= \left[S(q(\theta^*)) - \pi(\theta^*) - c(q(\theta^*), \theta^*) \right] f(\theta^*) \\ &+ \int_{\underline{\theta}}^{\theta^*} \left\{ \left[S'(q(\theta)) - c_q(q(\theta), \theta) \right] \frac{dq(\theta)}{d\theta^*} - \int_{\theta}^{\theta^*} c_{\theta q}(q(x), x) \frac{dq(x)}{d\theta^*} dx \right\} dF(\theta) \end{aligned}$$

Note that

$$\int_{\underline{\theta}}^{\theta^*}\int_{\theta}^{\theta^*} c_{\theta q}(q(x),x)\frac{dq(x)}{d\theta^*}dxdF(\theta) = \left[F(\theta)\int_{\theta}^{\theta^*} c_{\theta q}(q(x),x)\frac{dq(x)}{d\theta^*}dx\right]_{\underline{\theta}}^{\theta^*} + \int_{\underline{\theta}}^{\theta^*} c_{\theta q}(q(\theta),\theta)\frac{dq(\theta)}{d\theta^*}F(\theta)d\theta = \int_{\underline{\theta}}^{\theta^*} c_{\theta q}(q(\theta),\theta)\frac{dq(\theta)}{d\theta^*}F(\theta)d\theta$$

Hence, the rule becomes

$$\frac{dW}{d\theta^*} = \left[S(q(\theta^*)) - \pi(\theta^*) - c(q(\theta^*),\theta^*)\right]f(\theta^*) + \int_{\underline{\theta}}^{\theta^*}\left\{\left[S'(q(\theta)) - c_q(q(\theta),\theta)\right]\frac{dq(\theta)}{d\theta^*} - c_{\theta q}(q(\theta),\theta)\frac{dq(\theta)}{d\theta^*}\frac{F(\theta)}{f(\theta)}\right\}dF(\theta)$$

$$\frac{dW}{d\theta^*} = \left[S(q(\theta^*)) - \pi(\theta^*) - c(q(\theta^*),\theta^*)\right]f(\theta^*) + \int_{\underline{\theta}}^{\theta^*}\left\{\frac{\phi\int_{\underline{\theta}}^{\theta}\omega(x)dF(x)}{f(\theta)}c_{\theta q}(q(\theta),\theta)\frac{dq(\theta)}{d\theta^*}\right\}dF(\theta)$$

Note that the value of ϕ is

$$\phi = -\frac{v_\alpha(\pi(\theta^*),\alpha)}{v_\pi(\pi(\theta^*),\alpha) + v_\alpha(\pi(\theta^*),\alpha)\int_{\underline{\theta}}^{\theta^*}\omega(\theta)dF(\theta)}$$

Here, implicitely, we assume that the agent values only the profits get by participating agents, i.e. $\alpha = \int_{\underline{\theta}}^{\theta^*}\omega(\theta)\pi(\theta)dF(\theta)$.[4] Recall that $v(\pi(\theta^*),\alpha) = 0$ which implies that $\pi(\theta^*) = h(\alpha)$. Hence,

$$\phi = -\frac{v_\alpha(h(\alpha),\alpha)}{v_\pi(h(\alpha),\alpha) + v_\alpha(h(\alpha),\alpha)\int_{\underline{\theta}}^{\theta^*}\omega(\theta)dF(\theta)} = \frac{h'(\alpha)}{1 - h'(\alpha)\int_{\underline{\theta}}^{\theta^*}\omega(\theta)dF(\theta)}$$

$$\frac{d\phi}{d\theta^*} = \frac{\partial\phi}{\partial\alpha}\frac{d\alpha}{d\theta^*} + \frac{\partial\phi}{\partial\theta^*} = \frac{h''(\alpha)}{\left[1 - h'(\alpha)\int_{\underline{\theta}}^{\theta^*}\omega(\theta)dF(\theta)\right]^2}\frac{d\alpha}{d\theta^*} + \frac{\left[h'(\alpha)\right]^2\omega(\theta^*)f(\theta^*)}{\left[1 - h'(\alpha)\int_{\underline{\theta}}^{\theta^*}\omega(\theta)dF(\theta)\right]^2}$$

and hence

$$sign(\frac{d\phi}{d\theta^*}) = sign(h''(\alpha)\pi(\theta^*) + \left[h'(\alpha)\right]^2)$$

[4] Otherwise, the analysis should be conducted with $\alpha = \int_{\underline{\theta}}^{\theta^*}\omega(\theta)\pi(\theta)dF(\theta) + k\int_{\theta^*}^{\overline{\theta}}\omega(\theta)\pi(\theta^*)dF(\theta)$. Parameter k with value 1 represents the situation where the agent includes the non participating agents when computing α. When parameter k is zero, then the agent computes α only on the subset of participating agents.

But we have from the definition of h',

$$h'' = -\frac{1}{v_\pi}\left[v_{\pi\pi}h'^2 + 2v_{\pi\alpha}h' + v_{\alpha\alpha}\right]$$

The sign of $\frac{d\phi}{d\theta^*}$ explains the sign of $\frac{dq(\theta)}{d\theta^*}$. Suppose that $\phi > 0$ and suppose that $\frac{d\phi}{d\theta^*} > 0$ then $\frac{dq(\theta)}{d\theta^*} < 0$. Then the principal prefers to contract with only a subset of potentially "profitable" agents (that is where his utility $(S - \pi - c)$ is strictly positive) : there is under-participation because expanding the set of participating agents amounts to increase downward distortion on production levels.

On the contrary, if $\phi > 0$ but suppose that $\frac{d\phi}{d\theta^*} < 0$ then $\frac{dq(\theta)}{d\theta^*} > 0$ then there is over-participation. Here, expanding the set of contracting agents allows to reduce the intensity of distortion.

3.3 The impact of envy

To pursue further the analysis, let us suppose that $v = \pi + \rho(\pi - \alpha)$. There is thus jealousy or envy whenever the agent earns less than α. Then, $\pi(\theta^*) = \frac{\rho}{1+\rho}\alpha$ and

$$\phi = \frac{\rho}{1 + \rho - \rho\int_{\underline{\theta}}^{\theta^*}\omega(\theta)dF(\theta)}$$

Note that ϕ is positive if and only if $\int_{\underline{\theta}}^{\theta^*}\omega(\theta)dF(\theta) < \frac{1+\rho}{\rho}$. When $\omega(\theta) > 0$, we also get

$$\frac{d\phi}{d\theta^*} = \frac{\rho^2\omega(\theta^*)f(\theta^*)}{\left[1 + \rho - \rho\int_{\underline{\theta}}^{\theta^*}\omega(\theta)dF(\theta)\right]^2} > 0$$

which means that for a given θ the downward distortion is higher when the set of contracting types increases. Intuitively, the participation constraint is more and more stringent when θ^* increases. This means in turn that $\frac{dq(\theta)}{d\theta^*} < 0$ (and consequently $\frac{d\pi(\theta)}{d\theta^*} < 0$). In that case, there is under-participation. The principal would prefer to restrict participation to the contract more compared to a standard model without envy.

In the particular case where $\omega(\theta) = 1$ for any θ then

$$\phi = \frac{\rho}{1 + \rho - \rho F(\theta^*)} < \rho$$

and

$$S'(q(\theta)) = c_q(q(\theta), \theta) + \frac{F(\theta)(1+\phi)}{f(\theta)} c_{\theta q}(q(\theta), \theta)$$

which implies that the distortion is maximal when $\theta^* = \overline{\theta}$. Given the second order condition on $q(.)$, it follows that $\frac{dq}{d\phi} < 0$ and consequently $\frac{dq(\theta)}{d\theta^*} < 0$.

4 Does status-seeking behavior yield to more effort?

We consider an extension of the previous model where the agent exerts some effort e that allows to reduce the cost of providing the quantity q. We will consider for simplicity the following popular specification

$$c(q, e, \theta) = (\theta - e)q$$

used extensively by Laffont and Tirole (1991).

Exerting effort is costly and we denote $\psi(e)$ the disutility of effort which is increasing and convex ($\psi' > 0$ and $\psi'' > 0$) with $\psi(0) = 0$. We also assume that the utility of the type-θ agent is given by

$$\begin{aligned} U &= v(\pi, \alpha) - \psi(e) \\ &= \pi + \rho(\pi - \alpha) - \psi(e) \end{aligned}$$

where $\pi = t - c(q, e, \theta)$ and $\alpha = \int_\Theta \omega(\theta)\pi(\theta)dF(\theta)$. Facing the allocation (t, q) the agent chooses his effort such that

$$\begin{aligned} \max_e U &= v(\pi, \alpha) - \psi(e) \\ &= (1+\rho)\left(t - (\theta - e)q\right) - \rho\alpha - \psi(e) \end{aligned}$$

with the corresponding first-order condition

$$(1+\rho)q = \psi'(e) \tag{9}$$

The impact of envy is such that the marginal benefit of effort is higher ($\rho > 0$) for a given production level. Hence, ceteris paribus, envy leads to more effort. However, the production level depends itself on ρ and can be found by solving the principal's problem.

The program of the principal writes

$$\max_{q(.),t(.)} \int_{\Theta} [S(q(\theta)) - t(\theta)]\, dF(\theta)$$

s.t.

$$U(\theta) = (1+\rho)\left(t(\theta) - (\theta - e(\theta))q(\theta)\right) - \rho\alpha - \psi(e(\theta)) \geq 0$$

$$U(\theta) \geq U(\theta, \tilde{\theta}) \text{ for any } \theta, \tilde{\theta}$$

$$(1+\rho)q(\theta) = \psi'(e(\theta))$$

$$\alpha = \int_{\Theta} \omega(\theta)\pi(\theta) dF(\theta)$$

Solving this program allows to obtain the following proposition.

Proposition 4 *Assuming a separating equilibrium, the optimal allocation is such that*

$$S'(q(\theta)) = \theta - e(\theta) + \frac{1}{f(\theta)} \int_{\underline{\theta}}^{\theta} (1 + \phi\omega(x))\, dx + \phi\omega(\theta) \frac{\psi'(e(\theta))}{\psi''(e(\theta))}$$

with $\phi = \frac{\rho}{1+\rho}\left(1 + \int_{\Theta} \omega(\theta) f(\theta) d\theta\right) \geq 0.$

Proof: See appendix B. ■

In the absence of envy ($\phi = 0$), we obtain the standard equation stipulating the downward distortion on production as a result of the efficiency-rent extraction trade-of:

$$S'(q(\theta)) = \theta - e(\theta) + \frac{F(\theta)}{f(\theta)}.$$

Here, not only the presence of envy yields to distort even more the production level as

$$\frac{1}{f(\theta)} \int_{\underline{\theta}}^{\theta} (1 + \phi\omega(x))\, dx > \frac{F(\theta)}{f(\theta)}$$

but there is also an additional therm that tends increase the cost of production, namely $\phi\omega(\theta)\frac{\psi'(e(\theta))}{\psi''(e(\theta))}$. This term is due to the impact of production on the effort chosen privately by the agent which in turn affects the extent of the externality α. Intuitively, the presence of envy gives more incentives to exert some effort for a given production level but at the same time it also contributes positively to the size of the negative externality. The principal hence designs a contract that reduces the production level in order to internalize the impact of envy over effort.

5 A model of public regulation of externalities

To complete the analysis of status seeking behavior, we now examine a model of public regulation of externalities where a regulator seeks to maximise the welfare of individuals subject to a budget constraint and an environmental constraint. Indeed, we assume that producing q generates an environmental damage equal to $d(q)$.

The regulator seeks to solve the following program:

$$\max_{t(.),q(.)} \int_{\Theta} \pi(\theta) dF(\theta)$$

$$\text{s.t.}$$

$$\pi(\theta) = u(q(\theta),\theta) + t(\theta)$$

$$\pi(\theta) + \rho(\pi(\theta) - \bar{\pi}) \geq \pi(\theta,\tilde{\theta}) + \rho(\pi(\theta,\tilde{\theta}) - \bar{\pi}) \text{ for any } \theta, \tilde{\theta}$$

$$\pi(\theta) + \rho(\pi(\theta) - \bar{\pi}) \geq 0$$

$$\int_{\Theta} d(q(\theta)) dF(\theta) \leq \bar{D}$$

$$\int_{\Theta} t(\theta) dF(\theta) \leq B$$

As seen above we assume that the relative income assumption is such that the payoff U of a type-θ agent is

$$U(\pi,\bar{\pi}) = \pi(\theta) + \rho(\pi(\theta) - \bar{\pi})$$

with $\rho > 0$ a parameter which represents the intensity of preferences to relative income. An agent derives additional utility from having an income larger than the average and dislikes being below the average income. This formulation is highly restrictive in several ways. First, we avoid discussing the highly controversed problem of incorporating interdependent utilities in the welfare function because $\int_{\Theta} \pi(\theta) dF(\theta) = \int_{\Theta} U(\pi(\theta),\bar{\pi}) dF(\theta)$. Indeed, the individual preferences with respect to the relative income disappear at the aggregate level when one considers a utilitarian regulator. Second, this way of formulating interdependent utilities does not affect incentive compatibility constraints compared to the standard model with

$\rho = 0$. Indeed, the IC constraints rewrite as $\pi(\theta) \geq \pi(\theta, \tilde{\theta})$ for any $\theta, \tilde{\theta}$. This formulation has hence the interest of concentrating the analysis on the role of interdependent utilities on participation to the policy. Note that the purpose of intervention is not redistributing income among agents as the welfare is purely utilitarian, but rather limiting the adverse consequences of production/consumption in terms of environmental damage.

The participation constraints become

$$\pi(\theta) \geq \frac{\rho}{1+\rho} \int_{\Theta} \pi(\theta) dF(\theta)$$

and as $\dot{\pi}(\theta) = u_\theta > 0$ then (IR) reduces to $\pi(\underline{\theta}) \geq \frac{\rho}{1+\rho} \int_{\Theta} \pi(\theta) dF(\theta) = \frac{\rho}{1+\rho}\bar{\pi}$. Hence, by integration, we have

$$\pi(\theta) = \pi(\underline{\theta}) + \int_{\underline{\theta}}^{\theta} u_\theta(q(x), x) dx$$

and by integration over Θ, assuming that (IR) binds, we get

$$\begin{aligned} \int_{\Theta} \pi(\theta) dF(\theta) &= \pi(\underline{\theta}) + \int_{\Theta} \int_{\underline{\theta}}^{\theta} u_\theta(q(x), x) dx dF(\theta) \\ \frac{1}{\rho}\pi(\underline{\theta}) &= \frac{1}{1+\rho} \int_{\Theta} \pi(\theta) dF(\theta) = \int_{\Theta} u_\theta(q(\theta), \theta) \frac{1 - F(\theta)}{f(\theta)} dF(\theta). \end{aligned}$$

Also, the budget constraint rewrites as follows

$$\begin{aligned} \int_{\Theta} (\pi(\theta) - u(q(\theta), \theta)) dF(\theta) &\leq B \\ \int_{\Theta} \left[(1+\rho) u_\theta(q(\theta), \theta) \frac{1 - F(\theta)}{f(\theta)} - u(q(\theta), \theta) \right] dF(\theta) &\leq B \end{aligned}$$

The regulator's program reduces to:

$$\max_{q(.)} (1+\rho) \int_{\Theta} u_\theta(q(\theta), \theta) \frac{1 - F(\theta)}{f(\theta)} dF(\theta)$$

s.t.

$$\int_{\Theta} d(q(\theta)) dF(\theta) \leq \bar{D}$$

$$\int_{\Theta} \left[(1+\rho) u_\theta(q(\theta), \theta) \frac{1 - F(\theta)}{f(\theta)} - u(q(\theta), \theta) \right] dF(\theta) \leq B$$

and it is equivalent to maximize

$$\mathcal{H}(\theta) = (1+\rho) u_\theta(q(\theta), \theta) \frac{1 - F(\theta)}{f(\theta)} - \mu d(q(\theta)) + \nu(u(q(\theta), \theta) - (1+\rho) u_\theta(q(\theta), \theta) \frac{1 - F(\theta)}{f(\theta)})$$

The first-order condition is

$$\frac{\partial \mathcal{H}}{\partial q} = (1-\nu)(1+\rho)u_{\theta q}\frac{1-F(\theta)}{f(\theta)} - \mu d'(q) + \nu u_q = 0$$

or equivalently

$$u_q = \frac{\mu}{\nu}d'(q) - \frac{(1-\nu)(1+\rho)}{\nu}\frac{1-F(\theta)}{f(\theta)}u_{\theta q}$$

As $u_{\theta q} > 0$ and because $\nu > 1$, this means that there is a downward distortion for every type except for the highest one (pigovian taxation at the rate $\frac{\mu}{\nu}d'(q)$). This distortion increases with ρ which means that if we denote $q^*(\theta, \rho)$ the optimal solution, we have[5]

$$\begin{aligned} q^*(\overline{\theta}, \rho) &= q^{SB}(\overline{\theta}) \text{ for any } \rho \\ q^*(\theta, \rho) &\leq q^*(\theta, 0) \text{ for any } \rho \text{ and } \theta \end{aligned}$$

and we can show easily that $q^*(\overline{\theta}, \rho) - q^*(\theta, \rho)$ is increasing in ρ for any θ. Indeed, if we denote $H(q, \theta, \rho) = u_q - \frac{\mu}{\nu}d'(q) + \frac{(1-\nu)(1+\rho)}{\nu}\frac{(1-F(\theta))}{f(\theta)}u_{\theta q}$, then $H_q \leq 0$ because of concavity and consequently

$$\frac{\partial q^*(\theta, \rho)}{\partial \rho} = -\frac{H_\rho}{H_q} < 0$$

because $H_\rho = \frac{1-\nu}{\nu}\frac{1-F(\theta)}{f(\theta)}u_{\theta q} < 0$.

If utilities are interdependent with status seeking then the optimal contract amounts to distort production downward more than in the absence of status seeking ($\rho = 0$), in order for the income distribution to satisfy the participation constraint. This seems paradoxical because if status seeking increases then the social damage of production is reduced! The intuition of the result goes as follows. In the presence of status seeking, fullfilling the individual rationality constraints is more demanding and hence it calls for more distortions. As a consequence, status seeking is bad for welfare as there is too much reduction in production/pollution.

Interestingly, if the regulator neglects the interdependence between utilities, it will offer the optimal allocation $q^*(\theta, 0)$ and $\pi^*(\theta, 0)$ which is incentive compatible but the IR constraint

[5] We denote $q^{SB}(\theta)$ the second best optimum defined by $u_q = \frac{\mu}{\nu}d'(q)$.

will be violated for a subset of agents, namely all the agents between $\underline{\theta}$ (who gets 0 in the standard model) and $\tilde{\theta}$ defined by

$$\pi^*(\tilde{\theta}, 0) = \frac{\rho}{1+\rho}\, \bar{\pi}^*|_{\rho=0}\,.$$

The equilibrium profit is

$$\pi^*(\theta, \rho) = \rho \int_\Theta u_\theta(q^*(\theta, \rho), \theta) \frac{1-F(\theta)}{f(\theta)} dF(\theta) + \int_{\underline{\theta}}^{\theta} u_\theta(q^*(x, \rho), x) dx$$

and the impact of ρ on $\pi^*(\theta, \rho)$ is a priori ambiguous: on the one hand, $\pi^*(\theta, \rho)$ increases directly with ρ but on the other hand the allocation $q^*(\theta, \rho)$ decreases with ρ. Indeed, we have

$$\begin{aligned} \frac{d\pi^*(\theta, \rho)}{d\rho} &= \int_\Theta u_\theta(q^*(\theta, \rho), \theta) \frac{1-F(\theta)}{f(\theta)} dF(\theta) \\ &+ \rho \int_\Theta u_{\theta q}(q^*(\theta, \rho), \theta) \frac{\partial q^*(\theta, \rho)}{\partial \rho} \frac{1-F(\theta)}{f(\theta)} dF(\theta) + \int_{\underline{\theta}}^{\theta} u_{\theta q}(q^*(x, \rho), x) \frac{\partial q^*(x, \rho)}{\partial \rho} dx \end{aligned}$$

The equilibrium utility is

$$\begin{aligned} & \pi^*(\theta, \rho) + \rho \left[\pi^*(\theta, \rho) - \int_\Theta \pi^*(\theta, \rho) dF(\theta) \right] \\ = \;& (1+\rho)\pi^*(\theta, \rho) - \rho \int_\Theta \pi^*(\theta, \rho) dF(\theta) \\ = \;& (1+\rho)\pi^*(\theta, \rho) - \rho(1+\rho) \int_\Theta u_\theta(q^*(\theta, \rho), \theta) \frac{1-F(\theta)}{f(\theta)} dF(\theta) \\ = \;& (1+\rho) \left[\rho \int_\Theta u_\theta(q^*(\theta, \rho), \theta) \frac{1-F(\theta)}{f(\theta)} dF(\theta) + \int_{\underline{\theta}}^{\theta} u_\theta(q^*(x, \rho), x) dx \right] \\ & - \rho(1+\rho) \int_\Theta u_\theta(q^*(\theta, \rho), \theta) \frac{1-F(\theta)}{f(\theta)} dF(\theta) \\ = \;& (1+\rho) \int_{\underline{\theta}}^{\theta} u_\theta(q^*(x, \rho), x) dx \end{aligned}$$

which is also ambiguous with respect to ρ.

The average profit is

$$\bar{\pi}^* = (1+\rho) \int_\Theta u_\theta(q(\theta), \theta) \frac{1-F(\theta)}{f(\theta)} dF(\theta).$$

Its evolution with ρ is once again ambiguous. But the gap between the highest and the lowest profit decreases in ρ :

$$\begin{aligned}
&\pi^*(\overline{\theta},\rho)-\pi^*(\underline{\theta},\rho)\\
=\;& \rho\int_{\Theta} u_\theta(q^*(\theta,\rho),\theta)\frac{1-F(\theta)}{f(\theta)}dF(\theta)+\int_{\underline{\theta}}^{\overline{\theta}} u_\theta(q^*(x,\rho),x)dx-\rho\int_{\Theta} u_\theta(q^*(\theta,\rho),\theta)\frac{1-F(\theta)}{f(\theta)}dF(\theta)\\
=\;& \int_{\underline{\theta}}^{\overline{\theta}} u_\theta(q^*(x,\rho),x)dx
\end{aligned}$$

because $u_{\theta q}>0$ and $q^*(\theta,\rho)$ decreases with ρ. Hence, the presence of status seeking implies the reduction of the range between maximal and minimal profits. Simultaneously, as shown above, the gap between the quantity allocated to the highest type (which is constant w.r.t ρ) and any lower type increases in ρ.

6 Conclusion

We have explored in this note the consequences of status seeking preferences among agents contracting with a principal in the context of production. We have examined in particular the case of envy and we have shown that in general envy entails augmented distortions due to asymmetric information in optimal contracts. Furthermore if the principal neglects the preferences of the agents with respect to status, then potentially there is under-participation to the contract. We also showed that if the principal is free to choose who can participate to the contract, then under some conditions the principal may prefer to contract with only a subset of potentially "profitable" agents (that is where his utility is strictly positive). We then asked whether contracting with agents seeking status would yield to more incentives to exert unobservable effort. We actually show that the principal has incentives to discourage effort. In the last part of the paper, we considered the case of a public principal that seeks to reduce negative externalities from production under a budget constraint.

References

[1] Boskin M. and E. Sheshinski (1978), "Optimal redistributive taxation when individual welfare depends on relative income", *Quaterly Journal of Economics*, XCII:589-601.

[2] Corneo G. and H.P. Grüner (2002), "Individual preferences for political redistribution", *Journal of Public Economics,* 83:83-107.

[3] Dupor B. and W-F Liu (2003), "Jealousy and Equilibrium overconsumption", *American Economic Review*, XCIII:423-428.

[4] Luttmer E. (2005), "Neighbors as negatives: relative earnings and well-being", mimeo.

[5] Ireland N. (1998), "Status-seeking, income taxation and efficiency", *Journal of Public Economics,* 70:83-107.

[6] Oswald A. (1983), "Altruism, jealousy and the theory of optimal non linear taxation", *Journal of Public Economics,* XX:77-87.

[7] Rayo L. and G. Becker (2004), "Evolutionary efficiency and mean reversion in happiness", mimeo

[8] Samuelson L. (2004), "Information-based relative consumption effects", *Econometrica*, LXXII:93-118.

[9] Veblen T., *The theory of the leisure class* (New York, Macmillan, 1899).

Appendix

A Proof of proposition 1

As usual, incentive compatibility constraints reduce to the following first-order condition

$$u_q q' + u_t t' = 0$$

together with the second-order condition $q' \leq 0$. Note also that $U'(\theta) = u_\theta < 0$ so that the participation constraints reduce to $U(\overline{\theta}) \geq 0$. Then the Lagrangean writes as follows:

$$\mathcal{L} = \int_\Theta [S(q(\theta)) - t(\theta)]\, dF(\theta) + \int_\Theta \phi(\alpha - \omega(\theta)H(q(\theta), t(\theta), \theta))dF(\theta) + \int_\Theta \lambda(\theta)(u_q q' + u_t t')d\theta$$

Integrating by parts the last term, we obtain:

$$\begin{aligned}\mathcal{L} &= \int_\Theta [S(q(\theta)) - t(\theta)]\, dF(\theta) + \int_\Theta \phi(\alpha - \omega(\theta)H(q(\theta), t(\theta), \theta))dF(\theta) \\ &\quad + [\lambda(\theta)u(q(\theta), t(\theta), \theta, \alpha)]_{\underline{\theta}}^{\overline{\theta}} - \int_\Theta \left[\lambda'(\theta)u(q(\theta), t(\theta), \theta, \alpha) + \lambda(\theta)u_\theta(q(\theta), t(\theta), \theta, \alpha)\right] d\theta\end{aligned}$$

Deriving the Lagrangean and dropping arguments for clarity, we obtain the following necessary conditions:

$$\frac{\partial \mathcal{L}}{\partial q} = S'f - \phi\omega H_q f - \lambda' u_q - \lambda u_{\theta q} = 0 \tag{10}$$

$$\frac{\partial \mathcal{L}}{\partial t} = -f - \phi\omega H_t f - \lambda' u_t - \lambda u_{\theta t} = 0 \tag{11}$$

$$\frac{\partial \mathcal{L}}{\partial \alpha} = \int_\Theta \left[\phi f - \lambda' u_\alpha - \lambda u_{\theta\alpha}\right] d\theta = 0 \tag{12}$$

together with $\lambda(\underline{\theta}) = 0$ as $U(\underline{\theta})$ is free and $\lambda(\overline{\theta})U(\overline{\theta}) = 0$ with $\lambda(\overline{\theta}) \geq 0$, $U(\overline{\theta}) \geq 0$.

From equation (10), we get

$$\lambda' = \frac{1}{u_q}\left[S'f - \phi\omega H_q f - \lambda u_{\theta q}\right]$$

which is a linear differential equation in λ. The solution is given by

$$\begin{aligned}\lambda(\theta) &= \lambda(\underline{\theta})\left(\exp\int_{\underline{\theta}}^{\theta} -\frac{u_{\theta q}}{u_q}dx\right) + \int_{\underline{\theta}}^{\theta} \frac{1}{u_q}\left[S' - \phi\omega H_q\right]\left(\exp\int_x^\theta -\frac{u_{\theta q}}{u_q}dy\right) dF(x) \\ &= \int_{\underline{\theta}}^{\theta} \frac{1}{u_q}\left[S' - \phi\omega H_q\right]\left(\exp\int_x^\theta -\frac{u_{\theta q}}{u_q}dy\right) dF(x)\end{aligned}$$

recalling that $\lambda(\underline{\theta}) = 0$. Let us denote

$$\begin{aligned} A(\theta) &= \int_{\underline{\theta}}^{\theta} \frac{S'}{u_q} \left(\exp \int_x^{\theta} -\frac{u_{\theta q}}{u_q} dy \right) dF(x) \\ B(\theta) &= -\int_{\underline{\theta}}^{\theta} \frac{\omega H_q}{u_q} \left(\exp \int_x^{\theta} -\frac{u_{\theta q}}{u_q} dy \right) dF(x) \end{aligned}$$

then we get $\lambda(\theta) = A(\theta) + \phi B(\theta)$. Plugging this into equation (12), we obtain an expression for ϕ :

$$\begin{aligned} \phi &= \int_{\Theta} \left[\lambda' u_\alpha + \lambda u_{\theta\alpha} \right] d\theta \\ \phi &= \int_{\Theta} \left[\left(\frac{1}{u_q} \left[S' f - \phi \omega H_q f - (A + \phi B) u_{\theta q} \right] \right) u_\alpha + (A + \phi B) u_{\theta\alpha} \right] d\theta \end{aligned}$$

Rearranging, we get

$$\phi = \frac{\int_{\Theta} \left[\left(\frac{1}{u_q} \left[S' f - A u_{\theta q} \right] \right) u_\alpha + A u_{\theta\alpha} \right] d\theta}{1 + \int_{\Theta} \left[\frac{u_\alpha}{u_q} \left[\omega H_q f + B u_{\theta q} \right] - B u_{\theta\alpha} \right] d\theta}.$$

Finally, eliminating λ' in equations (10) and (11) and rearranging, we obtain:

$$S' + \frac{u_q}{u_t} = \frac{\lambda}{f} \left[u_{\theta q} - \frac{u_q}{u_t} u_{\theta t} \right] + \phi \omega \left[H_q - H_t \frac{u_q}{u_t} \right]$$

which concludes the proof.

B Proof of Proposition 4

The program of the principal is as follows:

$$\max_{t(.),q(.)} \int_{\Theta} \{ S(q(\theta)) - t(\theta) \} \, dF(\theta)$$

s.t.

$$U(\theta) = (1 + \rho) \left(t(\theta) - (\theta - e(\theta)) q(\theta) \right) - \rho \alpha - \psi(e(\theta)) \geq 0$$

$$\psi'(e(\theta)) = (1 + \rho) q(\theta)$$

$$U(\theta) \geq U(\theta, \tilde{\theta}) \text{ for any } \theta, \tilde{\theta}$$

$$\alpha = \int_{\Theta} \omega(\theta) \left(t(\theta) - (\theta - e(\theta)) q(\theta) \right) dF(\theta)$$

As usual, (IC) constraints reduce to

$$\dot{U}(\theta) = -(1+\rho)q(\theta) < 0$$
$$\dot{q} \leq 0$$

and we deduce that (IR) constraints can be reduced to $U(\overline{\theta}) \geq 0$. Replacing t and forgetting for the moment the second order condition, the program of the principal reduces to

$$\max_{\pi(.),q(.)} \int_\Theta \left\{ S(q(\theta)) - \left(\frac{U(\theta)+\rho\alpha+\psi(e(\theta))}{1+\rho} + (\theta - e(\theta))q(\theta) \right) \right\} dF(\theta)$$

s.t.

$$U(\overline{\theta}) = 0$$

$$\dot{U}(\theta) = -(1+\rho)q(\theta)$$

$$\alpha = \int_\Theta \omega(\theta) \left(\frac{U(\theta)+\rho\alpha+\psi(e(\theta))}{1+\rho} \right) dF(\theta)$$

The Lagrangean writes as

$$\begin{aligned} \mathcal{L} &= \int_\Theta \left\{ S(q(\theta)) - \left(\frac{U(\theta)+\rho\alpha+\psi(e(\theta))}{1+\rho} + (\theta - e(\theta))q(\theta) \right) \right\} dF(\theta) \\ &\quad + \int_\Theta \lambda(\theta)(-(1+\rho)q(\theta) - \dot{U}(\theta))d\theta \\ &\quad + \int_\Theta \phi(\alpha - \omega(\theta) \left(\frac{U(\theta)+\rho\alpha+\psi(e(\theta))}{1+\rho} \right))f(\theta)d\theta \end{aligned}$$

Integrating by parts, we obtain

$$\begin{aligned} \mathcal{L} &= \int_\Theta \left\{ S(q(\theta)) - \left(\frac{U(\theta)+\rho\alpha+\psi(e(\theta))}{1+\rho} + (\theta - e(\theta))q(\theta) \right) \right\} dF(\theta) - \int_\Theta \lambda(\theta)(1+\rho)q(\theta)d\theta \\ &\quad + \int_\Theta \dot{\lambda}(\theta)U(\theta)d\theta + \int_\Theta \phi(\alpha - \omega(\theta) \left(\frac{U(\theta)+\rho\alpha+\psi(e(\theta))}{1+\rho} \right))f(\theta)d\theta \end{aligned}$$

The first-order conditions are

$$\frac{\partial \mathcal{L}}{\partial q} = (S'(q) - (\theta - e(\theta)))f(\theta) - (1+\rho)\lambda(\theta) - \frac{1}{1+\rho}\phi\omega(\theta)f(\theta)\psi'(e(\theta))\frac{de}{dq} = 0 \quad (13)$$

$$\frac{\partial \mathcal{L}}{\partial \alpha} = -\frac{\rho}{1+\rho} + \phi - \frac{\rho}{1+\rho}\int_\Theta \omega(\theta)f(\theta)d\theta = 0 \quad (14)$$

$$\frac{\partial \mathcal{L}}{\partial U} = -\frac{1}{1+\rho}f(\theta) + \dot{\lambda}(\theta) - \frac{1}{1+\rho}\phi\omega(\theta)f(\theta) = 0 \quad (15)$$

together with the transversality condition $\lambda(\underline{\theta}) = 0$ as $U(\underline{\theta})$ is free and $\lambda(\overline{\theta}) \geq 0$ with $\lambda(\overline{\theta})U(\overline{\theta}) = 0$.

From (15), we get $\lambda(\theta) = \int_{\underline{\theta}}^{\theta} \frac{1+\phi\omega(x)}{1+\rho} dx$. From (14) we get

$$\phi = \frac{\rho}{1+\rho}\left(1 + \int_{\Theta} \omega(\theta) f(\theta) d\theta\right) \geq 0$$

And for the production level, we obtain

$$\begin{aligned}
S'(q(\theta)) &= \theta - e(\theta) + \frac{1}{f(\theta)} \int_{\underline{\theta}}^{\theta} 1 + \phi\omega(x)dx + \frac{1}{1+\rho}\phi\omega(\theta)\psi'(e(\theta))\frac{de}{dq} \\
S'(q(\theta)) &= \theta - e(\theta) + \frac{1}{f(\theta)} \int_{\underline{\theta}}^{\theta} 1 + \phi\omega(x)dx + \phi\omega(\theta)\frac{\psi'(e(\theta))}{\psi''(e(\theta))}
\end{aligned}$$

This concludes the proof.

3rd world congress of environmental and resource economists,
Kyoto, Japan, July 3-7 2006.

Private provision of environmental services and transaction costs: Agro-environmental contracts in France

Géraldine DUCOS* and Pierre DUPRAZ*

*French National Institute for Agricultural Research (INRA), Department of Economics, Rennes, FRANCE

ABSTRACT

Since the 1999-reform of the Common Agricultural Policy, the agro-environmental contract has become the main instrument used in the European Union to encourage farmers to produce environmental goods. This is a five-year contract between the State and the farmer who benefits a compensation to comply with given environmental friendly practices. Environmental outcomes highly depend on farmers' participation. Since it remains low, it is crucial to identify the driving factors of farmer's behavior with respect to agro-environmental contracts. Among other factors, there is empirical and theoretical evidence that private transaction costs have a significant role. While public transaction costs have been considered in the literature dealing with agro-environmental contracts, private ones did not. This paper addresses this issue by estimating private transaction costs. In addition, econometric modeling is used to identify the most significant factors that account for private transaction costs. The empirical analysis is based on a sample of 328 French farmers. Econometric results are consistent with the transaction cost theory. Indeed, they show that farmer's transaction costs are mainly due to human specificity, uncertainty and the technology of the subjacent production.

Acknowledgement: This document presents results obtained within the EU project SSPE-CT-2003-502070 on Integrated tools to design and implement Agro Environmental Schemes (http//:merlin.lusignan.inra.fr/ITAES). It does not necessary reflect the view of the European Union and in no way anticipates the commission's future policy in this area.
This research has benefited from a grant under the S3E program (Ministère de l'Ecologie et du développement durable)

JEL Classification: D23, Q12, Q28

I) INTRODUCTION

The degradation of environmental quality and rural landscape has resulted in a strong demand of rural amenities in European countries. However, farmers manage most rural areas, which leads environmental policies to be aimed at farming activities. The production of environmental goods by farmers has lots of particularities. Among others inputs are shared between several farmers, e.g. "collective production", and environmental goods are threshold and time dependant, i.e. environmental results may appear at a certain effort level and duration. All these conditions make the adoption rate of environmental friendly practices by farmers to be very important so as to achieve environmental outcomes.
Since the 1990s, agro-environmental schemes have become widespread in Europe. The 1999-CAP reform has confirmed this trend through the implementation of the "agro-environmental contract". This is a 5-year contract between the State and the farmer. The farmer's voluntary participation is compensated if he adopts more environmental friendly practices than what is mandatory. Before and after 1999, France has experienced several agro-environmental schemes that differ from their bottom-up or top-down elaboration and from a more or less decentralized implementation. Although they aim at coordinating and encouraging farmers, adoption rate remains globally low (12% of farms). Environmental results are therefore suspected not to be satisfying.
Obviously, farmer's adoption behavior is not known enough and compensations need to be adjusted. Some studies (Brotherton, 1991, Drake, et al., 1999, Morris, et al., 2000) have examined adoption determinants. They focused on the technology but did not consider the transaction cost component. However, agro-environmental contracts may involve some investments implying transaction costs that may negatively impact. While public transaction costs have been studied (Falconer, et al., 1999), the originality of this paper is thus to examine the importance of private transaction costs, to characterize their determinants and to identify interactions between them. According to our hypothesis, the determinants of private transaction costs significantly influence the probability of contracting, ceteris paribus. For that, the adaptation of a model of contract adoption has been carried out and estimated with survey data collected in 2005 among 328 farmers. Current agro-environmental contract attributes being the same (same duration, same possibilities of negotiation…), a set a questions was added according to the choice experiment method so as to be able to test different levels of contract attributes.
The analysis of transaction costs requires a theoretical detour to identify sources of transaction costs. It starts with the identification of the transaction parties: the transmitting party of the transaction, the State, and the supplier party, the farmer. Their respective behavior is a function of their own characteristics (bounded rationality and opportunistic behavior) and of environmental characteristics of the transaction (assets specificity, uncertainty, frequency). According to Williamson (1985), these aspects are connected to every transactions and determine the importance and nature of transaction costs. He particularly insists on asset specificity: "the organization of an economic activity is massively influenced by the degree to which the examined transaction is supported by investments which are specific to parties". Generally speaking, in the agro-environmental context, it is commonly assumed transaction costs mainly come from site specificity assets because environmental effects highly depend on practice localization. Outcome analysis does not support site specificity as the main private transaction cost determinant but rather as public ones.
In his 1995 article, Quiggin provides an analysis of transaction costs as arising from the interaction between the governance structure and the underlying technology of production. His paper is an attempt to integrate the transaction cost economics analysis of Williamson and others with the treatment of cost functions. The adoption model used in this study is also an

attempt to consider both transaction costs and operational costs. Indeed, among others it allows to observe the effects of technology characteristics on transaction costs, the farming system including its environmental production being the underlying technology of production Quiggin refers to.
In addition, it is important to remind the difference between sunk costs, operational costs linked to the contract implementation and transaction costs. Sunk costs that can be linked with specific assets, are costs incurred in advance of the contemplated exchange and whose value in alternative uses or by alternative users is greatly reduced (Williamson 1983). They are in fact a type of operational costs, this last ones corresponding to the whole of expenses relative to the transaction effective realization, i.e. to the supply of the good requested. Transaction costs, in the way they have been described above, do not take part of these costs but depend on them.
The Williamson's hostage principle (1983) is also required to describe some outcomes: " the buyer supplies a hostage to which he gives a value *h*, this hostage is delivered to the producer, who gives him a value *αh*, if the order is cancelled ". In other words, the buyer pays for part of the specific investments carried out by the producer. Bilateral efforts are thus observed to create and offer hostages. In this way, the transaction becomes safer.
Therefore, according to the theory a governance structure is preferred to another because it minimizes total transaction costs. Here, the study is not in keeping with this approach since the governance structure has been chosen by the State: the contract. Moreover, the State has been willing to apply more and more rigid contractual forms whose requirements are not negotiable and with no support to farmers before and during the whole contract duration. Thus, recent contracts are less costly for the exchequer but this orientation might not lead to more efficiency: does the agro-environmental contract, as it is proposed today, enable to minimize total transaction costs? This paper focuses on private transaction costs, as environmental results are dependant on the adoption rate, and tries to evaluate their importance and to identify their determinants.

Section 2 describes the adapted adoption model and the preference one. Section 3 provides survey conditions. Then, section 4 presents sensitive analysis results and section 5 concludes.

II) MODELS

The adapted adoption model and its estimation method is first presented. However, the direct estimation of contract attributes is irrelevant because current contracts do not show enough variability. This is notably for this reason a preference model is developed.

II.1) The adoption model with transaction costs

Effects of environmental characteristics (asset specificity, uncertainty and frequency), underlying technologies and farmers' ones on transaction costs are tested from an adapted adoption model.
Therefore, in order to assess the importance of private transaction costs and their determinants in the farmer's behavior, a transaction cost function is integrated in the adoption model validated in Dupraz et al. (2002) and tested using econometric methods.

II.2.1) Economic specification

Consider a utility maximizing farmer with an income constraint depending on farm profit. The restricted profit function, or short-term profit function, π^R, enables to derive the income from the on-farm activity with an agro-environmental contract that is attached to an area v (Dupraz, et al., 2003).

$$\underset{m,v}{Max}\, U\,(m,v,Z^U)$$

$$\text{sc. } m \leq \pi^R\,(p,v,Z^\pi) - TC\,(p,v,Z^U,Z^\pi,Z^C) + \rho v \qquad (1)$$

$$\text{sc. } v \geq 0$$

The parameters of the utility function are the farmer's private consumption m, expressed in monetary value, the quantity v (number of hectares) of environmental services co-produced by farming activities, and Z^U the utility function characteristics. This function is supposed to be increasing, concave and differentiable in m and v.

The farmer's restricted profit function π^R represents the agro-environmental technology using the dual approach by a short-term optimization of products and production factor variables of price p. Z^π is the profit function characteristics. π^R is assumed to be convex.

A transaction cost function is distinguished from π^R, called *TC(.)*. This function is assumed to depend on Z^C, the contract characteristics also called contract attributes, Z^U, Z^π, p and v. Finally, ρv is the agro-environmental payment associated to a commitment to an area v.

Resolving this program, the following relations is obtained for the first enrolled hectare:

If $-\pi_v^R - \dfrac{U_v}{U_m} + TC_v < \rho$, then the farmer contracts (2)

If $-\pi_v^R - \dfrac{U_v}{U_m} + TC_v > \rho$, then the farmer does not

$b_i = \rho + \pi_v^R + \dfrac{U_v}{U_m} - TC_v$ (3) is farmer i marginal gain or loss due to the contract, and v_i^* the optimal area to enroll.

II.2.2) Model adoption estimation

A probit model is used to describe the probability to accept an agro-environmental contract according to the utility maximization model. The latent variable of this model can be interpreted as the marginal gain to enroll for the first hectare. In first approximation, the marginal gain is a linear function of explanatory variables corresponding to the micro-economic model exogenous variables: p, Z^U, Z^π, ρ, Z^C, gathered in the vector x and of a perturbation u which is assumed to have a normal distribution.

$b_i = x_i\beta + u_i \qquad u_i \rightarrow N(0,\sigma)$

A probability function is built for the binary variable Y_i , which is 1 if the farmer adopts a contract and 2 if he doesn't:

$$Y_i = \begin{cases} 1 & if \quad b_i > 0 \\ 2 & if \quad b_i \leq 0 \end{cases} \tag{4}$$

$$with \;\; P(Y_i=1) = P(b_i > 0) = P(u_i > x_i\beta) = 1 - P\left(\frac{u_i}{\sigma} < \frac{-x_i\beta}{\sigma}\right) = 1 - \Phi\left(\frac{-x_i\beta}{\sigma}\right)$$

Let the likelihood function :

$$L(\beta,\sigma) = \prod_{Y_i=1} \Phi\left(\frac{-x_i\beta}{\sigma}\right) \prod_{Y_i=2} \left[1 - \Phi\left(\frac{-x_i\beta}{\sigma}\right)\right] \tag{5}$$

with Φ the repartition function of the reduced and centered normal distribution.

The maximization of this function leads to estimate $\frac{\beta}{\sigma}$.

Interpretation: The estimation of this adoption model allows to identify determinants of adoption, which corresponds to b>0, and not those of transaction costs. Even if some of these determinants are suspected to influence more transaction costs than other components of b, at this stage, it is not possible to conclude on whether their effects are significant on transaction costs.

II.3) The simple and complete preference models

The adoption analysis enables to study the variability impact of farmer' characteristics, Z^U , and his farming system, Z^π , on his gain b. However, general characteristics of contracts, Z^C , are the same for any current proposed contract. Thus so as to test the contract variability on farmers' adoption, a preference model is tested with the choice experiment method on alternative contracts. For each respondent, the alternative contracts presented in the choice experiment are based on one agro-environmental practice only. This method measures the variation of the contract yearly payment that is required to maintain the area under contract, when contract attributes vary. In accordance with our microeconomic model, the purpose of this experimental design is to measure variations of transaction costs (information searching, contract negotiation, control) rather than variation of operational costs, since the prescribed agricultural practice is the same, i.e. the farmer's investment is the same. However there is no clear cut between operational costs and transaction costs: for instance the contract attribute "to have the possibility to choose land plots" obviously affects both if farm land is heterogeneous. Then, a more complete preference model will allow to observe interactions between farmer's determinants and contract attribute on adoption. The economic specification and the preference model estimation by the choice experiment method have been adapted from Bonnieux et al. (2004).

II.3.1) The economic formalization

Let U_{jci} the maximized utility level associated to the contract j in the alternative c for the farmer i:

$$U_{jci} = V_i(\rho, a_{jc}) = U_i\left[v(\rho, a_{jc})\right] \tag{6}$$

The function $V_i(.)$ is the indirect utility function of the individual i, i.e. the solution of the adoption model (1). It values the maximized utility level incurred from contract attributes, Z^C , represented with a_{jc}.

The surveyed individuals are assumed to be rational: when they have alternatives, they choose the contract that suits them the best, i.e. the contract that gives them a maximum utility. Formally, this postulate of an individual's rationality is written as follows:

$$y_{jci} \equiv Arg \max_{j=0,1,2} \{U_{0ci}, U_{1ci}, U_{2ci}\} \ . \qquad (7)$$

II.3.2) Preference model estimation by the choice experiment method

This method principle is to use the information brought by individuals' choices in order to infer the value of attribute levels that are considered in different alternatives, i.e. contract forms. This value observation is made possible by variations of proposed attributes and the observation of choices within these alternatives only. Nevertheless, this identification relies on simplifying hypothesis. In particular, interactions between attributes are assumed to not have any particular value for interviewed individuals, i.e. the value of an alternative is the sum of its attribute values. In addition, the utility is assumed to be linear in this value. (Ruto et al. 2004) comes up with a random utility model:

$$U_{jci} \equiv V_i(\rho_{jc}, a_{jc}) + \eta_{jci} \equiv \sum_{k=1}^{4} \beta_{ki} a_{kjc} + \beta_{vi} \rho_{jc} + \eta_{jci} \qquad (8)$$

a_{kjc} : level of the attribute *k* in the contract *j* of the alternative *c*

ρ_{jc} : price (subsidy) proposed for the contract *j* of the alternative *c*

The term: $V_i(\rho_{jc}, a_{jc}) \equiv \sum_{k=1}^{4} \beta_{ki} a_{kjc} + \beta_{vi} \rho_{jc}$ represents the utility deterministic part. It depends on individuals' preferences and describes contract effect on the utility level. Moreover, parameters associated to attributes and prices of alternatives β_{ki} and β_{vi} (which are parameters to estimate) are assumed to depend neither on *j* nor on *c*, i.e. a contract value does not depend on its attribute values and its price only.

The η_{jci} is a random term that expresses the fact that only a part of individuals' choice determinants is observed. It represents the utility part of U_{jci} non explained by the form of the contract *j* of the alternative *c*. Since a_{jc} are chosen according to an experiment plan and do not depend on *i*, if their effects are correctly specified in $V_i(.)$, they are not linked to η_{jci}. Therefore, the term η_{jci} represents the status quo utility level for the interviewed individual, i.e. his current utility level.

So as to simplify the rest of the specification presentation, it is useful to decompose this term in two parts:

$$\eta_{jci} \equiv \alpha_i + \omega_{jci} \qquad (9)$$

The term α_i thus represents the interviewed individual's current utility level and the term ω_{jci} the actual survey effects. This last term is purely random and quasi-negligible if the evaluation procedure works correctly.

Status quo evaluation

It is possible to evaluate the status quo bias, i.e. rejection of any shift. To proceed, expression (8) must be taken and a variable is added for the parametrable status quo.

First of all, to consider the fact of not doing anything is a full attribute of the status quo alternative is the same as to assume that:

$$\omega_{jci} = b_{si} s_{jc} + e_{jci} \text{ with } E[e_{jci}] = 0 \qquad (10)$$

Therefore our model becomes:

$$U_{jci} \equiv \sum_{k=1}^{4} \beta_{ki} a_{kjc} + \beta_{vi} \rho_{jc} + \alpha_i + b_{si} s_{jc} + e_{jci} \qquad (11)$$

The variable s_{jc} equals 1 if the alternative is the status quo and 0 otherwise.

This alternative choice probability corresponds to a standard Conditional Logit model that will be estimated with the likelihood maximum method (Greene, 1997).

The attribute monetary value

Implicit prices enable to show relative importances interviewed individuals give to contracts. So as to calculate implicit prices, coefficients of estimated contract attributes and monetary ones are required. Such prices, also called willingness to pay, are marginal rate of substitution between an attribute level and money quantity.

So as to calculate the monetary value attributed by the individual into an attribute *k* in monetary units, - β_{vi} is considered as the marginal utility of income of individual *i*.

$$\partial U_{jci} / \partial \rho_{jc} = \beta_{vi} \qquad (12)$$

Therefore, in this linear utility model the price individual *i* is ready to pay for the attribute *k* (his income maximum amount he is ready to give up to get this attribute) is given by:

$$WTA_{ki} \equiv - \beta_{ki} / \beta_{vi} \qquad (13)$$

The term willingness to accept (WTA) is going to be used as the farmer accepts a subsidy in exchange of a rendered service.

Individuals' heterogeneity control

Farmers' behavioral variables (Z^U and Z^π variables) are now going to be integrated in this model.

The above estimated parameters of linear form are specific to attributes but attribute values are generally individual specific. It is possible to control, at least partially, this individual heterogeneity, considering parameters β_{ki}, βvi and b_{si} are parametrized functions of individuals' characteristics, i.e. of $\mathbf{x_i}$:

$$\beta_{ki} \equiv \beta_{k0} + \sum_{d=1}^{D} \beta_{kd} x_{di} \equiv \beta_{k0} + \beta'_k \mathrm{x_i} \qquad \text{: k=1,…,4 for attributes}$$

$$\beta_{vi} \equiv \beta_{v0} + \sum_{d=1}^{D} \beta_{vd} x_{di} \equiv \beta_{v0} + \beta'_v \mathrm{x_i} \qquad \text{: for contract subsidies} \qquad (14)$$

$$b_{si} \equiv b_{s0} + \sum_{d=1}^{D} b_{sd} x_{di} \equiv b_{s0} + b'_s \mathrm{x_i}$$

The need to take into account individuals' heterogeneity leads to propose a Conditional Logit model that will be estimated with the likelihood maximum method (Greene, 1997).

III) PRESENTATION OF THE SURVEY AND DATA

328 farmers were face to face interviewed in 2005, in the French region "Basse Normandie" made of three sub-regions "Calvados", "Manche" and "Orne". Among them, 171 are contracting farmers and 157 are non-contracting ones. The questionnaire addresses issues concerning their farm, their perceptions on agro-environmental contract, their preferences on

contract attributes (choice experiment method) and information on their income and hobbies. In addition, several questions were asked to contracting farmers on how they manage their agro-environmental contract and their required farming practices.
The sample is quite representative although contracting farmers are over represented on purpose in order to get better information on contracts.
The most frequent farming systems in the non contracting population are, by decreasing order: dairying, combined grazing livestock, crops and livestock combined, equal with field cropping. In the contracting population, they are: dairying, combined grazing livestock, field cropping.

III.1) Data collected to feed the adoption model

Several types of variables were collected. They describe the farmer (education level, environmental sensibility…), his production system (farm legal status, number of Full Time Equivalent workers…), his professional environment (involvement in agricultural organizations, administrative and technical advice services, trust in administrations…).
Some variables clearly describe the farmer's utility function: environmental awareness, children, age for instance. They are included in Z^U. Some other clearly describe the farm production system: farmed area (UAA), farm land use, labor, type of farming (organic), use of technical advice for example. They are included in Z^{π}. However, many variables probably affect both farmer's utility and farm profit and are included in both Z^U and Z^{π} : age & education, for instance.

The objective of this study is to identify and test the influence of transaction cost determinants. Data were carefully collected, and corresponding variables built, for this purpose. Some variables clearly affect transaction costs only. This is the case of "trust in the implementation process" which reduces transaction costs or the case of "good relationships with administrations" (Slangen et al.,2004). Other variables simultaneously affect the profit and the transaction costs. As transaction costs are not measured, it is impossible to disentangle these simultaneous effects with the estimated function. However, when variables have opposite effects on the profit loss and on transaction costs, it is possible to conclude. For instance, the "regular use of technical & administrative advice" or "general education" certainly increase profit thanks to better tuning of farming practices. Hence, on the one hand, they increase the profit loss due to contract prescriptions and discourage the contract adoption. On the other hand, the same variables may decrease transaction costs, and increase contracting probability, thanks to better access to information on agro-environmental schemes and higher capacity to deal with administrative aspects of contracting. Therefore, if they have a positive effect on the contracting probability, we can conclude their transaction cost effect is higher than their profit loss effect, and transaction costs thus matter. In previous studies (Bonnieux et al., 2001 & Dupraz et al., 2002) the positive effect of general education on contracting was interpreted in this way. Of course if a variable has convergent profit & transaction cost effects on adoption, we can not conclude this variable affect transaction costs although it might.

Finally, in order to use relevant variables, the primary data were gathered following different methods. First, "global variables" were created using the Multiple Correspondence Analysis (MCA) developed by Benzécri (1969). This method reveals possible relations existing between qualitative variables. From the data analysis point of view, a qualitative variable is a question and its modalities are the different possible answers. Global variables are sample

observations coordinates on selected axis provided by the MCA, MCA axis being selected according to usual rules. Annex (1) presents the composition of some of these variables (12 in total): for example, the continuous variable "environmental awareness" is made of farmer's answers to nine qualitative questions about his hobbies and opinions, by using MCA.
Then, ratios were created from, for example, the number of FTE workers variables or land use variables. 11 continuous variables were added up. Finally, some other qualitative variables were gathered into classes of variables as general education levels (3 classes), age (3 classes). 15 classes of qualitative variables were add up.

III.2) Data collected for the choice experiment method and its interpretation

A specific part of the survey questionnaire is devoted to the choice experiment method. The design of this experiment includes 24 sets of 4 choices between two alternative contracts and the status quo. Each respondent faced one of these sets of four choices. Alternative contracts are built by combining the different levels of the contract attributes to be valued, and the different levels of payment per year and per hectare under contract (Table 1).

The reference contract is an agro-environmental measure the respondent is familiar with. For contracting farmers, this is one of their contracted measure: winter coverage of arable land, hedge maintenance or extensive management of grassland (payment of about 100 euros per hectare for each). Non contracting farmers usually chose one of these common measures. When they had difficulty to decide their reference contract, the surveyor provided them with the description of the winter coverage of arable land measure as reference contract.
During the interviews, no problem was met by surveyors or farmers to do the choice experiment part of the questionnaire.

Table 1: Contract attributes and attribute levels in the choice experiment

Contract attributes	**Attribute levels of alternative contracts**	**Status quo attribute level (reference contract)**
Contract length (years)	5, 10, 20	5
Possibility to choose the land plots under contract	Yes, no	yes
Possibility to negotiate the contract requirements	Yes, no	no
Average paper work per month for contract management & control	Low (less than 30 minutes), medium (between 30 and 75 minutes) and high (more than 75 minutes)	low
Subsidy (% of the reference contract payment per year and per hectare)	5%, 10%, 20%	0%

Additional data were collected and revealed to be useful for the interpretation of the choice experiment results. The following table presents farmers' perceptions on certain questions relative to agro-environmental contracts (AEC):

Table 2:Farmers' statements vis-à-vis agro-environmental contracts

Statements	**Contracting farmers**	**Non contracting farmers**
AEC administrative tasks are simple		
Agree	27%	12%
Disagree	65%	65%
Don't know	2%	23%
AEC can be easily implemented on my farm		
Agree	88%	50%
Disagree	10%	39%
Don't know	2%	11%
AEC have environmental effects		
Agree	69%	43%
Disagree	29%	46%
Don't know	2%	11%
The compensation is sufficient to cover overcosts		
Agree	59 %	32%
Disagree	39%	53%
Don't know	2%	15%
Requirements are easy to understand		
Agree	49%	33%
Disagree	50%	45%
Don't know	1%	22%
Expected environmental effects are clear and easy to understand		
Agree	68%	43%
Disagree	29%	46%
Don't know	2%	16%

Non contracting farmers have a non answer rate that is always higher than contracting ones. Farmers having already had a contract and who have thus gained some experience in agro-environmental schemes, have a more clear cut opinions about the policy implementation system.

IV) RESULTS

The identification of private transaction cost determinants follows several stages.
Firstly, significant adoption determinants were identified by the estimation of the adoption model. These significant determinants affect the farmer's marginal gain to accept the contract *b*, through the profit function, $\pi^R(.)$, and/or the marginal rate of substitution, $\frac{U_v}{U_m}$, and/or the transaction cost function, *TC (.)*. As already explained, we can conclude a variable is a determinant of transaction costs in two cases: when the variable does not concern the technology or the utility function like "trust in procedures", and when the variable affects the adoption with an effect that is opposite of its expected effect through profit function variation, like "technical & administrative advices".
Secondly, variables having a significant effect on adoption that also interact significantly with contract attributes in the preference model are identified as determinants of transaction costs, like "general education" which reduces the WTA increase associated with contract length.

IV. 1) Farmer's determinants of adoption

Farmer's determinants concern his utility function characteristics, Z^U, and his production function characteristics, Z^π. Most of the studied variables affect both the utility function and the profit function. As marketed good prices *p* were not recorded by the survey, we implicitly assume they do not vary across farmers. This is a reasonable assumption since all respondents belong to the same region. Also Z^c is constant across farmers who all face the same type of contracts. However, a certain variability of contract payment per hectare (variable named "premium") is observed. Indeed, the agro-environmental scheme modulates the offered payments according to certain rules (farm types, zones).

The different parameter estimations are gathered in table 3. Significant variables only are presented. The model has kept every observations.

Table 3: Probit estimations of the adoption model (weighted observations)

Analysis of Parameter Estimates						
Variable	**DF**	**Estimate**	**Standard Error**	**Chi-Square**	**Pr > ChiSq**	**Label**
Intercept	**1**	**-3.06521**	**0.09055**	**1145.8296**	**<.0001**	**Constant**
age	2			389.0495	<.0001	**Farmer's age**
	1	0.32568	0.03988	66.6755	<.0001	Less than 40 years old
	1	0.84022	0.04304	381.0191	<.0001	More than 55 years old
	Reference modality					between 40 and 55 years old
nivgene	2			588.9340	<.0001	**General education level**
	1	-0.71583	0.03500	418.2648	<.0001	Inferior to high school diploma
	1	-0.96550	0.04881	391.3106	<.0001	Superior to high school diploma
	Reference modality					none
nivagri	3			40.1933	<.0001	**Agricultural education level**
	1	*0.0037194*	*0.03804*	*0.0096*	*0.9221*	*Medium*
	1	*0.06908*	*0.05227*	*1.7466*	*0.1863*	*High*
	1	-0.28712	0.04806	35.6909	<.0001	None
	Reference modality					Weak
child06	1	0.21387	0.03808	31.5514	<.0001	**To have less than 6 years old children**
child618	1	0.57701	0.03301	305.4704	<.0001	**To have between 6 and 18 years old children**
child18	1	-0.09561	0.03545	7.2733	0.0070	**To have more than 18 years old children**
sensi	1	-0.26929	0.01967	187.3588	<.0001	**To have an environmental awareness**
relation	1	-0.17967	0.01648	118.8981	<.0001	**To have a bad relationship with administrations**
orga	1	0.17796	0.01454	149.8198	<.0001	**Involvement in agricultural organizations**
tech	1	0.30637	0.01801	289.2343	<.0001	**To receive regularly tech. and adm. advices**
confiance	1	0.91891	0.02380	1490.6038	<.0001	**To trust the implementation process of AEC**
mat	1	-0.13248	0.01606	68.0545	<.0001	**Agricultural machinery ownership**
premium	1	0.01362	0.0005379	641.2080	<.0001	**payment/hectare**
partprop	1	0.42282	0.05533	58.4009	<.0001	**Land share in sole ownership**
partfermct	1	-0.13450	0.06521	4.2548	0.0391	**Land share in short term tenant farming**
experience	1	0.30784	0.03949	60.7662	<.0001	**No previous experience of AEC**
product	1	1.62344	0.08177	394.1606	<.0001	**Organic farming**
partgrass	1	0.83117	0.06053	188.5748	<.0001	**Grassland area /UAA**
partmaize	1	-0.55428	0.10454	28.1144	<.0001	**Corn area /fodder area**

Analysis of Parameter Estimates						
Variable	**DF**	**Estimate**	**Standard Error**	**Chi-Square**	**Pr > ChiSq**	**Label**
sautot	1	-0.0007539	0.0003228	5.4548	0.0195	**UAA**
chgt	1	-0.35593	0.02195	262.8332	<.0001	**Changes in the farming system in the last 5 years**
weurpha	1	-0.0008183	0.00004870	282.3389	<.0001	**Nb of FTE workers /ha**

Source : ITAES farm survey in Basse-Normandie, 2005

Estimation quality is given by the *ρ²* of Mac Fadden that measures the additional information brought by explicative variables in comparison with the simple finding of the observed individuals' repartition between those two eventualities. The *ρ²* value is 0.3578 that is correct[1] for this model type.

The estimation provides expected results for :
- the positive effect of the contract payment per hectare
- the positive effects of the grassland/UAA ratio and the organic farming
- the negative effect of corn/fodder area ratio.

These results mean that more extensive farming systems have lower profit losses due to agro-environmental prescriptions. Land tenure effects also confirm earlier results. According to Bougherara et al. (2005), it means that land owners expect long term benefits from AECs while tenants only expect benefits over the period of their land tenure. This explanation is based on the assumption that the re-negotiation of land tenure contracts is too difficult to take into account an optimal distribution of AEC long term benefits between tenants and land owners. Such re-negotiation transaction costs probably depend on the uncertainty which affect these long term benefits.

The results clearly support the importance of transaction costs in contracting decisions

Several variables that are expected to have effects on the transaction cost function only are highly significant with the expected sign:
- to be involved in agricultural organizations,
- to trust the implementation process of AEC,
- to have a bad relationship with institutions.

Several variables have significant effects on contract adoption but with a sign that contradicts their expected impact according to profit variation due to contract prescriptions. This means their transaction cost effect dominates their profit effect on contracting:
- to regularly receive technical and administrative advices increases the opportunity cost when adopting more environmental friendly practices but reduce transaction costs.
- To be less than 40 years old induces an increase of the opportunity cost because productivity is high whereas it reduces transaction costs as they may commit themselves to doing new investments.

However this interpretation of age may be questionable since it may also affect the utility function.
Of course other variables may also affect the transaction cost function but we can not conclude since we have no clear expectations about their influence on the different components of the farmer's marginal gain to accept the contract.

[1] The ρ² of Mac fadden has lower values than the determinant coefficient R^2, we consider if it values 0,4 it is equivalent to the 0,8 value of R^2: i.e. a correct adjustment.

Concerning variables with possible convergent profit and transaction cost effects, organic farming is a good example. Organic farms probably have lower profit losses due to the technical prescriptions of the contract, because they already use more extensive practices than conventional farms. They also have lower transaction costs, because their farm heads are already used to manage their agreement with the labeling agency of organic farming.

In order to test result robustness, the model was estimated in several sub-samples (see annex 2). Only 2 variables, both describing the farmer's professional environment, keep having the same sign, i.e. have the same effect on adoption whatever the sub-sample is, and thus do not interact with sub-sample divisions:

- to trust the implementation process of agro-environmental contracts
- to receive technical and administrative advices

This result supports the role of these variables in the farmer's adoption behavior as, it is assumed, significant determinants of the transaction cost function.

To a certain extent the results contradict previous studies

The present results are compared with former study outcomes on AEC adoption[2]. Several comparable variables have different effects on adoption, especially the environmental awareness, the previous experience of AEC and the general education. Only general education keeps its negative effect within the different sub-samples, while the effect of previous experience disappears (see annex 2). Some tracks may explain these differences:

Firstly, anterior studies have tested contract adoption before 1999. They concern contracts with different governance attributes and implementation systems. Farmers behavior having likely not changed since 1999, observed sign changes may come from attribute changes and particularly the fact that most of current contracts contains investment subsidies (Dupraz & Rainelli, 2004), a specificity which may interact with our variables. The great change in the French AEC implementation which occurred in 1999 may explain that previous experience of AEC has a negative effect on the adoption of new contracts. In addition the effect of previous experience disappear within sub-samples built according to farm types and sub-regions. So, in the total sample it may catches differences in the AEC implementation process according to sub-regions and farm types. Considering the general education, our interpretation is that its profit effect dominates its transaction cost effect on adoption.

Secondly, the unexpected negative effect of the "environmental awareness" is puzzling. In Delvaux et al. (1999) and Dupraz et al. (2003) its effect was very significantly positive. It is also the case in our present sub-sample of dairy farmers, but not in other sub-samples. One possible explanation could be that farmers with higher environmental awareness do not believe that current AEC have environmental effects, while most of the contractors do.
Compared with Delvaux et al. (1999), the relative effects of "environmental awareness" and "children" seems to remain consistent with our microeconomic model: U_m is the marginal utility of an additional euro in the monetary income (available for the household consumption of marketed good). If U_v is positive, $\frac{U_v}{U_m}$ is interpreted as the farmer's private subsidy to agro-environmental contract, i.e. his willingness to pay for the expected environmental good. If U_m is assumed to be increasing with the children number, therefore the children number decreases the adoption probability (Delvaux et al., 1999). With current agro-environmental

[2] Dupraz et al. (2002), Dupraz et al. (2000), Bonnieux et al. (2001), Wynn (2001) and Dupraz (2002)

contract, the environmental awareness negative effect on adoption implies U_v to be negative and $\frac{U_v}{U_m}$ becomes an adoption cost. If children are assumed to always have a positive effect on U_m, therefore $\frac{U_v}{U_m}$ decreases in absolute value with the children number and the adoption probability increases.

Finally, some farming system variables are significant: grassland area ratio, corn area ratio, UAA, changes in the farming system in the last 5 years, number of FTE workers per hectare. Two of these variables appear to be not consistent with anterior studies: labor force and UAA. To have a high UAA, an organic production and a high corn area share variables are also non robust when observing their effects in different sub-samples.

IV.2) Farmer and contract determinants of transaction costs

It is important to remind that in order to link farmers' preferences on contract attribute level, Z^C, with transaction costs, *TC(.)*, only one agro-environmental practice has been considered, and the following hypothesis was posed: the farmer's thought is based on a fixed area *v* to enroll. Elicited farmers' preferences on Z^C less depend on operational costs than on transaction costs.
Effects of some Z^C variables on farmers' WTA are presented first. Then, some farmers' determinants were integrated in order to observe their combined effect on transaction costs with contract attributes.

IV.2.1) Z^C determinants of transaction costs

The following two tables indicate the different governance attribute estimations in the contracting and non contracting populations and enable to observe attribute effects on farmers' WTA, i.e. his transaction costs.

Attributes must be interpreted in the following way:
- Contract length: increase of the contract length of 1 year from a 5 years minimum
- Plot choice: to not have the possibility to choose land plots
- Requirement negotiation: to not have the possibility to negotiate the contract's requirements
- Paper work time: increase of the time spent on administrative tasks per month: from 0 to 30 min, 30 to 75 min, more than 75 min
- Subsidy: increase of the proposed subsidy contract compared with the current one per hectare from 5% to 10% and 20%
- Status quo: to keep the current contractual form

In the contracting population:

Table 4: Z^C variable estimations of contracting farmers in the preference model

Analysis of maximum likelihood estimations						
Variable	**Parameters (std dev.)**	**Std. Error**	**Khi 2**	**Pr > Khi 2**	**Risq rate**	**WTA (%)**
Length	-0.10175	0.01112	83.7635	<.0001	0.903	1,92
Plot choice	-0.57925	0.12466	21.5898	<.0001	0.560	11,15
Requirement negotiation	-0.57471	0.11711	24.0825	<.0001	1.777	11,06
Paper work time	-0.27471	0.06518	17.7624	<.0001	0.760	5,38
Subsidy	0.05185	0.01042	24.7471	<.0001	1.053	
Status quo	-0.20619	0.16955	1.4790	0.2239	0.814	4

In the non contracting population:

Table 5: Z^C variable estimations of non contracting farmers in the preference model

Analysis of maximum likelihood estimations						
Variable	**Parameters (std dev.)**	**Std. Error**	**Khi 2**	**Pr > Khi 2**	**Risq rate**	**WTA (%)**
Length	-0.12057	0.01302	85.7243	<.0001	0.886	2
Plot choice	-0.65178	0.15031	18.8027	<.0001	0.521	10,8
Requirement negotiation	-0.29841	0.14252	4.3842	0.0363	1.348	4,8
Paper work time	-0.17254	0.07788	4.9076	0.0267	0.842	2,8
Subsidy	0.06053	0.01223	24.5085	<.0001	1.062	
Status quo	-0.51424	0.21043	5.9720	0.0145	0.598	8,5

Source: N. Quinio, 2005 based on ITAES survey in Basse Normandie, France

The model adjustment quality is quite weak as the pseudo R^2 of McFadden which measures the information gain brought by exogenous variables in comparison with the event realization frequency knowledge, is inferior to 0,2: $R^2 = 0.15$.

Obtained parameters are significant in every cases, except for the contracting farmers' status quo, and they support our hypothesis based on theoretical studies:

- Contract length: The WTA, which corresponds to the subsidy supplement that would maintain the same level of contracting farmers for an additional year, is positive. A contract superior to 5 years is therefore perceived as a constraint for the farmer, in other words, farmers' investments are not so much high and specific. Moreover they have an aversion to a hold up situation in which they couldn't react to political or economic contingencies.
- Plot choice and requirement negotiation: farmers prefer a contract with adaptable requirements.
- Paper work time: farmers have an aversion to time passed on administrative works.
- Status quo: farmers and even more non contracting ones have an aversion to current contractual forms.

Contracting and non contracting farmers' results are similar in the sense that they order attributes in the same way. They are also consistent with farmers' perceptions (Table 2):

- 2/3 of the interviewed farmers declare not to find administrative works easy.

- Half of the interviewed farmers almost think specifications (requirements) difficult to understand.
- Approximately 45% of the interviewed farmers think the remuneration doesn't cover overcosts.

Nevertheless, non contracting farmers were observed to not increase the flexibility of contracts more than contracting ones: their WTA is globally lower than the contracting farmers' ones. In particular, they under estimate the requirement fixity and administrative works, whereas they estimate plot choice and contract length in equivalent ways. It is all the more surprising to note that contracting farmers have a rather high WTA for the requirement fixity (11,06%) whereas 88% of them declare to find agro-environmental contracts easy to implement.

These results can be explained by the contracting farmers' experience. Indeed, they increase the value of contract attributes in a different way because they know their practical implications. Their information level is therefore superior to non contracting farmers that modifies the WTA interpretation between contracting and non contracting farmers.

IV.2.2) Combined effects on transaction costs

The complete preference model enables to observe interactions between farmers' attributes and contract attributes and their effect on farmers' WTA. To simplify the interpretation, observations were limited to the contractor population and to some Z^U and Z^π variables. The following table is a summary of these results (see annex 3 for detailed results). A positive effect accentuates the associated attribute WTA in absolute value, whereas a negative effect attenuates it:

Table 6: Z^C, Z^U, Z^π variable effects on the farmer's willingness to accept an agro-environmental contract

Z^C **variables**	Z^U **and** Z^π **variables**	**Effect on the WTA**
Contract length	High general education	Negative
	Age	Positive
Plot choice	To have already tested AEC	Negative
	Area in sole ownership	Negative
	To be involved in agricultural organizations	Negative
Requirement negotiation	To trust the implementation process of AEC	Negative
	Nb. of children	Negative
	To be involved in agricultural organizations	Positive
	Quota	Negative
Paper work time	Livestock units	Negative
	UAA	Positive

The model with heterogeneity is a little bit better than the preceding: the R^2 of McFadden has a value of 0,23. Even if estimated attribute effects have the same order of magnitude and the same signs than those estimated without any farmer heterogeneity control, farmers' variables have a significant effect on the value allocated to contract attributes.

The table has to be read in the following way: to have an higher general education reduces the WTA associated with an increased contract length. This might be a clue that general education affects private transaction costs, although it was not obvious according to the adoption model.

These results lead to 3 main conclusions:

- Some Z^U and Z^π variables do interact with contract attributes;
- They have significant effects on the WTA, and probably on transaction costs;
- Some of them may have different effects according to their combination with different attributes (cf. to be involved in agricultural organizations).

V) CONCLUSION

The analysis of private transaction costs requires two approaches, the adoption model and the preference model. The first one examine the influence of farmer and farm characteristics to distinguish significant variables on adoption and their effect on the gain *b* to enrol the first hectare. The second one seeks a measure of transaction costs variability according to contract attributes, that could not be tested with the adoption model since current contracts have similar attribute levels.

The importance of transaction costs in the farmer's adoption behaviour is evaluated by a detailed interpretation of the effects of farm Z^π and farmer's Z^U characteristics on the marginal gain *b* which triggers contracting. Three types of results were obtained.

Firstly, Z^U and Z^π variable effects on *b* were observed when considering the same type of contracts. Some of these variable effects on the transaction cost function could roughly be sorted out: variables describing the professional environment seem to have a superior effect on the transaction cost function, whereas those describing the farming system and the farmer himself have a superior effect on the profit function. Finally, only two of Z^U and Z^π variables are robust whatever the sample and concern variables which may have more effects on the transaction cost function:

- to trust the implementation process of agro-environmental contracts
- to receive regularly technical and administrative advice

Secondly, some contract attributes Z^C were examined. The simple preference model confirmed contract attributes have significant effects on transaction costs. Among them, the possibility to adapt contract prescriptions seem to highly influence transaction costs. However some other contract governance attributes, which have not been considered here, may also matter: the control frequency & sanction scale for instance.

Thirdly, there are evidences of combined effects of Z^U, Z^π and Z^C on transaction costs, Z^U and Z^π variables being those that are significant in the adoption model. Three conclusions were obtained:

- Z^U and Z^π variables do interact with contract attributes;
- They have significant effects on transaction costs, most of them supporting our expectations;
- Some of these variables may have antagonist effects on transaction costs according to the different contract attributes.

Our main conclusion is the following : private transaction costs matter and the determinants relative to the farmer (Z^U and Z^π) do not only influence the farmer's utility and profit function but his transaction cost function too through their interactions with contract attributes, Z^C, i.e. the governance structure. Here, outcomes join up with Quiggin's proposition: "the nature of transaction costs comes from the interaction between the organizations' set-ups and the technology of the subjacent production". This conclusion should therefore be taken into account in the aim of improving agro-environmental contracts. Let us take the example of the maintenance of hedges. An action is efficient in the long run, because a hedge taken out after 5 years is of little use. Our results show that the implementation of 10 year-contracts rather than 5 year-contracts, requires a payment increased by 10 % ceteris paribus. For farmers who received a university education, the required payment increase is less than 5%.

The supply of environmental goods by farmers is not only a transaction between the State and farmers but is a succession of interdependent transactions before and after the signature of the agro-environmental contract involving professional organizations, farmers' land owners, advisors and subcontractors. This study focused on the importance of private transaction costs and enabled to identify some determinants. Among them, characteristics regarding the farmer's professional environment, in other words regarding his public and private partners, have particularly robust effects on adoption and transaction costs, and thus catches our attention. Indeed, this result can be linked with the "hostage" principle of Williamson: when contract attributes engage the farmer in the long run and imply important private transaction costs, the State can reduce the farmer's aversion by also investing in the transaction and developing partnership.

It is also interesting to notice that site specificity is often mentioned as a source of transaction costs in the transaction of environmental goods. Although contrasted estimation results are observed by using sub-region samples, site specificity does not appear clearly at the level of the transaction between the State and the farmer. Indeed, even if high transaction costs are observed as a consequence of the contract attribute "to not have the possibility to choose land plots" that refers to site specificity, the real source of transaction costs linked to site specificity is to be found at the level of the transaction between the State and its public and private partners: the State has proposed animation loans to local project leaders in order that they should handle the regional coordination of agro-environmental schemes (example taken from Dupraz, Rainelli, 2004). As far as the farmer is concerned, transaction costs determinants are rather dependant on human specificity and uncertainty (general education, age, trust in institutions…), and on the underlying technology of production too (UAA, livestock units). The "agro-environmental transaction" must therefore be reconsidered globally in order to define better the extent of transactions that it involves.

REFERENCES

Baumol W., Panzar J., Willig R., 1982. Contestable markets and the theory of industry structure, Harcourt Brace Jovanovich, New York.

Benzécri, J.-P., 1969. Statistical analysis as a tool to make patterns emerge from data. Pages 35-. 60 in S. Watanabe, editor. Methodologies of pattern recognition. Academic Press, New York.

Bonnieux F., Carpentier A., Ledun J., Paoli J. C., 2004. Contribution à une "bonne gouvernance" de la forêt Corse : étude par la méthode des programmes. 4. Congrès Environnement International et Identité en Méditerranée, Corte (FRA), 2004/07/19-25.

Bonnieux F., Dupraz P. et Retière C., 2001. Farmer's Supply of Environmental Benefits, Vardal E. (ed), Multifonctionality of Agriculture, 105-133, University of Bergen.

Bougherara D., Dupraz P., Pech M., 2005. Le mode de faire-valoir influence-t-il la mise en œuvre de la politique agro-environnementale ? Premières Journées Scientifiques de l'Economie de l'Environnement: Les Stratégies des Acteurs, Alger, 1er et 2 octobre 2005.

Brotherton I., 1991. What Limits Participation in ESAs?, Journal of Environmental Management, Vol 32, pp 241-249

Delvaux L., Henry De Frahan B., Dupraz P. and Vermersch D., 1999. Adoption d'une MAE et consentement à recevoir des agriculteurs en région wallone, Economie rurale, N°249, pp 71-81.

Drake L., Bergström P., Svedsäter H., 1999. Farmers' attitudes and uptake, in Van Huylenbroeck G. and Whitby M., (1999) (eds.) Countryside stewardship: farmers, policies and markets. Pergamon, Amsterdam

Dupraz P., 2002. Mesures agro-environnementales et demande de travail agricole, Colloque SFER des 21 et 22 mars 2002 à Paris « La multifonctionnalité de l'activité agricole et sa reconnaissance par les pouvoirs publics ».

Dupraz P., D. Vermersch, B. Henry de Frahan, L. Delvaux, 2003. The Environmental Supply of Farm Households, a Flexible Willingness to Accept Model, Environmenal and Resource Economics, N°25, pp 171-189

Dupraz P., Henry de Frahan B., Vermerch D., Delvaux L., 2000, Production de biens publics par des ménages : une application à l'offre environnementale des agriculteurs, Revue d'économie politique, N°110, pp267-291

Dupraz P., Rainelli P., 2004. Institutional approaches to sustain rural landscapes in France. In: Sustaining Agriculture and the Rural Environment: Governance, Policy and Multifunctionality. Brouwer, F. (éd.). Edward Elgar Publishing, ISBN 1-84376-256-0, pp 162-182.

Dupraz P., Vanslembrouck I., Bonnieux F. et Van Huylenbroeck G., 2002. Farmers' participation in European agri-environmental policies, X Congress of EAAE: Exploring diversity in the european agri-food system, Zaragoza.

Dupraz, P. Arnaud S., 2005. WP8 Survey of Farmers : French Report, Document de travail ITAES, 16p

Falconer K and Whitby M, 1999. The invisible costs of scheme implementation and administration, in Van Huylenbroeck G. and Whitby M., (1999) (eds.) Countryside stewardship: farmers, policies and markets. Pergamon, Amsterdam

Granval C., 2005. Comportement des agriculteurs face aux contrats agro-environnementaux et influence des coûts de transaction privés, Rapport de stage, 132p

Greene W. H., 1997. Econometric analysis. Third edition. Prentice-Hall International, Inc.

Morris J., Mills J. and Crawford I.M., 2000. Promoting Farmer Uptake of Agri-environment Schemes: The Countryside Stewardship Arable option Scheme, Land Use Policy, Vol 17, pp 241-254

Quiggin J., 1995. Common Property in Agricultural Production, Journal of Economic Behaviour and Organization, Vol 26, pp 179-200
Quinio N., 2005. Analyse des préférences de agriculteurs par la méthode des choice experiments, Rapport de stage, 118p
Ruto E., Garrod G., 2004. Using Choice Experiments to Analyse Farmers' Preferences for the Governance Attributes of Agri-Environment Schemes, Document de travail ITAES
Slangen L., Jongeneel R.A. & N. Polman, 2004. Institutional analysis of multifunctional agriculture, 90th EAAE Seminar "Multifunctional agriculture, policies and markets: understanding the critical linkages", Rennes, October 28-29, 2004.
Williamson O.E., 1983. Credible Commitments: Using Hostages to Support Exchange, The American Economic Review, Vol. 73, N° 4, pp 519-540
Williamson O.E., 1985. The Economic Institution of Capitalism- Firms, Markets and Relational Contracts, The Free Press, New York
Wynn G., Crabtree B. and Potts J., 2001. Modelling Farmer Entry into the Environmentally Sensitive Area Scheme in Scotland, Journal of Agricultural Economics, Vol 52, N°1, pp 65-82

Annex 1: Global variable construction

Global variable heading	Global variable contents (related survey' questions)
"To have a bad relationship with institutions": how difficult the farmer perceives the AEC related administrative work and the relationship with administrative bodies	Reasons which explain the choices taken by farmer within the choice experiment (paper work) Are current contracts more complicated than previous ones (yes) The procedures for contract applications are easy (disagree) The rules and requirements are easy to understand (disagree) It is easy to find the right person to contact in the administration when there are problems (disagree) Regarding Agro-environmental schemes, administration behaviour is fair and responsible (disagree)
"Environmental awareness"	What are the farmer's hobbies Which reviews or newspapers is the farmer reading and how often Rank of the environmental degradation in the public policy topics Involvement of the farmer in Environmental organisations
"Property right on agricultural machinery"	24 variables related to the origin of agricultural machinery used on the farm

Annex 2: Sub-sample probit estimations of the adoption model (weighted observations)

Dairy farmer sub-sample

Analysis of Parameter Estimates						
Variable	**DF**	**Estimate**	**Standard Error**	**Chi-Square**	**Pr > ChiSq**	**Label**
Intercept	1	-1.71916	0.20748	68.6535	<.0001	Constant
statut	4			88.6209	<.0001	Farm status
	1	-1.20169	0.14202	71.5963	<.0001	EARL
	1	-0.81974	0.18911	18.7891	<.0001	GAEC
	1	9.58486	36776.8	0.0000	0.9998	GFA
	1	-5.28316	5466.0	0.0000	0.9992	SCEA
	Reference modality					Individual farm
age	2			243.8605	<.0001	Farmer's age
	1	0.61885	0.14789	17.5092	<.0001	To be less than 40 years old
	1	2.51728	0.16147	243.0485	<.0001	To be more than 55 years old
	Reference modality					Between 40 and 55 years old
nivgene	2			45.8476	<.0001	General education level
	1	-0.53382	0.12379	18.5955	<.0001	Inferior to high school diploma
	1	-0.86521	0.14221	37.0150	<.0001	Superior to high school diploma
	Reference modality					None
nivagri	3			45.0525	<.0001	Agricultural education level
	1	-0.41549	0.12653	10.7823	0.0010	Medium
	1	-0.57982	0.15665	13.7011	0.0002	High
	1	0.45441	0.12210	13.8513	0.0002	None
	Reference modality					Weak
child06	1	-0.46525	0.12042	14.9273	0.0001	To have less than 6 years old children
child618	1	1.98425	0.15293	168.3386	<.0001	To have between 6 and 18 years old children
child18	1	-1.05080	0.11029	90.7785	<.0001	To have more than 18 years old children
product	1	11.41249	9448.0	0.0000	0.9990	Organic farming
partgrass	1	0.34769	0.17790	3.8196	0.0507	Grassland area /UAA
partmaize	1	-3.44812	0.94818	13.2246	0.0003	Corn area /fodder area
sautot	1	0.0040467	0.0010450	14.9970	0.0001	UAA
sensi	1	0.15811	0.05519	8.2069	0.0042	Environmental awareness
relation	1	0.01936	0.04921	0.1548	0.6940	To have a bad relationship with administration
chgt	1	-0.06948	0.07528	0.8519	0.3560	Changes in the farming system in the last 5 years
orga	1	-0.12536	0.04203	8.8953	0.0029	To be involved in agricultural organizations
tech	1	1.48702	0.08417	312.1050	<.0001	To regularly receive tech. and adm. advices
mat	1	-0.54590	0.05535	97.2723	<.0001	Agricultural machinery ownership
confiance	1	1.14552	0.07689	221.9768	<.0001	To trust the implementation process of AEC
weurpha	1	-0.0006441	0.0001278	25.4130	<.0001	Nb of FTE workers /ha
prime	1	0.0011878	0.0014959	0.6305	0.4272	Payment/hectare
partprop	1	-0.52019	0.13635	14.5559	0.0001	Land share in sole ownership
partfermct	1	-4.61199	0.38466	143.7532	<.0001	Land share in short tenant farming

Non dairy farmer sub-sample

Analysis of Parameter Estimates						
Variable	**DF**	**Estimate**	**Standard Error**	**Chi-Square**	**Pr > ChiSq**	**Label**
Intercept	1	-5.38228	0.27086	394.8526	<.0001	Constant
statut	3			191.7015	<.0001	Farm status
	1	-0.80320	0.06165	169.7332	<.0001	EARL
	1	-0.09212	0.06190	2.2144	0.1367	GAEC
	1	0.16876	0.13364	1.5946	0.2067	SCEA
	0	0	0	.	.	Individual farm
age	2			43.9389	<.0001	Farmer's age
	1	0.12530	0.05848	4.5907	0.0321	To be less than 40 years old
	1	0.43058	0.06506	43.8025	<.0001	To be more than 55 years old
	Reference modality					Between 40 and 55 years old
nivgene	2			481.4738	<.0001	General education level
	1	-0.95491	0.04859	386.1571	<.0001	Inferior to high school diploma
	1	-1.33449	0.07457	320.2418	<.0001	Superior to high school diploma
	Reference modality					None
nivagri	3			9.6171	0.0221	Agricultural education level
	1	-0.11212	0.05169	4.7042	0.0301	Medium
	1	0.03901	0.07524	0.2688	0.6041	High
	1	-0.15518	0.07490	4.2924	0.0383	None
	Reference modality					Weak
child06	1	0.58584	0.05158	129.0000	<.0001	To have less than 6 years old children
child618	1	0.82663	0.04733	305.0675	<.0001	To have between 6 and 18 years old children
child18	1	-0.29446	0.05557	28.0793	<.0001	To have more than 18 years old children
product	1	1.57392	0.11317	193.4331	<.0001	Organic farming
partgrass	1	2.61263	0.23717	121.3464	<.0001	Grassland area /UAA
partmaize	1	2.99309	0.32827	83.1318	<.0001	Corn area /fodder area
sautot	1	-0.0000737	0.0006814	0.0117	0.9139	UAA
sensi	1	-0.87101	0.05577	243.9561	<.0001	Environmental awareness
relation	1	0.20870	0.02630	62.9716	<.0001	To have a bad relationship with administration
chgt	1	-0.58530	0.03079	361.3206	<.0001	Changes in the farming system in the last 5 years
orga	1	0.26946	0.02291	138.2785	<.0001	To be involved in agricultural organizations
tech	1	0.26031	0.02426	115.0982	<.0001	To regularly receive tech. and adm. advices
mat	1	-0.08361	0.02314	13.0502	0.0003	Agricultural machinery ownership
confiance	1	1.21720	0.03458	1239.1283	<.0001	To trust the implementation process of AEC
weurpha	1	-0.0010032	0.00007851	163.2878	<.0001	Nb of FTE workers /ha
prime	1	0.02085	0.0008969	540.2526	<.0001	Payment/hectare
partprop	1	0.84292	0.08533	97.5727	<.0001	Land share in sole ownership
partfermct	1	0.22223	0.09238	5.7870	0.0161	Land share in short tenant farming

Calvados sub-sample

Analysis of Parameter Estimates						
Variable	**DF**	**Estimate**	**Standard Error**	**Chi-Square**	**Pr > ChiSq**	**Label**
Intercept	1	-1.29548	0.11806	120.4045	<.0001	Constant
statut	4			25.6342	<.0001	Farm status
	1	-0.09830	0.07598	1.6737	0.1958	EARL
	1	0.33226	0.09190	13.0704	0.0003	GAEC
	1	8.12628	3106.3	0.0000	0.9979	GFA
	1	-0.42356	0.15726	7.2544	0.0071	SCEA
	0	0	0	.	.	Individual farm
age	2			93.6141	<.0001	Farmer's age
	1	-0.30485	0.08926	11.6648	0.0006	To be less than 40 years old
	1	0.56561	0.07494	56.9686	<.0001	To be more than 55 years old
	0	0	0	.	.	Between 40 and 55 years old
nivgene	2			518.2944	<.0001	General education level
	1	-1.31495	0.06991	353.7872	<.0001	Inferior to high shcool diploma
	1	-1.64121	0.07884	433.3511	<.0001	Superior to high school diploma
	0	0	0	.	.	None
child06	1	1.02556	0.07795	173.0808	<.0001	To have less than 6 years old children
child618	1	0.24013	0.06358	14.2627	0.0002	To have between 6 and 18 years old children
product	1	1.61414	0.13029	153.4787	<.0001	Organic farming
partgrass	1	1.68181	0.11558	211.7501	<.0001	Grassland area /UAA
partmaize	1	0.87388	0.18639	21.9815	<.0001	Corn area /fodder area
sautot	1	0.0044672	0.0006135	53.0127	<.0001	UAA
sensi	1	-0.28907	0.02864	101.8493	<.0001	Environmental awareness
relation	1	-0.40748	0.02815	209.4645	<.0001	To have a bad relationship with administration
orga	1	0.23695	0.02629	81.2101	<.0001	To be involved in agricultural organizations
tech	1	0.30351	0.03194	90.2863	<.0001	To regularly receive tech. and adm. advices
confiance	1	0.47260	0.03816	153.3933	<.0001	To trust the implementation process of AEC
prime	1	-0.01001	0.0008944	125.2131	<.0001	Payment/hectare
partprop	1	-0.21284	0.10410	4.1805	0.0409	Land share in sole ownership
partfermct	1	0.11337	0.15119	0.5623	0.4533	Land share in short tenant farming

Manche sub-sample

Analysis of Parameter Estimates						
Variable	**DF**	**Estimate**	**Standard Error**	**Chi-Square**	**Pr > ChiSq**	**Label**
Intercept	1	-10.00987	0.39985	626.7007	<.0001	Constant
statut	3			140.1343	<.0001	Farm status
	1	-1.02827	0.09886	108.1953	<.0001	EARL
	1	-1.01460	0.10537	92.7195	<.0001	GAEC
	1	-0.07943	0.31346	0.0642	0.8000	SCEA
	0	0	0	.	.	Individual farm
age	2			61.9222	<.0001	Farmer's age
	1	0.29481	0.09760	9.1232	0.0025	To be less than 40 years old
	1	0.76893	0.09773	61.9036	<.0001	To be more than 55 years old
	0	0	0	.	.	Between 40 and 55 years old
nivgene	2			151.4861	<.0001	General education level
	1	-0.80929	0.07724	109.7772	<.0001	Inferior to high shcool diploma
	1	-1.32709	0.12266	117.0614	<.0001	Superior to high school diploma
	0	0	0	.	.	None
child06	1	2.33110	0.13986	277.8155	<.0001	To have less than 6 years old children
child618	1	0.75853	0.08137	86.9077	<.0001	To have between 6 and 18 years old children
product	1	-0.40557	0.18028	5.0610	0.0245	Organic farming
partgrass	1	3.04435	0.30788	97.7765	<.0001	Grassland area /UAA
partmaize	1	2.72675	0.39745	47.0678	<.0001	Corn area /fodder area
sautot	1	0.01050	0.0009841	113.9270	<.0001	UAA
sensi	1	-1.43860	0.09899	211.1846	<.0001	Environmental awareness
relation	1	-0.76940	0.06332	147.6503	<.0001	To have a bad relationship with administration
orga	1	0.52825	0.04256	154.0886	<.0001	To be involved in agricultural organizations
tech	1	0.43427	0.04590	89.5337	<.0001	To regularly receive tech. and adm. advices
confiance	1	1.85495	0.07636	590.1330	<.0001	To trust the implementation process of AEC
prime	1	0.04283	0.0016218	697.4326	<.0001	Payment/hectare
partprop	1	1.43254	0.13075	120.0379	<.0001	Land share in sole ownership
partfermct	1	1.68593	0.20922	64.9310	<.0001	Land share in short tenant farming

Orne sub-sample

Analysis of Parameter Estimates						
Variable	**DF**	**Estimate**	**Standard Error**	**Chi-Square**	**Pr > ChiSq**	**Label**
Intercept	1	-9.51285	0.56317	285.3279	<.0001	Constant
statut	3			181.7172	<.0001	Farm status
	1	-1.75361	0.14079	155.1334	<.0001	EARL
	1	0.21510	0.16771	1.6449	0.1996	GAEC
	1	-1.62476	5944.5	0.0000	0.9998	SCEA
	0	0	0	.	.	Individual farm
age	2			58.4595	<.0001	Farmer's age
	1	0.78506	0.10362	57.4025	<.0001	To be less than 40 years old
	1	0.23925	0.14191	2.8423	0.0918	To be more than 55 years old
	0	0	0	.	.	Between 40 and 55 years old
nivgene	2			8.3261	0.0156	General education level
	1	0.16834	0.12204	1.9026	0.1678	Inferior to high shcool diploma
	1	-0.24773	0.14871	2.7750	0.0957	Superior to high school diploma
	0	0	0	.	.	None

Analysis of Parameter Estimates						
Variable	**DF**	**Estimate**	**Standard Error**	**Chi-Square**	**Pr > ChiSq**	**Label**
child06	1	0.33223	0.13476	6.0778	0.0137	To have less than 6 years old children
child618	1	0.64607	0.11157	33.5294	<.0001	To have between 6 and 18 years old children
product	1	10.31127	10666.1	0.0000	0.9992	Organic farming
partgrass	1	2.11254	0.27460	59.1849	<.0001	Grassland area /UAA
partmaize	1	1.93417	0.30702	39.6867	<.0001	Corn area /fodder area
sautot	1	-0.0028586	0.0009358	9.3312	0.0023	UAA
sensi	1	-1.01942	0.16729	37.1322	<.0001	Environmental awareness
relation	1	0.40252	0.06143	42.9377	<.0001	To have a bad relationship with administration
orga	1	0.55571	0.05703	94.9325	<.0001	To be involved in agricultural organizations
tech	1	0.67291	0.07705	76.2801	<.0001	To regularly receive tech. and adm. advices
confiance	1	1.35344	0.07030	370.6792	<.0001	To trust the implementation process of AEC
prime	1	0.06083	0.0042990	200.1877	<.0001	Payment/hectare
partprop	1	1.55178	0.21703	51.1233	<.0001	Land share in sole ownership

Annex 3: Conditional Logit estimations and effects of farmers' variables

Results of the conditional Logit model estimations and effects of contracting farmers' variables					
Variable	Estimated parameter	Std. Error	Khi 2	Pr > Khi 2	CAR (%)
Contract lengh					1,99
Constant (average ind.: β_{10})	-0.11431	0.01240	84.9518	<.0001	
Age	-0.00263	0.00169	2.4171	0.1200	
High general education	0.07231	0.03036	5.6728	0.0172	
Plot choice					13,73
Constant (average ind.: β_{20})	-0.79301	0.15375	26.6030	<.0001	
Area in sole ownership (ha)	0.01061	0.00588	3.2607	0.0710	
Area in long term tenant farming (ha)	0.00795	0.00378	4.4248	0.0354	
Livestock units	-0.00921	0.00336	7.5246	0.0061	
FTE workers	-0.40642	0.23428	3.0094	0.0828	
To be involved in agricultural organizations	0.55170	0.29192	3.5717	0.0588	
To have already tested AEC	0.72213	0.36577	3.8978	0.0484	
Requirement negotiation					-11,64
Constant (average ind.: β_{30})	0.66812	0.13703	23.7740	<.0001	
Quota	-0.00259	0.0009789	6.9902	0.0082	
Nb. of children	-0.17254	0.11379	2.2992	0.1294	
To be involved in agricultural organizations	0.63049	0.27833	5.1314	0.0235	
To trust the implementation process of AEC	0.45945	0.26670	2.9679	0.0849	
Paper work time					4,18
Constant (average ind.: β_{40})	-0.24238	0.07518	10.3943	0.0013	
High general education	-0.31891	0.19143	2.7755	0.0957	
UAA	-0.00373	0.00179	4.3546	0.0369	
Livestock units	0.00173	0.0008095	4.5542	0.0328	
To have already tested AEC	-0.45737	0.21000	4.7437	0.0294	
Status quo					2,96
Constant	-0.17382	0.19307	0.8105	0.3680	
Age	-0.03184	0.01869	2.9031	0.0884	
Quota	-0.00290	0.00112	6.7072	0.0096	
Livestock units	0.00330	0.00154	4.6110	0.0318	
Nb. FTE workers	0.52825	0.23131	5.2155	0.0224	
To have already tested AEC	0.65037	0.40075	2.6338	0.1046	
To be involved in agricultural organizations	0.48606	0.29826	2.6558	0.1032	
Subsidy					
Constant	0.05740	0.01146	25.0841	<.0001	
Income	0.01451	0.00608	5.7008	0.0170	

Results of the conditional Logit model estimations and effects of non contracting farmers' variables					
Variable	Estimated parameter	Std. Error	Khi 2	Pr > Khi 2	CAR (%)
Contract lengh					2,18
Constant	-0.14697	0.01533	91.9638	<.0001	
High general education	-0.11100	0.04482	6.1341	0.0133	
Nb. of children	0.02750	0.01157	5.6509	0.0174	
Plot choice					11,42
Constant	-0.77636	0.17201	20.3712	<.0001	
High general education	-1.68130	0.52773	10.1500	0.0014	
Quota	-0.00241	0.00129	3.5060	0.0611	
To have already tested AEC	0.91171	0.44853	4.1318	0.0421	
Requirement negotiation					-5,96
Constant	0.40176	0.17106	5.5163	0.0188	
Livestock units	0.00242	0.00151	2.5512	0.1102	
Nb. FTE workers	0.00235	0.00154	2.3385	0.1262	
Nb. of children	-0.53231	0.25449	4.3751	0.0365	
To have already tested AEC	-0.27349	0.12987	4.4348	0.0352	
To trust the implementation process of AEC	0.76627	0.45337	2.8566	0.0910	
Paper work time					3,96
Constant	-0.26687	0.09087	8.6241	0.0033	
Livestock units	-0.00161	0.0009537	2.8668	0.0904	
To trust the implementation process of AEC	0.41871	0.17979	5.4235	0.0199	
Status quo					9,90
Constant	-0.66748	0.24157	7.6349	0.0057	
High general education	-0.97874	0.59468	2.7087	0.0998	
Nb. FTE workers	-0.52199	0.33920	2.3682	0.1238	
Environmental awareness	-0.51361	0.33208	2.3922	0.1219	
To have already tested AEC	1.35940	0.53566	6.4404	0.0112	
Subsidy					
Constant	0.06739	0.01361	24.5105	<.0001	
Income	0.00954	0.00752	1.6111	0.1043	

Rapport restituant les résultats de l'enquête auprès des acteurs institutionnels pour les mesures agri-environnementales en Basse-Normandie.

Facteurs déterminant l'efficacité des Programmes Agro-environnementaux : le cas de la Basse-Normandie

Arnaud S., Desjeux Y., Dupraz P., Lepage D.
INRA, UR122 Economie et Sociologie Rurales
F-35011 Rennes, FRANCE

Dec. 2006

Ce document présente des résultats obtenus dans le cadre du Projet Européen SSPE-CT-2003-502070 'Integrated Tools to design and implement Agro-Environmental Schemes' (http://merlin.lusignan.inra.fr/ITAES). Il n'engage que la responsabilité des auteurs et non celle de l'Union Européenne. De plus ce travail ne permet en aucun cas d'anticiper les choix de la Commission Européenne quant aux futures politiques mises en place dans ce domaine.
Ce travail a également bénéficié du soutien du programme S3E du Ministère de l'Ecologie et du Développement Durable.

1 Contexte de l'étude

Présentation du Projet ITAES :

L'INRA de Rennes, en coopération avec 8 autres pays de l'Union Européenne[1], mène depuis Janvier 2004 un projet de recherches axé sur les politiques agro-environnementales.
Le but est de développer, à destination des décideurs, des outils d'évaluation de ces politiques. De manière globale les activités du projet s'articulent autour des grands thèmes suivants: (*i*) les aspects institutionnels liés à la définition et la mise en place des politiques agro-environnementales, (*ii*) leur mise en place au niveau de l'exploitation agricole et (*iii*) les impacts environnementaux des mesures. C'est ainsi dans le premier point que s'intègre la majeure partie de ce travail.

Le choix de la Région Basse-Normandie :

Le choix de la Basse-Normandie comme région d'étude s'est facilement imposé. L'INRA, ayant réalisé, en coopération avec EUREVAL-C3E, l'évaluation à mi-parcours du RDR en Basse-Normandie, bénéficie en effet d'une expertise importante sur ce territoire enrichie par des partenariats notamment avec le Parc Naturel Régional des Marais du Cotentin et du Bessin.

Méthodologie :

Les résultats présentés ici s'appuient principalement sur une enquête visant à évaluer l'impact de l'organisation institutionnelle des procédures d'élaboration et de mise en oeuvre des contrats agro-environnementaux sur leur efficacité économique et environnementale.

Cette enquête repose sur un questionnaire en six parties qui visent à rendre compte de :

A) La participation au dispositif des institutions interrogées et la charge de travail que cela a impliqué;

B) Leur perception des problèmes environnementaux liés à l'agriculture dans la région Basse-Normandie ;

C) La façon dont les mesures agro-environnementales répondent à ces problèmes;

D) La participation, les échanges d'information et, plus largement, les relations entre les différentes parties concernées par le dispositif;

E) Les alternatives envisageables au dispositif CTE/CAD (notamment en vue de la mise en oeuvre du nouveau RDR) ;

F) Les coûts publics inhérents au dispositif.

Afin d'analyser les différentes procédures d'élaboration et de mise en œuvre des contrats, les institutions ayant effectivement participé à au moins l'une de ces deux phases ont été rencontrées. Par ailleurs, des acteurs qui n'avaient pas forcément été très impliqués dans les procédures d'élaboration et de mise en oeuvre des MAE mais qui auraient pu y être invités du fait de leurs compétences dans les domaines de l'environnement et/ou du développement territorial ont été également interrogées. Au total, en France, 38 institutions ont ainsi été enquêtées au niveau national, régional et départemental. Sauf mention contraire, les résultats présentés dans les parties 3, 4 et 5 sont tirés de cette enquête. La taille de l'échantillon ne permet pas de prétendre à la représentativité statistique, mais sa diversité permet de repérer les éléments de consensus et de désaccord.

[1] Allemagne, Angleterre, Belgique, Finlande, Irlande, Italie, Pays-Bas et République Tchèque.

2 Les objectifs de recherche

La question de l'efficacité des politique agro-environnementales a souvent été posée. Ainsi, en France, une littérature abondante en matière d'évaluations des CTE existe : il s'agit de l'évaluation à mi-parcours officielle effectuée en 2003 et de nombreux rapports d'audit et d'évaluation commandités par le Ministère de l'Agriculture ou l'Assemblée Nationale.

Un élément important transparaît dans ces évaluations : les inégalités constatées entre départements. Dans une vingtaine d'entre eux, plus de 18% des exploitations professionnelles ont signé un CTE, tandis que dans une vingtaine d'autres, elles sont moins de 6%. Des caractéristiques agricoles et environnementales expliquent en partie ces différences. Cependant, des départements comparables présentent également des différences marquées. C'est le cas des départements de Basse-Normandie où la configuration des dispositifs agro-environnementaux est très différente tant du point de vue de leur fonctionnement que des résultats obtenus.

Les départements ayant eu une importante marge de manœuvre pour l'application du dispositif, nous cherchons ici à identifier les facteurs de gouvernance ayant une influence sur l'efficacité des Mesures Agro-Environnementales.

Pour cela, il est nécessaire dans un premier temps de mesurer l'efficacité des Programmes agro-environnementaux. En Economie, l'évaluation d'une politique suppose l'utilisation d'analyses coûts-avantages ou coûts-efficacité.

Or, mesurer l'efficacité des contrats agro-environnementaux se révèle très difficile, et ce pour plusieurs raisons. D'une part, l'adaptation au niveau local de l'élaboration et de la mise en œuvre de la politique rend parfois difficile l'identification des objectifs des contrats agro-environnementaux. Et d'autre part, les effets produits ne sont pas toujours mesurables du fait, notamment, de l'absence de définition d'un état initial (état 0) précisant l'état de l'environnement avant la mise en place de la politique.

Dans les évaluations officielles telles que celles citées ci-dessus, les mesures d'efficacité des contrats agro-environnementaux sont basées principalement sur le taux de contractualisation. Mais le taux de contractualisation n'est pas le seul critère qui permet de juger de l'efficacité des MAE. En effet, dans de nombreuses régions, la volonté de multiplier les contrats signés a conduit à standardiser les procédures d'élaboration, et souvent à évacuer la complexité d'une logique de construction de projet (territorial et individuel) au profit d'une simple démarche de guichet.

Or, dans le cadre d'une relation contractuelle entre l'Etat et l'agriculteur visant à satisfaire une demande de plus en plus importante de nature, de respect de l'environnement émanant de la société, il est important de se demander dans quelle mesure les attentes de la société ont été prises en compte. Ces attentes n'étant pas forcément celles qui ont gouverné la conception des contrats offerts, elles devront préalablement faire l'objet d'une analyse approfondie.

On a donc choisi de mesurer l'efficacité des MAE à partir d'un indicateur du rapprochement entre offre et demande de biens et services non marchands auquel les contrats agro-environnementaux sont parvenus. Pour cela, on s'intéresse:

- Au niveau de contractualisation,
- Au degré de pertinence des contrats qui permet de voir dans quelle mesure la politique mise en œuvre vise à répondre aux attentes exprimées par la société, au travers de différents acteurs institutionnels.

- A l'ampleur des réalisations, c'est à dire à la façon dont les contrats agro-environnementaux signés répondent effectivement aux objectifs pour lesquels ils ont été mis en place.

Dans un deuxième temps, nous analyserons les phases de d'élaboration et de mise en œuvre des MAE dans les trois départements afin d'évaluer les facteurs institutionnels suivants :

- La concertation entre acteurs d'horizon divers, et notamment l'implication d'acteurs autres que les acteurs agricoles « traditionnels » de la politique, dans les procédures d'élaboration et de mise en œuvre de MAE ;
- Les moyens mis en œuvre par les institutions pour élaborer et mettre en œuvre la politique ;
- L'environnement institutionnel.

L'objectif est de confronter cette analyse au niveau de succès des MAE mesurée dans les trois départements de la Manche, du Calvados et de l'Orne, afin d'établir les facteurs de gouvernance influant sur l'efficacité des politiques agro-environnementales.

3 La relation contractuelle entre agriculteurs et société : les objectifs des parties au contrat

Pour répondre à la fois aux attentes des agriculteurs et à la demande sociale et satisfaire ainsi les deux parties au contrat, les MAE doivent répondre à trois principaux enjeux que l'on peut résumer comme suit :

- Préserver l'environnement;
- Maintenir l'équité entre agriculteurs et entre territoires;
- Permettre l'adoption de nouvelles pratiques plus respectueuses de l'environnement tout en maintenant l'activité agricole.

Ces objectifs sont hiérarchisés. Ainsi, la priorité est donnée aux objectifs environnementaux et, avant tout autre chose à la réduction des externalités négatives, notamment en matière de qualité de l'eau. L'objectif d'améliorer la production d'aménités vient seulement en seconde position, et ce alors même que les MAE ont, à l'origine, été conçues pour répondre en priorité à ce problème.

Parallèlement, la question du ciblage environnemental divise (Figure 1). Ainsi, malgré le caractère consensuel que soulève la nécessité d'endiguer les pollutions de l'eau par l'activité agricole, de nombreux acteurs sont contre l'idée d'ajuster les paiements à la gravité du problème environnemental rencontré dans une zone, arguant que ce mode de calcul reviendrait à bafouer le Principe Pollueur-Payeur en octroyant des subventions conséquentes à la dépollution.

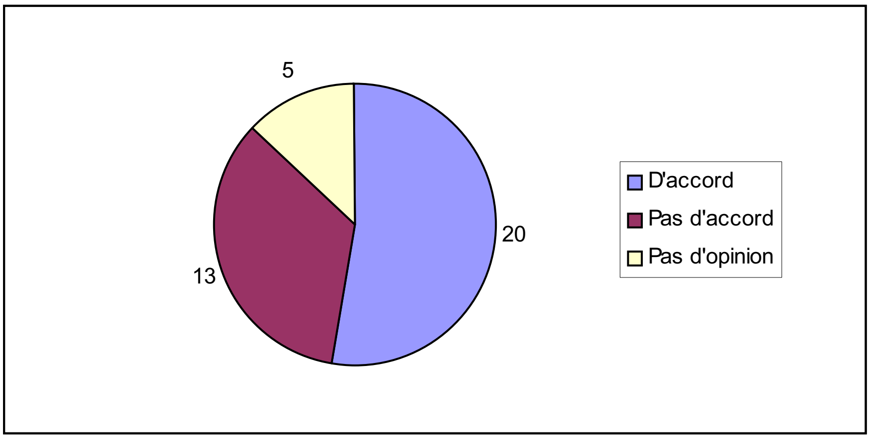


Figure 1: Opinion des institutions interrogées concernant l'affirmation : « les paiements devraient être ajustés à la gravité du problème environnemental rencontré dans une zone spécifique »

En fait, il existe différentes raisons pour lesquelles les acteurs sont à la fois attachés à la primauté de l'amélioration de la qualité de l'eau par rapport à d'autres objectifs environnementaux et opposés à un ciblage des soutiens dans les zones les plus polluées. Pour certains, il s'agit de légitimer des aides aux revenus agricoles, pour d'autres, c'est l'occasion d'exhiber une politique d'ampleur en faveur de la qualité de l'eau qui, même si elle ne suit pas le Principe Pollueur-Payeur, ne permet pas non plus de subventionner uniquement les pollueurs, ce qui serait politiquement inacceptable.

Les autres objectifs sont étroitement liés aux positions affichées par les institutions sur les questions environnementales.

L'équité, objectif essentiellement agricole, fait l'objet de nombreuses interprétations et c'est pourquoi nous écarterons cet aspect dans la suite de l'analyse.

Deux visions différentes se confrontent :
- L'équité entendue comme l'égalité de tous les agriculteurs devant la possibilité d'adopter un contrat (position défendue par la FDSEA), notamment pour compenser la baisse des soutiens procurés par le 1^er^ pilier.
- L'équité entendue comme la nécessité d'utiliser les MAE pour corriger les inégalités résultant de l'allocation des soutiens du 1^er^ pilier (position défendue par la Confédération paysanne).

Ces deux visions, qui ne sont que l'expression de points de vue différents quant à l'allocation des revenus opérée par les MAE, conduisent à rejeter tout principe de ciblage sur des enjeux de réduction des externalités négatives.

Enfin, la question de la modalité des soutiens dépend aussi assez largement des priorités arrêtées en matière environnementale.

Ainsi, à la volonté d'améliorer la production d'aménités est associée l'idée d'un soutien pérenne puisqu'elle implique la rémunération des agriculteurs pour des actions qu'ils ne continueraient pas à assurer sans soutien.

Au contraire, la réduction des effets négatifs, qui fait de plus en plus l'objet de réglementations, est plutôt synonyme de soutiens à vocation transitoire, puisqu'elle est essentiellement perçue comme un appui à la mise en conformité avec la législation, voire à des mutations plus profondes.

4 Evaluation de l'efficacité des MAE

L'objectif de cette partie est d'évaluer l'efficacité des politiques agro-environnementales. La logique « ascendante » de la politique agro-environnementale et la diversité de contrats et de mesures à laquelle cette logique a conduit rend difficile la mesure des résultats de cette politique. C'est pourquoi nous parlons ici d'évaluation du succès de la relation contractuelle.

Nous chercherons à comparer le succès de la relation contractuelle dans les trois départements de Basse-Normandie. Les indicateurs définis et utilisés pour évaluer ce succès sont de deux types :

- quantitatifs (niveau de contractualisation) ;
- qualitatifs : il s'agit d'une part d'une mesure de l'adéquation entre les objectifs de la politique et la demande des parties (pertinence de la politique) et, d'autre part, d'une estimation de la réalisation des objectifs de la politique.

4.1 Niveau de contractualisation

Le niveau de contractualisation est un indicateur incontournable du succès de la relation contractuelle puisqu'il suppose qu'il y a eu rencontre entre l'offre et la demande de biens et services environnementaux. Un taux de contractualisation élevé implique en effet :

- d'un côté, que les agriculteurs sont satisfaits de ce qu'on leur propose et adhèrent aux clauses du contrat à travers lesquelles s'expriment les attentes de la société ;
- et de l'autre, que les effets environnementaux sont susceptibles d'être forts et donc de répondre à la demande sociale. Ainsi, pour le Ministère de l'agriculture*, «la contractualisation est également un élément essentiel à l'efficacité »* ;

A l'échelle de la Région Basse-Normandie, 22,5 % des exploitations professionnelles[2] ont souscrit des contrats agro-environnementaux.

Tableau 1: Contractualisation en Basse-Normandie à la fin de l'année 2005

Département	Nombre d'exploitations professionnelles	Nombre de CTE/CAD signés fin 2005	**% CTE/CAD (exploitations professionnelles)**
Manche	6900	1639	**24%**
Calvados	4483	1101	**25%**
Orne	4430	815	**18%**
Basse-Normandie	15813	3555	**22,5%**

Sources : Agreste et ADASEA

La contractualisation n'est pas uniforme sur l'ensemble du territoire bas-normand. En effet, le département de la Manche a vu se concrétiser sur son territoire un nombre bien plus important de contrats que les deux autres départements, Calvados et Orne. L'expérience de l'agro-environnement acquise lors des précédents dispositifs agro-environnementaux dans

[2] Source : Agreste, *Mémento régional Basse-Normandie* et ADASEA *Contrats d'Agriculture Durable, Observatoire régional, Normandie 2005*.

lequel ce département s'était déjà investi, a sans doute contribué à créer rapidement une dynamique autour des CTE.

Cependant, ce n'est pas dans ce département mais dans celui du Calvados que le taux de contractualisation (nombre de contrats rapporté au nombre d'exploitations professionnelles) est le plus élevé. En effet, la Manche comptant un nombre plus important d'exploitations et une SAU moyenne par exploitation plus faible, le taux de contractualisation ainsi que les surfaces contractualisées y sont moins importantes que dans le département du Calvados[3].
L'Orne, par contre, reste le département où nombre de contrat, taux de contractualisation et surfaces contractualisées sont les plus faibles.

Il est également important de souligner qu'à l'intérieur même des départements, des disparités sont constatées en terme de contractualisation.
Ainsi, dans le département de la Manche, c'est surtout au nord (Presqu'île du Cotentin) que la contractualisation est importante avec un taux de contractualisation dans certaines zones supérieurs à 21 % (Côte du Bessin, La Hague) voire à 31 % (Val de Saire).

Dans le Calvados, deux zones se démarquent : le Bessin avec un taux en moyenne supérieur à 11% et qui excède 21 % dans certaines zones et le Pays d'Auge.
Enfin, dans l'Orne, le taux de contractualisation est certes plus homogène sur l'ensemble du territoire mais il peine à dépasser les 10 %, sauf sur le territoire des Parcs Naturels Régionaux, notamment sur celui du Perche, et, plus récemment, sur le PNR Normandie-Maine[4].

Par ailleurs, sur la centaine de mesures retenues dans la synthèse agro-environnementale de la région, seules une dizaine ont une contractualisation conséquente. En fait, six mesures représentent près de 80 % de la surface contractualisée. Il s'agit de :

- la mesure 0301A (implantation d'une culture intermédiaire sur sol laissé nu en hiver), qui représente à elle seule près de 23% des MAE contractualisées en 2003;
- la mesure 2001 (gestion extensive de la prairie par la fauche) dont les trois options représentent 25% de la surface contractualisée ;
- La mesure 0602A (entretien des haies) qui représente à elle seule 94% du nombre de mètres linéaires contractualisés ;
- Les mesures 0801A (lutte raisonnée), 0901A (réduction de 20% des apports azotés par rapport à des références par culture) et 0903A (adapter la fertilisation en fonction des résultats d'analyse), essentiellement contractualisées dans le Calvados

Deux autres mesures méritent également d'être considérées :

- la mesure 1601A (utilisation tardive de la parcelle), retenue par le projet ITAES car elle constitue un exemple de mesure particulièrement précise et territorialisée. Conçue pour répondre aux attentes du territoire du PNR des Marais du Cotentin et du Bessin, elle était également accessible aux agriculteurs du Parc du Perche. Néanmoins, elle n'a eu un taux de contractualisation significatif que dans les marais du Cotentin et du Bessin et essentiellement dans le département de la Manche ;

---

[3] Eureval-C3E, *Evaluation à mi-parcours portant sur l'application en France du règlement Cen°1257/99 du Conseil, concernant le soutien au développement rural, partie sur le soutien à l'agro-environnement (chapitre IV du RDR) et le Contrat Territorial d'Exploitation, lot Basse-Normandie n°8b, Rapport final MAE*, 15 juin 2003.
[4] ADASEA de Normandie, Observatoire des Contrats Territoriaux d'Exploitation, Normandie - n°1.

- la mesure 0202A (introduction de cultures supplémentaires non légumières dans les exploitations légumières), importante non pas parce qu'elle a un taux de contractualisation élevée, mais parce qu'elle a un poids financier non négligeable. Elle représente en effet près de 14,5 % du budget prévu pour les MAE alors qu'elle ne concerne que 3600 hectares très localisés. Bien que proposée dans les trois départements, cette mesure n'a été prisée que par les producteurs légumiers de la Manche et les surfaces sous contrat sont donc confinées dans trois secteurs : le Val de Saire, la côte sud de la Hague et la côte du Coutançais.

Le niveau de contractualisation laisse ainsi apparaître des différences entre départements ; le Calvados et la Manche affichant des résultats nettement plus positifs que l'Orne. Cela permet également d'esquisser des zones où le rapprochement entre l'offre et la demande s'est mieux réalisé qu'ailleurs. C'est le cas notamment du nord de la Manche avec la zone légumière du Val de Saire.

Cependant, prendre en considération le seul niveau de contractualisation ne permet pas de voir comment les attentes exprimées par chacun des acteurs ont été prises en compte dans les contrats proposés. Ces derniers ont en effet pu être contractualisés simplement parce qu'ils convenaient aux seules attentes des agriculteurs, auquel cas on ne sait rien de la façon dont ils intègrent les attentes exprimées par la société. C'est pourquoi il convient d'évaluer l'adéquation entre les objectifs visés par les contrats et les souhaits formulés par les différentes parties.

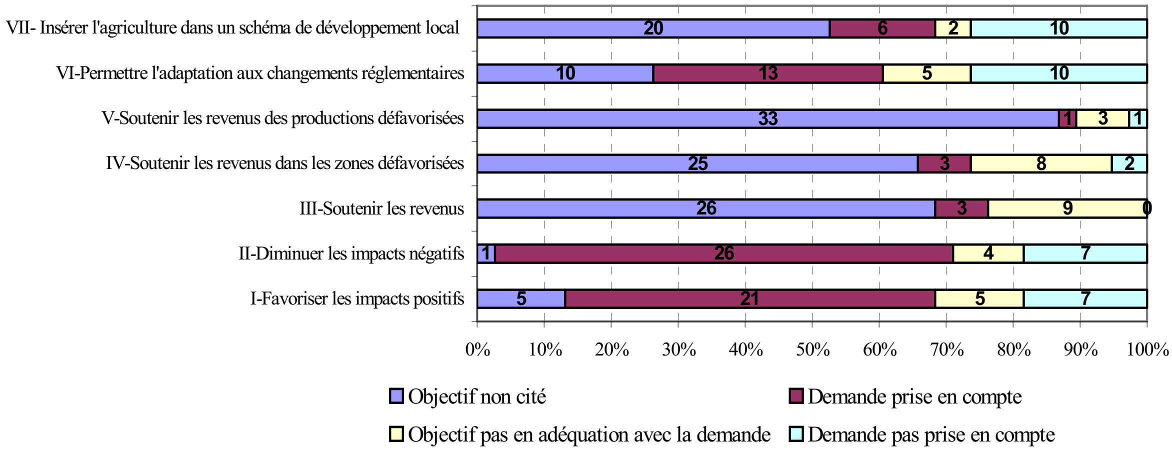
4.2 Adéquation entre la demande des parties et les objectifs des contrats

- **Une politique plus ou moins en adéquation avec les attentes exprimées par les parties**

L'analyse des objectifs des MAE tels qu'ils sont perçus par l'ensemble des institutions interrogées montre une relative adéquation avec les principaux souhaits formulés. Ainsi, d'après les acteurs interrogés, les enjeux environnementaux ont été prioritaires pour les MAE, avec, en premier lieu, la réduction des externalités négatives, puis l'amélioration de la production d'aménités.

Par contre, il est difficile de conclure quant à la prise en compte des demandes moins consensuelles telles que l'équité ou la question de la modalité des soutiens (transitoires ou pérennes) dans la mise en œuvre des MAE.

Le graphique suivant indique, par objectif, le nombre d'institutions pour lesquelles l'objectif perçu correspond à l'attente individuellement exprimée.



> *« Objectif non cité »* signifie que l'objectif en question n'a été mentionné ni comme étant perçu comme un objectif principal de la politique par les personnes interrogées, ni comme étant une attente vis à vis des contrats.
> *« Objectif pas en adéquation avec la demande »* signifie que l'objectif en question est perçu comme faisant partie des principaux objectifs visés par les contrats alors qu'il ne fait pas partie des attentes des institutions vis à vis de la politique agro-environnementale.
> *« Demande pas prise en compte »* concerne des attentes exprimées par les acteurs mais qu'ils ne perçoivent pas comme faisant partie des objectifs principaux des contrats mis en place.
> *« Demande prise en compte »* fait référence à des attentes exprimées qui sont perçues comme ayant bien été intégrées dans les objectifs des contrats.

Figure 2 : Prise en compte de la demande des parties dans les objectifs des MAE

Plusieurs résultats apparaissent ici :

- Les MAE telles qu'elles sont définies dans le cadre des CTE/CAD intègrent, bien dans leurs objectifs, la demande émise par l'ensemble des acteurs d'une amélioration de l'état de l'environnement ;
- La demande d' « adaptation des systèmes aux changements de prix et aux politiques environnementales » est également considérée comme étant prise en compte par 13 des acteurs interrogés. Cependant, pour cet objectif, l'adéquation avec la demande est plus discutable. Cela s'explique en partie par les différentes interprétations qui ont pu en être faites. En effet, ceux qui défendaient ici l'idée que les MAE devaient permettre d'amener les systèmes d'exploitations à s'extensifier en adoptant des pratiques plus durables (idées d'aides transitoires), ont globalement considéré que leur demande n'avait pas été prise en compte par les MAE. Par contre, ceux qui entendaient par cet objectif que les MAE devaient permettre aux exploitations de maintenir leur compétitivité tout en s'adaptant à la baisse des prix du marché et aux nouvelles réglementations environnementales (conditionnalité, par exemple) ont considéré que leur demande avait été prise en compte dans la mise en œuvre des CTE/CAD.
- Enfin, pour un cinquième des personnes interrogées, le soutien au revenu s'est imposé comme un objectif des MAE telles qu'elles ont été définies et mises en œuvre alors qu'il ne correspondait pas à une demande des parties au contrat. Pour la plupart des institutions, le soutien au revenu agricole est un enjeu majeur de la politique agricole et les MAE ont été détournées au profit de cet enjeu alors qu'elles ne constituent pas un outil adéquat pour y répondre. La majorité des acteurs considèrent que les objectifs de soutien au revenu n'ont, en effet, aucun rapport avec l'agro-environnement et, pour

eux, ils ne devraient absolument pas entrer en ligne de compte dans la politique agro-environnementale.

Globalement, trois objectifs des contrats apparaissent donc en adéquation avec les attentes exprimées par les acteurs institutionnels : réduire les impacts environnementaux négatifs de l'agriculture, améliorer les effets positifs et de façon moins certaine, permettre l'adaptation des systèmes aux changements de prix et aux politiques environnementales. Cependant, les demandes exprimées par les acteurs ont été plus ou moins bien prises en compte selon les départements.

❖ Une adéquation plus importante dans le département de la Manche

L'adéquation entre objectifs perçus et attentes des acteurs est bien meilleure dans la Manche puisque sur l'ensemble des objectifs mentionnés, les acteurs de ce département ont considéré à 70 % que leur demande était bien prise en compte.

L'Orne et le Calvados, avec une prise en compte des demandes estimée à 40 %, ont une adéquation nettement inférieure.

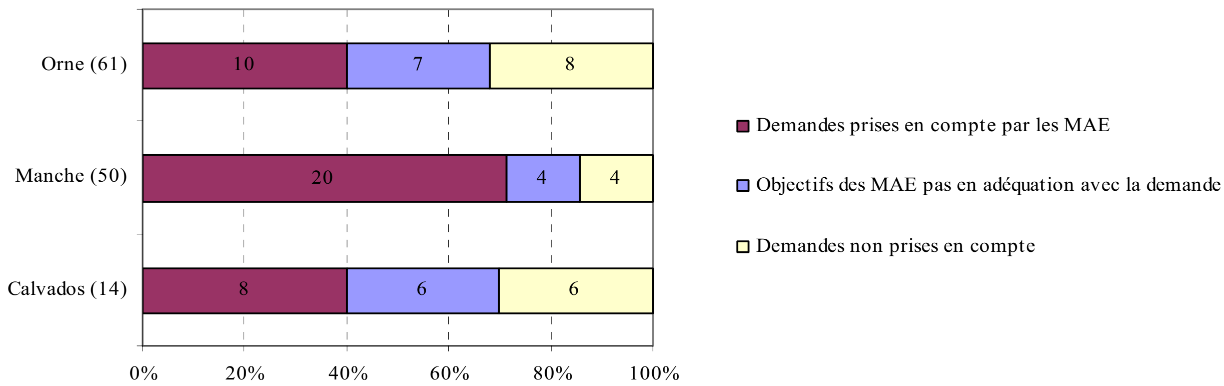


Figure 3 : Adéquation entre objectifs des CTE/CAD tels qu'ils ont été perçus et les attentes exprimées Comparaison entre départements

Un complément d'information doit être apporté en confrontant les mesures les plus importantes en terme de contractualisation avec l'ensemble des attentes identifiées afin de voir comment celles-ci sont intégrées dans les contrats proposés.

❖ Des objectifs pas également pris en compte par toutes les mesures

Six mesures, parmi les huit citées précédemment, ont été retenues pour cette analyse : les mesures 0301A, 2001 et 0602A, de par leur taux de contractualisation important, la mesure 202A de par son importance budgétaire, la mesure 1601 et enfin la mesure 801A. Ces différentes mesures sont présentées en Annexe 1.

L'évaluation environnementale des mesures réalisée par un panel d'experts dans le cadre du projet ITAES (WP5) donne un certain nombre d'informations quant aux objectifs réellement intégrés par les mesures et à leur pertinence technique par rapport aux enjeux identifiés.

La confrontation des résultats obtenus aux attentes des différentes parties telles qu'elles ont été identifiées précédemment permet d'en déduire la façon dont chacune de ces mesures tient compte des principaux objectifs des parties.

Tableau 2: Intégration des objectifs par les mesures retenues

Objectifs	**Réduire les impacts négatifs**	**Augmenter les effets positifs**		**Ciblage environnemental**	**« Vocation temporelle » des soutiens**
Mesures	eau	paysage	biodiversité		
0202A	++	0	+	++	Transitoire
0301A	++	0	+	0	Transitoire
0602A	+	++	++	0	Pérenne
0801A	+	0	0	0	Transitoire
1601	+	+	++	++	Pérenne
2001	+	+	+	0	Pérenne

++ : la mesure prend très bien en compte l'objectif
+: la mesure prend en compte l'objectif
0 : la mesure ne prend pas en compte l'objectif

Trois mesures intègrent globalement bien l'ensemble des attentes des acteurs. Il s'agit des mesures 1601, 0602A et 0202A. Il convient néanmoins de souligner qu'elles correspondent à des logiques très différentes :

La mesure 0202A vise essentiellement à réduire les intrants agricoles utilisés pour les cultures maraîchères, sources de pollution importante des eaux. Les experts considèrent que ses effets potentiels sur la qualité de l'eau sont forts. Accessoirement, la moindre utilisation de traitements phytosanitaires peut également avoir des répercussions sur la biodiversité. Mais son objectif prioritaire est bel et bien de réduire les impacts négatifs.

Par ailleurs, cette mesure répond à une logique de soutien transitoire. En effet, l'introduction d'une autre famille de cultures dans la rotation apporte une amélioration agronomique notoire, qui incite les producteurs à poursuivre cette pratique sans que l'aide soit reconduite.

Ce n'est pas le cas **des mesures 0602A et 1601**, qui elles, ont pour vocation première d'améliorer la production d'aménités.

Aussi, ces deux mesures justifient un soutien qui a vocation à se pérenniser dans la mesure où, sans prise en charge par la société des surcoûts induits par ces pratiques, les agriculteurs abandonneraient ces activités.

Néanmoins, les mesures 0202A et 1601 ont un point commun : elles répondent à une logique de ciblage environnemental. Ce sont, en effet, des mesures très spécifiques à une production, les cultures légumières, ou à un contexte particulier, l'agriculture en zone de marais, et qui sont, de ce fait, localisées sur des zones relativement restreintes.

Cependant, la logique de distribution des revenus inhérente à ces deux mesures est différente : alors que la 1601 permet une allocation des aides favorables à des agriculteurs moins favorisés par le premier pilier, et peut donc être considérée comme conforme à l'objectif d' « équité » tel que défendu par la Confédération Paysanne, la 0202A revient à distribuer des primes très élevées à l'une des activités agricoles les plus polluantes de la région. Une logique de répartition qui est largement contestée par l'ensemble des acteurs agricoles.

Les mesures 0301A et 2001 offrent une adéquation moyenne entre les objectifs des MAE et les attentes des parties en particulier parce que leur impact sur l'environnement est jugé limité. De plus, aucune de ces deux mesures ne répond à une logique de ciblage. La distribution de revenu opérée par ces mesures correspond aux attentes exprimées par la FNSEA, à savoir une accessibilité des soutiens au plus grand nombre.

Une différence importante entre les deux mesures est à noter. La 2001 est essentiellement une aide au maintien des systèmes herbagers, qui a donc vocation à se pérenniser. La 0301A, par contre, est typiquement une mesure à vocation transitoire puisque les règles imposées par son cahier des charges sont aujourd'hui intégrées aux obligations à respecter dans le cadre des BCAE[5], exigences qui entrent dans le champs de la conditionnalité des aides PAC. De plus, comme pour la 0202A, l'amélioration agronomique résultant du couvert incite les agriculteurs à poursuivre ces pratiques au-delà de la période du contrat.

La mesure 0801A ne concorde pas avec la demande exprimée par les différents acteurs institutionnels. En effet, son impact environnemental sur la qualité de l'eau est jugé faible et, par ailleurs, elle ne prend en compte aucun des deux enjeux relatifs aux aménités (paysage et biodiversité). De plus, elle ne fait pas l'objet d'un ciblage environnemental.

Enfin, elle fait partie des mesures que la réglementation a aujourd'hui rattrapées, notamment avec le projet de loi sur l'eau et l'intégration de la directive Nitrate à la conditionnalité des aides PAC.

L'observation des zones où ces mesures sont contractualisées nous indique que l'adéquation entre attentes des parties et les objectifs effectivement visés par les MAE est meilleure dans le département de la Manche.

Toutes les mesures jugées pertinentes ont été contractualisées de façon significative dans ce département. C'est notamment le cas des mesures 0202A et 1601, contractualisées uniquement dans la Manche et plus particulièrement dans certaines zones comme le Parc des marais du Cotentin et du Bessin et le Val de Saire.

Le Calvados affiche des résultats moins bons, son taux de couverture ne pouvant être qualifié d'important que pour la mesure 0801A, c'est à dire celle qui intègre le moins bien les attentes des agriculteurs et de la société.

L'Orne, qui n'a de couverture importante pour aucune de ces mesures, est sans conteste le département dans lequel l'adéquation est finalement la plus mauvaise. Seul une petite partie ouest du département semble significativement couverte, mais par des mesures prenant moyennement en considération la demande des acteurs.

Une bonne prise en compte par les MAE des attentes affichées par les différentes institutions est une condition nécessaire mais pas suffisante à l'efficacité des MAE. En effet, la politique doit parvenir à atteindre ses objectifs pour pouvoir être qualifiée d'efficace.

[5] Bonnes Pratiques Agricoles et Environnementales

4.3 Réalisation des objectifs

La réalisation des objectifs ne pouvant pas être directement mesurée, nous cherchons à estimer le niveau de satisfaction des acteurs interrogés vis à vis de la politique mise en œuvre.

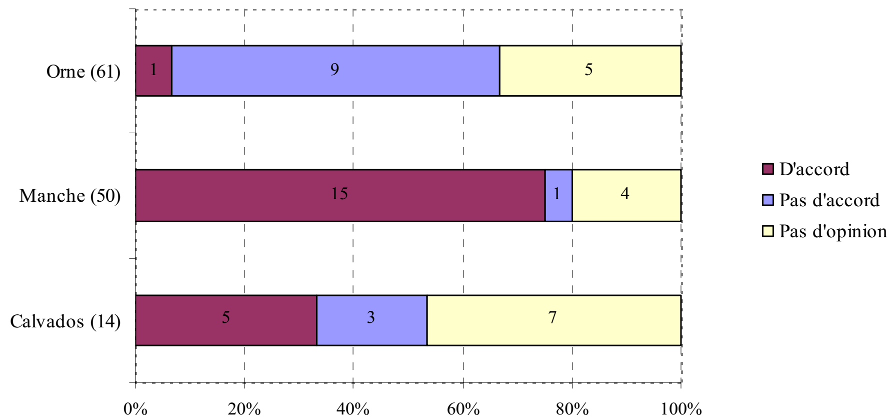


Figure 4 : Opinion exprimée par les acteurs concernant l'affirmation: "Les MAE s'attaquent suffisamment aux problèmes environnementaux Comparaison entre départements

Globalement, les MAE ne sont pas perçues comme réalisant bien les objectifs pour lesquelles elles ont été mises en œuvre. En effet, pour plus de la moitié des institutions interrogées, les MAE n'apportent pas une réponse satisfaisante aux objectifs visés.

Etant donné la diversité des mesures contractualisées d'un département à l'autre, les réponses obtenues par département diffèrent.

L'ensemble des enjeux environnementaux est à priori beaucoup mieux traité dans la Manche que dans les deux autres départements. La réalisation des objectifs environnementaux est effectivement estimée médiocre dans le département du Calvados, et très mauvaise dans l'Orne, où un seul acteur la juge satisfaisante. En effet, l'impact environnemental des mesures est, pour beaucoup, largement insuffisant, surtout en terme de réduction des effets négatifs. La politique souffre par ailleurs d'un manque de ciblage. Elle est souvent dénoncée comme étant simplement du « saupoudrage » d'actions sur un trop large territoire, d'autant plus inefficace que la contractualisation n'est pas suffisante pour atteindre des effets significatifs et visibles.

Néanmoins, des nuances existent selon l'enjeu considéré. Ainsi, les questions liées à l'amélioration des effets positifs (paysage et biodiversité) semblent nettement mieux traitées dans le département de la Manche. D'après la perception des acteurs institutionnels de ce département, les MAE mises en place offrent des résultats satisfaisants dans ce domaine. Par contre, c'est dans le Calvados que les MAE sont perçues comme traitant le mieux les problèmes relatifs à la qualité de l'eau. Enfin, quel que soit l'enjeu, l'Orne concentre le plus grand nombre d'avis exprimés défavorables quant à l'efficacité des MAE.

Il faut noter que, globalement, de nombreux acteurs reconnaissent aux CTE/CAD le mérite d'avoir insufflé une réelle prise de conscience au sein du monde d'agricole de l'impact que l'agriculture a sur l'environnement et de la nécessité de mettre en place des actions en faveur de celui-ci.

4.4 Synthèse : évaluation de l'efficacité des MAE

Tableau 3: Evaluation de l'efficacité des MAE par département

	Contractualisation	Adéquation	Réalisation	**Indicateur d'Efficacité**	Remarques
Calvados (14)	++	+	-	+	L'indicateur d'efficacité peut être considéré comme moyen à satisfaisant pour la qualité de l'eau
Manche (50)	++	++	++	++	Les objectifs liés à la production d'aménités mieux réalisés que ceux liés à la réduction des nuisances
Orne (61)	-	-	-	-	Aucun enjeu ne semble réellement être traité de façon satisfaisante

Le Tableau 3 indique que, globalement, l'efficacité des MAE ne peut être jugée satisfaisante que dans la Manche. Fort de ce constat et au vu des disparités importantes qui existent entre départements, voire à l'intérieur même d'un département, il est important de s'interroger sur les facteurs qui peuvent conduire à de tels écarts.

5 Les facteurs favorisant l'efficacité des MAE

L'objectif de cette partie est d'expliquer les différences d'efficacité constatées dans les trois départements bas-normands.

Trois types de facteurs susceptibles d'influencer la réussite de la politique ont été identifiés : la concertation, c'est à dire la participation d'acteurs diversifiés, les moyens déployés par les institutions et l'environnement institutionnel.

L'analyse de ces trois éléments dans les procédures d'élaboration et de mise en œuvre des MAE et leur mise en perspective avec les différentes configurations départementales permet de voir dans quelle mesure ils ont influencé chacune des composantes de l'indicateur d'efficacité que nous avons défini (contractualisation, adéquation et réalisations).

5.1 Nombre et qualité des acteurs participants au dispositif : l'importance d'une large concertation

Plusieurs hypothèses peuvent être faites quant à la participation des différents types d'acteurs et à leur rôle dans l'ensemble du processus, c'est à dire dans les phases d'élaboration (de la définition des enjeux du territoire à la rédaction des contrats-types) et de mise en œuvre (montage des dossiers, suivi des différents projets, conseils administratifs ou techniques aux agriculteurs etc.). Une véritable concertation est souvent assimilée à un gage de réussite, et ce pour plusieurs raisons :

- elle permet une meilleure prise en compte de la demande sociale, de tous les intérêts en présence, et a donc une influence positive sur l'adéquation entre objectifs des parties et objectifs intégrés dans les contrats ;

- elle permet également un partage d'expériences, de compétences et de savoir-faire entre les différents domaines (agricole, environnement, territoire, économie) que recouvre le concept de multifonctionnalité de l'agriculture, et influence donc positivement sur les réalisations, dans la mesure où l'efficacité des mesures est améliorée ;

- enfin, la qualité des différents acteurs associés à cette concertation joue sur le niveau de contractualisation. Certains acteurs sont en effet en contact direct et régulier avec des agriculteurs (par exemple, les coopératives avec leurs adhérents) et ont donc plus de facilités que d'autres pour les atteindre.

L'étude du déroulement des procédures d'élaboration et de mise en œuvre des MAE dans chaque département permet de tester la validité de ces hypothèses.

❖ Les acteurs impliqués dans chaque département

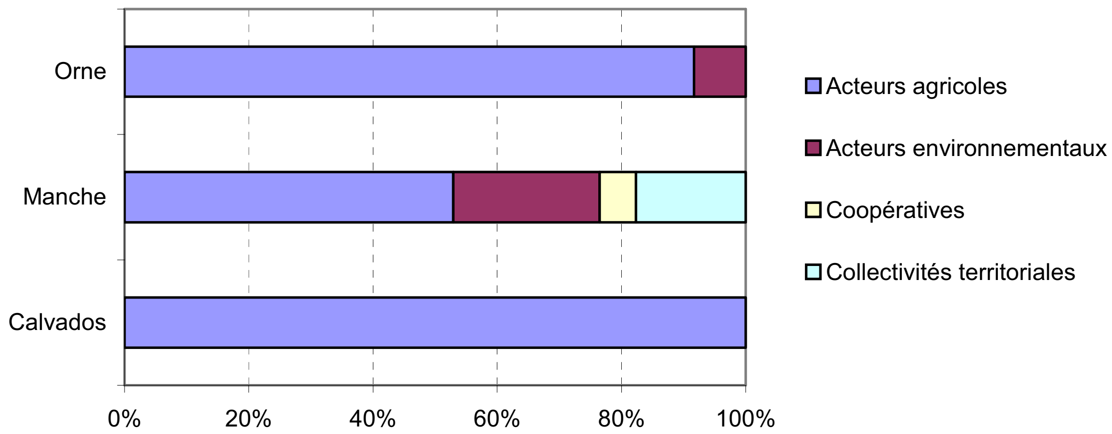


Figure 5 : Influence des différentes catégories d'institution dans le processus d'élaboration des MAE. Comparaison entre départements.

➢ *Calvados*

Dans le Calvados, la phase d'élaboration des contrats a été assurée conjointement par les trois institutions agricoles « traditionnelles » : la DDAF, la chambre d'agriculture et l'ADASEA.
La chambre d'agriculture a d'ailleurs bénéficié d'une très forte influence sur l'élaboration des contrats. Partie prenante de la définition des enjeux, elle a ensuite vraisemblablement eu une part active dans la rédaction des cahiers des charges des mesures, puis dans l'élaboration des contrats-types. L'emprise de la chambre d'agriculture est confirmée par son omniprésence dans le dispositif puisqu'elle a eu également un rôle important dans la procédure de mise en œuvre. Il est à noter que les collectivités locales sont absentes du dispositif.

➢ *Manche*

Dans le département de la Manche, le nombre d'institutions parties prenantes à la phase d'élaboration est plus important. Les étapes de définition des enjeux et de rédaction des cahiers des charges ont essentiellement été prises en charge par l'administration agricole, aidée des chambres d'agriculture et de l'ADASEA.

A l'issue de la phase de préfiguration (définition des enjeux), le département a été découpé en six territoires homogènes[6]. A chacun de ces territoires devait correspondre un contrat-type.

Deux collectivités territoriales ont été porteuses d'un projet sur leur territoire.
- Le Parc Naturel Régional des Marais du Cotentin et du Bessin qui a mis en place un contrat-type « Région de Marais ». Pionnier dans l'utilisation des MAE, le Parc s'est impliqué dans la rédaction des cahiers des charges dans le but d'adapter les mesures aux besoins de son territoire.
- La Communauté de communes de La Hague a été à l'initiative d'un contrat-type « Hague ».

A coté de ces approches territoriales, des démarches de filières ont été instaurées par des coopératives, qui ont également joué un rôle non négligeable.

- Les Maîtres Laitiers du Cotentins, ont porté un contrat pour la filière lait ;
- Le Groupement d'Intérêt Economique SILEBAN (organisé autour de deux coopératives légumières) a élaboré des contrats destinés aux cultures maraîchères du Val de Saire et de la côte ouest pour la filière légumes.

Contrairement à ce qui avait été constaté dans le Calvados, aucun acteur n'a jouit ici d'une influence prépondérante par rapport aux autres dans la phase d'élaboration.

La phase de mise en œuvre a essentiellement été assurée par les acteurs « traditionnels » : ADASEA, syndicats agricoles, Chambre d'agriculture. Les coopératives agricoles ainsi que le PNR des Marais du Cotentin et du Bessin se sont également investies dans cette phase, pour ce qui concerne principalement l'appui et conseil aux agriculteurs.

On constate donc une hétérogénéité des forces d'influence et un relatif équilibre entre acteurs agricoles et intérêts sociétaux représentés par l'administration environnementale et les collectivités territoriales et ce sur l'ensemble des étapes de la politique. En effet, aucune phase (excepté les fonctions de notification et de paiement, exclusivement réservées à l'administration de contrôle) n'est monopolisée par un seul acteur.

➢ *Orne*

Dans l'Orne, la position dominante de l'administration agricole est indéniable. En effet, dans ce département, face aux réticences initiales de toute une frange de la profession agricole vis à vis des CTE et à l'inertie qui en a découlé, l'administration s'est vue dans l'obligation de prendre les devants et « d'imposer » la mise en oeuvre de la politique sur le territoire. Cela s'est soldé par l'élaboration d'un contrat-type accessible à tous les agriculteurs du département et offrant un choix de mesures assez générales et peu contraignantes.

Ce n'est donc qu'après un démarrage tardif que d'autres acteurs, jusqu'alors confrontés au rejet initial de la politique par les principales Organisations Professionnelles Agricoles (OPA) du département, ont eu enfin la possibilité de s'impliquer, et ce peu de temps avant le

[6] Hague, Cotentin, Coutançais, Saint-Lois, Moratinais, Avranchin.

remplacement du CTE par le CAD, pour lequel l'administration est redevenue l'acteur central de la politique.

Malgré ces circonstances, différentes dynamiques ont vu le jour :

- Certaines collectivités territoriales se sont ainsi impliquées dans l'élaboration des MAE. Le PNR du Perche a été porteur d'un projet et le PNR Normandie-Maine a été impliqué dans la rédaction de certains cahiers des charges (exemple : vergers poiriers de haute tige). Par ailleurs, le Conseil général a tenté de porter un projet collectif autour de l'enjeu eau mais celui-ci a été refusé en CDOA ;
- La Confédération paysanne, syndicat rencontré dans ce département, a tenté de mettre en place un contrat-type autour d'une mesure spécifique, la mesure 0104, destinée à convertir les systèmes d'exploitations en systèmes fourragers à base d'herbe et à faible niveau d'intrants. Elle a ainsi beaucoup travaillé à la définition et à la territorialisation de cette mesure qui s'est heurtée à la réticence d'autres acteurs agricoles (la FDSEA, notamment, y était opposée). La mesure a finalement été validée mais seulement peu de temps avant que les CTE ne soient remplacés par les CAD, ce qui n'a pas permis un décollage de la contractualisation.

La phase de mise en œuvre a, ici aussi, essentiellement été assurée par les acteurs « traditionnels » : ADASEA, et Chambre d'agriculture principalement. Par ailleurs, les PNR ont également tenté d'être présents sur l'ensemble du dispositif et ont contribué au montage des dossiers, au suivi des projets et, dans une moindre mesure, au conseil des agriculteurs.

La domination des acteurs agricoles, et plus particulièrement ici de l'administration, reste toutefois très marquée. Les autres catégories d'acteurs institutionnels ne sont pas réellement parvenues à s'impliquer et à imposer leur vision des choses. Ces difficultés, dues à la très forte réticence d'une partie de la profession agricole et au fait que la seule solution finalement proposée par l'administration pour surmonter cet obstacle a été un contrat-type « standard » accessible à tous, témoignent du manque d'ambition flagrant de la politique de ce département.

Un constat s'impose : la plus forte pluralité du dispositif agro-environnemental dans la Manche allant de paire avec un découpage du territoire en fonction des enjeux environnementaux. Le nombre d'acteurs impliqués et, surtout leur diversité y est plus importante que dans les deux autres départements où la dominance d'une institution par rapport aux autres et le nombre restreint et peu diversifié des autres participants caractérise le fonctionnement du dispositif.

❖ La concertation : facteur essentiel au succès de la relation contractuelle

La participation apparaît donc comme un facteur de nature à favoriser le succès de la politique.

Dans une large mesure, le déséquilibre des rapports de force au profit des acteurs agricoles, (Chambre d'Agriculture et Administration agricoles) est fortement ressenti par les acteurs qui expriment clairement la volonté de voir associer au dispositif des associations environnementales ou autres représentants de la société rurale. En effet, ces acteurs défendent des intérêts sociétaux directement concernés par l'agro-environnement et leur implication pourrait conduire à une meilleure prise en compte de l'intérêt général et, donc, à une meilleure adéquation entre demande sociale et objectifs des contrats, condition indispensable à une acceptation de la politique.

Les collectivités territoriales font également partie des institutions dont beaucoup d'acteurs, notamment dans le Calvados et dans l'Orne, considèrent que l'influence devrait être renforcée. En effet, leurs représentants étant directement élus par la population locale, elles ont toute légitimité pour porter la demande sociale de leur territoire. De plus, un dispositif pensé et décidé par les autorités publiques locales est susceptible de fournir des solutions plus adaptées aux enjeux locaux et une meilleure territorialisation, et donc précision, de la politique. Une plus grande efficacité environnementale pourrait ainsi être atteinte.

Ainsi, l'étendue plus importante des prérogatives des collectivités dans la Manche peut être un argument avancé pour justifier à la fois une meilleure adéquation des objectifs des contrats aux attentes des parties et des réalisations plus satisfaisantes dans ce département. Les exemples du PNR des Marais du Cotentin et du Bessin et de la Hague, où l'efficacité des MAE est jugée satisfaisante, confirment ces arguments.

Enfin, le succès constaté sur le territoire du PNR est aussi lié à l'implantation d'acteurs économiques. En effet, une plus forte implication des acteurs de type coopératives ou groupements de producteurs correspond à une approche plutôt basée sur une logique économique. L'idée est de voir comment améliorer la rentabilité de l'exploitation ou mieux valoriser la production, tout en prenant en considération les contraintes environnementales.

L'apport de ce type d'acteurs peut être intéressant :

- pour la contractualisation : les contrats s'adressant, en premier lieu, aux adhérents, il existe déjà des liens réciproques entre la structure porteuse de projet et les contractants potentiels (il est facile pour la coopérative d'atteindre ceux à qui le contrat s'adresse et symétriquement, l'accès à l'information des agriculteurs est presque assuré) ;
- mais aussi en terme de réalisation : les coopératives possédant une connaissance fine du fonctionnement technique des exploitations, elles sont en mesure de proposer des contrats adaptés au contexte des producteurs à qui elle s'adresse, permettant ainsi une meilleure combinaison entre contraintes liées à la production et contraintes liées à l'environnement, ce qui peut jouer sur leur efficacité.

Aussi, une large part du succès rencontré par les MAE dans le Nord de la Manche est imputable aux initiatives conduites par la coopérative des Maîtres Laitiers du Cotentin et par le SILEBAN, le premier étant implanté au cœur de la presqu'île du Cotentin et le second visant essentiellement les bassins légumiers du Val de Saire et de la Côte Ouest, zones où les trois indicateurs de succès de la politique sont jugés plus satisfaisants qu'ailleurs.

Le cas du département de la Manche et les aspirations de l'ensemble des institutions interrogées nous enseigne que c'est la combinaison de trois éléments qui conditionne largement le succès des MAE, du point de vue de l'adéquation et des réalisations mais aussi de la contractualisation :

- l'hétérogénéité des acteurs participants ;
- la concertation entre ces acteurs ;
- une « subsidiarité » des actions menées : c'est à dire des démarches adaptées à chaque contexte (territorial, de production etc.) et ce à l'échelon le plus adapté.

5.2 Les moyens déployés par les institutions

De l'avis de nombreuses personnes interrogées, les MAE, parce qu'elles ont été mises en place dans un contexte particulier et qu'elles ont, depuis 1999, vocation à toucher un nombre important d'agriculteurs, ont requis la mobilisation de compétences techniques et de moyens humains et matériels importants.

Plusieurs hypothèses liées aux moyens déployés par les institutions peuvent être avancées :

- La disponibilité de moyens humains et techniques a un impact important sur le niveau de contractualisation dans la mesure où ils permettent un effort plus important de communication autour des contrats et surtout, où ils offrent la possibilité de traiter un nombre conséquent de dossiers ;
- L'importance des compétences disponibles a une influence sur l'adéquation entre attentes des parties et objectifs visés par les contrats. En effet, la connaissance implique, pour les acteurs, une certaine crédibilité. Il devient alors plus facile, pour une institution, de faire valoir ses positions;
- L'ensemble des moyens et compétences disponibles joue beaucoup sur les réalisations. Ils permettent d'atteindre une plus grande précision des mesures, dans leur conception mais aussi dans leur mise en œuvre.

L'étude des moyens à disposition des institutions concernées montre que selon les départements, ces institutions n'étaient pas nécessairement toutes « armées » pour s'investir dans la mise en application du dispositif.

❖ **L'importance des moyens mobilisés**

➢ *Sur la contractualisation*

Dans la Manche, où moyens, techniques, humains et compétences étaient disponibles au sein de plusieurs institutions, des résultats satisfaisants ont pu être atteints du point de vue de la contractualisation.

Il convient de distinguer la situation de la Manche de celle du Calvados. Dans le premier département, ces moyens sont répartis entre acteurs d'horizon divers (coopératives, PNR etc.) mais ont fait défaut, lors du lancement de la politique, aux principaux acteurs agricoles du dispositif (Chambre d'agriculture et ADASEA, qui ont dû beaucoup investir). Dans le second, où le taux de contractualisation est plus important, seule la chambre d'agriculture disposait dès le départ des moyens nécessaires à l'élaboration et la mise en œuvre des MAE.

Ainsi, la conséquence des moyens disponibles, si elle est indéniablement un facteur favorisant la contractualisation, s'avère plus efficace lorsqu'elle concerne les acteurs traditionnels agricoles. En effet, de par leur plus grande proximité avec les agriculteurs, il leur est plus facile d'en atteindre un nombre important et de bien allouer les moyens dont ils disposent à cet objectif (communication importante, moyens pour monter un grand nombre de dossiers etc.).

La situation un peu particulière du département de l'Orne ou, malgré le fait que plusieurs institutions estimaient disposer des moyens nécessaires à leurs tâches relatives aux MAE, le niveau de contractualisation est moindre, permet par ailleurs de souligner un autre point : le manque de moyens humains et l'impréparation à un tel programme de l'administration, qui a souvent eu le sentiment de ne pas avoir pu s'impliquer au delà de ses missions strictement administratives.

Dans ce département, l'administration agricole a en effet dû, face au rejet d'une partie de la profession de toute autre initiative, porter presque seule le dispositif, alors qu'elle n'en avait pas les moyens. La contractualisation n'a, de ce fait, pas atteint un niveau satisfaisant. Ce qui confirme le rôle important des moyens à disposition des acteurs agricoles sur le niveau de contractualisation.

Les moyens peuvent également avoir un impact sur l'adéquation entre demande sociale et objectifs visés par le contrat.

➢ *Sur l'adéquation entre la demande des parties et les objectifs de la politique*

L'adéquation globalement bien plus satisfaisante constatée dans la Manche peut s'expliquer en partie par l'importance des moyens, et plus spécifiquement des compétences disponibles, et ce rapidement, au sein d'institutions diversifiées, porteuses d'intérêts autres qu'exclusivement agricoles (rôle important du PNR des Marais du Cotentin et du Bessin) ou, du moins, ayant une approche différente de celles des acteurs traditionnels (cas des coopératives MLC et SILEBAN).

L'importance de compétences disponibles implique en effet que ces acteurs ont les moyens de faire entendre leur voix, leurs revendications dans le dispositif et, donc, de véritablement représenter des intérêts plus en phase avec la demande sociale.
Ainsi, un des griefs majeurs à l'encontre des CDOA, et l'argument le plus souvent avancé pour expliquer son échec en termes de concertation est le manque de moyens et surtout de connaissances et de compétences des représentants d'autres intérêts sociétaux (associations environnementales, de consommateurs etc.) sur le sujet et leurs difficultés à faire entendre leur voix ou même à prendre part concrètement aux débats.

Si les attentes de l'ensemble des parties ont pu être mieux prises en compte dans la Manche, la « toute-puissance » de la chambre d'agriculture dans le Calvados a fait qu'une seule aspiration, certes la plus importante, mais aussi la plus consensuelle (donc moins difficile à faire accepter aux agriculteurs), a été prise en compte : la nécessité d'améliorer les effets négatifs de l'activité agricole sur la qualité de l'eau.

Plus encore que sur l'adéquation, la répartition des moyens permettant à d'autres institutions que les acteurs traditionnels agricoles de faire valoir leur point de vue, a un impact important sur les réalisations des contrats.

➢ *Sur les réalisations de la politique*

Globalement, le déploiement de moyens importants a un impact sur les réalisations. En effet, l'importance des connaissances conduit à l'élaboration de mesures plus efficaces en terme environnemental.

La formation supplémentaire qu'ont acquis les organismes impliqués dans la mise en œuvre des mesures concerne souvent le contenu des cahiers des charges et ce dans le but d'aider les agriculteurs à respecter le mieux possible les prescriptions des mesures.

Cela a notamment été le cas des Chambres d'agriculture du Calvados et de la Manche, de la FDSEA dans la Manche et de la Confédération paysanne dans l'Orne, cette dernière n'ayant cependant pas mis à profit les compétences acquises puisqu'elle n'a pas pu être impliquée dans la mise en œuvre des contrats.

Le résultat escompté est une application plus précise des mesures par les agriculteurs, qui doit logiquement conduire à une plus grande efficacité.

Une meilleure précision dans l'application des mesures que permet également l'importance des moyens techniques, puisque les investissements réalisés concernent souvent des logiciels de systèmes d'information géographique, facilitant la localisation des parcelles (et donc un choix opportun) ainsi, ensuite, que leur suivi.

Enfin, l'importance des moyens humains permet un meilleur suivi des agriculteurs et des actions engagées.

Ainsi, l'ensemble des moyens disponibles a un impact fort sur l'efficacité environnementale des mesures. Ceci est d'autant plus vrai lorsque ces moyens sont à disposition d'acteurs diversifiés (environnementaux, mais aussi économiques) qui sont susceptibles d'apporter une expertise complémentaire et, donc, de permettre une meilleure précision des mesures que ce soit dans leur élaboration ou dans la façon dont elles sont mises en œuvre. L'importance relevée ici du partage de moyens et de compétences conforte les hypothèses relatives à l'importance d'un dispositif concerté développées dans la partie précédente.

5.3 Environnement institutionnel

Les relations entre agriculteurs et institutions mais aussi entre institutions parties prenantes de la politique peuvent avoir un impact non négligeable sur le succès des contrats.

Trois éléments sont ici analysés :

- La lisibilité de la politique est particulièrement importante dans le cas d'une politique de type volontaire comme c'est le cas pour les MAE. Une bonne lisibilité de la procédure de montage de dossier, des obligations des parties au contrat ainsi que des résultats attendus de la politique permet en effet aux agriculteurs de raisonner leur choix d'engagement et aux institutions impliquées de mieux délimiter leur rôle dans le processus. Elle peut ainsi conduire à un taux de contractualisation plus élevé ainsi qu' à une meilleure réalisations des objectifs.
La lisibilité de la politique permet également de justifier celle-ci auprès des tiers au contrat.

- La transparence de la politique est évaluée en considérant les opinions des personnes interviewées sur la ponctualité des paiements agro-environnementaux, et sur la bonne gestion des contrats par l'administration. Argument de promotion des contrats, elle agit sur la motivation des agriculteurs à rejoindre le dispositif et surtout à respecter leurs engagements.

- Le climat de confiance, est évalué en considérant les opinions des personnes interviewées sur la stabilité des réglementations relatives aux MAE ; et sur le niveau de confiance des Ministères de l'Agriculture et de l'Environnement vis à vis des réseaux d'acteurs agricoles impliqués dans la mise en œuvre de la politique (ADASEA, chambres d'agriculture etc.). Un bon climat de confiance favorise les échanges ce qui induit des effets positifs à la fois sur la contractualisation, l'adéquation entre attente des parties et objectifs des contrats et les réalisations de la politique.

L'analyse des trois critères dans chaque département ne permet pas vraiment de confirmer ces hypothèses. (Figure 6).

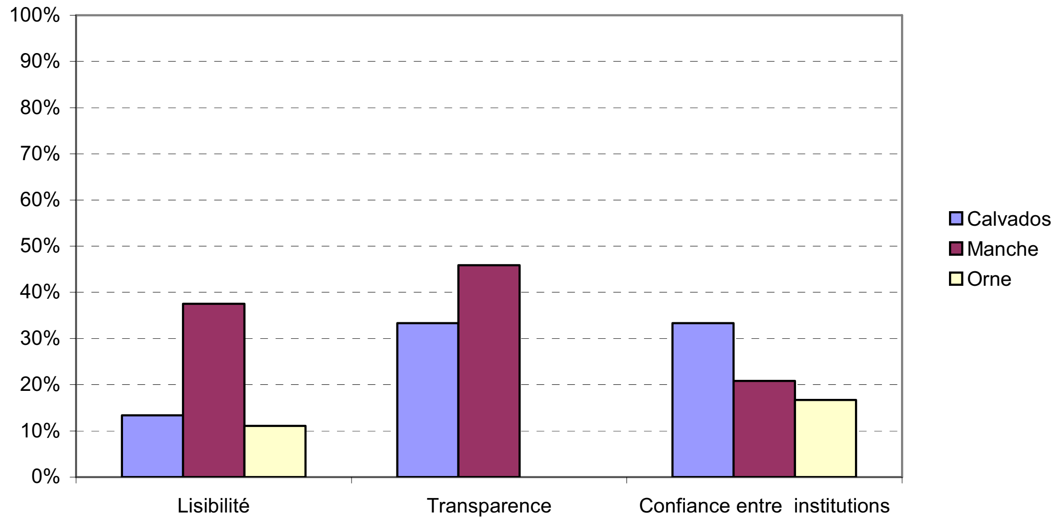


Figure 6: Perception de l 'environnement institutionnel par les institutions

Un premier constat d'ordre général peut être fait : la lisibilité de la politique, la transparence de la procédure et le niveau de confiance entre institutions sont jugés médiocres dans les trois départements.

➢ *Lisibilité de la politique*

En ce qui concerne la lisibilité de la politique, de nombreux acteurs ont en effet exprimé le sentiment d'une politique précipitée, où le temps de la réflexion a été écourté. Les premiers contrats ont été signés alors même que certains cahiers des charges n'avaient pas fait l'objet d'une validation officielle. Les organismes professionnels agricoles ont ainsi souvent eu le sentiment d'avoir été poussés à faire signer un maximum de contrats alors même que l'ensemble des règles du jeu n'avaient pas été définies.

Ainsi, mis à part dans la Manche, où le taux de réponses positives est légèrement supérieur, les acteurs du Calvados et de l'Orne considèrent que ni la finalité des MAE (effets environnementaux), ni ce qui est demandé aux agriculteurs pour atteindre cette finalité ne sont clairs.

Cette différence de perception peut s'expliquer par un démarrage plus rapide de la politique dans le département de la Manche où l'avancée des réflexions en a fait en quelque sorte une référence lors de la rédaction de la synthèse régionale en Basse-Normandie. L'harmonisation régionale a ainsi été perçue comme une extension des mesures proposées dans la Manche aux deux autres départements[7]. De ce fait, les mesures étaient plus adaptées au contexte manchois ce qui a pu permettre une meilleure lisibilité globale de la politique dans ce département, avec des mesures mieux adaptées impliquant des cahiers des charges et des effets attendus plus clairs.

Ceci est néanmoins à nuancer puisque dans la Manche comme dans le Calvados et l'Orne, plus de la moitié des agriculteurs ayant souscrit un contrat estiment ne pas toujours bien cerner le dispositif dans lequel ils se sont engagés, tant du point de vue des actions à mettre en œuvre et de la procédure administrative à suivre que des effets environnementaux attendus.

[7] Euréval-C3E, déjà cité

➢ *Transparence de la procédure*

Lourdeurs administratives, retards de paiements, et excès de zèle de l'administration sont décriés. Ce dernier point, pour les personnes interrogées, est largement lié au manque de clarté de la politique et à une mauvaise définition des cahiers des charges, ce à quoi il faut ajouter une absence de souplesse et de flexibilité vis-à-vis des exigences des cahiers des charges.

Ces travers sont flagrants dans le département de l'Orne, où aucun acteur n'est satisfait.

➢ *Confiance entre institutions*

La confiance entre institutions, légèrement plus élevée dans le Calvados et dans la Manche que dans l'Orne, suggère que ce facteur peut justifier en partie un taux de contractualisation plus élevé dans ces deux départements:

- Dans la Manche, une bonne coordination entre les différents participants a eu un effet positif sur le taux de contractualisation ;

- Dans le Calvados, la confiance des autres institutions envers la chambre d'agriculture lui a offert plus de crédibilité et une marge de manœuvre importante pour faire accepter les contrats aux agriculteurs.

Le niveau de confiance entre institutions n'atteint cependant pas un niveau très important dans les deux départements, ce qui relativise ces apports potentiels.

Une explication peut être avancée pour justifier ceci : la rupture politique entre les CTE et les CAD qui a en effet laissé des traces, notamment au sein des ADASEA et des Chambres d'Agriculture quant aux relations qu'ils entretenaient avec l'administration agricole. D'autant plus que cette rupture est intervenue à un moment où, sous la pression de l'administration, les OPA s'investissaient beaucoup pour convaincre les agriculteurs de souscrire des contrats. Au moment où les demandes étaient les plus importantes, en plein « boom » des CTE, la décision de mettre un coup d'arrêt à cette politique a été prise, décrédibilisant fortement les OPA aux yeux des agriculteurs. Cet épisode a été très mal vécu, notamment par les Chambres d'agriculture, et ce dans les trois départements.

De plus, l'ampleur plus importante du climat de méfiance entre institutions dans l'Orne est probablement liée au fait que, devant la force de la résistance aux MAE d'une partie de la profession, les pressions de l'administration ont été plus importantes sur ces organismes.

5.4 Synthèse : effets des facteurs identifiés sur l'efficacité des MAE

L'importance de la concertation et des moyens déployés dans le succès de la relation contractuelle ne fait aucun doute.

- La concertation tient en effet une part importante dans l'explication des meilleures adéquation et réalisations rencontrées dans le département de la Manche, liées à la participation d'acteurs non agricoles (les collectivités locales, essentiellement). Elle permet également d'expliquer son taux de contractualisation globalement satisfaisant, plutôt lié à une forte implication d'acteurs économiques (coopératives).

- Les moyens déployés et leur répartition entre les différentes catégories d'acteurs institutionnels expliquent essentiellement les différences de taux de contractualisation et de réalisation, et, dans une moindre mesure, d'adéquation :

- ✓ Les moyens importants concentrés entre les mains des acteurs agricoles traditionnels ont permis au département du Calvados d'atteindre un taux de contractualisation plus important que dans les deux autres départements ;
- ✓ Les moyens importants répartis entre différentes catégories d'acteurs institutionnels (collectivités locales, acteurs économiques) ont entraîné une plus grande efficacité des mesures mises en œuvre. Ils ont également permis une meilleure prise en compte des attentes sociétales.

Cependant la comparaison des trois départements ne permet pas, dans l'absolu, de juger des effets de l'environnement institutionnel sur le succès de la relation contractuelle. Il semblerait en effet, qu'en Basse-Normandie, ce facteur ait assez peu joué et ne permette pas d'expliquer de façon convaincante les différences entre départements.

6 Conclusion

Ce travail souligne que l'efficacité des Programmes Agro-Environnementaux peut être améliorée par l'exercice d'une large concertation avec l'ensemble des acteurs locaux lors du processus d'élaboration des mesures. Cela va dans le sens de la nouvelle programmation[8] qui appelle les collectivités locales, et plus spécialement les Régions, à prendre part au financement des futures MAE.

Or, les collectivités locales ne bénéficient pas des mêmes moyens financiers que l'Etat et n'ont, en outre, bien souvent, pas les compétences nécessaires pour s'impliquer dans l'agro-environnement. Ainsi, il est clair que la politique prévue en matière de MAE pour la période 2007-2013 sera moins ambitieuse que la précédente, c'est à dire celle des CTE/CAD.

Dans ces conditions, il convient de s'interroger sur la pertinence de l'outil MAE pour traiter des externalités négatives et notamment de la question de la pollution de l'eau. Pour obtenir des résultats significatifs et mesurables sur la qualité de l'eau, il faut mener des opérations particulièrement coûteuses. En effet, les mesures les plus efficaces supposent en général des changements d'occupation du sol dans des zones bien ciblées, donc des modifications profondes des systèmes de production, ce qui implique des coûts d'administration élevés. Les MAE, reposant sur le principe de participation volontaire des agriculteurs, ne peuvent que difficilement répondre à un tel enjeu. D'ailleurs, l'intégration des principes de lutte raisonnée et de couverture des sols nus en hiver dans la réglementation va dans ce sens (Eco-conditionnalité, Loi sur l'Eau).

De plus, utiliser les MAE pour réduire la pollution de l'eau revient à subventionner la dépollution, ce qui va à l'encontre du principe « pollueur-payeur » ainsi que l'ont souligné de nombreuses personnes interrogées.

Par contre, rémunérer les agriculteurs pour qu'ils assurent la production d'aménités positives, que sont principalement l'entretien des paysages et la préservation de la biodiversité, doit devenir l'objectif prioritaire des MAE. En effet, il existe aujourd'hui une demande forte de la société pour la production de ces biens environnementaux. Or, ces biens ne pouvant être rémunérés par le marché, les agriculteurs n'ont pas intérêt à les produire.

[8] Règlement CE n° 1698/2005 du Conseil du 20 septembre 2005 concernant le soutien au développement rural par le FEADER.

C’est avant tout pour remédier à cette situation sous-optimale qu’ont été créées les MAE et c’est sur cette base que les nouveaux dispositifs à mettre en œuvre doivent être élaborés.

7 Bibliographie

ADASEA, *Contrats d'Agriculture Durable, Observatoire régional*, Normandie 2005

ADASEA de Normandie, *Observatoire des Contrats Territoriaux d'Exploitation*, Normandie n°1

AGRESTE, *Memento régional Basse-Normandie*, Agreste Basse-Normandie, 2004

Eureval C3E, Centre Européen d'expertise en Evaluation, 2003- Evaluation à mi-parcours portant sur l'application en France du règlement C.E n° 1257-1999 du Conseil, concernant le soutien au développement rural, partie sur le soutien à l'agro-environnement (Chapitre VI du RDR) et le Contrat Territorial d'Exploitation) ; lot Basse-Normandie n°8b, Rapport final CTE, 64 p + annexes.

Lepage D., 2006. Influence des structures de gouvernance sur l'efficacité des Mesures Agro-Environnementales: Le cas de la Basse-Normandie. Mémoire de fin d'Etudes Master2 Ingénierie Economique_Mention Politiques Rurales. Soutenu à l'INRA-ESR de Rennes le 20 septembre 2006.

Annexe 1 : Présentation des mesures agro-environnementales.

0202A « Introduction de cultures supplémentaires non légumière dans l'assolement légumier »

- Sur terre franche : 30 % au moins de l'assolement consacré à une culture autre que légumière : céréales, prairie temporaire etc.)
  - Rotation triennale : 90 % au moins de la sole légumière porte une culture non légumière en 3 ans.

- Sur sable : 20 % au moins de l'assolement consacré à une culture non productive (non légumière ou améliorante)
  - Rotation quinquennale : chaque parcelle reçoit au moins une culture non productive durant le contrat.

0301A « Implantation d'une culture intermédiaire sur sol laissé nu l'hiver »

- Couverture au minimum de 2 ha et au moins 5% de la SAU
- Mesure tournante
- Espèces autorisées : graminées (ray-grass, seigle…), crucifères (moutraden colza…),légumineuses et hydrophyllacées (Phacélie) utilisées seules ou en mélange
- Prescriptions techniques :
  - ✓ Semis dans les 15 jours suivant la récolte
  - ✓ Pas d'emploi de phytosanitaires (sauf destruiction du Ray-Grass)
- Fertilisation organique possible si semis du couvert antérieur au 1er octobre (limité à 25t de fumier ou 30m3 de lisier)

0602A « Entretien des haies »

- Taille en hauteur et en épaisseur 3 fois en 5 ans avec du matériel n'éclatant pas les branches.
- Enlèvement des branches et des arbres morts, remplacement des manquants.
- Nettoyage au pied de la haie.
- Pas d'intervention pendant les périodes de nidification

0801A « Lutte raisonnée »

- Raisonner la nature des produits utilisés sur la base d'un diagnostic parcellaire
- Traitements phytosanitaires localisés
- Contrôle et réglage des pulvérisateurs tous les 3 ans par un organisme agréé et tenue d'un cahier d'enregistrement parcellaire
- Pas d'utilisation d produits phytosanitaires pendant les périodes de risque de transfert
- Surveillance attentive des parcelles
- Utilisation de variétés moins sensibles aux maladies
- Zone non traitée en bordure de cours d'eau

0901A « Réduction de 20% des apports azotés par rapport aux références locales »

Mesure obligatoirement cumulée avec la 0903A (« adapter la fertilisation en fonction des résultats d'analyse »)

- Toutes les surfaces de l'exploitation sensible aux apports de nitrates (zones de captages, bords de cours d'eau etc.) doivent être contractualisées
- Surfaces non contractualisées soumises au respect d'un plafond de fumure azotée fixé par un plan de fumure d'un organisme agréé par la commission de suivi des CTE
- Réduction de 20% calculée pour chaque culture par rapport à la référence individuelle (méthode normalisée du bilan azoté : analyse de sols et de reliquats)
- Tenue d'un carnet parcellaire pour enregistrer les pratiques sur toutes les parcelles de l'exploitation

0903A « Adapter la fertilisation en fonction des résultats d'analyse »

Engagement de l'ensemble de l'exploitation.

- Définition de rendements objectifs par parcelle, selon les références disponibles (historique, budget fourrager, cubage de silo, potentiel local des sols…
- Plan de fumure détaillé pour établir les besoins en NPK à partir de la méthode normalisée des bilans
- Analyse des terres sur toutes les parcelles ou groups de parcelles homogènes avec au minimum une analyse sur 3 ha sur les 5 ans
- Analyse du reliquat d'azote en sortie d'hiver pour les cultures d'hiver avec au minimum une analyse pour 20 ha chaque année
- Enregistrement des apports d'éléments fertilisants

Un cumul de cette mesure avec la 0901A entraîne une diminution des aides de la 0901A de 11,13€.

1601A « utilisation tardive de la parcelle »

Concerne les parcelles en prairie naturelle dont la localisation dépend des espèces à protéger.

- Pas de modification de l'état initial des parcelles
- Fertilisation minérale ou organique interdite
- Traitements phytosanitaires interdits sauf utilisation localisée d'herbicides (chardons, renoncules et rumex) selon accord de la DDAF
- Travaux mécaniques interdits. Rejets ligneux éliminés manuellement
- Trois dates possibles d'utilisation de la parcelle en Basse-Normandie en fonction des options : 30 juin, 14 juillet ou 25 juillet. Pas d'utilisation de la parcelle avant ces dates.
- Parcelles fauchées ou pâturées (chargement compris entre 0,6 et 1,4 UGB/ha). Les refus de pâturage doivent obligatoirement être fauchés.

2001 « Gestion extensive des prairies par la fauche »

3 options :

- 2001A
    - ✓ chargement limité (1,8 UGB/ha en cas de pâturage)
    - ✓ chargement moyen annuel sur les prairies non contractualisées de l'exploitation limité à 2,2 UGB/ha)
    - ✓ cahier de pâturage et de fauche tenu sur l'ensemble de l'exploitation
- 2001B: suppression de la fertilisation organique :
    - ✓ suppression de la fertilisation organique
    - ✓ fertilisation minérale limitée à 60-60-60 (NPK)
- 2001C : limitation de la fertilisation minérale à 30-20-20