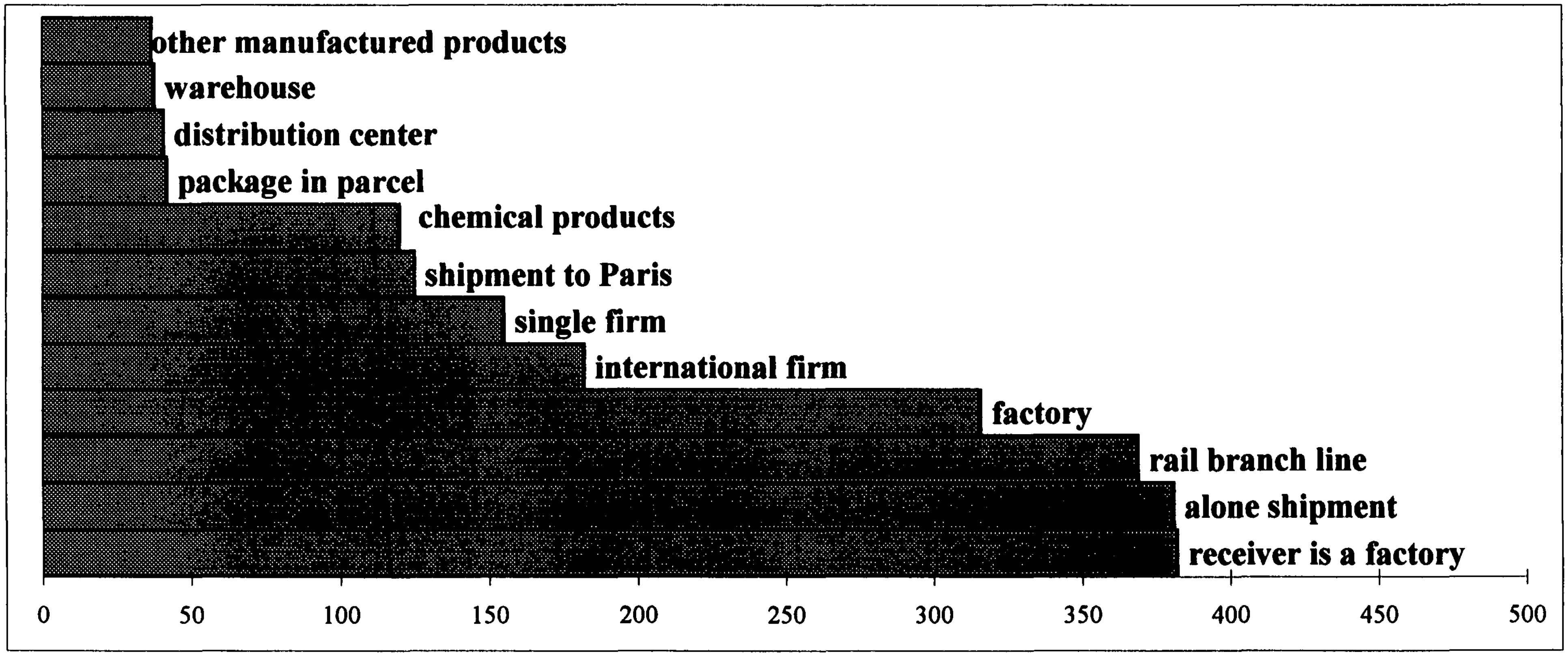
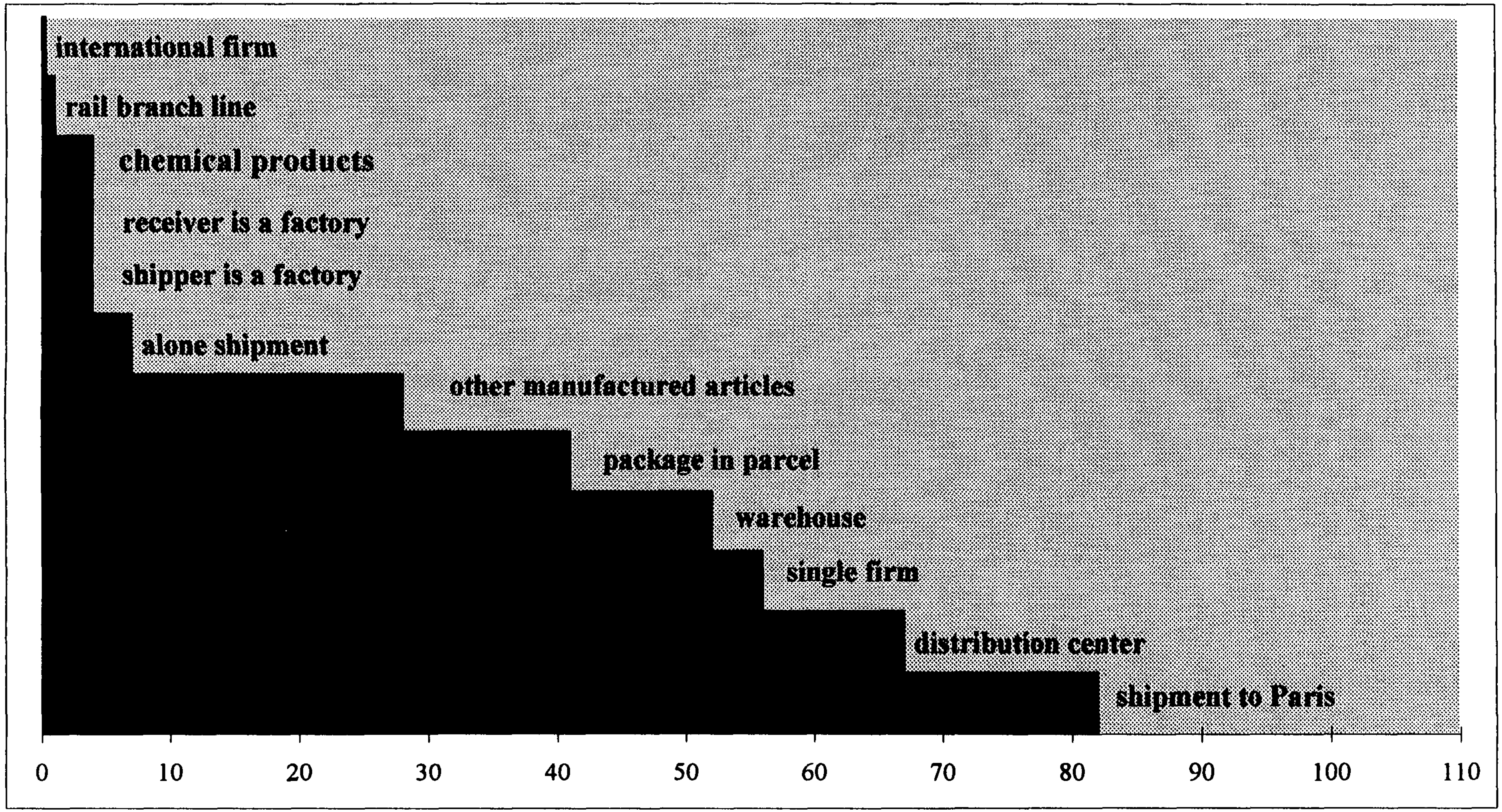
Effects of the logisticals characteristics on the VOT

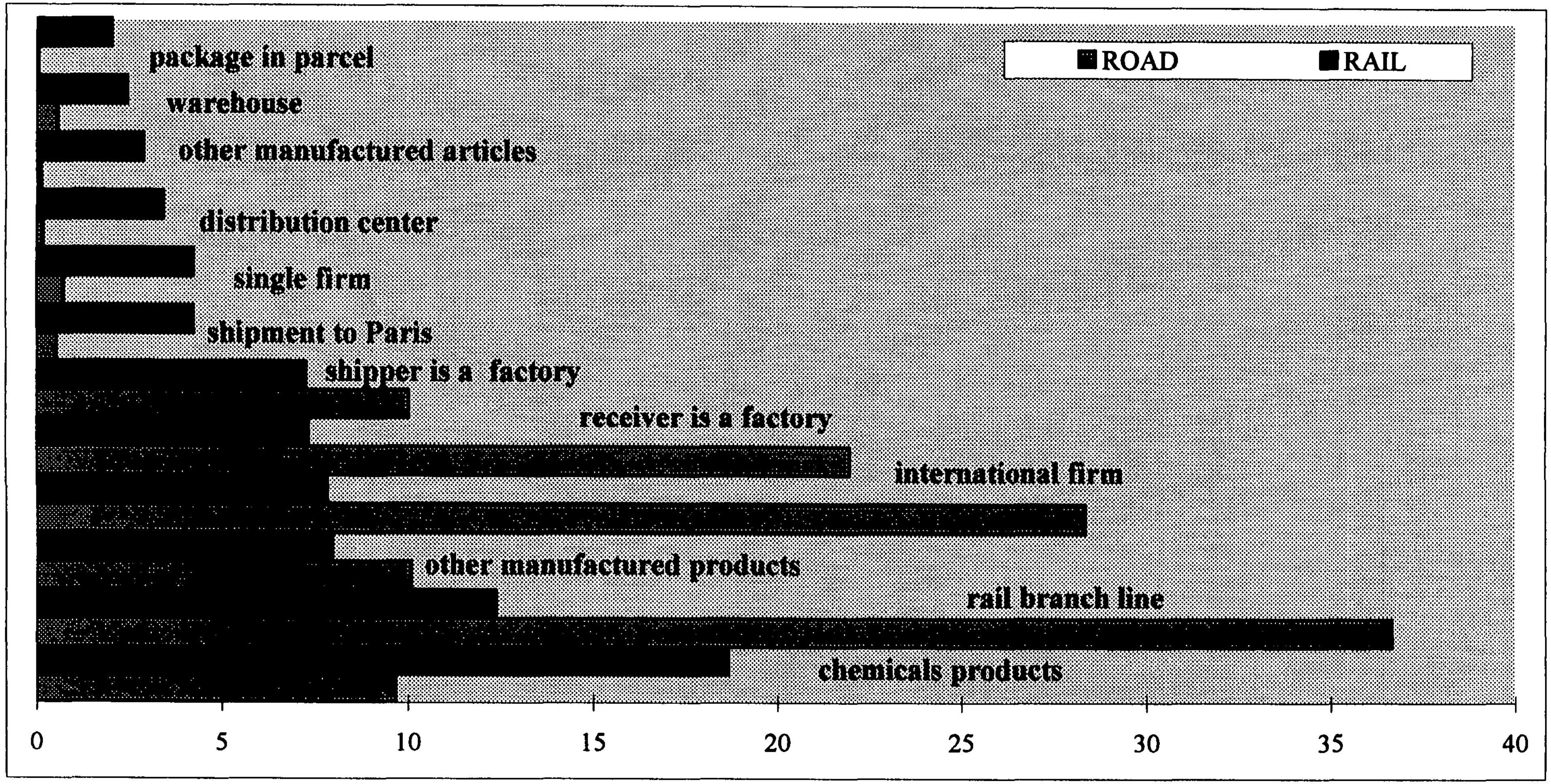
VOT by road per hour per shipment



VOT by rail per hour per ton



Average shipment's size



VALUE OF TIME

COMPARISON OF THE RESULTS

VOT in goods transport per shipment per hour by road (FF)

Country	authors	Year	VOT	Data used
Sweden	Widlert & Bradley	1992	**40**	SP
Norway	Fridstrom, Madslien	1994	**30**	SP
Denmark	Fosgerau	1996	**180-410**	SP
Netherlands	De Jong, Gommers, Klooster	1992	**250**	SP
Netherlands	De Jong, van de Vyvere, Inwood	1995	**230-250**	SP
Germany	De Jong, van de Vyvere, Inwood	1995	**190**	SP
UK	De Jong, van de Vyvere, Inwood	1995	**210-270**	SP
France	**De Jong, van de Vyvere, Inwood**	**1995**	**200**	**SP**
France	**'Official value'**	**1994**	**195**	**-**
France	**Wynter**	**1994**	**420-840**	**TP**
France	**Jiang, Calzada**	**1988**	**158-172**	**RP**

VOT in goods transport per hour per ton by rail (FF)

Country	authors	Year	VOT	Data used
Sweden	Widlert and Bradley	1992	**0,2**	SP
UK	Fowkes, Nash, Tweddle	1991	**0,5-7,5**	SP
USA	Vieira	1992	**4**	RP+SP
Netherlands	De Jong, Gommers, Klooster	1992	**5**	SP
France	**Jiang, Calzada**	**1988**	**10-11**	**RP**

Les élasticités de la probabilité de choix sur le prix et le temps

probabilité de choix	prix de transport			temps de transport		
	route	combiné	fer	route	combiné	fer
route	-0,0116	0,0162	**0,0291**	-0,0300	0,0349	**0,0725**
combiné	0,3527	[redacted]	0,0291	0,9135	[redacted]	0,0725
fer	0,3527	0,0162	**-1,2851**	0,9135	0,0349	**-3,2045**

REMARQUES

1. les effets du temps et du prix ferroviaires sur les probabilités de choix sont plus forts que ceux du temps et du prix routier

par exemple

élasticité directe

l'élasticité de la probabilité de choix ferroviaire au temps ferroviaire est de -3,2045

élasticité croisée

l'élasticité de la probabilité du choix ferroviaire au temps routier est de 0,9135

2. les élasticités de la probabilité de choix sur le temps de transport sont beaucoup plus fortes que celles sur le prix de transport

3. en ce qui concerne le transport combiné, c'est le temps et le prix de lui-même qui ont les influences les plus importantes sur la probabilité de choix

CONCLUSION

1. Le système logistique influence le choix modal marchandise, les facteurs les plus importants sont:

nature du chargeur (entrepôt, usine, magasin)
équipement ferroviaire et localisation de la destination
petit camion en propre du chargeur
envoi en lot
système d'information des entreprises
caractéristiques des envois (distance, fréquence et taille)

2. Pour modifier le partage modal marchandise, le temps de transport ferroviaire est un facteur très important.

3. Comme un facteur important pour l'évaluation des services et infrastructures, la valeur du temps dépend aussi du système logistique, ceux qui ont l'exigence la plus forte pour le temps sont :

établissements uniques
usines
envois vers Paris
envois en colis
autres produits manufacturés

SHIPPER'S DEMAND CHARACTERISTICS AND THEIR VALUE OF TIME: AN ANALYSIS ON THE FREIGHT MODE CHOICE

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Abstract--Nowadays, there are many studies that consecrated to the modeling of freight transport mode choice using the disaggregate discrete model, but few of them relate directly the mode choice to the demand characteristics because of the very demanding data-collection efforts. By mean of a large scale national disaggregate RP investigation to shippers in France in 1988 that covered 51 quantitative and qualitative characteristics, this paper try to understand the firm's demand factors behind the mode choice and explores an attempt to analyze the influences of these demand factors on the freight mode choice by a nested multinomial logit model. In the other hand, transport supply factors: transport times and costs are considered and the distribution of the value of time according to the different demand factors are analyzed. It is founded that firm's characteristics and shipment's characteristics influence strongly the freight mode choice, and for the different firms and shipments, their value of time are very different.

1. INTRODUCTION

In France, the freight transport is characterized by an ever increasing predominance of road transport as others developed countries, which result the negative external effects on the community and should in the future compel public authorities to undertake actions in order to reduce the importance of such effects. The French Ministry of Transportation, in co-operation with others french organizations of transport research (ENPC[1] and INRETS[2]), intend for the first time to establish a freight analysis system for the transportation planning, in which the firm's mode choice are essential.

The decision making of transport mode choice for companies depend on the characteristics of demand-side and supply-side. Firm's demand characteristics as firm's nature, firm's location, firm's traffic flow management and shipment's characteristics etc., are principally determined by firm's logistical system. A new logistic system in the firm for adapting the process of production and distribution results in many changes which make firms have a new transport demand and maybe choose a new transport mode.

On the side of supply, the transport cost and especially transport time are the principle factors which influence shipper's mode choice. In fact, the competition between companies and their different logistic systems resulted that shipper's value of time in different markets are very different, which influence also the evaluation of transport infrastructures.

So the decision making of mode choice for companies are the trade-off between the generalized costs (transport cost and time) and firm's logistical costs. Unfortunately, because of the insufficiency of the database, how the demand characteristics influence this decision process stay in not very clear. For example, in France there is only one single value of time (VOT) for freight transport which does not take into account the intrinsic value of the commodities being transported and the characteristics of transport demand.

This paper aim to analyze how the firm's demand characteristics as firm's and shipment's characteristics relate to and influence the mode choice and shipper's value of time. The contents of the paper are as follows:

1. ENPC: Nationale College of Bridge and Road
2. INRETS: National Research Institute for Transport and their Safety

First, we present the data base and the demand variables, in the same time the transport costs and times for the evaluation of VOT are estimated. Secondly, we examine the marginal effects of the demand characteristics on the freight mode choice by a nested multinomial logit model. The first level model treat with the choice between road, rail and combined transport, the second level treat with the choice between the road transport with single link and with multiple link. In each case, when and how the demand factors prefer which transport mode are fined out. Thirdly, we estimate and compare the marginal effects of transport cost and time on the mode choice. Finally, we analyze the distribution of the VOT according to the changes of demand characteristics.

2. DATA BASE

2.1 shipper's survey in 1988

Insofar as the national revealed disaggregated data is concerned, there is presently only one source in France: the Shippers' Survey carried out by the INRETS in 1988. This survey was in keeping with the priority themes of the transport and freight research and development program, the objective of which was to provide a quantitative evaluation of the observable changes in the behavior patterns and practices of shippers. Shipper's survey covered 51 quantitative and qualitative characteristic variables concerning the transport service, the goods to be transported, the market and the shipper.

The scope of the survey includes several transport modes : rail, road, inland waterways, air, maritime, pipelines and combined transports. This paper is based only on transport on hire, and relates only to the following three principal transport modes :

- rail transport, which is broken down into transports of which the departure or arrival point is by rail branch line, those which include rail + road, and successions of road and rail segments with passage through stations.
- road transport, with a distinction between single and multiple link.
- combined rail/road transports which include passage through a CNC or Novatrans (two combined transport companies in France) loading yard.

The data base includes 2,052 observations, which break down as follows: 1,866 observations related to road transport, of which 961 for single link transports and 905 for multiple link, 123 observations for rail transport, and 63 observations for combined transport. The whole of the demand characteristic variables for mode choice are presented as follows:

the long term factors:

1. firm's nature as factory, warehouse and distribution center
2. firm's size represented by the number of salaried employees
3. firm's location represented by the accessibility to rail branch line and highway
4. firm's information system
5. firm's structure as single firm, french firm and international firm

the short term factors:

1. shipment's characteristics as size, value and packaging
2. flows management characteristics as frequency, speed and shipment's grouping method
3. shipment's geography distribution characteristics as distance, shipment's origin and destination
4. firm's own truck

2.2 Estimation of the Transport Time and Cost for Each Mode

In order to analyze the VOT and the effects of transport times and costs on the modal choice, we must have time and cost data for each mode at one's disposal. Unfortunately, in the Shippers' Survey, the only time and cost data included relate exclusively to the mode chosen in each O-D. As a result, a Tobit model (Heckman method) was used to simulate the times and costs of the alternative which was not chosen. The equation for time and cost estimation is given by:

$$P = C' * X + \theta * \lambda + \varepsilon \qquad (1)$$

where

$$\hat{\lambda} = \frac{\varphi(\hat{B}'Z)}{\Phi(\hat{B}'Z)} \qquad (2)$$

In equations (1) and (2) the variables and parameters are defined as:

P	is the time or cost variables to be estimated
X	is the demand characteristic variables matrix to explain P
C	is the parameter matrix
λ	is the inverse Mills ratio by a probit model and is introduced as a explanatory variable
$\Phi(.)$	is a normal distribution function
$\varphi(.)$	is normal density function
Z	is the exogène demand variable matrix for probit model
B	is the parameter vector

The results of these estimations are presented in Appendix A, where the dependent variable is a logarithm of the transport rate per kilogram and per kilometer.

In order to eliminate the 'abnormal values' of rail times, we have used the criterion of commercial transport speed, which is considered to be a ratio of the distance over the time and we retained 'normal commercial speeds' between 8 and 30 km/h. For rail transport, we find that the factors which have the most significant influence on the transport time are the distance involved and the nature of the commodities, while for road transport, it is more a question of distance and weight of commodities.

3. MARGINAL EFFECTS OF DEMAND CHARACTERISTICS ON MODE CHOICE

The characteristics of the transport demand are known as individual-specific, which means that the values for these variables are the same for all alternatives. Two types of variables have been used : continuous variables such as distance, shipment's size, shipment's value, etc., and dummy variables including firm's nature, packaging, destination, and so on. A nested multinomial logit model is used to estimate the effects of the characteristics of the transport demand on the mode choice for commodities.

First of all, with a MNL model we analyze the choice between three transport modes including : road, rail and combined transport. Afterwards, a second step includes a decomposition of the road transport between choices for single link and multiple link with a binary logit model.

3.1 interpretation of the models

An interpretation of the model's estimated parameters will be based on two points :

1. the marginal effects of each explanatory variable on the utility of each alternative, this is a ratio between the probabilities of choosing the alternative before or after having changed a unit of the explanatory variable in question.

$$exp(U) = prob(Y=1)/(1-prob(Y=1)) \quad (3)$$

where U is the utility function.

2. with a group of given average values for the explanatory variables, the marginal effects of an explanatory variable on the probability of the choice, for a dummy variable, this is marginal effect on the probability of an event:

$$\frac{\partial \operatorname{Prob}(y=j)}{\partial x_k} = P_j\left(\beta_{jk} - \sum_{j=1}^{J-1} P_j \beta_{jk}\right) \quad (4)$$

where P_j is short for Prob(y=j) which is the choice probability for alternative $j \in J$; β_{jk} is the parameter for demand characteristic variable X_k.

for continuous variables, the marginal effect can be represented by elasticity:

$$E_{x_k}^{P_j} = \frac{\partial P_j}{\partial x_k} * \frac{x_k}{P_j} = \left[1 - \sum_{j=1}^{J-1} P_j\right] x_k \beta_k \quad (5)$$

3.2 "First level" Multinomial Logit Model

The interpretation of the MNL model and the marginal effects of the explanatory variables are presented in the Appendix B, in which the first column represents the marginal effect on the utility function, and the second column indicates the marginal effect of the change of a unit of the explanatory variable in question on the probabilities of the choice, with constant average values for the other explanatory variables.

We have introduced four *continuous variables* : the transport distance, the shipment's size (weight of the commodities), the firm's size (number of employees) and the shipment's frequency (annual number of shipments), the value of the commodities does not appear to be significant. In the other hand, we used five groups of explanatory *dummy variables*: firm's nature, firm's location (accessibility to the infrastructure), packaging, shipment's geography distribution, and shipper's own truck.

In general, increasing the values for the three following continuous variables: distance, firm's size and annual number of shipments tends to favor recourse to combined transport and rail mode. The only exception relates to the weight of the shipments, in this case, the probability of choosing combined transport diminishes in direct proportion to the increase of the weight of the shipment, while the probability of choosing rail transport increases inversely. As for the road transport, if shipments weighing less than for exemple 40 t, the probability of choosing road transport increases with the weight of the shipment, and then decreases after that point (> 40 t).

Another interesting phenomenon relates to combined transport: this mode has the greatest elasticity with regard to distance. If the transport distance exceeds 1000 km, combined transport becomes a significant competitor for road transport.

With regard to the influences of the demand dummy characteristics on the mode choice, between rail and road, the following factors favor the choice of road transport : the existence of receiver's information network, packaging in tanker-trucks, multiple packaging or on palettes, shipments as part of a circuit or in one lot, shipper's direct access to highway, shipments to foreign country.

The other factors favor rail transport : shipper being a warehouse, shipper's and receiver's direct access to rail branch line, shipments from Paris, shipper's own small trucks or wagons.

As for the choice between combined transport and rail transport, the existence of the receiver's information network, packaging in tanker-trucks or on palettes, shipments as part of a circuit and shipment to Paris favor combined transport. Finally, between road and combined transports, the fact of being a warehouse, packaging on palettes, shipments to Paris and shipper's own wagons orient the choices towards combined transport.

The Table 1 present all demand characteristics in order which favor a transport mode each time. We can see that for shipment to Paris the choice is between rail and combined transport, and for shipment in a circuit, the choice is between road and combined transport, and so on.

Table 1. The demand factors in order favoring the transport modes

rail	road	combined
shipper is a warehouse	shipment in lot	shipment to Paris
recerver's rail branch line	package in barrels-tanks	shipper is a distribution centre
shipper's own truck(3-6.6ton)	multiple package	shipper's rail branch line
shipper is a distribution centre	receiver's information network	package in pallets
shipper's own truck (<3 ton)	package in pallets	receiver's rail branch line
shipment from Paris	shipment in a circuit	shipper's own truck(3-6.6ton)
shipment to Paris	shipment to foreign country	shipment in a circuit
shipper's rail branch line	shipper's direct access to highway	

3.3 "Second level" Binary Logit Model

The second level binary logit model for the choice between single link and multiple link transports is presented in the Appendix C. In the third and fourth columns are listed the final marginal probability effects of the demand variables and final elasticities of the choice probability for single and multiple link road transport comparing with other two modes of transport : rail and combined transport.

On the second level, only four continuous variables are significant in the modeling of the mode or chain choice between a single link and multiple link road transport. The firm's size does not influence the choice between these two modes or chains, whereas the shipment's value does play a role, although it does not influence the mode choice on the first level.

For the choice between a single link and multiple link transport, it is safe to say that very large shipments or those with a high value prefer single link transports, whereas long distance and high frequency transports prefer multiple link road transports.

In the other hand, fifteen dummy variables appear significant in the modeling: shippers being warehouses, shipments in a lot, shipments from Paris and shippers having their own small trucks opt for multiple link road transports. The opposite is the case for shipments in containers, on palettes and in bulk, shipments as part of a circuit, shipments to foreign country and to Paris, and shipper's with direct access to the highways, in which cases single link road transports are preferred. Moreover, we can find that shippers and receivers who have direct access to rail infrastructures but who have not chosen rail transports prefer single link road transports.

4. MARGINAL EFFECT OF TIME AND COST

The transport supply characteristics variables include the transport time and cost which are said to be alternative-specific, because for different alternatives, the values of these variables change. So a conditional logit model for the estimation of the VOT is used.

According to the binary conditional model, the marginal effects of time and cost on the choice probability are presented in the table 2. In the last column, we note that if the rail transport time is increased by 1%, this increases by 0.03% the probability of choosing road transport, while decreasing by 1.14% the probability of choosing rail transport, and the rail transport time appears to have a stronger effect on the choice probability than the road time has. This means that if we wish to change the rail vs. road distribution of traffic from shippers, changing the rail transport time will have more impact than changing the road transport time.

Table 2: Marginal effects of transport rates and time by binary model

Variable	Mean	Utility effects		Probability effects		Elasticities	
		Road	Rail	Road	Rail	Road	Rail
Rail time	30,6		0,895		-9,45E-4	0,030	-1,142
Rail rate	1820,3		0,999		-9,81E-6	0,018	-0,704
Road time	25,4	0,964		-5,66E-4		-0,015	0,567
Road rate	1686,7	1,000		-2,92E-6		-0,005	0,194

Rates in francs (1988)

In the other hand, we found, in comparison with costs, the time element of transports has a greater effect on modal share. Furthermore, we observe that the cost of rail transport has a stronger effect on the choice probability than the road cost has, although these effects of cost, whatever the transport mode, are quite low.

The table 3 summarizes the marginal effects of time and costs on the choice probability between three modes. First of all, one can say that the effects of time on the choice probability are stronger overall than are the effects of cost, as was the case for the choice between two modes: rail and road.

Table 3: Marginal effects of transport rates and time by MNL model

Variables	Mean	Utility effects			Probability effects			Elasticities		
		Road	Combined	Rail	Road	Combined	Rail	Road	Combined	Rail
Road rates	1 687	1,000			-7,0E-6	2,0E-6	4,6E-6	-0,012	0,353	0,353
Road times	25	0,964			-1,1E-3	3,5E-4	8,0E-4	-0,030	0,914	0,914
Combined rates	1 820		0,999		8,6E-6	-9,0E-6	2,0E-7	0,016	-1,659	0,016
Combined times	31		0,889		1,1E-3	-1,1E-3	2,5E-5	0,035	-3,579	0,035
Rail rates	1 820			0,999	1,5E-5	1,5E-7	-2,0E-5	0,029	0,029	-1,285
Rail times	31			0,899	2,3E-3	2,3E-5	-2,3E-3	0,073	0,073	-3,205

Rates in francs (1988)

Moreover, if one compares the effects of time on the choice probability, rail time has a significant influence on the choice of rail or road, but little influence on the choice of combined transport. In fact, for combined transports, it is it's own transport time that has the most important impact on it's own choice probability. To sum up, in order to modify the modal distribution between these three modes, changes in the time and cost element of combined transports and rail will be more efficient than changes in road transports time and cost.

5. DISTRIBUTION OF VOT ACCORDING TO DEMAND FACTORS

An analysis of the average VOT leads to three principal observations : first of all, the results are very similar when examining either two modes or three modes; secondly, it is clear that the VOT for road transport is greater than is the case for rail transport; finally, the VOT per hour and per ton for combined transport is much higher than those for rail or road transport (table 4).

Table 4: Means of VOT

Modes	VOT / hour / shipment		VOT / hour / ton	
	2 modes	3 modes	2 modes	3 modes
Rail	143,3	128,3	11,1	9,9
Road	158,2	171,8	23,4	25,4
Combined		148,2		108,4
All modes	142,8	153,6	20,9	22,4

Table 5 present the results of the effects of the demand characteristics on the VOT. First of all, we consider the VOT per hour and per ton. Firstly the packaging of shipments has an influence on VOT. For example, the VOT for shipments in parcels are three times greater than that for those packaged in containers, in other words, if one accepts the shipments to be grouped in container, time requirements are less significant than with parcels. Secondly, the flows management influence the VOT. We can find, the VOT of the shipments in a lot are less pronounced than that of the isolated shipments, which indicates that for the shippers who will not group the shipments, the gains in time will be more significant. Thirdly the destination of the shipments also has an influence on the VOT. The VOT of the shipments to Paris are much greater than those of shipments heading towards foreign country. The latter fall into the domain of long distance transports, where the gain of an hour is of lesser significance.

Table 5: Effects of the logisticals characteristices on the VOT

demande factors	VOT / hour / shipment			VOT / hour / shipment		
	All modes	Road	Rail	All modes	Road	Rail
shipper is a warehouse	47	38	30	24	15	52
shipper is a factory	205	316	44	28	44	4
shipper is a single firm	137	155	42	35	36	56
shipper is a international firm	159	182	10	23	23	0,3
shipper's Rail branch line	120	369	35	9	30	1
receiver is a factory	260	382	78	32	52	4
receiver is a distribution center	56	41	13	19	12	67
alone shipment	227	381	67	28	48	7
shipment in parcel	105	42	3	57	20	41
shipment to Paris	171	125	45	44	29	82
basic chemicals products	110	120	42	6	6	4
other manufactured articles	118	37	4	45	13	28

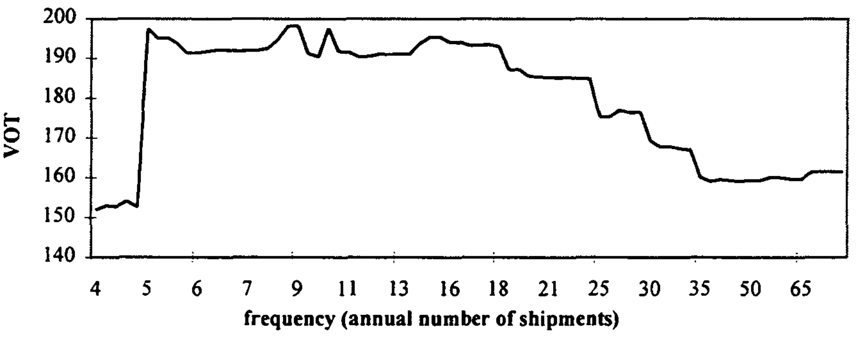
As for those demand characteristics of long term, those shippers who is located near the rail infrastructures and generally undertake heavy shipments (average weight per shipment : 13.6 t) – have the VOT among the very lowest. With regard to the firm's nature, we noticed that VOT for factories are greater than that for warehouses, shop and distribution centers, this is because the transports for factories integrated into the production chain, and their requirements for transport time are greater than that those of warehouses and distribution centers.

We can distinguish the VOT by rail and road transports. We found, for the shipments which are isolated or are sent by a factory or by a worldwide firms, or by a shipper who own rail branch, the shipment sizes are very large. In this case, by the VOT per ton and per hour for rail and road, we can say that if some of these shipments are transported by road, it means that they will have more significant time constraints than those transported by rail. On the other hand, for the shipments which are manufactured goods, or are packaged in parcels, or are destined for Paris, or are sent by a warehouse or by a single firm, or are sent to a receiver being distribution center, the shipment sizes are very small, the shippers who send them by rail accept paying higher costs in order to save time than those who send them by road.

In the other hand, for the VOT per shipment and per hour, we notice that the VOT for rail transport are overall much lower than those for road transport. Those shipments which are a alone shipment, or sent or received by a factory or a single firm, or are sent to Paris, have the most pressing time demand.

Finally, an analysis of the effects of continuous variables (distance, shipment's size, shipment's value, shipment's frequency and firm's size) on VOT implies knowing how the VOT change according to the modification of these variables. The graph 1 shows the changes in VOT according to the annual number of shipments. We see that in general the VOT have an overall tendency to decrease with the shipment's frequency. With regard to the other variables, they generally have positive influences on the VOT. Nevertheless, there are certain differences according to the variable being analyzed. For example, if the distance is beyond a threshold the VOT decrease with distance. As for the shipment's value, it has little influence on the VOT if this value is not very high.

Graph 1. the effect of shipment's frequency on the VOT



6. CONCLUSION

In this study, we introduced for the first time in France the firm's demand characteristics in a disaggregate discrete choice model and concentrated on how these characteristics influence on the freight mode choice and VOT. For the mode choice, we found out the importance hierachie of these factors for each mode and noticed that shipper's nature and location, shipment's destination, rail transport time and combined transport time are the critical factors for the development of rail transport and combined transport.

As for the VOT, although the values obtained are very near to that of others studies (Table 6), our study show that the VOT for different firms are very different, especially, the demande factors as factory, alone shipment, single firm and shipment to Paris have the pressing transport time demand.

VOT in goods transport

Country	authors	Year	Data used	road*	rail**
Denmark	Fosgerau	1996	SP	180-410	
Netherlands	De Jong, Gommers, Klooster	1992	SP	250	5
Netherlands	De Jong, van de Vyvere, Inwood	1995	SP	230-250	
Germany	De Jong, van de Vyvere, Inwood	1995	SP	190	
UK	De Jong, van de Vyvere, Inwood	1995	SP	210-270	
UK	Fowkes, Nash, Tweddle	1991	SP		0,5-7,5
USA	Vieira	1992	RP+SP		4
France	De Jong, van de Vyvere, Inwood	1995	SP	200	
France	Official value	1994		195	
France	Wynter	1994	TP	420-840	
France	Jiang, Calzada	1988	RP	158-172	10-11

** VOT per hour per shipment ** VOT per hour per ton*

Finally, we think, the study results seem to be useful for traffic prediction and transport planning. They point to the need for careful analysis of the changes of the firm's logistical system in predicting traffic mode share and evaluating transport infrastructures. So we suggest that a new shipper's survey considering more logistical system and transport supply factors and incorporating the stated preference data should be made in France, then further studies about the effects of the changes of firm's logistical system on the firm's transport demand characteristics should be taken.

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Appendix A: Estimations of transport rate and cost

Explanatory variables	Rail rates	Rail times	Road rates	Road times
constant	3,232 ***	0,232	1,837 ***	-2,170 ***
log (distance)	-0,911 ***	0,663 ***	-0,747 ***	0,928 ***
log (weight)	-0,500 ***		-0,546 ***	-0,019 ***
log (annual number of shipments)	-0,034 ***		-0,013 ***	
log (value of the shipment)			0,010 ***	
shipper is a warehouse			-0,152 **	
shipper's own trucks(< 3 live load tons)	-0,181 **			
receiver is a distribution center			-0,166 ***	
receiver is a factory		-0,126 **		
shipment including in a lot			-0,155 ***	-0,132 **
containerised packaging	0,419 **	0,228 ***		
bulk packaging				-0,093 *
multiple packaging	-0,413 **			
shipment to foreign countries	0,530 ***		0,128 **	0,098 *
shipment from Paris	0,288 ***	-0,153 **		
ferrous metals products		-0,574 **		
construction materials		-0,758 **		
other basic chemicals products		-0,491 ***		0,109 **
other manufactured articles		-0,204 **		
food				0,101 **
transport and agricultural equipment	0,371 **		0,141 **	
machinery	0,218 ***		0,142 ***	
ratio de Mills	-0,147	-0,393	1,213 ***	-0,171
R-squared	0,950	0,865	0,906	0,837
Number of observations	137	79	1465	814

*: significance at the 10% level, **: significance at the 5% level, ***: significance at the 1% level

Appendix B: Marginal effects of the demand characteristics on the choice probaility (MNL model)

Explanatory Variables	*Utility effects*			*Elasticities*		
	road vs rail	combined vs rail	road vs combined	road	combined	rail
distance	0,998	1,003	0,995	-0,028	1,816	0,594
weight	1,000	1,000	1,000	0,003	-0,506	0,016
shipper's number of employees	0,999		0,999	-0,006	0,174	0,174
annual number of shipments	1,000			-0,002	0,050	0,050
				Probabiilty effects		
shipper is a warehouse	0,267	0,270		-6,1E-2	-3,2E-4	6,1E-2
shipper is a distribution center	0,440		0,410	-3,6E-2	6,7E-3	2,9E-2
receiver's rail branch line	0,275	0,350		-5,3E-2	1,2E-3	5,2E-2
receiver's information system	6,050	5,207		2,5E-2	-7,0E-4	-2,5E-2
shipper's rail branch line	0,536			-2,2E-2	4,1E-3	1,8E-2
shipper's direct access to highway		0,378	2,455	4,8E-3	-4,9E-3	1,3E-4
packaging in barrels-tanks	8,004	2,000		2,6E-2	-1,7E-3	-2,4E-2
multiple packaging	4,263			2,6E-2	-4,8E-3	-2,1E-2
packaging on pallets	2,239	3,190	0,640	1,4E-2	2,4E-3	-1,7E-2
shipment including in a circuit	1,602	1,768		9,1E-3	6,8E-4	-9,8E-3
shipment including in a lot	8,415			4,0E-2	-7,5E-3	-3,3E-2
shipment to foreign country		0,009	104,585	8,4E-3	-8,6E-3	2,3E-4
shipment to Paris	0,667	2,349	0,307	-2,3E-2	1,2E-2	1,1E-2
shipment from Paris	0,455	0,435		-2,6E-2	-4,2E-4	2,7E-2
shipper's own trucks (< 3 tons)	0,417	0,447		-2,9E-2	2,3E-4	2,9E-2
shipper's own truck (3 <tons< 6.6)	0,336	0,415		-4,4E-2	1,0E-3	4,3E-2
shipper's own wagon	0,970		0,968	-9,5E-4	1,8E-4	7,7E-4

Appendix C: Marginal effects of the demand variables (second level model)

Explanatory variables	utility effects	final probability effects*		final elasticity	
		single link	multiple link	single link	multiple link
distance (km)	0,999	-292,9E-6	194,3E-6	-0,162	0,244
weight (kg)	1,000	57,3E-6	-56,8E-6	0,436	-0,979
value of the shipment (francs 1988)	1,000	174,7E-9	-174,7E-9	0,024	-0,054
annual number of shipments	1,000	-2,9E-6	2,7E-6	-0,046	0,097
shipper is a distribution center	0,415	-0,218	0,168		
shipper's own trucks (< 3 tons)	0,453	-0,190	0,149		
shipper's own truck (3 - 6.6 tons)	0,569	-0,149	0,088		
receiver's rail branch line	1,497	0,037	-0,110		
shipper's direct access to highway	1,304	0,057	-0,050		
shipper's rail branch line	1,779	0,094	-0,125		
packaging in container	11,936	0,276	-0,276		
packaging on paletts	1,663	0,109	-0,090		
special packaging	3,269	0,187	-0,187		
bulk	3,992	0,213	-0,213		
shipment including in a circuit	2,039	0,133	-0,121		
shipment including in a lot	0,625	-0,078	0,134		
shipment to foreign country	2,097	0,139	-0,127		
shipment to Paris	1,416	0,050	-0,082		
shipment from Paris	0,576	-0,136	0,100		

* $\partial Pfinal = \partial P1 * P2/1 + P1 * \partial P2/1 + \partial P1 * \partial P2/1$

ESTIMATION D'UNE ELASTICITE DE SUBSTITUTION ET D'UNE FONCTION DE DEMANDE DE TRAVAIL DANS LE TRM

Guillaume DELVAUX et Richard DUHAUTOIS, bureau des synthèses économiques et sociales sur les transports.

En novembre 1994 et janvier 1995, un accord appelé « contrat de progrès », a été signé entre les employeurs et les syndicats du secteur (sauf la CGT). Il stipule, entre autres, une diminution du temps de travail des conducteurs grands routiers (cela concerne surtout la zone longue) avec revalorisation salariale. Ce contrat a été appliqué en théorie à partir du 1er octobre 1995. Au départ, il était censé améliorer les conditions de travail des conducteurs. Par la suite, la conjoncture de l'emploi aidant, la réduction du temps de travail s'est orientée vers un moyen de créer des emplois.

On tentera de répondre à deux questions centrales : comment s'adaptent les entreprises à une augmentation du coût du travail à production donnée ? Comment évolue la demande de travail s'il existe, en même temps, une augmentation de la production (un effet volume) ?

Généralement, une augmentation du coût du travail se traduit par trois effets : un effet positif sur la demande, un effet négatif sur la compétitivité des entreprises et un effet de substitution entre facteurs de production. Ce dernier effet dépend de l'élasticité de substitution. Lorsqu'il y a deux facteurs (le capital et le travail), elle mesure le pourcentage de variation du capital par tête après une modification de 1 % du coût relatif du travail et du capital.

Dans un premier temps, on cherche à estimer cette élasticité de substitution à l'aide d'un panel d'entreprises de zone longue de 1986 à 1995,. Ce qui nous intéresse est donc de savoir comment un transporteur combine ses unités de capital et de travail pour produire une quantité de bien. Il va choisir ses unités de capital et travail de façon à minimiser ses coûts. On se propose d'estimer cette élasticité à partir d'une fonction de production C.E.S (Constant Elasticity of Substitution). Dans un second temps, on cherche à estimer la demande de travail du secteur. Elle dépend, cette fois, de la production, de l'élasticité de substitution calculée auparavant et de la part du coût du travail dans le coût total (ici égal à la somme du coût du travail et du coût du capital).

Pour effectuer ces estimations, on a utilisé l'économétrie des données de panel. Cette technique prend en compte, à la fois, la dimension individuelle et la dimension temporelle. La base de données est issue de l'Enquête Annuelle d'Entreprises (EAE). Au départ, on s'est attaché à trois types d'entreprises : les entreprises de transports de proximité, les entreprises de transports inter-urbains et les entreprises de messagerie et de fret express. L'hétérogénéité des différents types d'entreprises nous a d'abord donnés des résultats qui manquaient de robustesse. On s'est donc concentré sur les entreprises de transports inter-urbains, entreprises concernées par le contrat de progrès. Le panel contient 311 entreprises de ce type.

Les principaux résultats :

- L'élasticité de substitution dans le secteur des transports inter-urbains s'établit à 0.2 : les facteurs sont proches de la complémentarité.
- La demande de travail est fortement liée à la croissance de la production du secteur ; l'accroissement du coût relatif du travail (par rapport au coût du capital) est un facteur beaucoup moins important.

Documents fournis :

- copie des transparents
- note de synthèse à venir courant 1998.

Modèle à erreurs composées :

$$y_{it} = x_{it} b + u_{it} \quad \text{avec} \quad u_{it} = \alpha_i + \beta_t + \varepsilon_{it}$$

Fonction de production CES (Constant Elasticity of Substitution) :

$$f(K_{it}, L_{it}) = \left[(\alpha K_{it})^{\frac{\sigma-1}{\sigma}} + ((1-\alpha) L_{it})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma\theta}{\sigma-1}} \quad \text{avec } 0 < \alpha < 1$$

où K_{it} est le facteur capital,
L_{it} le facteur travail

$$\underset{K,L}{\mathrm{Min}}(rK + wL) \text{ sous contrainte } f(K,L) \geq Q$$

$$\mathrm{Log}\left(\frac{K}{L}\right) = -\sigma\,\mathrm{Log}\left(\frac{r}{w}\right) + (\sigma - 1)\mathrm{Log}\left(\frac{\alpha}{1-\alpha}\right)$$

$$\mathrm{Log}\left(\frac{K}{L}\right) = \underset{(0{,}0243)}{-0{,}2072}\ \mathrm{Log}\left(\frac{r}{w}\right) + \underset{(0{,}0283)}{0{,}2951}$$

La fonction de demande de travail :

$$\mathrm{LogL} = \frac{1}{\theta}\mathrm{LogQ} + \sigma\pi\mathrm{Log}\left(\frac{r}{w}\right) + c^{te}$$

$$\pi = \frac{rK}{rK + wL}$$

$$\mathrm{LogL} = \underset{(0{,}0089)}{0{,}9416}\ \mathrm{LogQ} + \underset{(0{,}0173)}{0{,}1480}\ \mathrm{Log}\left(\frac{r}{w}\right) + \underset{(0{,}0319)}{0{,}9174}$$

LE PROGRAMME DE RECHERCHE EUROPEEN REDEFINE: LES DETERMINANTS LOGISTIQUES DES TRANSPORTS DE MARCHANDISES TOUT PREMIERS RESULTATS

Maurice GIRAULT (SES/DEE)
Frédéric LERAY (SES/DEE)

Les objectifs du programme:

- Analyser les déterminants de la croissance du transport routier de marchandises en relation avec les processus industriels et logistiques: analyse macro- et micro-économiques, pour 14 secteurs dans 5 pays européens F GB D NL S;
- Evolutions technologiques et mesures de politiques de transport susceptibles de maîtriser la croissance du transport routiers et de ses coûts externes, sans porter atteinte aux performances logistiques et à la compétitivité de l'économie;
- Prévoir l'impact de stratégies technologiques et politiques alternatives afin d'éclairer les politiques nationales et européenne des transports.

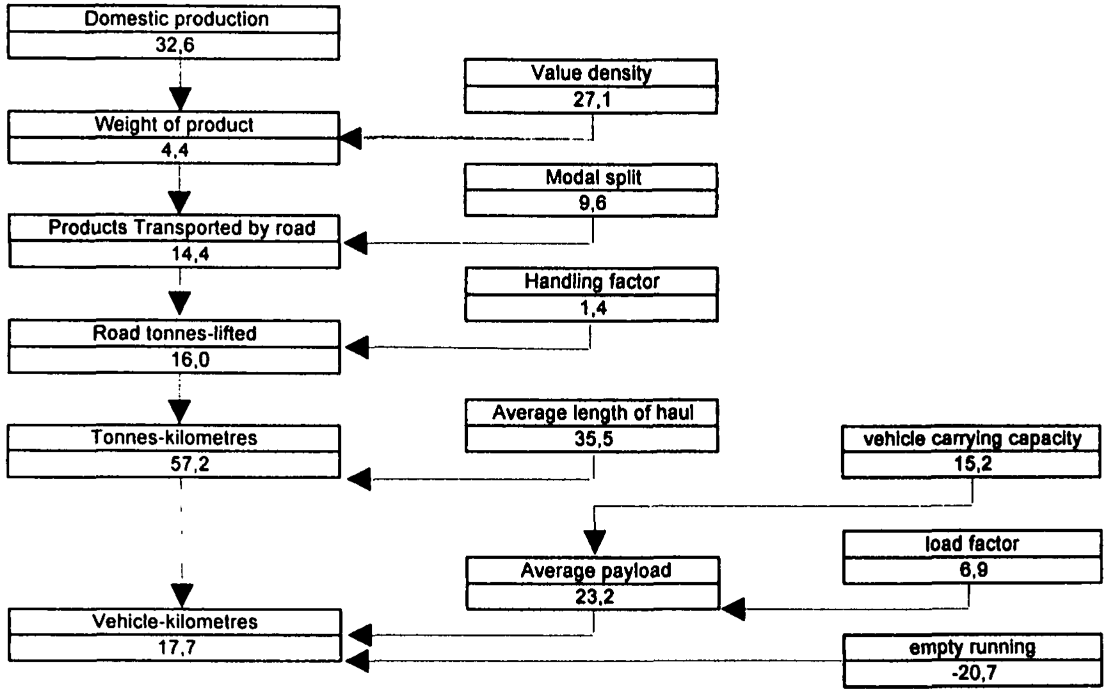
Le cadre du recueil de données pour chaque secteur, pour les années 1980-85-90-95:
- la production en valeur (pour le marché intérieur et l'exportation),
- la densité,
- la production en tonnage,
- la production transportée → le facteur de manutention,
- le partage modal,
- les distances moyennes de transport routier
(y compris à l'étranger, y compris l'activité des camions étrangers),
- les chargements moyens des PL,
- les parcours à vide,
- les trafics.

L'analyse des résultats:
- Les trends logistiques: restructuration des systèmes logistiques, les chaînes d'approvisionnements, organisation de la production, le transport,
- La concentration industrielle,
- Les chargements moyens et le juste à temps.

<u>Documents fournis :</u>

- copie des transparents
- extrait du Draft (version 1) de la tâche 1 du programme Redefine

all sector



IV Change in Production and Transport for all sector between 1985 and 1995

TABREDEF.XLS31/10/1997

The Importance of Key Logistical Trends, 1985 to 1995: Sectoral Break-down.

Key: 1 = high Importance 2 = medium importance 3 = low importance

14 REDEFINE sectors:	Restructuring of logistical systems				Realignment of supply chains						Rescheduling of product flow				Changes in the management of transport resources					
	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	2.5	2.6	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	4.5	4.6
0 Agricultural	1	1						1							2		1			
1 Food & Drink	1	1	2				1	1		3			3	1	3	1	2	2	3	3
2 Wood & Pulp	1	2	1	2	3	3	3	3	3	3	1	1	1	1	2	2	1	1	1	1
3 Textiles & Clothing	3	1	1	3	3	3	2	1	1	3	2	1	2	2	1	2	3	1	1	3
4 Building Materials	2	2	3	3	3	3	2	2	2	3	3	2	3	3	3	3	3	1	2	3
5 Other Crude Minerals	2	2	2	3	3	3	3	3	3	2	2	3	2	2	3	3	3	3	3	3
6 Chemicals	1	1	2	2	3	1	2	1	3	2	1	2	1	2	2	1	2	2	2	3
7 Petrol & oil products	3	1	3	3	3	3	3	3	1	3	3	3	3	3	3	2	1	3	1	2
8 Coal & Coke	2	3	2	3	3	3	3	3	3	2	2	3	3	2	3	3	3	3	3	3
9 Metal & Metal Ores	1	2	3				2	2		1				2	1	3	2	3		
10 Transport Equipment	2	2	3	2	1	1	1	3	3	3	1	3	1	2	2	1	2	2	2	2
11 Machinery	1	1	1	2	1	1	1	1	1	2	1	1	3	1	3	2	2	3	2	3
12 Other Manufactured	1	2	2	3	2	3	3	1	2	3	2	2	3	2	3	3	3	3	3	3
13 Miscellaneous	3	2	1	1	3	3	3	1	3	1	3	1	3	3	2	3	1	1	1	2

Taxonomy of Key Logistical Trends, 1885 to 1995.

1 Restructuring of logistical systems
1.1 Spatial concentration of production; either through
1.1.1 reduction in plant numbers, or
1.1.2 increased plant specialisation ('focused production')
1.2 Spatial concentration of inventory
1.3 Development of break-bulk / transhipment systems
1.4 Centralisation of sorting operation in hub-satellite network

2 Realignment of supply chains
2.1 Vertical disintegration of production
2.2 Increase in single sourcing
2.3 Wider sourcing of supplies
2.4 Wider distribution of finished products
2.5 Increase in retailer's control over supply chain
2.6 Concentration of international trade on hub ports

3 Rescheduling of product flow
3.1 Application of JIT principle in manufacturing
3.2 Adoption of Quick Response and Efficient Consumer Response in retail distribution
3.3 Growth of 'nominated day' deliveries
3.4 Proliferation of booking-in / timed-delivery systems

4 Changes in management of transport resources
4.1 Modal shift
4.2 Increased use of outside transport / distribution contractors
4.3 Changes in vehicle size, weight, type or mix
4.4 Changes in handling systems
4.5 Increased use of Computerised Vehicle Routing and Scheduling
4.6 Increase in return loading

Deliverables D1 & D2

Research framework on macro level

Analysis of collected data and selection of goods flows - sector combinations

Status: Public

REDEFINE
Contract No. RO-97-SC.1091

Project Co-ordinator: Netherlands Economic Institute

Authors: Netherlands Economic Institute
Heriot-Watt University
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Service Economiques et Statistique
Temaplan AB

Version: 1 (draft)

Date: 7 October 1997

PROJECT FUNDED BY THE EUROPEAN COMMISSION UNDER THE TRANSPORT RTD PROGRAMME OF THE 4th FRAMEWORK PROGRAMME

Table of contents

1 Introduction

1.1 Background

All European countries experience a growth in road freight traffic in both national and international transport. However, the relationship between the growth of road freight movement, measured in tonne-kilometres, and general economic growth, measured by gross domestic product has been fairly stable as long as freight transport statistics have been collected. Indeed in some European countries it appears that these trends have begun to diverge.

Domestic and European transport statistics can serve as a guideline for recognizing developments for a broad set of commodity-flows in terms of volume and modal split through the years but can never attribute these developments to the underlying factors. The processes that cause the road freight traffic growth have not been studied yet in an European context. National studies, in for example the United Kingdom, conclude that in the 1950s much of the growth in lorry traffic was attributable to increases in the physical mass of goods produced and consumed and to the transfer of freight from rail to road. In the 1970s, the main cause of freight traffic growth appears to have been the spatial concentration of economic activity. Over the past ten years, the shortening of order lead times and an increase in the amount of subcontracting have begun to make a significant contribution to traffic growth. Also the increased division of labour and consequent increase of intra-EU goods traffic following the implementation of the Common Market need to be mentioned as a cause of freight traffic growth.

Recent Dutch research concludes that around fifty percent of the freight transport growth can be explained by economic growth. Other important factors for growth are spatial and logistic developments, like concentration of production-facilities and (international) expansion to new markets, and changes in the composition of the total transport-flow (a shift from commodities which are usually transported over short distances to commodities which are transported over longer distances). For these reasons, forecasting the growth of lorry traffic based on economic growth only will not be sufficient. Therefore, research at a micro- and a macro level is proposed for this project.

Research on a macro level includes research at the level of national and international transport statistics. In order to formulate effective policy measures which influence road freight traffic, research on the level of the individual firm is also necessary. Research at the level of the firm will hereafter be indicated as the micro-level.

1.2 Project objectives

An important objective of policy making is on the one hand maintaining, even improving, economic performance with the aim to maintain economic competitiveness and thus employment and on the other hand reducing the negative effects transport has on the environment (through pollution and depletion of natural resources) and on the economic performance itself through congestion. Transport policy measures should not only be aimed at the vehicle or infrastructure level (like road pricing or vehicle taxes), but can also be designed to influence the shippers, forwarders and other parties in the logistical chain. To be able to assess the impact of common European transport policy measures, it is important to select the appropriate policy measures and the appropriate target of the measures. For this reason it is necessary to have insight into the decision making processes of individual firms. Decisions on the organisation of transport are taken by individual firms. These decisions are very much related with other business functions like the marketing and sales functions and also with the decision making of suppliers and customers. Growing international competitiveness demands a close co-operation between firms in the logistical chain. Logistic decisions of firms become more and more interrelated. Insight in the way firms react in response to the changes in the logistics environment and possible policy measures is therefore extremely important.

The overall *objectives* of the project REDEFINE will be:

a. To model the factors affecting the increased demand for road freight and the way these factors relate to changes in the industrial processes and logistics.
b. To develop strategies and mechanisms to manage and improve road freight transport and logistics in order to maintain or improve the logistical performance and the economic competitiveness, while at the same time reducing or at least delimiting the negative external costs caused by transport through environmental impact and congestion.
c. To forecast effects of alternative strategies in order to contribute to a comprehensive transport policy and to offer guidance to national and regional governments.

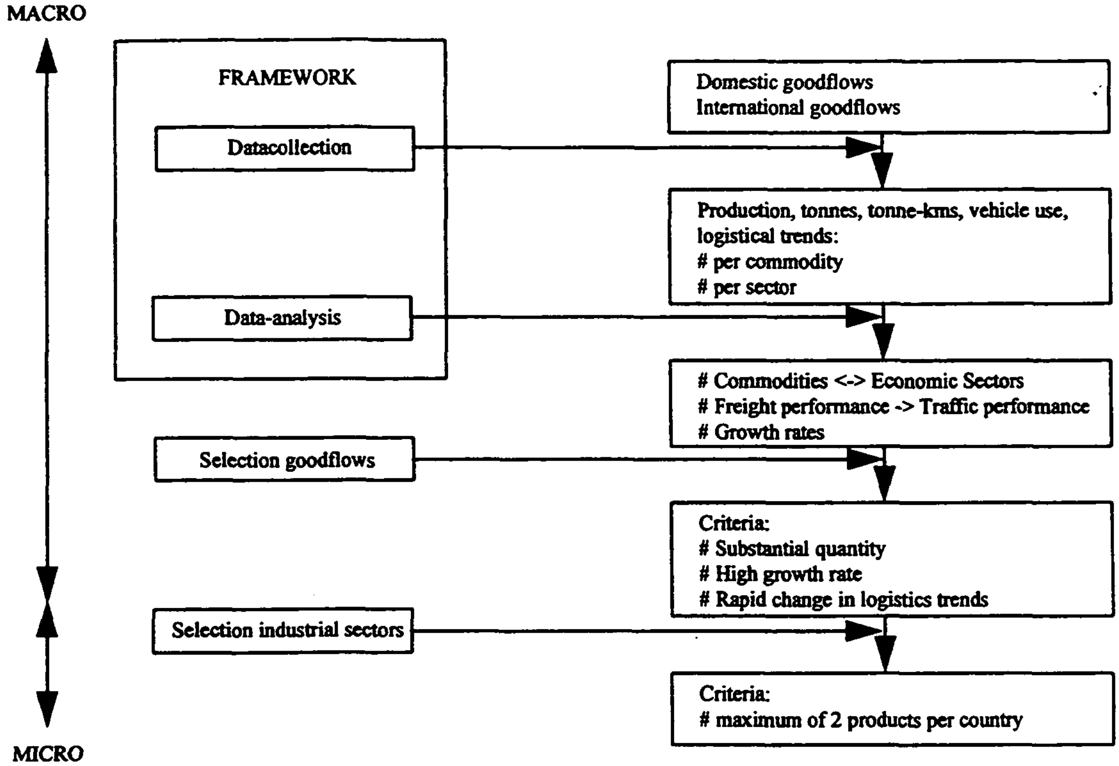
From the above can be concluded that in this study possible strategies for transport policy making and the effects of these strategies on both economic performance and negative impacts like pollution and congestion will be assessed.

1.3 WP-1 objectives

The REDEFINE-project consists of 4 Research-Workpackages. Workpackage 1 is engaged with the research on macro-level research, or in other words for European situations. The relation between Workpackage 1 and the other Workpackages is presented in paragraph 1.4. In figure 1.1 the structure of Workpackage 1 is given, which consist of four major tasks:

1.1 Development of the data collection framework.
1.2 Data collection.
1.3 Analysis of data.
1.4 Selection of goods flow - industrial sector combinations.

Figure 1.1 Structure of Workpackage 1



As is pointed out in the figure, in the last task the translation of a macro to a micro level is made.

Task 1.1 Framework development

Datacollection and data-analysis for each country has to be done in the same way. However in advance some specific problems can be mentioned that have to be tached in this Workpackage. Problems that have to be tackled are for instance:

- ▲ Definition of autonomous trends.
- ▲ Translation of value based production into weight based production by using value densities.
- ▲ Translation of freight performance (tonnes, tonkilometres) into traffic performance (vehiclekilometres).
- ▲ Connection of classification in Production Statistics (SITC) and Transport Statistics (NSTR).
- ▲ Determining which part of change in freight and traffic performance is GDP-related and which part is related to other logistical factors.
- ▲ Estimation of foreign freight performance on national territory and freight performance of own country registered drivers on foreign territory.

Task 1.2 Datacollection

In this task data on production and transport performance concerning five EC-countries (France, Germany, Netherlands, Sweden, United Kingdom) are collected. These data are quantified in terms of:

- ▲ Actual height (Ecu's) of production value.
- ▲ Value density.
- ▲ Modal split (road share).
- ▲ Actual number of tonnes and tonkilometres.
- ▲ Use of vehicles: vehicle carrying capacity, load factor, empty running.
- ▲ Description of relevant trends/developments in logistics per goods flow/-commodity.
- ▲ Number of plants (used for concentration ratio analysis).
- ▲ Average payload per type of vehicle (used for JIT-analysis).

Data are gathered for four years: 1980, 1985, 1990 and 1995.

Task 1.3 Analysis of data

In this task the data on production and freight performance collected in task 1.2 will be analysed. In order to be able to determine which part of growth in freight traffic in the past is related to production and which part to 'other factors' (logistics changes), the following analysis has to be carried out.

- ▲ Connection of economic sectors (SITC) and commodities (NSTR).
- ▲ Translation of value based production into weight based production by use of value densities.
- ▲ Estimation of products transported by road (weight based) by use of modal split (road share).
- ▲ Calculation of handling factor.
- ▲ Translation of freight performance (tonnes, tonkilometres) in traffic performance (vehiclekilometres). This translation is made by use of data on average load factors, vehicle capacity and empty running.
- ▲ Analysis on growth factors for freight performance, traffic performance, and production, by use of the data for various years.

Task 1.4 Selection of goods flow - industrial sector combinations

On the basis of the output of task 1.2 and 1.3 it is possible to select the most important goods flows. In this task the most important goods flows are selected for further analysis. These goods flows will be selected using the criteria substantial quantity, high growth rate and logistic trends.

1.4 Relation with other workpackages

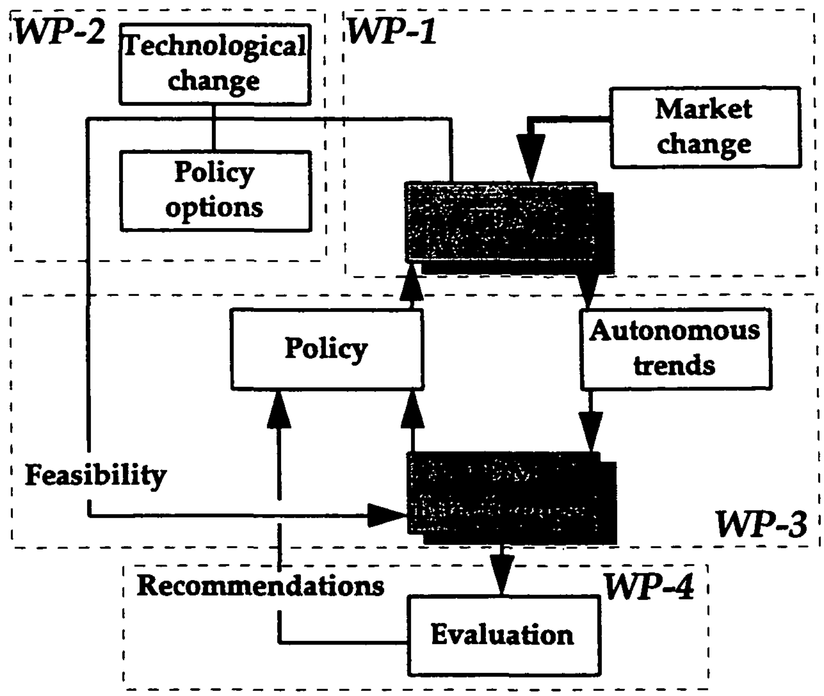
The REDEFINE project consists of 5 Workpackages. These are the following:

Workpackage 1: The Macro-level research (European situations).
Workpackage 2: Inventory of current policy options and technological change.
Workpackage 3: The Micro-level research (decisions of individual firms).
Workpackage 4: Evaluation of policy options and recommendations.

These four Workpackages are divided in several tasks, which give more detail about the activities associated with each Workpackage. Workpackage 5 deals with the dissemination and the exploitation plan.

The workcontent of REDEFINE is described in the following scheme:

Figure 1.2 Contents of the project



As the figure shows two major parts have been distinguished:
- ▲ Transport Demand Analysis (= TDA).
- ▲ Transport Demand Management (= TDM).

As part of the TDA there are technological and market changes which influence the total transport demand. Therefore the study has to focus on goods flows and sectors in the European Community where these changes will be of major importance. Some of these changes are autonomous trends, which can not be influenced, although these trends lead to an increase or decrease in freight transport. Other changes which also lead to an increase/decrease in freight transport can be influenced by policy. Policy options are not limited to *regulatory* measures (e.g. road pricing, vehicle tax, traffic restrictions), but will also include *soft* measures (e.g. collaboration of forwarders/ shippers to increase vehicle utilisation or bundle goods flows). However, these policy options and technological changes have to be more or less feasible and effective. Feasibility has two sides: *regulatory* measures need to be politically acceptable in order to find a political majority and the will in Member States to implement/impose them. *Soft* measures cannot be imposed but have to be adopted by actors on a voluntary basis. For these soft measures the accompanying stimulants are an important element of any such policy. This is studied in WP-2.

Policy options and technological changes which are highly effective and feasible are preferred. Policy options and technological changes which are less effective and/or less feasible have to be analysed in order to make them more effective and/or feasible.

In this study policy options and both sort of changes, technological and market, will be investigated in more detail in order to quantify the impact on transport demand management (TDM). This quantification will happen at *micro* and *macro* level. Therefore the TDA will be at the level of total goods flows between several European countries (macro level) as well as goods flows/product flows of specific companies (micro level). WP-1 is limited to a TDA on macro-level.

1.5 How to read this report?

First of all, in the next chapter the analytical framework is described. This framework defines the guidelines of data collection and data analysis by which each partner engaged in WP-1 will be adhering.

In the following chapter (3) for each country the main problems encountered during collection and analysis of data are described. Furthermore the solutions and assumptions in order to solve the problems are debated.

The results of the data analysis at an aggregate level (sum of sectors by country) is pointed out in chapter 4. Chapter 5 discusses sectoral key logistical trends as a result of logistical trend studies held in the five countries. Chapter 6 deals with the data analyses at a detailed level. The outcomes are described as percentage changes in production and transport aggregates and ratio's for different periods of time. These outcomes are presented in 'standard' figures, for the sum of sectors as well as for each sector separately. This results in more than eighty figures. In the final report, the outcomes will be presented in more clear figures per aggregate/ratio, where the results for different countries will be combined in one figure. This will improve the readability substantially.

The last chapter gives the conclusions. Moreover some logistical developments, which might influence freight performance, are discussed. Last, recommendations for further analysis on a micro-level (WP-3) are pointed out.

2 Trends and Framework

2.1 Introduction

In most European countries there has, for several decades, been a close relationship between road freight movement and economic growth. Most road freight traffic forecasts have been based on the assumption that these variables will remain closely correlated for the foreseeable future. This is essentially an act of faith, as there is no guarantee that the traffic levels and economic growth will continue to follow parallel trends. Indeed in some European countries it appears that these trends have begun to diverge. It has also been found that the relationship between output and traffic levels is much weaker at a sectoral level than across the economy as a whole.

There is a need, therefore, to investigate the underlying causes of road freight traffic growth. This will reduce reliance on extrapolatory forecasts and improve understanding of the workings of the freight transport system.

In adopting this 'causal' approach, it is necessary to examine the factors that can influence the relationship between output (usually expressed in value terms) and road freight traffic. Working on *a priori* basis, one can identify six factors:

- ▲ *Value density*: the ratio of value of product to its weight.
- ▲ *Modal split*: the division of freight between road and other transport modes.
- ▲ *Handling factor*: the ratio of the tonnes-lifted statistic to the actual weight of goods produced / sold. This is usually regarded as a crude measure of the number of links in the supply chain.
- ▲ *Average length of haul*: the average distance that each unit of freight moves on a single journey. This is considered to be an average measure of the length of each link in the supply chain. It translates tonnes-lifted into tonne-kms.
- ▲ *Average payload weight*: the average weight of product carried on loaded journeys. This determines how much lorry traffic (measured in vehicle-kms) is required to handle a given amount of freight movement (measured in tonne-kms).
- ▲ *Empty running*: proportion of vehicle-kms run empty.

Values have been obtained for these key parameters for the movement of fourteen commodity groups in five European countries. This permits a highly disaggregated analysis of the relationship between output and traffic levels which can identify the key drivers of traffic growth in individual sectors.

The value density parameter relates to the nature of the product and prevailing market conditions. All the other parameters are associated with the way in which firms structure and manage their production and distribution operations (what will, hereafter, be called 'logistical' operations). They can be affected by a broad range of logistical decisions made at different levels within a business.

In the course of Workpackage 1, previous research on logistical trends has been reviewed in an effort to explain changes in the main parameters. These trends are outlined in the following section.

2.2 Key Logistical Trends

The key logistical trends can be divided into four categories:

Restructuring of logistical systems: affecting the numbers, locations and capacity of factories, warehouses and handling facilities.

Dominant trends:

1.1 Spatial concentration of production:
- ▲ reduction plant numbers;
- ▲ increased plant specialisation ('focused production').

1.2 Spatial concentration of inventory.
1.3 Development of break-bulk / transhipment systems.
1.4 Centralisation of sorting operations in hub-satellite networks.

Realignment of supply chains: affected by commercial decisions on sourcing, sub-contracting and distribution. These decisions determine the pattern of freight flow a company's premises to those of its trading partners.

Dominant trends:

2.1 Vertical disintegration of production.
2.2 Increase in single sourcing.
2.3 Wider sourcing of supplies.
2.4 Wider distribution of finished product.
2.5 Increase in retailer's control over the supply chain.
2.6 Concentration of international trade on hub ports.

Rescheduling of product flow: the scheduling of production and distribution operations translates inter-company transactions into discrete freight flows. Changes in the scheduling of these activities can therefore have a major impact on freight traffic levels.

Dominant trends:

3.1 Application of the JIT Principle in Manufacturing.
3.2 Adoption of Quick Response and Efficient Consumer Response in Retail Distribution.
3.3 Growth of 'nominated day' deliveries.
3.4 Proliferation of booking-in /timed-delivery systems.

Changes in the management of transport resources: within the framework defined by decisions made at the previous three levels, there have been significant changes in the utilisation of transport capacity.

Dominant trends:

4.1 Modal shift.
4.2 Increased use of outside transport / distribution contractors.
4.3 Changes in vehicle size, weight and type.
4.4 Changes in handling systems.
4.5 Increased use of computerised vehicle routing and scheduling (CVRS).
4.6 Increase in return loading.

2.2.1 Logistical Restructuring

The geographical concentration of industry has long been regarded as a major cause of the growth in freight movement. Despite the importance of the relationship between industrial geography and freight traffic volumes, it has not been the subject of detailed and rigorous study. Research on this topic has been based on a combination of official statistics, which are largely unsuited to this type of analysis, the results of relatively small surveys and anecdotal evidence. It is nevertheless possible, on the basis of these data, to build up a fairly persuasive case that centralisation has been a dominant factor in freight traffic growth.

Spatial Concentration of Production
Firms have been concentrating their production to take advantage of economies of scale in manufacturing. Analysis of production data reveals that, in most sectors, there has been a significant reduction in the numbers of plants over the past 25 years. In some cases this reflects the contraction of an industry. In most sectors, however, total output has increased at the same time, indicating that there has been a concentration of production capacity. Many firms have also been adopting a 'focused production' strategy, increasing the degree of specialisation within existing plants. Many firms have retained the same number of plants, but concentrated the manufacture of particular items in particular locations.

The increasing tendency for firms to subcontract parts of the production processes has resulted in the 'down-scaling' of premises in some sectors. It would be wrong, however, to regard this as a reversal of the trend towards more centralised production. To appreciate why it is important to distinguish between the horizontal and vertical forms of concentration:

Horizontal concentration occurs where activities at the same stage in the production process are brought together at the one site.

Vertical concentration occurs where activities at different stages in the process are integrated at a single site.

During the 1960s and 70s both forms of concentration were widespread. During the 1980s and 90s levels of horizontal concentration have continued to increase, though in the vertical dimension, the process has gone into reverse. The consequences of this vertical 'disintegration' of manufacturing for the freight transport system are examined below.

Spatial Concentration of Inventory
The centralisation of production will also have had the effect of concentrating inventory in fewer locations. It is not known what proportion of manufacturers' inventory is held at the production site rather than off-site warehouses, though it is likely to be at least 60%. In 1990, roughly 43% of this inventory in the UK was 'work-in-progress' and thus intrinsic to the production process. A further 29% was in the form of materials, stores and fuel awaiting input into the production process. Most of this inventory would also be held at the production site.

'Off-site' inventory, either of industrial inputs or finished product, has also become concentrated in fewer locations. There are no official statistics available to allow a general analysis of warehouse centralisation. A reasonable amount of survey data have

accumulated, however, to suggest that over the past 20 years storage capacity in the manufacturing sector has become much more concentrated.
Inventory centralisation has also been occurring in the wholesale and retail sectors. Most of the larger retailers operate a two-tier stockholding system, with inventory held at both shop and warehouse levels. Within the retail distribution channel inventory has been centralised in two respects:

- ▲ by transferring the stockholding function from shop to warehouse level;
- ▲ by centralising warehousing operations.

Retailers in sectors such as grocery, clothing and general goods have also been concentrating particular categories of inventory within their existing warehouse systems. As a result of this *'focused distribution strategy'* warehouses are specialising to a much greater extent by product type, speed of turnover etc.

Development of Break-bulk/Transhipment Systems
Traditionally the stockholding and break-bulk functions were combined at a local distribution depot. Many firms have geographically separated them, centralising inventory while retaining a network of non-stockholding, break-bulk facilities to maintain the efficiency of their transport operation. This has enabled them to continue consolidating loads on long distance trunk hauls and confining the movements of small delivery vehicles to local areas. The transport cost penalties associated with inventory centralisation have thus been minimised. Within the European warehouse property market there has been a polarisation of demand for larger warehouses and smaller break-bulk depots.

Centralisation of Sorting Operations in Hub - Satellite Networks.
Centralisation has also occurred in parcel and mail delivery systems. In the traditional parcel delivery system, the sorting operation was undertaken at local depots and each pair of depots linked by a direct trunk-haul. This minimised the average distance that each consignment travelled between collection and delivery point. Many parcel carriers have now abandoned this mode of operation and opted instead for 'hub-satellite' systems in which all but local traffic passes through a centralised sorting facility (or 'hub'). The complex networks of inter-depot links have been replaced by a radial route structure focused on the hub. This has enabled carriers to improve:

- ▲ the speed and efficiency of the sorting operation by mechanisation;
- ▲ the utilisation of the trunk vehicle fleet.

The adoption of hub-satellite systems has increased the volume of parcel movement, measured in tonne-kilometres, amplifying the effect of the steep growth in the parcel business on the transport system. It is likely to have had a much smaller effect on vehicle-kms as the load factors on trunk vehicles have been substantially raised.

2.2.2 Realignment of Supply Chains

This has affected both the number and length of links in the supply chain.

Vertical Disintegration of Manufacturing Operations
Over the past 10-15 years, firms have been concentrating their resources on core activities and contracting out ancillary functions which can often be performed more cheaply and effectively by outside agencies. This trend has been particularly pronounced in sectors such as electronics, automotive manufacturing and mechanical

engineering. The vertical disintegration of manufacturing operations has effectively added extra links to the supply chain. Processes that were previously undertaken in close proximity on the same production site now take place in different locations creating a demand for additional freight movement.

Increased Single Sourcing
Many firms have been cutting the number of suppliers. In the past, most companies preferred to buy the same item from several suppliers to spread the risk of disruption and promote competition among vendors. The trend over the past 10-15 years has been for firms to reduce the number of suppliers and in many cases move to 'single-sourcing'. The rationalisation of the supply base is closely associated with the adoption of just-in-time and total quality management, techniques which require close co-operation from outside suppliers.

Single sourcing also has important implications for the freight transport as it permits a higher degree of consolidation of inbound movements. This is particularly important where firms are operating within a JIT regime. Had JIT not been accompanied by a reduction in supplier numbers, its impact on the transport system would undoubtedly have been much greater. The traffic effects of JIT are discussed more fully below.

Wider Sourcing of Supplies / Wider Distribution of Finished Product
Most firms' sourcing and distribution operations are becoming more geographically extensive. Clear evidence of this trend emerged in surveys undertaken by A.T. Kearney Ltd. in 1987 and 1992 of, respectively 500 and 1000 European manufacturers. This found that, on average, a declining proportion of purchases and sales were being made within the domestic market and a higher proportion at European and global levels. There is considerable anecdotal evidence to suggest that firms are geographically extending their supply bases. This trend has been particularly pronounced in the sourcing of retail supplies, particularly in the grocery sector.

Increase in Retailer's Control over the Supply Chain
Over the past 20 years, however, there has been a major diversion of product flow from manufacturers' distribution depots and wholesale warehouses to retailers' 'regional distribution centres' (RDCs). Large retailers across Europe have become heavily involved in logistical operations upstream of the shop and now channel a large proportion of these supplies through their RDCs.

The substitution of retailer-controlled RDCs for wholesale warehouses and manufacturers' depots has maintained the number of links of the logistical channel. As the RDCs are much more centralised and serve wider hinterlands, the move to retailer-controlled distribution has considerably lengthened the last link in the chain from warehouse to shop. In addition, a higher frequency of deliveries to shops and a lesser frequency of deliveries of RDC's is expected by the retailers themselves. Despite this increased separation of warehouse and shop, the consolidation of retailer-controlled deliveries in much larger vehicles is likely to have reduced total vehicle-kms.

The reduction in lorry traffic at the secondary distribution level must be set against the increases in traffic volumes at the primary distribution level, resulting from the wider sourcing of supplies (referred to in the previous section) and the adoption of quick response systems (discussed below).

Concentration of International Trade on Hub Ports and Airports.
Across Europe there has been a concentration of port capacity and trade flows partly as a result of the 'hubbing' strategies of deep-sea container shipping lines and air freight operators. Direct deep-sea container services have been withdrawn from regional ports, forcing exporters and importers to transport consignments longer distances overland to hub ports.

2.2.3 Production And Distribution Scheduling Decisions

The way in which transactions between trading partners materialise as discrete freight journeys depends on the scheduling of production and distribution operations. Over the past decade the scheduling of these operations has been transformed by the introduction of new management systems designed to minimise inventory levels.

Application of the Just-in-Time Principle in Manufacturing
A large proportion of European businesses are committed to JIT. Of 1500 businesses surveyed for UPS in 1992, 46% claimed to be delivering or receiving products on a JIT basis, 57% in the manufacturing and construction sectors. It was predicted that by 1997, the corresponding proportions would be 55% and 69%. A World Bank survey in 1990 of 625 North American and 225 European firms found that 28% of all freight shipments were being delivered on a JIT basis and that this proportion was likely to rise to 33% by 1995.

Conventional wisdom suggests that firms operating on a JIT basis minimise inventory by sourcing supplies in small quantities at frequent intervals. It is alleged that, by reducing average consignment size and increasing delivery frequency, JIT generates additional road traffic, increasing the ratio of vehicle-kms to tonne-kms and to total tonnes delivered. If JIT were having a pronounced effect on road freight operations, one would expect to see average payloads weights declining. It has been disputed, however, that JIT is generating additional lorry traffic. The British Freight Transport Associates argues that, on the contrary, it has been increasing the degree of load consolidation.

The impact of JIT on lorry traffic levels can been mitigated by the consolidation of JIT supplies through:
- ▲ Milk-round collection feeding supplies directly into the plant.
- ▲ Radial delivery from suppliers into a warehouse (or 'supply house') where supplies are consolidated for final delivery to the plant.

Adoption in Quick Response and Efficient Consumer Response in Retail Distribution
'Quick response' (QR) can be regarded as the application of the JIT principle to retail distribution. As the ratio of total sales to inventory (i.e. the 'stock turn rate') is critical to retail profitability, retailers have a strong incentive to minimise stock levels. One of the main ways in which they can do this is by ordering supplies more frequently and in smaller amounts and by pressurising suppliers into reducing order lead times.

QR has essentially been a retailer-driven initiative. More recently Efficient Consumer Response (ECR) has been advanced as a means of cutting inventory levels and smoothing product flow through closer collaboration between manufacturers and retailers. Several ECR-type relationships have so far developed between retailers and manufacturers in the fast-moving consumer goods sector.

Growth of Nominated Day Deliveries
There has been a widespread adoption of the 'nominated day' principle over the past 20 years. Firms operating a nominated day delivery system achieve much higher levels of transport efficiency by forcing customers to adhere to a ordering and delivery timetable. Customers are informed that a vehicle will be visiting their area on a 'nominated' day and that to receive a delivery on that day, they must submit their order a certain period in advance. The advertised order lead time is thus conditional on the customer complying with the order schedule. By concentrating deliveries in particular areas on particular days, suppliers can achieve higher levels of load consolidation, drop density and vehicle utilisation. The resulting reductions in traffic levels can be significant.

Proliferation of Booking-in/Timed-delivery Systems
The scheduling of freight movement has become more tightly disciplined by the introduction of timed-delivery at factories, warehouses and shops. In the past vehicles might be scheduled to arrive sometime during a particular day or more specifically in the morning or afternoon. Many premises now operate booking-in systems which confine deliveries to narrow time-windows, typically of 30 minutes duration. Failure to adhere to these schedules can result in vehicles having to wait for long periods or, in extreme cases, being turned away and required to make a new appointment. In order to meet these tighter delivery schedules, particularly in areas with severe traffic congestion, firms may have to increase vehicle numbers and trips.

2.2.4 Transport Management Decisions

Decisions made at the previous three levels dictate a company's transport requirements. It is for transport managers, increasingly working within a broader logistical framework, to meet these requirements at minimum cost. Some decisions specifically relating to transport, on issues such as contracting out and modal choice, usually require higher level consultation and approval within the organisation, but this still leaves transport managers with a considerable amount of discretion.

Modal shift
One of the key determinants of road freight volumes is the allocation of freight between transport modes. For most firms, the choice of transport mode is essentially a strategic decision, made infrequently, often at a time when the production and distribution system is being redesigned. The use of rail, for example, often requires capital investment in sidings, rolling stock and handling equipment and fundamental changes to operating systems. With the development of combined transport, firms are being offered more flexible services combining the advantages of the different transport modes.

Increased Use of Outside Transport / Distribution Contractors
Since the early 1980s, there has been a substantial increase in the proportion of road freight movement handled by outside contractors. The contracting out of logistical services can be seen as part of a more general trend by firms, outlined above, to concentrate on core activities and externalise lower-order functions.

In assessing the effects of the externalisation of road freight operations on vehicle utilisation and lorry traffic levels, it is important to allow for differences in the nature of work done by in-house and third-party vehicles. Allowance must also be made for the increase in the proportion of third-party transport provided on a dedicated basis for individual clients. This has weakened one of the traditional roles of the haulage contractor which was to group traffic from several clients into a larger loads. In recent years, however, some firms have been relaxing their requirement for dedication and increasing their demand for 'shared user' services.

Changes in Vehicle Size, Weight and Type
Road transport operators have been under mounting pressure to maximise vehicle loading within service level constraints. The degree of load consolidation is strongly influenced by the composition of the vehicle fleet. Firms have taken advantage of increases in legal size and weight limits and the development of new types of lorry such as of multi-compartment vehicles and double-deck trailers, which accommodate larger loads.

Changes in Handling Systems
Equipment designed to improve ease of handling can impair vehicle utilisation. The standard wooden pallet, for instance, takes up around 10-12% of the cubic capacity of a vehicle, while the roll (or cage) pallets now extensively used in retail distribution require around 40% more. Through their choice of unitised loading systems, firms have been trading greater efficiency in handling against lower vehicle utilisation and hence higher transport costs. The volume of primary and secondary packaging has also been increasing, further augmenting vehicle space requirements. By using returnable trays, containers and stillages, firms have been able to reduce the quantity of packaging material, though not necessarily improve vehicle load factors. Moreover, the need to return the equipment can limit the scope for proper backloading.

The way in which handling equipment is used also has implications for vehicle utilisation. A key factor here is the height to which pallet loads are built. The design of warehouse racking systems often restricts pallet heights to a lower level than can be handled by road vehicles and thus causes a loss of vehicle operating efficiency.

Increased Use of Computerised Vehicle Routing and Scheduling (CVRS)
The quality and cost-effectiveness of computerised vehicle routing packages have greatly improved over the past decade and their use has become much more widespread. It is generally believed that CVRS can, on average, cut transport costs and distance travelled by between 5 and 10%, depending on the quality of the previous manual load planning.

Increased Return Loading of Vehicles
Traditionally around a third of lorry-kms have been run empty. In some countries, such as the UK and France, this proportion has been declining. An analysis of the possible reasons for this trend identified five contributory factors: the lengthening of lorry journeys, increasing number of drops per trip, the expansion of load-matching services, a growth in the reverse flow of packaging material / handling equipment and supply chain initiatives designed to improve return loading.

2.3 Framework

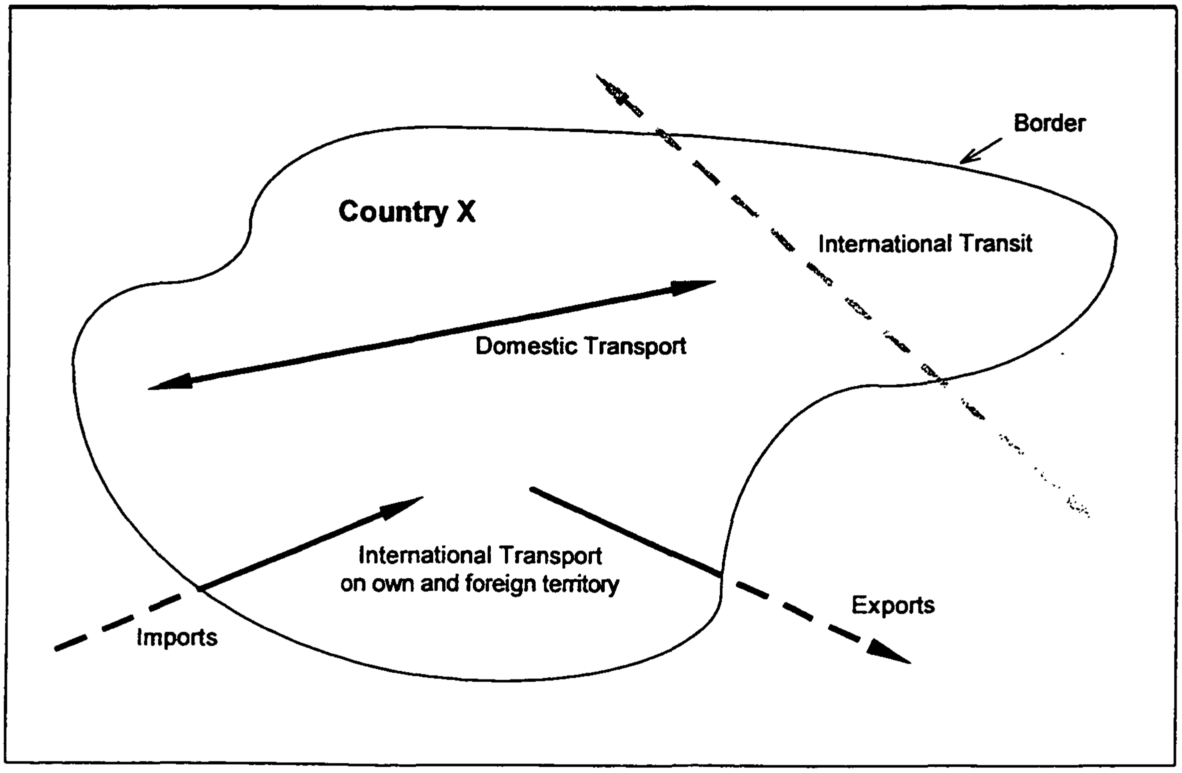
2.3.1 Defining the boundaries

The main objectives of Work Package 1 (WP1) are to analyse road freight traffic trends, to examine the relationship between these trends and macro-economic variables and to review previous research on the restructuring of firms' logistical systems. The framework within which this initial phase of the REDEFINE project has been carried out, establishes the guidelines to which each of the partners engaged in WP1 will be adhering.

In this section the boundaries are described with regard to the following aspects:
- ▲ scope of tranport;
- ▲ scope of sectors;
- ▲ vehicle type;
- ▲ time period;
- ▲ transport modes.

Scope of transport
Figure 2.1 illustrates the definitions of domestic and international freight transport flows to be used in this project. In the case of domestic transport, the origin and destination of the consignments are within a single country, while international flows have origins and destinations in different countries. International freight movements are differentiated into imports, exports and transit traffic.

Figure 2.1 Domestic and International Freight Transport Flows



For the analysis of domestic and international road freight trends, the minimum data requirements are as follows:

- ▲ tonnes-lifted;
- ▲ tonne-kilometres;
- ▲ average payload weight;
- ▲ load factor (defined as the ratio of the tonne-kms that a vehicle actually carries to the tonne-kms it could have carried if on every loaded trip it was running at its maximum gross weight);
- ▲ empty running (% of vehicle-kms run empty); and
- ▲ total vehicle-kms.

In the case of international traffic, data will only be collected for imported and exported goods. As international transit traffic is considered to have little or no relationship to the transit country's GDP it will be excluded from the analysis of freight traffic growth.

Scope of sectors

Domestic road freight data will be disaggregated for 14 sector - commoditiy combinations:

Table 2.1 Split of indutrial sectors in sector - commodity combinations

Domestic Commodity-Sector groups	
0	Agricultural products
1	Food and drink
2	Wood and paper/pulp
3	Textiles and clothes
4	Building materials
5	Other Crude materials
6	Chemicals and fertilisers
7	Petrol and petroleum products
8	Coal and coke
9	Ores, iron and steel
10	Transportation equipment
11	Machinery
12	Other manufactured articles
13	Miscellaneous articles

The 14 categories into which domestic road freight transport movements have been divided are, in the main, designed to be homogeneous and closely associated with particular industrial sectors and/or sections of the supply chain. Categorising products with respect to their physical state and stage of processing, eases the problem of calculating handling factors, as it is only necessary to establish the volume of production, in terms of weight, at one point in the supply chain: for most categories this will be the initial point of production (or extraction) or import; for food and drink products the point of consumption/export shall be used. A full break down of the categories, for NST/R and their equivalent SIC(92) classifications can be found in Appendix 1.

The quantity and quality of data available are much greater for domestic road freight movement than for international flows. Fortunately, the vast majority of freight movement in all the countries concerned is domestic. Collection and manipulation of international road freight data are likely to prove difficult in each of the five countries, particularly for haulage work undertaken by foreign-registered hauliers. This is discussed more fully in the next chapter.

Vehicle type
Data on small vans (of under 3.5 tonnes gross weight) is patchy across the five countries. Each WP-1 participant has used what official statistics are available to compile tonne-kms and/or vehicle-kms estimates for these vehicles. Because in terms of tonne-kilometres and vehicle-kilometres vans play a minor role in freight transport, this vehicle type is left out of the analysis.

Time period
Data have been collected for the period 1980 to 1995 at five-yearly intervals. If it is not possible to obtain data for these end years, then the earliest (post-1980) and latest values are used.

Freight modal split
As shown in figure 2.2, the modal split is an important parameter, as shifts in traffic to/from other transport modes affects road freight volumes and can be indicative of underlying logistical trends. Analysis of modal split data will also reveal if there is a relationship between road's share of the freight market and production. In this study, modal split is measured by the ratio of tonnes-lifted by road divided by tonnes-lifted by all transport modes (road, rail, inland shipping and if relevant short sea and pipeline).

2.3.2 Analysis of data

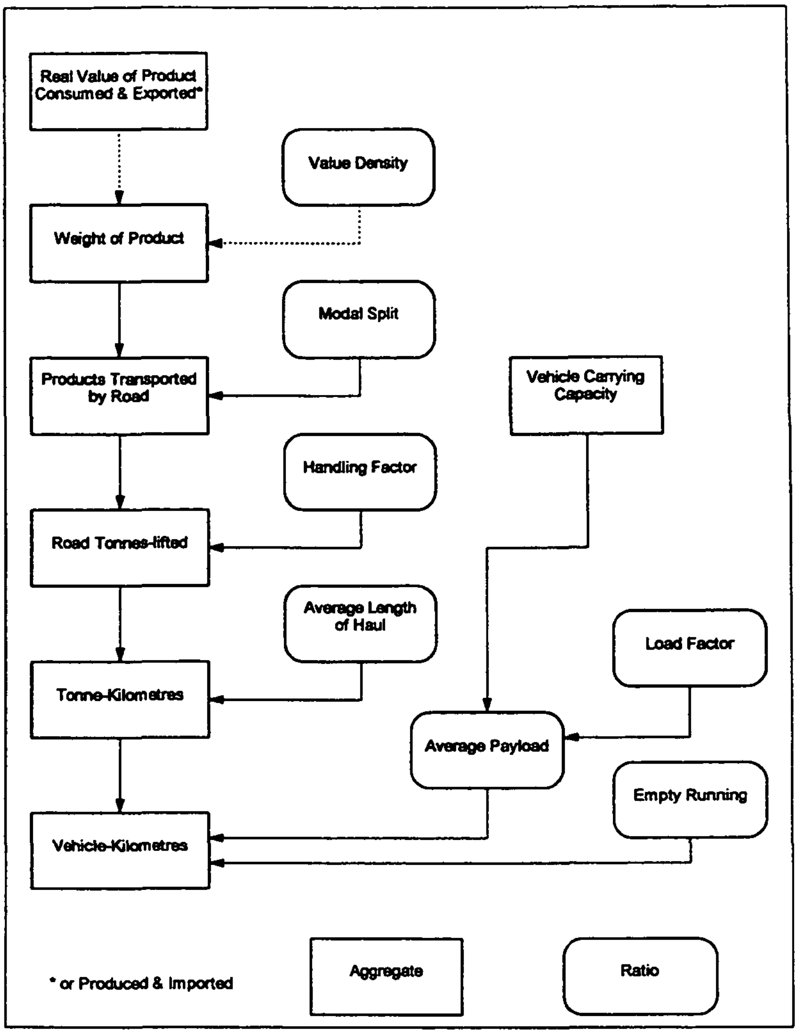
Demand analysis from a supply chain perspective
Industrial manufacturers as well as agricultural, fishery, forest and mining industries produce goods, which they supply on the goods market. On the goods market other manufacturers as well as wholesalers, retailers, construction industries, service industries etcetera, demand those goods. After adding value, those industries can supply the goods on the market again.

Transport is supplied by the transport sector or is provided for own account by shippers. Transport is always[1] demanded by suppliers of goods on the goods market, whether it is provided by the transport sector or for own account. By analysing transport from the shipper's view transport demand is central. By concerning transport as demand of the producers of goods, the transport demand gets a supply chain perspective in the REDEFINE report.

The relationship between road freight traffic and economic variables (figure 2.2) will be analysed both at an aggregate level for each national economy and at a disaggregated level for each of the 14 sector-commodity combinations.

[1] The only exception concerns the transport of fast moving consumer goods in the UK, where retailers (sometimes) pick up their orders from manufacturers for own account.

Figure 2.2 Linking economic activity and road freight traffic



The framework for this analysis is illustrated in figure 2.2. This is derived from previous research on road freight traffic growth undertaken by Heriot-Watt University and Cranfield University (*Logistical Restructuring and Freight Traffic Growth* respectively *Modelling the Links between Economic Acitvity and Vehicle Kilometres).* It shows how the relationship between the value of goods produced / consumed is determined by a series of critical ratios. The first of these ratios, **value density,** translates value-based measures of output into weights. The **modal split** establishes the proportion of freight moved by road. Each unit of freight carried by road is loaded onto road vehicles several times during its movement from raw material source to final point of sale. The same consignment can therefore be recorded several times as it progresses along the supply chain. The **handling factor** (i.e. the ratio of tonnes-lifted to the weight of goods produced/consumed see appendix 2) measures the extent of this multiple-counting and can be regarded as a rough index of the number of separate links in the supply chain. The **average length of haul** represents the average length of each of these links and converts tonnes-lifted into tonne-kms. To see how tonnes-kilometres of freight movement materialise as lorry traffic on the road (i.e. as vehicle-kilometres), it is necessary to consider both the available carrying capacity of the vehicle fleet and its relative utilisation. Utilisation is determined both by the **average payload weight** on loaded trips and the proportion of vehicle-kilometres run empty (i.e. the **empty running** ratio).

If each of these ratios remained stable, road freight traffic would be perfectly correlated with changes in the value of goods produced/consumed (= autonomous trend). In practice, each of these ratios can vary independently. For example, roads relative share of the freight market can change, the 'vertical dis-integration' of manufacturing operations can add extra links to the supply chain, wider sourcing of supplies extends the average length of haul and just-in-time delivery can reduce average payload weight. By estimating changes in each of the key ratios through time, it should be possible to establish how much of the growth of lorry traffic is a function of (value-based) economic growth and how much is attributable to these other logistical changes.

Shift Share analysis
In previous research (*Trends in Road Goods Transport, 1962-1977* and *The Growth of Road Freight in the UK*) on road freight trends, shift-share analysis has been used to assess the effect of industrial restructuring on the average length of haul. This requires the collection of commodity-specific data on tonnes-lifted and average length of haul. As indicated earlier, these statistics are collected by all the WP-1 participants for the years 1980, 1985, 1990 and 1995. Shift-share analyses will be carried out for different time periods (e.g. 1980-1995, 1985-1995, 1990-1995) on the basis of the 14 main sector-commodity groups.

Concentration ratios
In some countries, it is possible to obtain data on the proportion of manufactured output originating from the factories of the top five or ten producers in each sector. By analysing changes in the number of plants operated by these firms and relating that to changes in the real value of their output, it is possible to calculate a crude concentration ratio. This gives an indication of the degree of geographical restructuring within a sector, which is one of the factors affecting the demand for road freight transport.

Analysis of average payload weight
It is frequently claimed that just-in-time (JIT) management has been a major cause of road freight traffic growth. For example, the European Commission's white paper on a 'Common Transport Policy', published in 1992, partly attributed the growth in lorry traffic to 'changes in production methods of manufacturing industry which have led more and more towards stock-reducing, flexible, diverse, rapid and tailored transport with reductions in shipment size and increases in shipment frequency.' It is assumed that more frequent delivery of smaller orders will have reduced average payload weight and hence generated more vehicle-kms per tonne of product sold. If this JIT-effect were having a pronounced effect on traffic levels one would therefore expect to see average payload weights diminishing. Average payload weights have been calculated for several countries by dividing tonne-kms by loaded-kms both for the whole lorry fleet and for different categories of vehicle.

Logistic trends and developments
The logistical trends/developments are linked to one or more of the 14 commodity-sector groups.

2.3.3 Sector-commodity combinations

Finally, a selection of important sector-commodity combinations is made, which will be subject to more detailed analysis in the case-studies. In Workpackage 3 some representative product/supply chains on a micro level are selected, in order to be able to analyse relevant developments and factors in logistics, which affect freight traffic at a macro level. The selection of sector-commodity combinations is based on three criteria:

- *Substantial quantity*: the most substantial goods flows measured in production, tonne-kilometres and vehicle-kilometres,
- *High growth rate*: sector-commodity groups with the highest growth rate in production, tonne-kilometres and vehicle-kilometres over the last decade.
- *Logistical trends*: sector-commodity groups which are now and also in future affected by trends in logistics and therefore will contribute to an increase in tonne-kilometres and vehicle-kilometres.

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7 Conclusions

7.1 Selection of sector-commodity combinations

As is indicated in the Technical Annex of the REDEFINE-project (1996) there is an input-output relation between this first workpackage and workpackage 3. A selection of important sector-commodity combinations is made in the last task of workpackage 1. These sector-commodity combinations will be subject to more detailed analysis in the case-studies in workpackage 3. The selection is made by using the three criteria indicated in paragraph 2.3.3:

- *Substantial quantity*: the most substantial goods flows measured in production (value), tonne-kilometres and vehicle-kilometres.
- *High growth rate*: sector-commodity groups with the highest growth rate in production (value), tonne-kilometres and vehicle-kilometres over the last decade.
- *Logistical trends*: sector-commodity groups which are now and also in future affected by trends in logistics and therefore will contribute to an increase in tonne-kilometres and vehicle-kilometres.

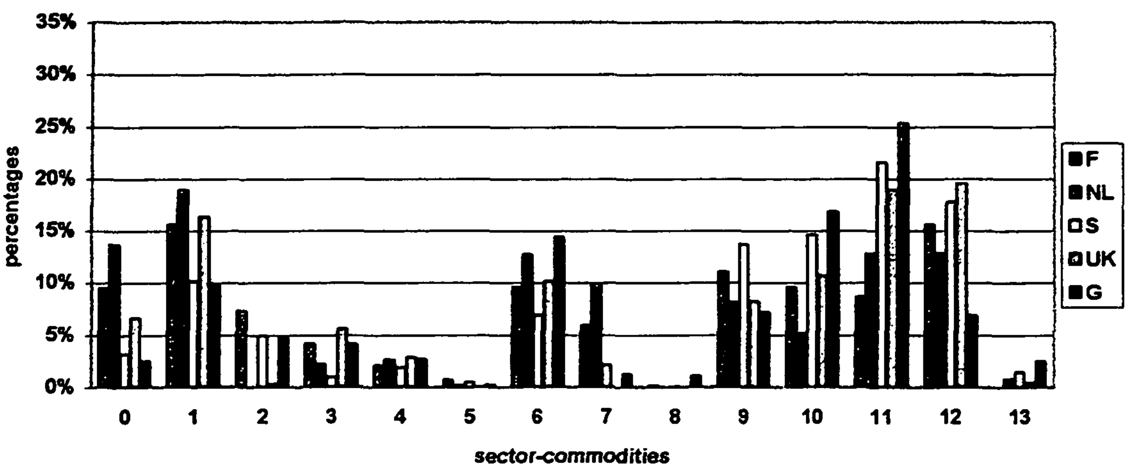
7.1.1 Substantial quantity

First of all, sector-commodity combinations which represent a substantial part of:

- total production in value terms,
- freight performance,

are eligible for further analysis. Freight performance is measured in tonne-kilometres and vehicle-kilometres. The following three figures are showing production and transport and traffic performance for each sector as share of the total performance in a country.

Figure 7.1 Share of sectoral production in total production



In production value based terms, the most important sectors are Agricultural products (0), Food and drink (1), Chemicals and fertilisers (6), Ores, iron and steel (9), Transport equipment (10), Machinery (11) and Other manufactured articles (12).

Figure 7.2 Share of tonne-kilometres in total transport performance

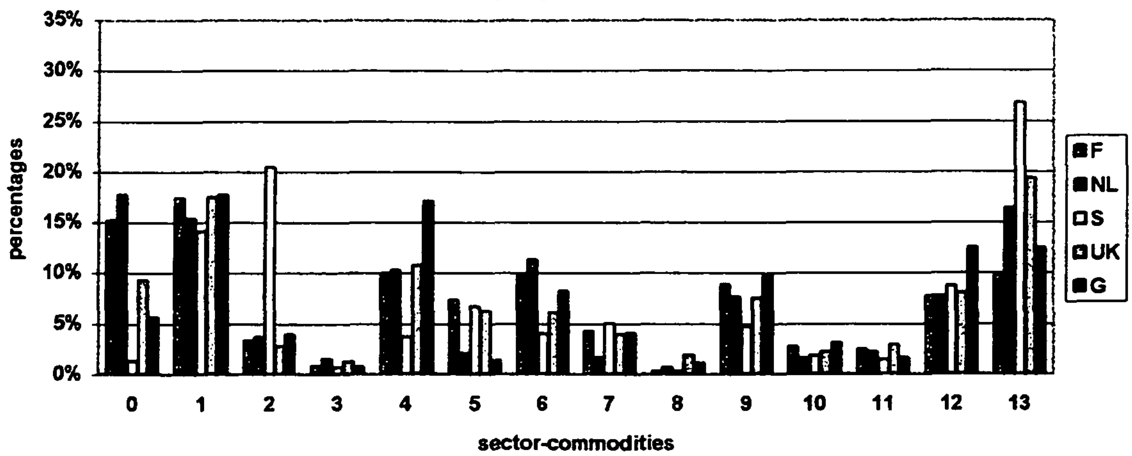
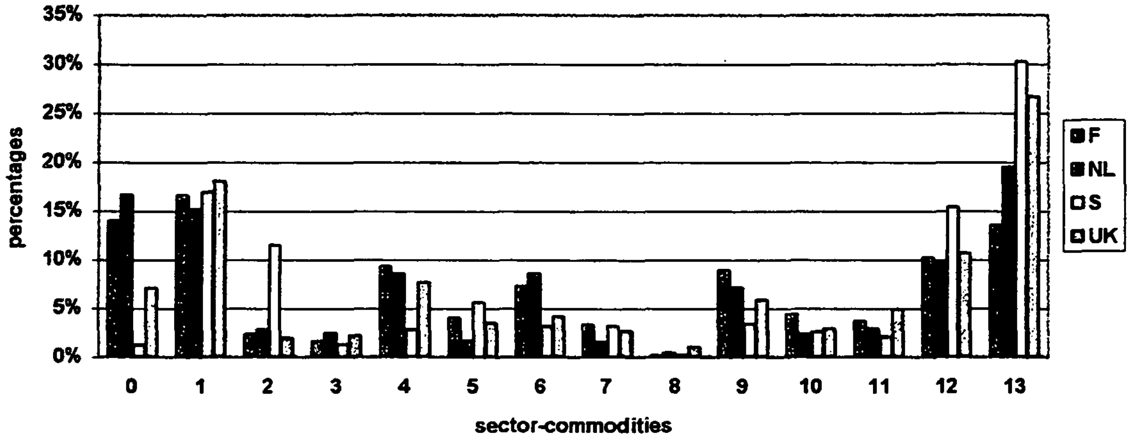


Figure 7.3 Share of vehicle-kilometres in total transport performance



No data are available on vehicle-kilometres per sector in Germany.

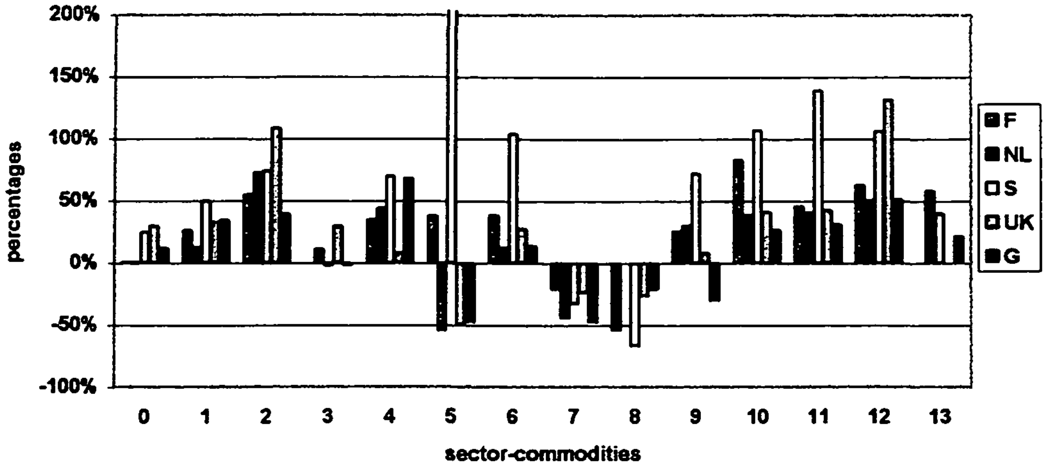
One can derive from the combination of the freight performance figures, that the sectors Agricultural products (0), Food & drink (1), Building materials (4), Other manufactured articles (12) and Miscellaneous articles (13) are representing the majority of transport and traffic performance in most countries. Wood and paper/pulp (2) has a large share in Sweden, however it plays a minor part in other countries.

To what extent sectors have increased during the last decade, is debated in the following paragraph.

7.1.2 High growth rate

The second criterium, by which sector-commodity combinations are selected for further analysis, is the level of growth rate with regard to total production and freight performance. Sectors which play a minor part in total freight performance at the moment, could become important in future, if production, and as a result of that freight performance, are increasing. The following three figures show growth rates of production and tonne- and vehicle-kilometres during the period 1985-1995 (1985-1993 for Germany, because of the unification).

Figure 7.4 Growth in production during last decade



In production terms the sectors Wood and paper/pulp (2), Building materials (4), Transport equipment (10), Machinery (11), Other manufactured articles (12) and Miscellaneous articles (13) show a fast increase in almost all countries. Other crude minerals (5) are increasing extremely fast only in Sweden, in three of the other countries however this sector-commodity combination is decreasing.

Figure 7.5 Growth in tonne-kilometres during last decade

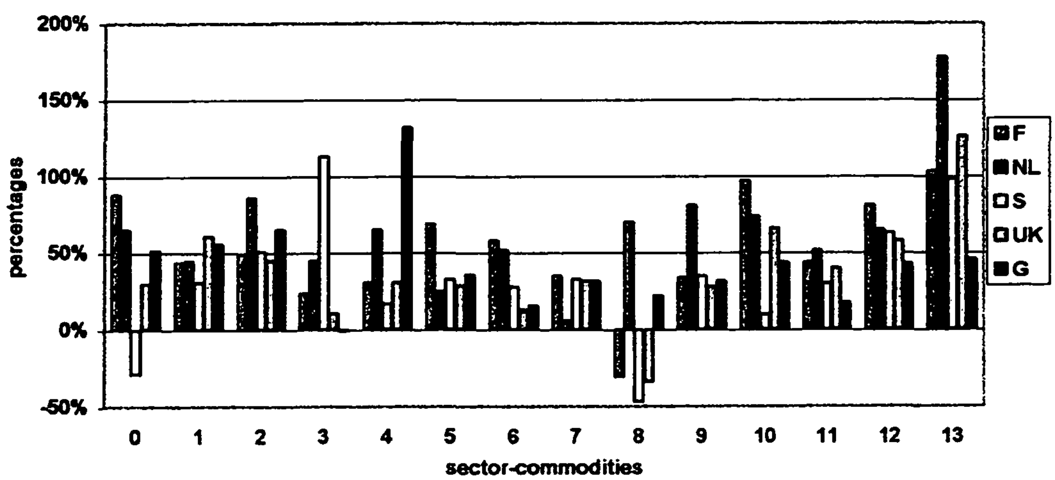
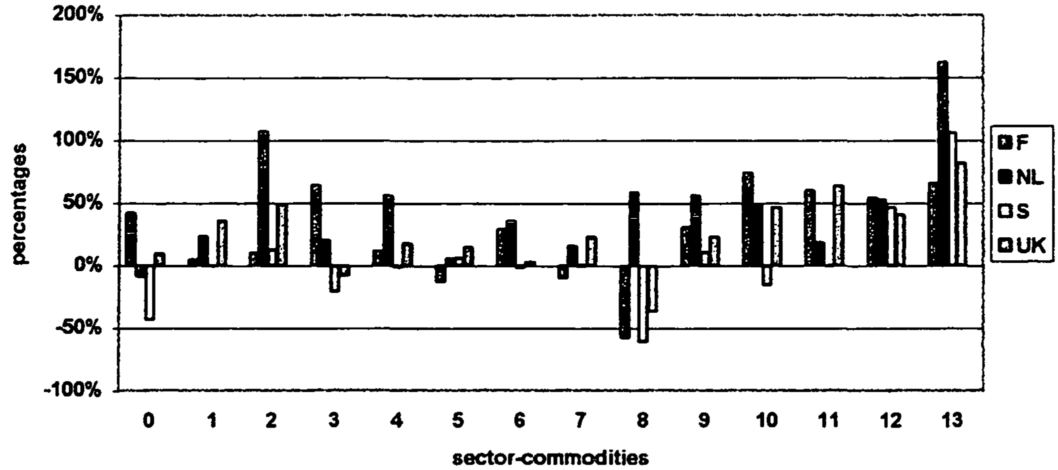


Figure 7.6 Growth in vehicle-kilometres during last decade



Freight performance in terms of tonne-kilometres is increasing rapidly in the sector-commodity combinations Agricultural products (0), Wood and paper/pulp (2), Building materials (4), Transport equipment (10), Other manufactured articles (12) and Miscellaneous articles (13). More or less the same goes on for growth rates based on vehicle-kilometres. Vehicle-kilometres within the Miscellaneous articles sector (13) are increasing dramatically.

7.1.3 Logistical trends

The third criterium is focusing on sector-commodity groups which are now and also in future affected by trends in logistics, and therefore will contribute to an increase in tonne-kilometres and vehicle-kilometres. In chapter 6 the results of sectoral studies on the key logistical trends have already been summarised in a table. This table represents the qualitative importance (categorized high/medium/low) of key logistical trends in the various sector-commodity combinations. From the table one can derive, that a serious number of key logistical trends are affecting now and will affect in future especially the sectors Wood and paper/pulp (2), Textiles and clothing (3), Machinery (11) and Miscellaneous (13).

7.1.4 Selection of sector-commodity groups

On the basis of the three criteria, which have been debated in the former paragraphs, the following sector-commodity groups are recommended for an analysis on micro-level (WP-3):

1. Agricultural products (0).
2. Food & drink (1).
3. Wood & paper (2).
4. Building materials (4).
5. Transport equipment (10).
6. Other manufactured articles (12).
7. Miscellaneous articles (13).

This recommendation is based upon the following findings: The sector-commodity groups (0), (1), (2), (4), (12) and (13) all represent a substantial quantity in total transport. Furthermore sectors (2), (4), (10), (12) and (13) are subject to a high growth rate in tonne- and/or vehicle-kilometres. Besides that, a serious number of key trends in logistics take place in some of the above mentioned sector-commodity groups, in particular in (2) and (13). Last but not least, one can conclude that sectors 12 (*other manufactured articles*) and 13 (*miscellaneous articles*) are very heterogeneous. For that reason, it is recommended to analyse these sector-commodity combinations in more detail in workpackage 3.

7.2 A matter of .....?

In this paragraph three different developments are debated, for which it has frequently been claimed to have caused an increase in traffic performance:

- *Sectoral shift*: Sectors whose products typically travel long distances increasing in importance and/or those characterised by short hauls declining.
- *Concentration ratio*: The extent to which production capacity has become geographically concentrated. It has long been argued that industrial concentration is one of the main causes of road freight traffic growth as it increases the average distance between point of production and point of consumption.
- *Just-in-time concept*: It is frequently claimed that just-in-time (JIT) management has been a major cause of road freight traffic growth.

7.2.1 Sectoral shift

The analysis of official transport statistics has shown that increases in the average length of haul have been one of the main causes of road freight traffic growth in all the countries concerned. It has also revealed that there are wide inter-sectoral variations in the rate at which average haul lengths have been increasing. It is possible that much of the overall increase in mean haul length is the result of industrial restructuring, with sectors whose products typically travel long distances increasing in importance and/or those characterised by short hauls declining.

The effect of industrial restructuring, or, to be more precise, changes in the composition of industrial output, can be assessed by means of shift-share analysis. This technique, which has been widely used in regional economics, has been applied previously in this context (Cundill and Shane, 1980; McKinnon 1989). It provides a means of dividing the overall change in the (weighted) average length of haul (ΔH) into three components:

$$\Delta H = \sum_{i=1}^{n} p_i^o \, \Delta h_i + \sum_{i=1}^{n} h_i^o \, \Delta p_i + \sum_{i=1}^{n} \Delta p_i \, \Delta h_i$$

where:

p_i^o is the proportion of tonnes-lifted in sector i in the base year (1985)

hi^o is the average length of haul for freight movements by sector i in the base year (1985)

Δp_i is the change in the proportion of tonnes-lifted in sector i between the base and end years (1985 and 1995)

Δh_i is the change in the average length of haul for freight movements in sector i between the base and end years (1985 and 1995).

$p_i^o \Delta h_i$ is a 'length of haul' component which measures the extent to which the overall change in average length of haul is the result of changes in haul lengths at sectoral level. Any industrial restructuring effects are eliminated by holding the division of tonnes-lifted between sectors constant.

$h_i^o \Delta p_i$ is a 'structural component' which measures the extent to which the overall change in average length of haul caused by changes in the proportion of tonnes-lifted generated by different sectors. To isolate this effect, the average length of haul for each sector is held constant.

$\Delta p_i \Delta h_i$ is a 'residual component' representing the situation where a sector both increases its share of total tonnes-lifted and experiences an increase in average length of haul.

Table 7.1 presents the result of the shift-share analysis for France, the Netherlands, the UK and Sweden for the period 1985-1995, and for Germany over the period 1980-90 (because of the re-unification of Germany, freight data for 1995 are not comparable with those for the earlier dates).

Table 7.1 Shift-share Results: % Contribution of Components

	Period	Increase in weighted average length of haul	*length of haul*	*structural*	*residual*
France	1985-95	18.5 km	82	6	12
Germany	1980-90	1.1 km	21	78	1
Netherlands	1985-95	12.3 km	81	21	-3
UK	1985-95	13.7 km	105	-1	-4
Sweden	1985-95	21.2 km	89	9	2

There was a wide variation in the contribution of structural change to increases in the average length of haul. It was a dominant factor in the case of Germany, though, as the increase in the mean haul length in this country, was very small, the net effect on road traffic levels would have been marginal. It is necessary to exercise caution in interpreting these results for Germany, however, as the compilation of average length haul statistics differs from that in the other four countries.

In the other countries, where the average length of haul rose by a much greater margin, the increase was due mainly to a broadly-based increase in mean haul lengths across the various sectors. Changes in the distribution of tonnes-lifted among sectors had only a minor impact in France, the UK and Sweden, though was slightly more important in the Netherlands. In the UK, it was found that, other things being equal, changes in the commodity mix would have yielded a slight reduction in the average length of haul, when, in practice, it rose by 16%. Similar results were emerged from shift-share analyses of UK freight data for earlier periods (Cundill and Shane, 1980; McKinnon, 1989).

7.2.2 Increase in concentration ratio

It has long been argued that industrial concentration is one of the main causes of road freight traffic growth as it increases the average distance between point of production and point of consumption. To test this hypothesis empirically, one must establish:
- ▲ The extent to which production capacity has become geographically concentrated.
- ▲ The relationship between the concentration and the average length of haul.

In this workpackage, attention will be confined to the first of these issues. It is not possible to analyse the second issue on the basis of official statistics and other secondary data sources. The link between industrial restructuring and road freight demand will be investigated in the course of the case studies conducted as part of workpackage 3.

It is possible to obtain a crude measure of the degree of plant concentration from official surveys of manufacturing activity. These indicate the numbers of plants firms operate and the value of their output. This permits the calculation of concentration indices. The index adopted here is the average value of output per plant expressed in constant prices. Increases in this index can be the result of three trends:
- ▲ Plant numbers declining, while total output rises.
- ▲ Plant numbers and total output declining, with the former falling at a faster rate.
- ▲ Plant numbers rising at a lower rate than total output.

Across the countries able to provide the necessary data, there are examples of each of these trends both at national and sector levels.

The data available are far from ideal for this type of analysis for several reasons:
- ▲ It is all value-based and gives no indication of the physical quantity of freight originating from the plants.
- ▲ The definition of manufacturing establishment varies both between countries and through time. As a result of changes to its definition in the UK in the early 1990s, figures after 1992 cannot be directly compared with the earlier series.
- ▲ The data are not available for all countries for the same type period.
- ▲ Individual sectors can heavily skew the results. In the case of the Netherlands, for example, trends in the petroleum sector have been highly anomalous. To eliminate this distortion this sector has been excluded from the Dutch calculations.
- ▲ It gives no indication of the degree of plant specialisation within sectors. Within some sectors, firms have been adopting a 'focused production' strategy, concentrating the manufacture of particular product lines in particular plants. The number of plants and their individuals output might therefore remain the same, but their market areas would greatly expand. Separate case studies and survey evidence are required to investigate this effect.
- ▲ The data relate solely to production operations. There are no general statistics available on the concentration of stockholding in larger warehouses.

Table 7.2 summarises the results of the analysis for four countries:

Table 7.2 Industrial Output, Plant Numbers and Concentration Indices

	1985-95		1985-93	1980-90
	Sweden	Netherlands	Germany[a]	UK[b]
Total output	28.8%	17.1%	5.8%	10.4%
No. of plants	-4.4%	-6.6%	0.3%	-32.1%
Concentration index	35.0%	25.3%	5.5%	62.5%

a. relates to the Federal Republic as it was prior to unification;

b. relates to plants operated by the five largest enterprises in sectors with an annual turnover in 1990 of £500 million or more.

This shows that there has been a quite pronounced concentration in Sweden, the Netherlands and the UK. In Germany (which, for the purposes of this analysis, comprises the eleven states of the Federal Republic prior to re-unification) there appears to have been a slight concentration.

The situation in each country requires some comment:

- *Sweden:* there was a marginal decline in plant numbers, but a sharp increase in their total output.
- *Netherlands:* the reduction in plant numbers a third greater that Sweden, but the growth in output a third less, resulting in a significantly smaller rise in the overall concentration index. If petrol and petroleum products are included, the concentration index declines by 6.6%, so great is the impact of this one sector.
- *United Kingdom:* the data are not directly comparable with those of the previous two countries as they relate to an earlier period and to the manufacturing systems of only the five largest enterprises in each sector. The very high concentration index results mainly from the sharp decline in plant numbers, which occurred mainly in the early 1980s. The figures probably exaggerate the overall degree of concentration as the share of total manufacturing output held by these firms declined from 45% to 39% during this decade (Black et al., 1995).
- *Germany:* the combination of an slight increase in the number of plants and small reduction in total output depressed the overall concentration index by around 5%.

Table 7.3 identifies those sectors which have experienced the highest degree of concentration in the four countries.

Several sectors, such as wood and paper, food and drink, chemicals and transport equipment, appear to have exhibited a relatively high degree of spatial concentration in several countries.

Table 7.3 Sectors with the Highest Industrial Concentration:

Sweden	Netherlands	Germany	UK
Chemicals and fertiliser Petrol and petroleum products Machinery Transport equipment	Wood and paper Building materials Transport equipment Food and drink	Wood and paper Food and drink Other manufacturing	Machinery Textiles / cloth Food and drink Chemicals

7.2.3 Just-in-time

It is frequently claimed that just-in-time (JIT) management has been a major cause of road freight traffic growth. For example, the European Commission's white paper on a 'Common Transport Policy', published in 1992, partly attributed the growth in lorry traffic to 'changes in production methods of manufacturing industry which have led more and more towards stock-reducing, flexible, diverse, rapid and tailored transport with reductions in shipment size and increases in shipment frequency.' It is assumed that more frequent delivery of smaller orders will have reduced average payload weight and hence generated more vehicle-kms per tonne of product sold. If this JIT-effect were having a pronounced effect on traffic levels one would therefore expect to see average payload weights diminishing.

Average payload weights have been calculated for several countries by dividing tonne-kms by loaded-kms both for the whole lorry fleet and for different categories of vehicle.

The results of this analysis suggest that on balance JIT is not a major cause of freight traffic growth, though there appear to be significant international variations in payload trends.

In all the countries for which appropriate data were available, average payload weight rose over the 15 year study period, a period during which the JIT principle has been widely adopted. Aggregate figures for the full vehicle fleet, however, conceal significant differences between vehicle types and weight classes (Table 7.4). At this more disaggregated analysis, difference emerge between countries. Differences in vehicle classification schemes, however, make direct comparison difficult.

Table 7.4 Trend in Average Payload Weights

	UK			Netherlands			Sweden[1]		
	rigid	*artic*	*total*	*rigid*	*artic*	*total*	*small*	*large*	*total*
1980	5.3	13.9	8.5	3.5	16.0	7.4	3.3	21.0	13.7
1985	5.1	14.6	8.8	3.7	16.1	8.4	3.4	22.5	14.5
1990	4.7	14.5	8.8	4.1	16.5	9.3	3.6	24.4	15.5
1995	4.5	14.4	9.2	4.3	16.0	10.2	4.5	27.2	17.8

1 small = max. payload < 5 tonnes large = max. payload > 5 tonnes

In the UK, the average payload carried by rigid vehicles has been steadily declining since 1982. This may be evidence of a JIT-effect because these vehicles are typically used to deliver supplies to assembly plants and shops.

No similar trend was observed in the other countries, however. In the Netherlands, the average payload weight for rigids went up by 23% between 1980 and 1995. In Sweden, the average payload of smaller vehicles with a maximum carrying capacity of 5 tonnes, which would present the lighter rigid vehicles, went up by 37% over this time period.

This disparity between the UK and these other countries may be partly attributable to the wide differences in the relative proportions of drawbar-trailer unit in the national lorry fleets and the way in which the activities of these vehicles are recorded in national statistics. This will require further investigation.

In both the UK and the Netherlands the average payload weight on articulated lorries has fluctuated and shown no clear upward or downward trend. Also in both countries there has been a migration of loads from rigids to artics. This is reflected in a large increase in the proportion of loaded-kms run by articulated lorries. In the Netherlands, for example, this proportion went up from 32% in 1980 to 51% in 1995.

In assessing payload trends, therefore, it is not enough simply to consider changes in average payload weight separately for each category of vehicle. The average payload weight for the vehicle fleet as a whole can be affected just as much by changes in the relative importance of these vehicle categories. In the UK, the shift from rigids to artics has more than offset the decline in the average rigid payload, slightly increasing average payloads overall. The decline in the average payloads of rigids may, in part, be the result of loads at the upper end of the rigid vehicles' payload weight distribution transferring to artics, thus reducing the average weight of the remaining rigid loads.

In Sweden, the average payloads of small (< 5 tonne) and large (>5 tonne) lorries and of the fleet as a whole has risen sharply over the past 15 years.

There is no evidence, therefore, that at an aggregate level JIT is reducing vehicle loading. On the contrary, there appears to have been a net consolidation of loads across national vehicle fleets.

It is possible, however, that some sectors have been subject to a strong JIT effect and that this has been offset by load consolidation in other sectors. To test this hypothesis, UK data on the payload weights of rigids and artics were disaggregated for the 14 sectors (Table 7.5). This revealed that:

- All but two sectors had experienced a net consolidation of loads. The two exceptions, machinery and miscellaneous articles, exhibited a slight deconsolidation overall. In the case of machinery, this may be significant, as this is a sector in which there is strong commitment to JIT. The overall increase in average payload weight was, nevertheless, the result of a broad multi-sectoral trend and not, as hypothesised above, due to the offsetting of conflicting trends at sectoral level.
- The largest reduction in the average payload weights of rigids are not in the assembly-type manufacturing sectors, which are most closely associated with JIT, but in the primary processing sectors which handle bulk, low-value product. Curiously, there was no change in the average payload weight of rigids moving transport equipment.

Table 7.5 Sectoral Disaggegration of Average Payload Weights: UK Data. Percentage change in average payload weight between 1982 and 1995

Sector	Rigid Vehicles	Articulated Vehicles	Total Fleet
Agricultural products	-14	17	26
Food and drink	-12	0	27
Wood and paper	-6	15	11
Textiles and cloth	0	-14	16
Building materials	-22	19	3
Other crude minerals	-3	21	4
Chemicals and fertiliser	-6	8	26
Petrol and petroleum products	-21	18	13
Coal and coke	-39	19	8
Metals and metal ores	0	19	23
Transport equipment	0	17	17
Machinery	-7	-11	-2
Other manufactured goods	0	8	25
Miscellaneous articles	-24	6	-1

Finally, a decline in average payload weight need not indicate the presence of JIT-effect. In some sectors, it could be the result of a decline in the density and/or 'stackability' of products, reducing the maximum weight of payload that can be carried within cubic capacity / deck area constraints. In the absence of volumetric data on road freight movement, it is not possible to differentiate this effect from that of JIT.

7.3 Recommendations for further analysis on micro-level in WP-3

For each of the selected sector-commodity groups a case-study will be done in WP-3. The case-studies should give empirical explanation of the driving forces which influence the ratio quantified in WP-1. The following ratios will be examined in depth during the casestudies:
1. value density;
2. handling factor;
3. modal split;
4. average length of haul;
5. vehicle carrying capacity;
6. load factor;
7. empty mileage.

The distribution of case-studies among the WP-3 participants (and thus countries) is indicated in table 7.6.

Table 7.6 Linking sector-commodity groups and case studies

Sector-commodity groups	Case-studies	WP-3 participants/Countries
Agricultural products	Agricultural products	Inrets (France)
Beverages and other foodstuffs	Food products	Inrets (France)
Wood & paper	Forest products	TFK (Sweden)
Building materials	Building materials	TNO (Netherlands)
Transport equipment	Assembly products automotive equipment	Uni-HH (Germany)
Other manufactured articles	see Wood & paper	TFK (Sweden)
Miscellaneous articles	Parcel service	TNO (Netherlands)
	Postal service	Cranfield (UK)

Because an important portion of *Other manufactured articles* consists of manufacturing of wooden products and paper articles, this sector-commodity group will be subject to the *Forest products* case study. Within this case-study special attention should be paid to final products, in order to get insight in factors causing changes in transport within the *Other manufactured articles* group. Because of the high share in total transport, *Miscellaneous articles* is subject to two case-studies. However an additional problem concerns the high heterogeneity of this group. Therefore special attention has to be paid to the problem of generalising case-study results to macro-level findings in WP-4. By analysing parcel services and postal services the expected covering of this group is in between 15% and 30%. It is not clear to what extent a postal service case study is feasible within the time frame of the project. If it does not seem feasible, a case study concerning petrol products will be done (reserve case study option). By selecting a long supply chain for petrol products, this case-study should cover both the chemical and the petrol/petroleum products sector-commodity group.

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MODELISATION DYNAMIQUE DE LA FILIERE LOGISTIQUE BOIS-PAPIER-CARTON

Valérie GACOGNE (IMTL)

Parallèlement aux travaux menés dans la cadre du programme de recherche européen Redefine centré sur l'analyse économique de 'familles logistiques', il est apparu intéressant de développer une analyse micro-économique d'une famille logistique précise, celle de la filière papier-carton.

A cette fin plusieurs travaux on été entrepris :

- des études des monographies disponibles sur la filière,
- la réalisation d'entretiens qualitatifs auprès de chargeurs de la filière,
- la conception et la passation d'un questionnaire dit 'logistique' auprès d'une quarantaine de professionnels,
- la construction d'un système dynamique de la filière sur la base des réponses au questionnaire et à l'aide du logiciel Stella, permettant l'analyse prospective à 25 ans de la filière, suivant différents scénarios.

Les résultats présentés viseront à la fois à montrer dans le cadre de la filière comment interagissent logiques productives et transport dans le passé comme dans le futur, ainsi que l'intérêt du recours à une modélisation de type dynamique.

Pour en savoir plus :

Modeling Dynamic Economic Systems, Matthias RUTH, Bruce HANNON, with 244 Illustrations and a CD-ROM (STELLA run-time), Springer, 1997, ISBN 0-387-94849 X.

INTRODUCTION

L'objet de ce travail sur la filière bois-papier-carton était de parvenir à réaliser un modèle explicatif sur l'évolution de la filière en France, et plus particulièrement sur la fabrication de pâte à papier, avec ce que cela peut impliquer au niveau des flux.

Le stage s'est donc déroulé en deux temps, d'une part un travail préliminaire de recherche et d'autre part la modélisation elle-même. Le choix de la dynamique des systèmes pour la modélisation n'est pas anodin, il apporte une autre manière de concevoir la modélisation à moyen terme et permet de prendre en compte de nombreux paramètres et les relations qui les lient entre eux. Son intérêt est également de pouvoir envisager de nombreux scénarios en agissant, comme le souhaite l'utilisateur, sur les diverses variables qui le composent.

1. Présentation du travail

1.1 L'objectif de la modélisation

L'objectif de ce travail a consisté à observer les évolutions des flux de pâte à papier en France, selon divers scénarios. Ces simulations ont été réalisées sur une durée de 25 ans. Dans un premier temps, mon travail a consisté à mettre en évidence au cours d'une activité de recherche et de compilation d'informations, les facteurs propres à cette filière qui pourraient être à l'origine de l'évolution des structures de production. Les flux peuvent en effet être considérablement modifiés de ce fait, en fonction des incidences sur la fabrication de pâte à papier marchande en France (destinée donc à être vendue), ou au contraire sur l'intégration de sa fabrication (la pâte est transformée en papier dans la même usine), ou encore sur la nécessité d'en importer. Les volumes transportés ne sont pas simplement liés à la production de papier et à une situation économique générale, mais également à une organisation de la production qui dépend de paramètres inhérents à cette filière.

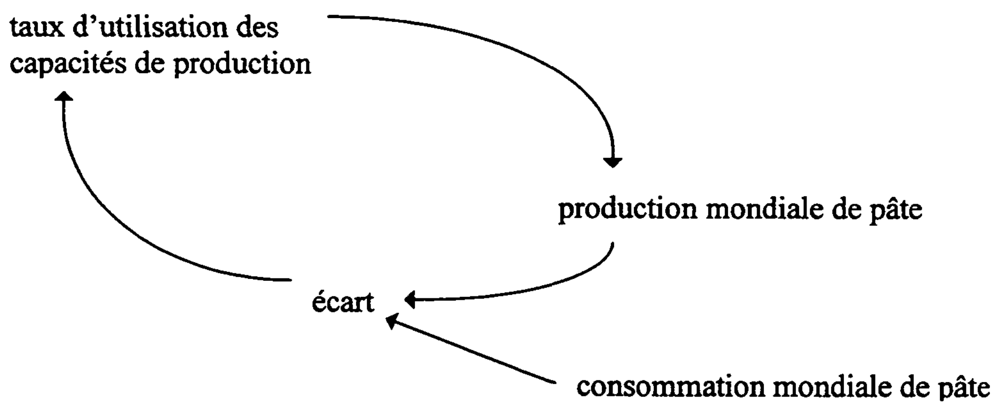
Les variations du PIB n'ont pas été prises en compte dans le modèle. D'une manière générale, la consommation de papier (donc de pâte à papier) suit les tendances du PIB en les accentuant à la hausse comme à la baisse, cependant à long terme, la demande n'est non pas influencée par l'activité économique mais par des facteurs structurels. Il s'agit notamment de la prolifération des photocopieuses, des fax et ordinateurs personnels accompagnés d'imprimantes... C'est ainsi que l'on constate une croissance annuelle moyenne de la demande de l'ordre de 3 % à long terme, avec des fluctuations importantes selon la conjoncture économique générale. Or l'intérêt du modèle étant de connaître le sens des évolutions des volumes transportés à moyen terme, ces phénomènes cycliques amplifiés par des comportements spéculatifs n'ont pas été pris en considération. Ce modèle fait référence à des moyennes et à des tendances, et peut être considéré comme *une* représentation de la réalité.

A cela nous devons ajouter, que les résultats quantitatifs obtenus ne doivent pas être considérés comme des prévisions. L'intérêt étant avant tout de comprendre quel rôle peuvent jouer certains facteurs dans l'évolution du système. La mission du modèle peut être qualifiée d'explicative.

1.2 Pourquoi une modélisation en dynamique des systèmes?

Le modèle a été construit à partir d'un logiciel de dynamique des systèmes appelé Stella. Ce type de modélisation permet de rendre compte des effets de boucles de rétroaction avec éventuellement des décalages dans le temps. Ces boucles appelées aussi feedbacks, ou encore cercles vertueux ou vicieux, proviennent de variables qui interagissent entre elles, d'où la notion de système. Enfin, la variable principale de ces modèles est le temps : comment le système va-t-il évoluer dans le temps? Les conséquences d'événements se font ressentir souvent après des délais qui, en se combinant, augmentent la complexité de l'évolution de l'état du système. On évite ainsi la tendance qui consiste à ne percevoir que les conséquences immédiates.

L'exemple suivant, qui fait référence au marché mondial de la pâte à papier, est une illustration simple d'une boucle de rétroaction.



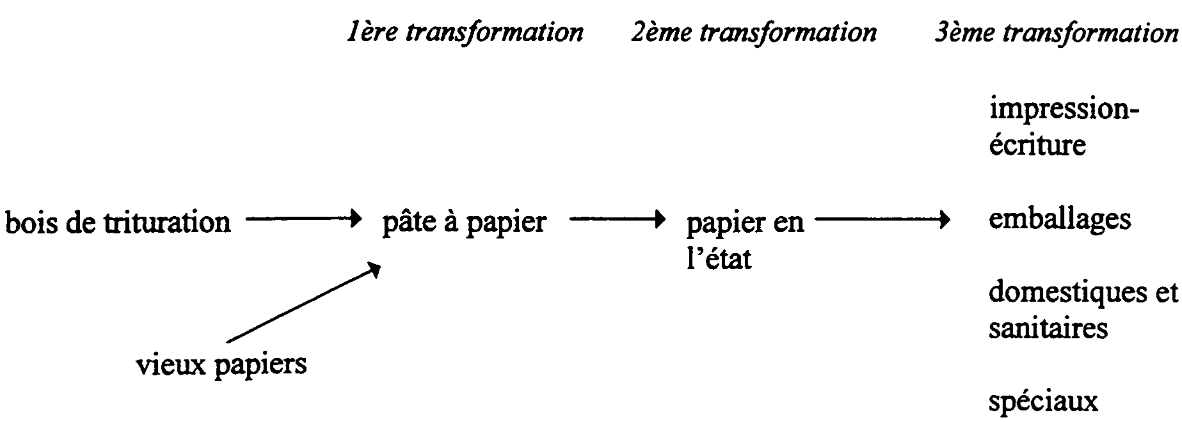
Comme l'indique le schéma, en cas de surproduction, les usines diminueront leur capacité de production afin de s'ajuster à la consommation. Cette boucle s'insère en fait dans un système complexe, car les producteurs décident de diminuer leur taux d'utilisation lorsque les prix ont fortement diminué du fait de la hausse des stocks mondiaux invendus (stocks Norscan). De plus, cette décision demande de la part des producteurs de s'organiser et n'intervient pas immédiatement.
Cette décision aura également d'autres conséquences telle que l'augmentation des coûts de production, dans une industrie très capitalistique.

1.3 Quelques éléments sur la filière bois - papier - carton

Cette partie constitue une présentation sommaire de la filière, qui a fait l'objet d'un travail préalable de recherche et de rencontres avec des professionnels du secteur. Elle permettra de fournir quelques éléments utiles à la compréhension du modèle.

La sous-filière papier

Le papier-carton est considéré comme une sous-filière de la filière bois. Le terme généralement employé est papier, car le carton se distingue du papier uniquement par son grammage, c'est-à-dire au-delà de 224g/m². Cette sous-filière comprend la fabrication de pâte à papier à partir de bois ou de vieux papiers, la fabrication du papier dit « en l'état » et enfin les articles en papier et carton.



Le bois de trituration provient des bois d'éclaircies sous forme de rondins ou plaquettes, et des produits connexes des scieries (dosses, délignures). En 1996, le bois a constitué 51 % des approvisionnements de la première transformation, le reste se compose de fibres cellulosiques de récupération (vieux papiers recyclés), dont la part ne cesse de progresser (voir en annexe 1 les statistiques).
Le papier dit « en l'état » se présente sous forme de bobines ou coupé selon des dimensions adaptées à la dernière transformation. Il existe quatre grandes sortes de papier, les principales étant l'impression-écriture et les emballages, avec une production qui représente en 1996 respectivement 46 % et 45 % de la production totale de papier en tonnes.

Dans le modèle, le terme pâte à papier fera référence uniquement à la pâte de bois, c'est-à-dire fabriquée non pas à partir de vieux papiers mais de bois de trituration. Quant à la production de papier, seul le papier en l'état, issu de la deuxième transformation, a été considéré. Autrement dit, la troisième transformation n'a pas été prise en compte.

Production et consommation de papier

D'après la COPACEL (Confédération Française de l'Industrie des Papiers, Cartons et Celluloses), l'industrie des papiers-cartons comptait, en 1996, 110 entreprises et 141 usines, avec une capacité de production de 10 800 Kt (voir en annexes 2 et 3 la production par région papetière et leur localisation). Le taux de croissance annuel moyen de la production s'élève, entre 1986 et 1996, à 4 %. Quant à la consommation, son taux de croissance est évalué à 3 % sur le long terme. L'industrie française couvre ainsi actuellement environ 90 % de sa consommation. Cependant, près de la moitié est exportée, essentiellement à destination de l'Union Européenne avec qui elle effectue 85 % de ses échanges.

L'industrie papetière a beaucoup évolué au cours de ces quinze dernières années, avec de nombreuses fusions et acquisitions favorisées par des investissements unitaires croissants. Le coût de certaines machines dotées d'une capacité de production de 200 000 tonnes par an, peut atteindre 2,5 milliards de francs. Près de 40 % des entreprises françaises sont aujourd'hui sous le contrôle de grands groupes étrangers tels que Smurfit (Irlande), International Paper (Etats-Unis), UPM-Kymmene (Finlande), Cascades (Canada), Kimberly Clark (Etats-Unis)...
La taille moyenne des entreprises françaises reste cependant encore modeste face aux producteurs américains et scandinaves, laissant présager d'autres restructurations, dans cette industrie très capitalistique.
En outre, l'une des caractéristiques de l'industrie papetière française est l'absence d'intégration verticale en amont avec la fabrication de pâte et surtout l'exploitation forestière, et également en aval avec la transformation du papier en produit fini et la distribution.

Production et consommation de pâte à papier

Comme nous l'avons déjà précisé, le terme pâte à papier sous-entend exclusivement ici la fabrication de la pâte à partir de bois.

Le marché de la pâte à papier est un marché mondial cyclique, qui réagit vivement aux variations de la consommation, et aux problèmes de sur et sous-capacités de production au niveau mondial. Les stocks Norscan, constitués par la pâte nord-américaine et scandinave non vendue, constituent une référence. Dès qu'ils augmentent, en principe au-delà de 1,4 ou 1,5

millions de tonnes, les prix baissent, et inversement. Ces cycles sont amplifiés en raison des comportements spéculatifs à l'achat. Cependant, de temps à autres, la production est contrôlée dès lors que les producteurs se sont organisés en réduisant les taux d'utilisation de leurs unités de production, lorsque les prix ont beaucoup fléchi.
Le marché mondial de la pâte vit actuellement une surcapacité de production, qui a tendance à le désorganiser.

L'industrie des pâtes comprend actuellement en France 18 entreprises et 20 usines (voir en annexe 4 leur localisation). Trois d'entre elles produisent uniquement de la pâte marchande, c'est-à-dire destinée à être vendue aux usines de papeterie. Il s'agit de Tartas, Cellurhône et Pyrenecell, ainsi que Greenfield, située à Château-Thierry et bientôt exploitée, mais qui ne produira que de la pâte à partir de fibres cellulosiques de récupération. Les autres sont soit intégrées, soit partiellement intégrées, autrement dit tout ou partie de la pâte fabriquée est transformée en papier sur le même site.

En 1996, on a produit 2 500 Kt de pâte à papier et importé près de 2 000 Kt. Quant aux exportations, elles sont modestes, de l'ordre de 360 Kt. La pâte importée provient essentiellement d'Amérique du Nord et de Scandinavie, qui restent encore aujourd'hui les principaux producteurs malgré l'émergence de pays en développement situés notamment en Amérique du Sud (Brésil, Chili, Argentine) et en Asie du sud-est (tel l'Indonésie). Les importations s'effectuent essentiellement par voie maritime, la DTMPL (Direction des Transports Maritimes, des Ports et du Littoral) a fourni pour 1995 les chiffres suivants :
- La Rochelle 436 068 tonnes,
- Boulogne 349 463 tonnes,
- Rouen 247 199 tonnes,
- Sète 178 174 tonnes.

Ces quatre ports français, représentant 68 % des volumes importés en 1995, et Anvers sont les principaux ports d'importation de pâte en France.

La faiblesse relative de la production française est due aux approvisionnements en bois peu compétitifs, en raison des coûts d'exploitation (50 % du coût total). Ce qui peut paraître contradictoire dans un pays qui possède 15 millions d'hectares d'espaces boisés. Les arguments avancés sont souvent un morcellement de la forêt, caractérisée par un taux élevé de la propriété privée (70 % de la surface), et une seule forêt industrielle : les Landes, d'où une disparité des essences qui n'est pas favorable à la fabrication de pâte. Néanmoins, certaines de ces caractéristiques ne sont pas le seul fait de la France, et ces coûts d'exploitation élevés tiennent également à l'organisation des exploitants forestiers et de la filière amont.

2. Description du modèle

Le modèle est composé de 12 secteurs (voir en annexe 5 la représentation du modèle), qui sont reliés entre eux par l'intermédiaire d'une ou de plusieurs variables. Ils sont intitulés de la manière suivante :
- offre-demande pâte de bois,
- offre-demande papier,
- bois (offre, demande, coût),
- production petites et moyennes papeteries,
- production grandes papeteries,
- prix et coût papier,
- production pâte de bois intégrée,
- marché mondial pâte de bois,
- Modo Paper,
- Pyrenecell,
- Cellurhône,
- Tartas.

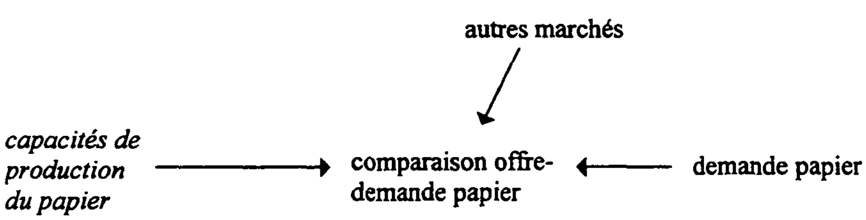
Modo Paper est une usine de pâte à papier partiellement intégrée, tandis que Pyrenecell, Cellurhône, et Tartas sont trois usines qui produisent exclusivement de la pâte marchande, comme nous avons pu le voir précédemment.

Ces secteurs qui forment en réalité un tout, vont être explicités de manière à en comprendre le fonctionnement et les relations importantes qu'ils comportent.

2.1 Les secteurs offre-demande pâte de bois et papier et le secteur bois

Le premier diagramme fait référence au secteur offre-demande papier et le second aux secteurs concernant la pâte à papier (offre-demande) et le bois de trituration (offre-demande, coût).

Les variables en italique signifient qu'elles proviennent d'un autre secteur.



secteur offre-demande papier

Ce secteur est composé de relations simples, néanmoins la variable issue de la comparaison de l'offre et de la demande est essentielle, car elle aura des incidences sur les décisions d'investissement des usines et sur les prix.
Nous pouvons noter également la présence d'une autre variable appelée « autres marchés » et sur laquelle nous pourrons jouer lors des divers scénarios. Elle permet d'ouvrir aux producteurs un marché qui ne serait pas limité à la dimension du marché français, tout en sachant que les échanges tant du point de vue des importations que des exportations sont déjà développés avec l'Union Européenne. Cependant, ces échanges ont tendance à se compenser ou à être actuellement déficitaires. Il n'est pas improbable d'imaginer des possibilités nouvelles d'exportation à destination de l'Europe de l'Est, dès lors que les producteurs sur le territoire français auront les moyens d'augmenter de manière conséquente leurs capacités de production. Cette région tout comme l'Asie possède un fort potentiel de croissance de la demande.

Par ailleurs, ce diagramme étant quelque peu simplifié, nous pouvons préciser que la demande de papier varie en fonction de la croissance estimée de la population française, ainsi qu'en fonction d'un taux de croissance annuel moyen qui est actuellement de l'ordre de 3 %. Ce taux tend à diminuer lorsque le marché parvient à maturité, avec une consommation « maximum » fixée à 330 Kg par personne. Cette valeur correspond à la consommation actuelle des Etats-Unis qui ne progresse plus que de très peu. On constatera ainsi que la consommation per capita atteinte au bout de 25 ans est de 289 Kg, alors qu'elle se situe actuellement à 160 Kg.

Secteur offre-demande pâte de bois

La demande de pâte est naturellement directement liée à la production de papier, qui est en quelque sorte le point de départ de ce secteur. Cependant, une partie de la production de la pâte étant intégrée, il faut considérer la demande de pâte marchande qui peut être satisfaite en partie par la production nationale, le reste étant importé.

Quant au recyclage des vieux papiers, leur utilisation croissante diminue d'autant la demande totale de pâte. Le taux d'utilisation des fibres cellulosiques de récupération passe ainsi sur 25 ans de 49 % à 58 %. L'évolution de son utilisation a été déterminée de manière arbitraire, car elle dépend des progrès techniques à venir, et du type de papier qui sera fabriqué. Le papier journal et les emballages utilisent notamment beaucoup de fibres recyclées. Quoiqu'il en soit la constatation actuelle est que la consommation de pâte de bois est sensiblement inférieure à celle du papier du fait du recyclage des vieux papiers.

Secteur bois

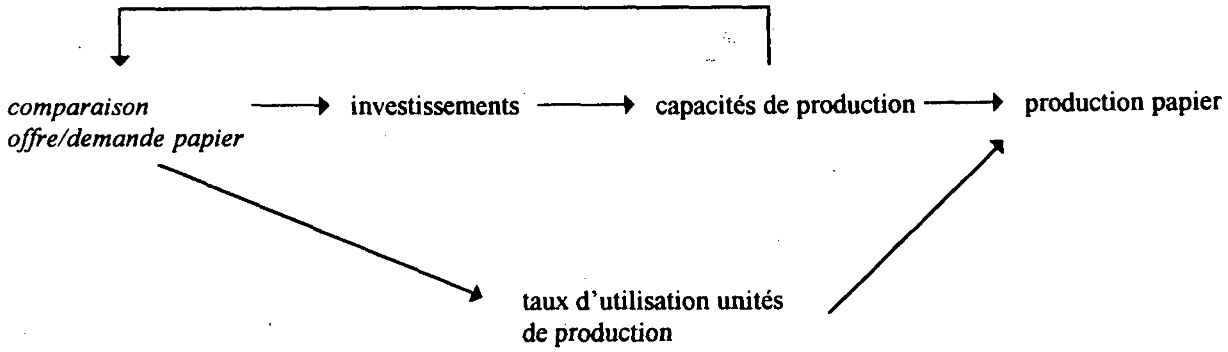
La production de pâte agit sur la demande de bois de trituration, qui est plus ou moins satisfaite par une offre constituée par les ressources de bois mobilisable. Ces ressources ont tendance à croître du fait des reboisements commencés en 1947, et devront continuer à progresser dans les quinze années à venir. Elles peuvent être également influencées par la variable « Massif Central », et sur laquelle on peut émettre des scénarios selon que l'on décide ou non d'y aménager des infrastructures en créant des chemins de desserte et des places de dépôt pour le bois. Ce massif constitue en effet un potentiel important en bois d'industrie, difficile à évaluer, mais peu exploité.

Quant au coût du bois, sa structure actuelle est la suivante : 50 % coûts d'exploitation, 35 % coût de transport, 15 % coût du bois sur pied. Les coûts d'exploitation feront l'objet de scénarios en fonction de l'aptitude des exploitants à réaliser des gains de productivité, actuellement indispensables pour l'industrie française de la pâte. Le coût du bois sur pied dépend naturellement de la demande en bois.

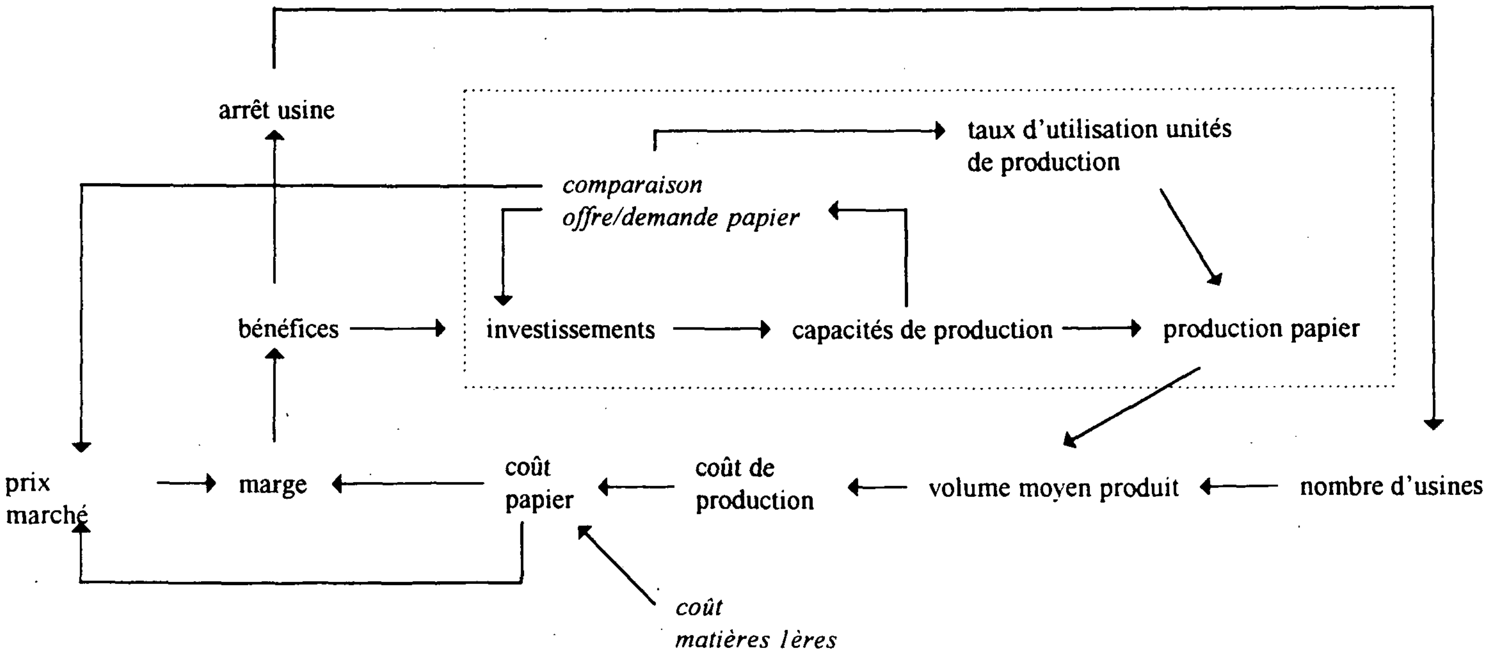
Enfin, le coût de transport est fonction de la distance moyenne à parcourir qui, elle-même, dépend du volume moyen de production des usines de pâte. En effet lorsque ce volume augmente, les distances moyennes croissent car l'importance des quantités nécessite souvent de s'approvisionner dans plusieurs massifs.

2.2 Les secteurs de production des papeteries et le secteur prix et coût papier

En 1996, on recensait 141 usines dans l'industrie des papiers-cartons, c'est-à-dire fabricant du papier « en l'état », et le transformant éventuellement après en produit fini. Parmi ces usines, nous avons distingué les petites et moyennes, des grandes en fonction de leur capacité de production. Leurs coûts de production, de même que leur capacité à investir ne sont pas comparables, et beaucoup de petites usines ne sont pas jugées aujourd'hui viables. Nous sommes partis du principe que 35 usines pouvaient être qualifiées de grandes avec des volumes annuels de production dépassant les 100 000 tonnes, et qu'elles étaient toutes considérées comme rentables. Bien que figurant dans deux secteurs distincts, les diagrammes suivants concernent aussi bien les petites et moyennes usines que les grandes, car leur principe est semblable.



Dans ce premier diagramme causal, nous retrouvons la comparaison offre-demande papier issue du secteur explicité précédemment. Si la demande est supérieure à l'offre, les usines auront tendance à investir afin d'accroître leur capacité de production, qui elle-même agira sur la comparaison offre-demande papier. Enfin, si l'offre est supérieure à la demande, les usines seront contraintes d'ajuster leur production à la consommation en diminuant leur taux d'utilisation. Ce diagramme s'intègre dans un second qui résume le fonctionnement global du secteur de production des papeteries associé au secteur prix et coût papier.

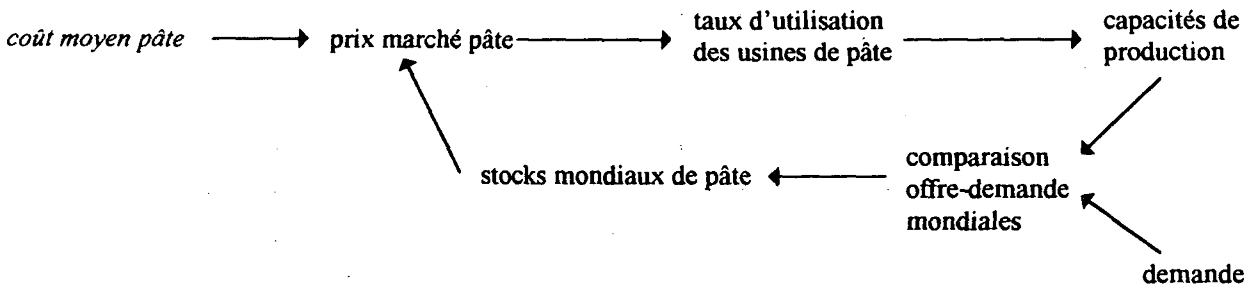


Le modèle fonctionne selon un raisonnement qui s'appuie sur une usine dont les caractéristiques sont des moyennes, d'où la distinction entre petites et grandes unités de production à l'aide de deux secteurs. Leurs coûts de production, bénéfices et capacités à investir diffèrent.
Par ailleurs, nous pouvons remarquer d'après le diagramme que la variation du volume de production entraîne une hausse ou baisse des coûts de production. Ces derniers agissent sur le prix du papier. Une usine qui réalise des gains de productivité aura tendance à diminuer ses prix à la vente, ou éventuellement à répercuter des hausses. Mais une autre variable, essentielle, agit sur le prix, il s'agit de la comparaison offre-demande : une surcapacité de production diminue les prix tandis qu'une hausse de la demande insatisfaite les augmente.

En outre, la variable appelée bénéfices peut être en fait négative lorsque l'usine réalise des pertes. C'est ainsi que des petites unités de production sont contraintes de fermer, diminuant leur nombre.

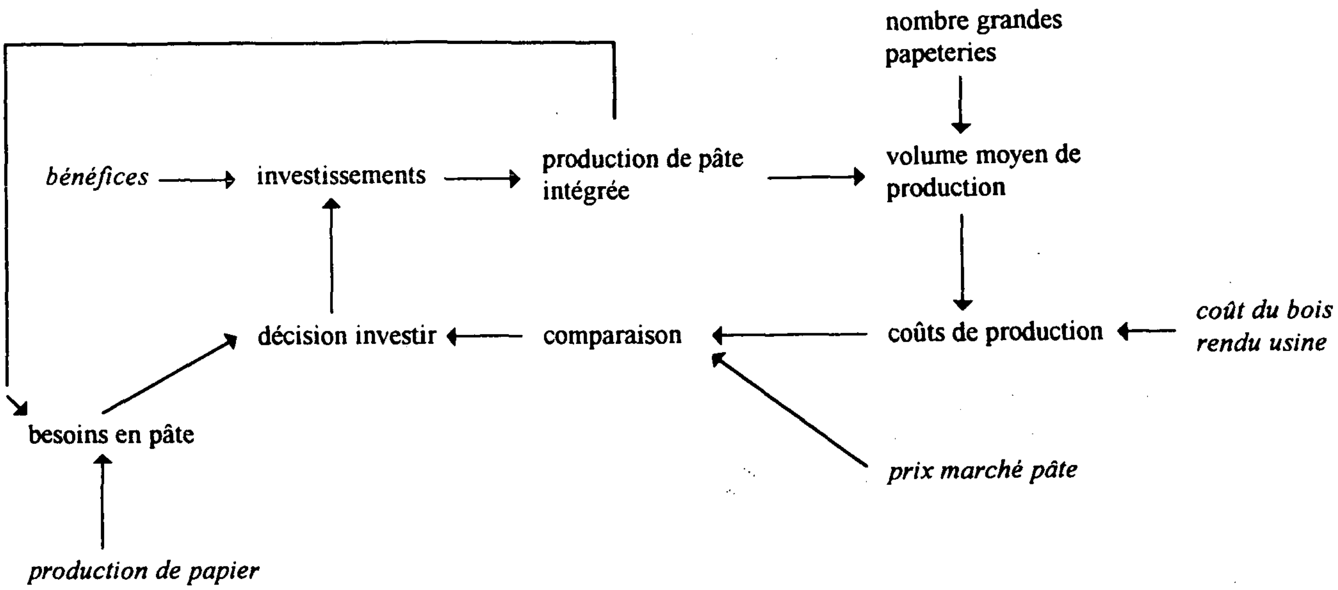
2.3 Le secteur marché mondial pâte de bois

Le diagramme suivant résume le principe du secteur, cependant il n'a pas été construit rigoureusement de cette manière car la comparaison offre-demande a été déterminée de sorte à obtenir une variable qui oscille entre une situation de surproduction et de demande insatisfaite, afin de représenter le caractère cyclique de ce marché. Cette inadéquation entre l'offre et la demande a été établie arbitrairement car elle n'est pas prévisible sur 25 ans. Nous sommes partis du principe que les capacités de production dépassaient la demande de pâte. Cet excédent de l'offre au niveau mondial correspond à la situation actuelle du marché.



Dès que les stocks mondiaux (Norscan) dépassent 1,4 ou 1,5 millions de tonnes, les prix baissent et entraînent à terme une diminution du taux d'utilisation des capacités de production. Quant au coût moyen de la pâte, il influence le prix du marché.

2.4 Le secteur production de pâte de bois intégrée

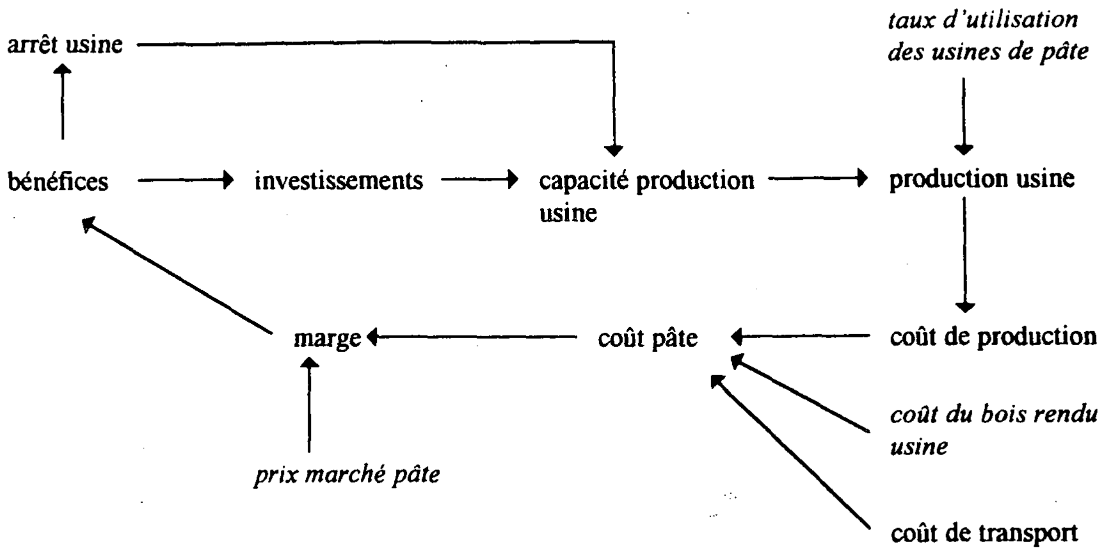


Nous sommes partis de l'hypothèse que seules les usines de grande taille pouvaient investir dans la fabrication de pâte, en raison du coût élevé des machines. Ces usines décident donc d'investir d'une part si leurs bénéfices le leur permettent et d'autre part en fonction de leurs besoins, et de la comparaison du prix du marché et de leur propre coût de revient de la pâte. Cette comparaison constitue une variable essentielle car en période haute des prix du marché de la pâte, les usines préféreront accroître leur production de pâte. Leurs bénéfices seront ainsi répartis entre une augmentation de capacité de la production de pâte et de papier.

Il est important de noter que la logique de fabrication de la pâte intégrée diffère de la pâte marchande. En effet, les usines de pâte, comme nous allons le voir dans le chapitre suivant, exploitent ou non leur pleine capacité de production en fonction du taux d'utilisation déterminé par le marché mondial de la pâte. En revanche, les papeteries fabriquent la pâte dont elles ont besoin c'est-à-dire en fonction de leur fabrication de papier, ou en fonction du taux d'utilisation de leur capacité de production de papier si leur capacité de production de pâte est égale à celle du papier.

Par ailleurs, le coût de la matière première des grandes papeteries dépendra à la fois du coût de la pâte intégrée (sans marge, ni coût de transport) et du prix de la pâte achetée selon les volumes consommés de chaque sorte. Tandis que les petites papeteries ne sont soumises qu'au prix du marché, les grandes doivent prendre en considération d'autres paramètres tels que le coût du bois rendu usine.

2.5 Les secteurs de production des usines de pâte



Le principe de ces secteurs est comparable à celui de la fabrication du papier.

Les usines 2, 3 et 4 se distinguent uniquement par leur capacité de production, tandis que l'usine 1 possède une particularité supplémentaire. Elle est considérée comme une usine de pâte marchande, bien qu'elle approvisionne sur le même site une papeterie du même groupe. Elle est donc en fait partiellement intégrée et possède une capacité de production supérieure aux autres usines, de l'ordre de 300 000 tonnes par an. Celle-ci produit donc en partie de la pâte marchande et en partie de la pâte intégrée, la répartition est effectuée selon le volume de production de la papeterie, qui évolue de la même manière que celui des grandes papeteries. Nous devons noter également que sa production de pâte, tout comme celle des grandes papeteries, ne dépend pas du taux d'utilisation des unités de production de pâte. Elle produit en effet pour sa propre consommation et vend le reste, même en cas de surcapacité du marché, au risque de provoquer une nouvelle baisse des prix. Les usines de pâte intégrée ou partiellement intégrée préfèrent généralement produire à 100 % de leur capacité, c'est-à-dire vendre éventuellement à bas prix leur surplus, alors que les usines de pâte marchande cherchent à vendre à bon prix, donc à éviter une baisse trop importante des prix par une offre excédentaire. Autrement dit, leurs intérêts divergent.

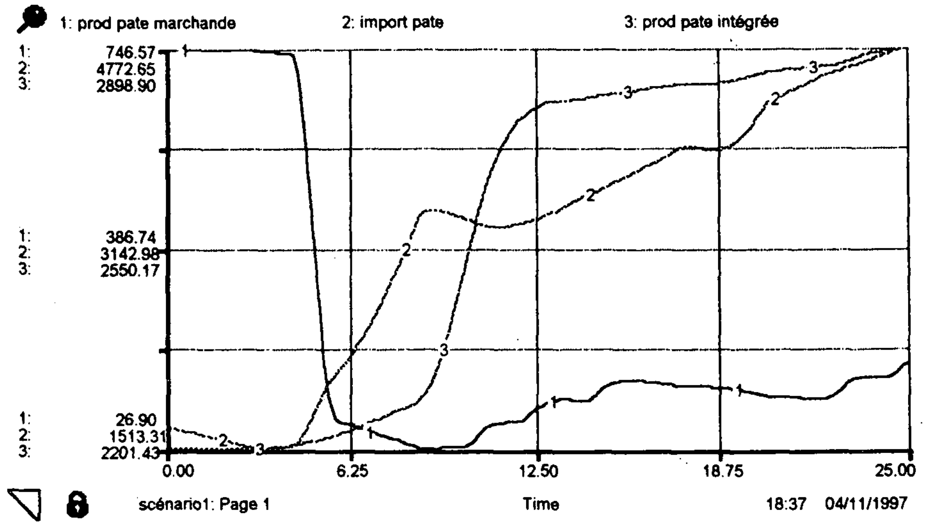
3. Quelques scénarios

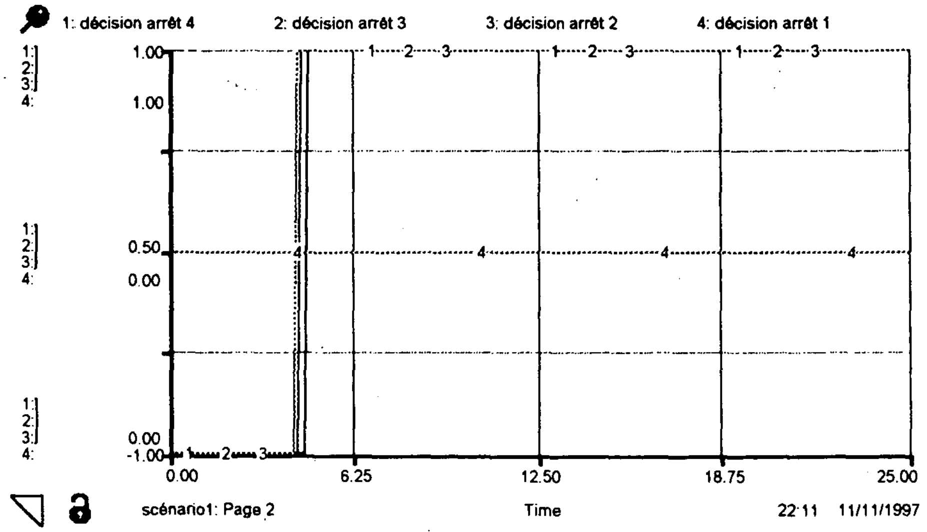
Toutes les simulations sont réalisées sur une durée de 25 ans. L'évolution de chaque variable peut être visualisée sous forme de graphe ou de table. L'utilisateur peut envisager d'autres scénarios que ceux présentés « en jouant » sur les variables.

3.1 Premier scénario

Dans ce premier scénario, on suppose qu'aucun gain de productivité ne permet de réduire les coûts d'exploitation du bois (organisation des exploitants forestiers et en amont de la filière, formation des bûcherons...).

Production et consommation de pâte



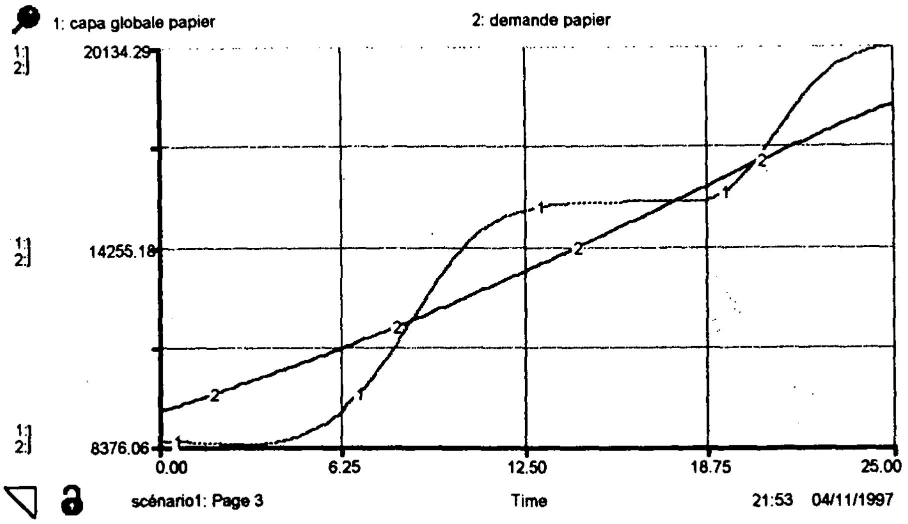


Sur le premier graphe, nous pouvons observer une chute de la production de pâte marchande, qui correspond, comme nous pouvons le voir sur le second graphe, à la fermeture des trois usines de pâte marchande (la décision de fermer prend la valeur 1). Seule l'usine 1, qui produit également de la pâte non marchande, ne ferme pas.

Quant à la production de pâte intégrée, elle progresse dans des proportions telles que la production nationale n'évolue quasiment pas sur 25 ans. En effet, la chute de la production marchande est en quelque sorte compensée par la production intégrée. En conséquence, la croissance de la consommation de pâte est satisfaite par une augmentation des importations.

Nous allons expliquer ces diverses évolutions à la lumière des graphes suivants.

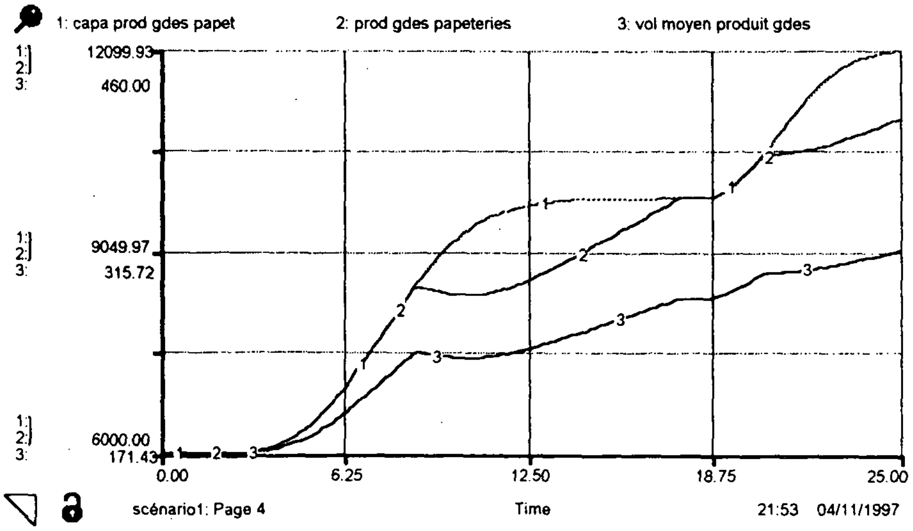
Production et consommation de papier

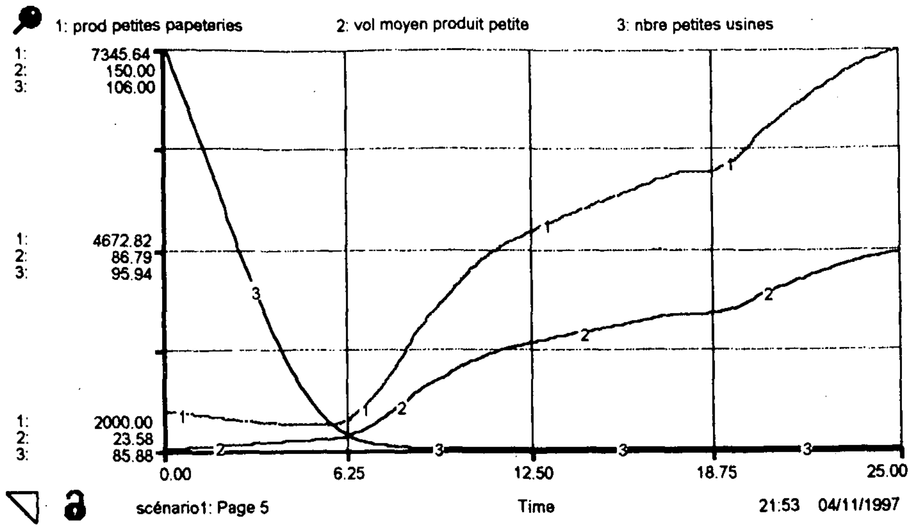


La variable capacité globale papier correspond à la capacité française de production de papier, qui regroupe toutes les usines. On observe dans un premier temps qu'elle est insuffisante pour satisfaire la demande, et qu'elle a même tendance à décroître légèrement. Nous verrons que cette baisse correspond à la fermeture de petites usines. Les investissements croissent ensuite rapidement entraînant un fort taux de croissance de la production jusqu'à dépasser même la demande. Dans une dizaine d'années, la France serait donc en mesure de couvrir sa demande.

Cette situation de surproduction entraîne un ralentissement des investissements et les capacités de production cessent de progresser pour retourner à une situation de quasi sous-production, les investissements repartent alors...

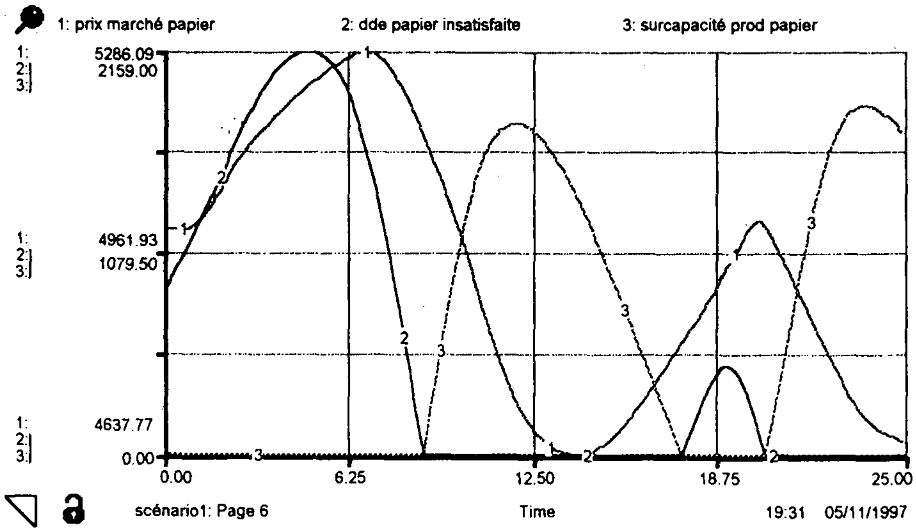
Les capacités de production tendent à s'ajuster à la demande, mais il ne faut pas oublier que les décisions d'investissements se réalisent en général au même moment et peuvent créer ainsi par la suite une situation de surproduction. D'autant plus qu'il faut attendre 2 à 3 ans pour qu'un investissement puisse produire son plein effet.





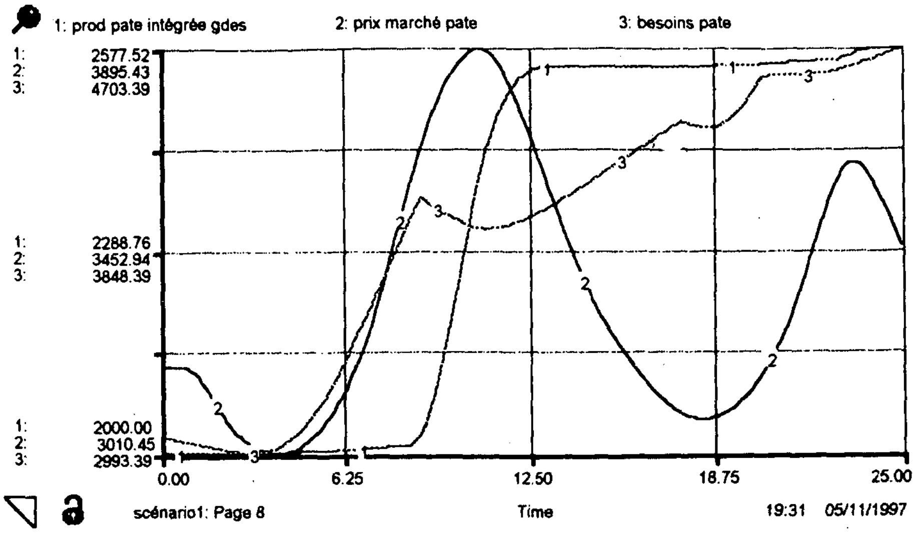
Sur le graphe 4, les situations de surcapacité sont évidentes : la production des grandes papeteries montre que les capacités ne sont pas utilisées à 100 % à deux reprises. Cette baisse du taux d'utilisation doit par ailleurs entraîner une hausse des coûts de production.
En outre, on remarque que leur volume moyen de production passe sur 25 ans de 171 000 tonnes à 316 000 tonnes par an. Ce volume moyen de production suit naturellement les tendances de la production, et sa hausse permet de réduire les coûts de production.

Sur le graphe 5, le nombre des petites (et moyennes) usines diminue pendant une dizaine d'années : une vingtaine d'usines sont contraintes de fermer. Il s'agit en principe des plus petites dont les coûts de production sont également les plus élevés. Ceci explique une baisse de la production dans un premier temps. Quant aux autres usines, rentables, elles investissent à l'image des grandes papeteries. Leur volume moyen de production passe de 24 000 tonnes à 86 000 tonnes, tout en sachant que cette progression est due en partie aux investissements et en partie aux usines, de moindre tonnage, qui ont cessé leur activité.



Ce graphe permet de voir que le prix du papier dépend essentiellement de la comparaison offre-demande papier, son évolution correspond en effet à celle-ci (demande de papier insatisfaite ou surcapacité), avec toutefois un temps de retard.
En principe, le coût du papier agit également sur le prix, mais il ne constitue pas une variable essentielle.

Production de pâte intégrée

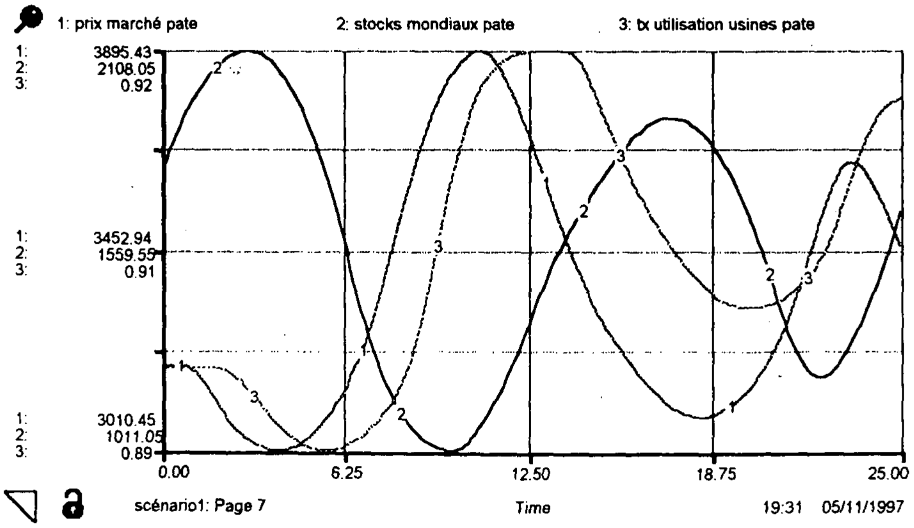


Comme nous l'avions précisé lors de la description du modèle, nous sommes partis du principe que seules les grandes papeteries pouvaient prendre la décision de fabriquer de la pâte, en raison du coût élevé de l'investissement.

Elles peuvent réaliser cet investissement à partir du moment où leurs bénéfices le leur permettent. C'est donc en fonction d'une part de leurs besoins en pâte et d'autre part de la comparaison du coût de fabrication de la pâte intégrée avec le prix du marché que l'investissement s'effectuera. On peut observer sur ce graphe que c'est dans une période haute du prix de la pâte, c'est-à-dire lorsqu'on se retrouve en situation de sous-capacité au niveau mondial, que la production de pâte intégrée augmente fortement.

Nous devons noter, par ailleurs, que l'évolution des besoins en pâte suit naturellement l'évolution de la production de papier vue précédemment.

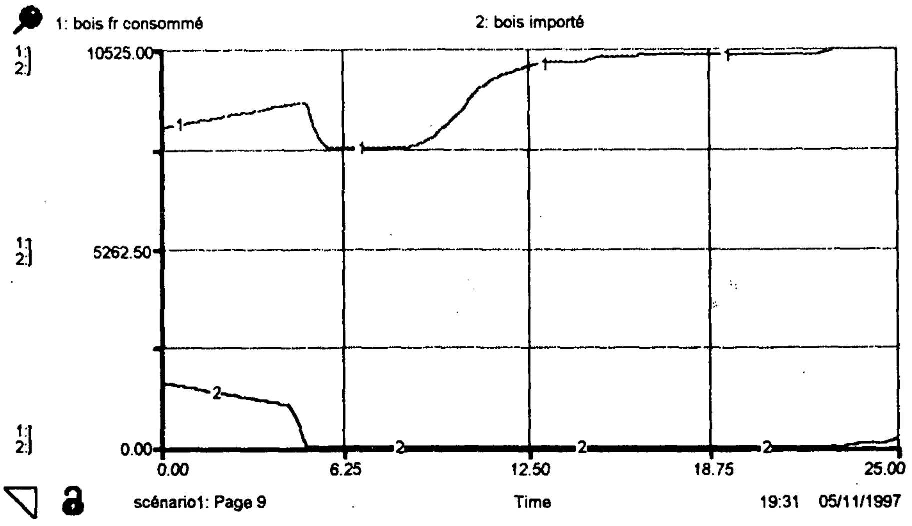
Le graphe suivant montre de quelle manière le prix de la pâte varie.



Nous ne devons pas oublier qu'il s'agit avant tout d'un marché mondial. Les variations des stocks mondiaux ont été déterminés de manière arbitraire, ils correspondent aux situations cycliques de sur et sous-capacités de production que l'on retrouve au niveau mondial (tout en sachant que nous sommes actuellement dans une période de surcapacité). Cette situation de départ, difficile, augmente la fragilité des usines de pâte marchande.

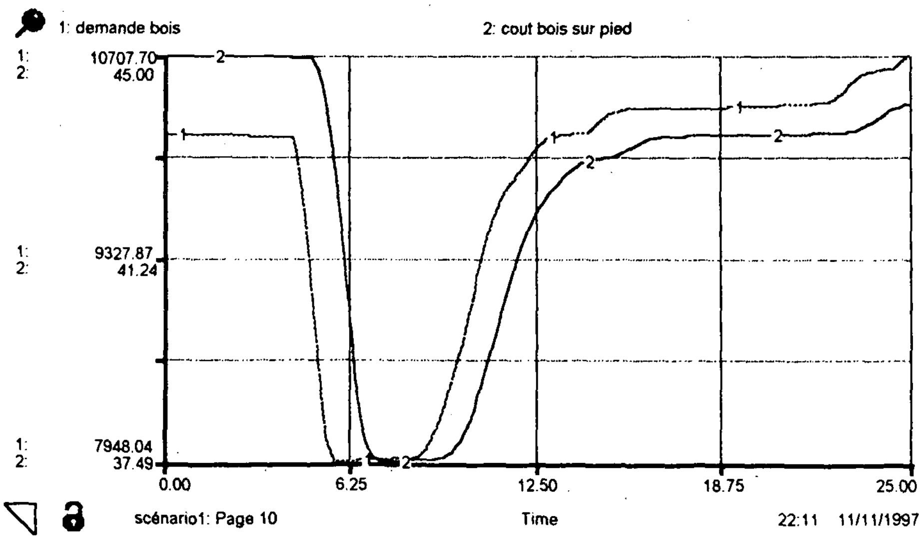
On peut observer sur le graphe que les prix suivent l'évolution de ces stocks avec un temps de retard. De même, les taux d'utilisation suivent l'évolution des prix mais également après un délai qui correspond en quelque sorte à un temps d'adaptation.

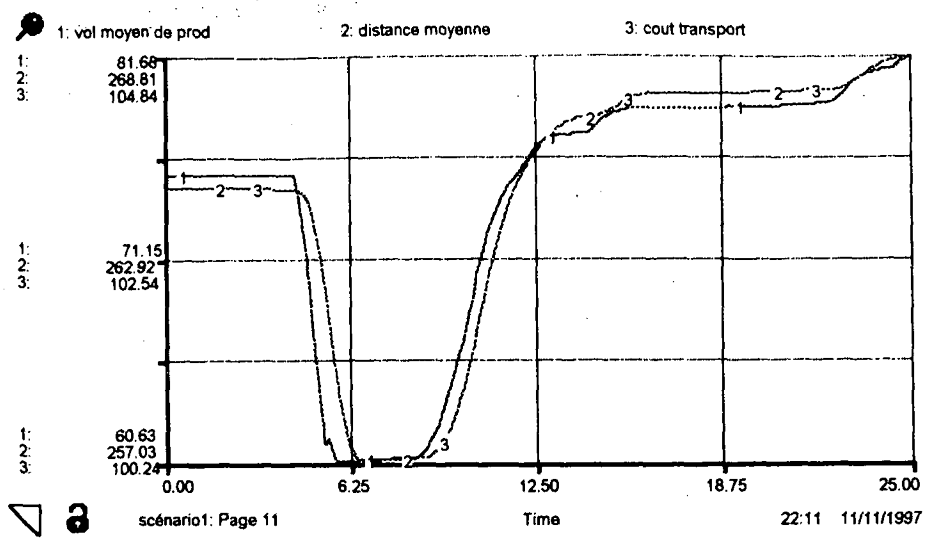
Quantité de bois disponible, demande et coûts



Dans la première partie de ce graphe, la quantité de bois français a tendance à augmenter au détriment des importations. Il s'agit en fait des quantités supplémentaires mises sur le marché du fait des reboisements.
La chute, relative, de la consommation de bois correspond à la fermeture des trois usines de pâte. Enfin, elle progresse à nouveau en raison de la fabrication de pâte intégrée.

Tandis que les coûts d'exploitation du bois dépendent des gains de productivité (sur lesquels portent les deux scénarios) que peuvent réaliser les exploitants forestiers, les autres coûts résultent de l'évolution de la production de pâte à papier comme l'indiquent les deux graphes suivants.





Le coût du bois sur pied varie selon la demande de bois, avec toujours un temps de retard. Quant au coût de transport, il est fonction de la distance qui tend à augmenter lorsque les volumes moyens de production progressent, car les usines ont généralement besoin de s'approvisionner en partie dans des massifs plus éloignés.

Bilan du scénario

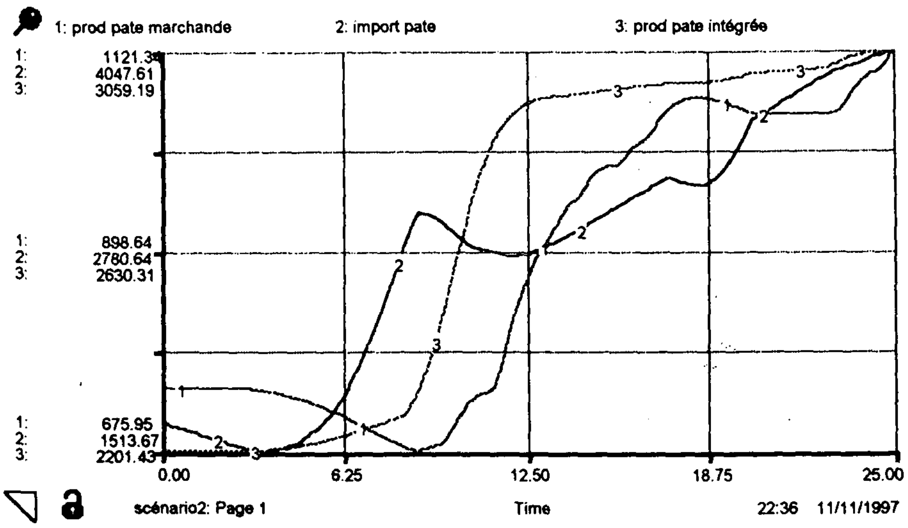
Ce scénario montre que la production de pâte (et donc de bois de trituration) ne suit pas l'évolution de la production de papier, et laisse présager une forte croissance des importations. Un port tel que La Rochelle pourrait, comme ses dirigeants le souhaitent, se développer pour approvisionner aussi bien la région ouest que la région Rhône-Alpes. Actuellement près de 70 % des importations proviennent de quatre ports (La Rochelle, Boulogne, Rouen et Sète). De plus, la fermeture des trois usines de pâte marchande élimine les flux existants en provenance de ces usines et à destination des régions papetières. Autrement dit, les flux de pâte à papier devraient changer tant du point de vue géographique que des volumes.

Quant au bois, l'évolution des flux reste stable au niveau des volumes puisque la production nationale de pâte ne progresse quasiment pas. En revanche, leur évolution d'un point de vue géographique sera différente. Car les quantités, actuellement à destination des trois usines de pâte marchande, seraient reportées sur les régions papetières. Or les trois usines auxquelles nous faisons référence ne se situent pas dans les principales régions papetières.

3.2 Deuxième scénario

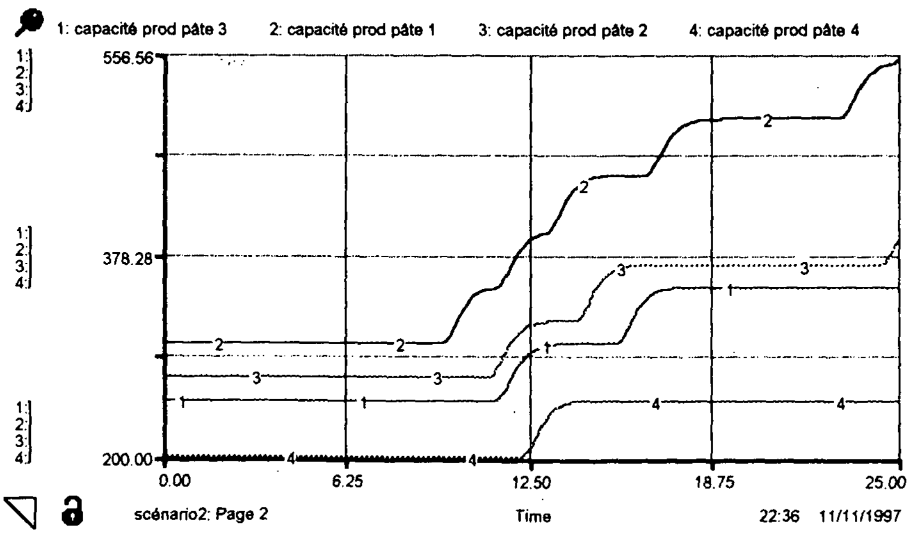
L'hypothèse des gains de productivité change par rapport au premier scénario, et permet une baisse substantielle des coûts d'exploitation du bois, de l'ordre de 20 % sur 5 ans.

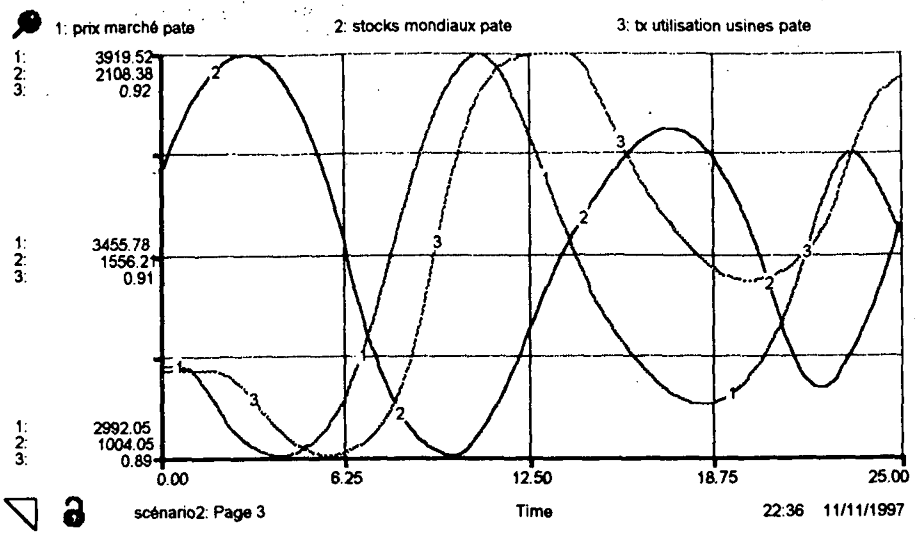
Production et consommation de pâte



Nous pouvons observer immédiatement que la production de pâte marchande ne chute pas, mais progresse jusqu'à doubler quasiment en 25 ans. Les importations de pâte demeurent cependant importantes, puisqu'elles atteignent 4 millions de tonnes, bien que diminuées par la production de pâte marchande.

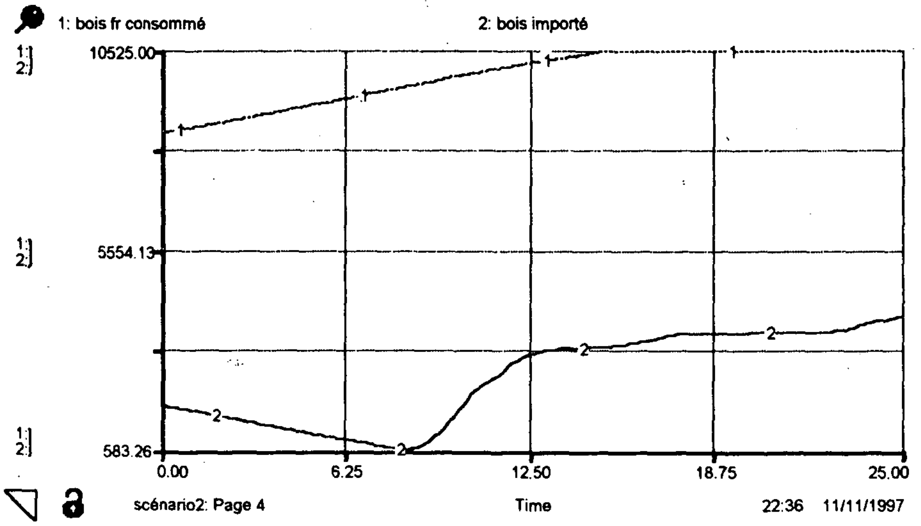
Quant à la production de pâte intégrée, elle n'a pratiquement pas évolué par rapport au premier scénario. Ces investissements dépendent, en effet, essentiellement de la situation mondiale du marché de la pâte.

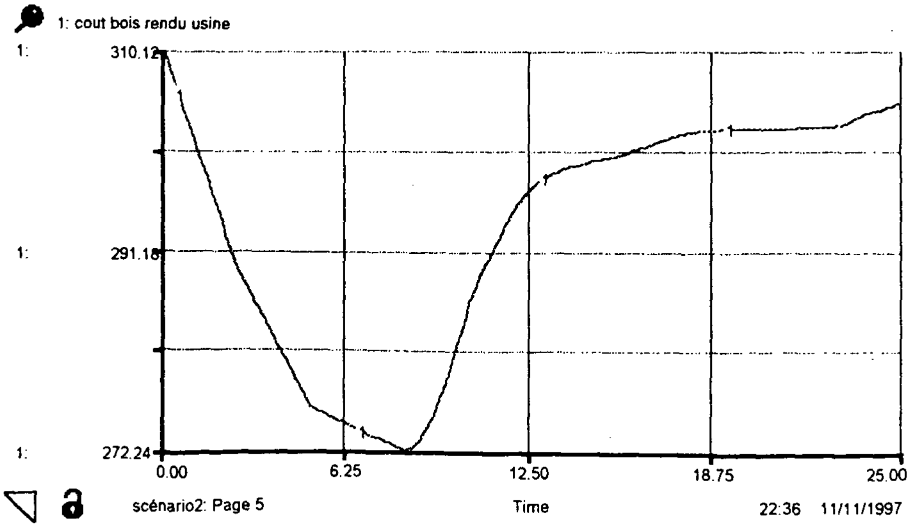




Le graphe 2 nous montre que toutes les usines de pâte investissent, et augmentent ainsi leurs capacités de production. Les trois usines de pâte marchande sont en mesure d'investir après que le marché de la pâte leur soit redevenu favorable. La baisse des coûts d'exploitation était néanmoins indispensable pour éviter d'une part que les usines ne ferment et d'autre part pour qu'elles soient en mesure de réaliser par la suite des investissements.

Demande de bois et coût





Cette production supplémentaire de pâte exige d'importer du bois. On remarque sur le graphe 5 que le coût du bois rendu usine diminue rapidement grâce aux coûts d'exploitation puis augmente en raison du coût du bois sur pied et du coût de transport. Cependant, les usines de pâte marchande ont diminué leurs coûts de production en augmentant leurs capacités grâce à la baisse des coûts d'exploitation. Elles sont ainsi en mesure de supporter cette hausse, à laquelle elles concourent en accroissant la demande de bois et leur volume moyen de production.

Bilan du scénario

Une baisse des coûts d'exploitation du bois est aujourd'hui indispensable à l'industrie de la pâte marchande, car leur avenir dépend de la compétitivité de leurs approvisionnements. En outre, nous pouvons noter que dans ces deux scénarios jamais la production de pâte à papier n'évolue dans les mêmes proportions que celle du papier, en raison de paramètres inhérents à la filière.

Dans ce scénario, les flux de bois augmentent par rapport au premier scénario et ne peuvent se répartir de la même manière du fait de leur origine (bois français ou bois importé) et de leur destination (usines de pâte marchande ou régions papetières). Il en est de même de la pâte à papier, puisque les importations diminuent au profit d'une production nationale..

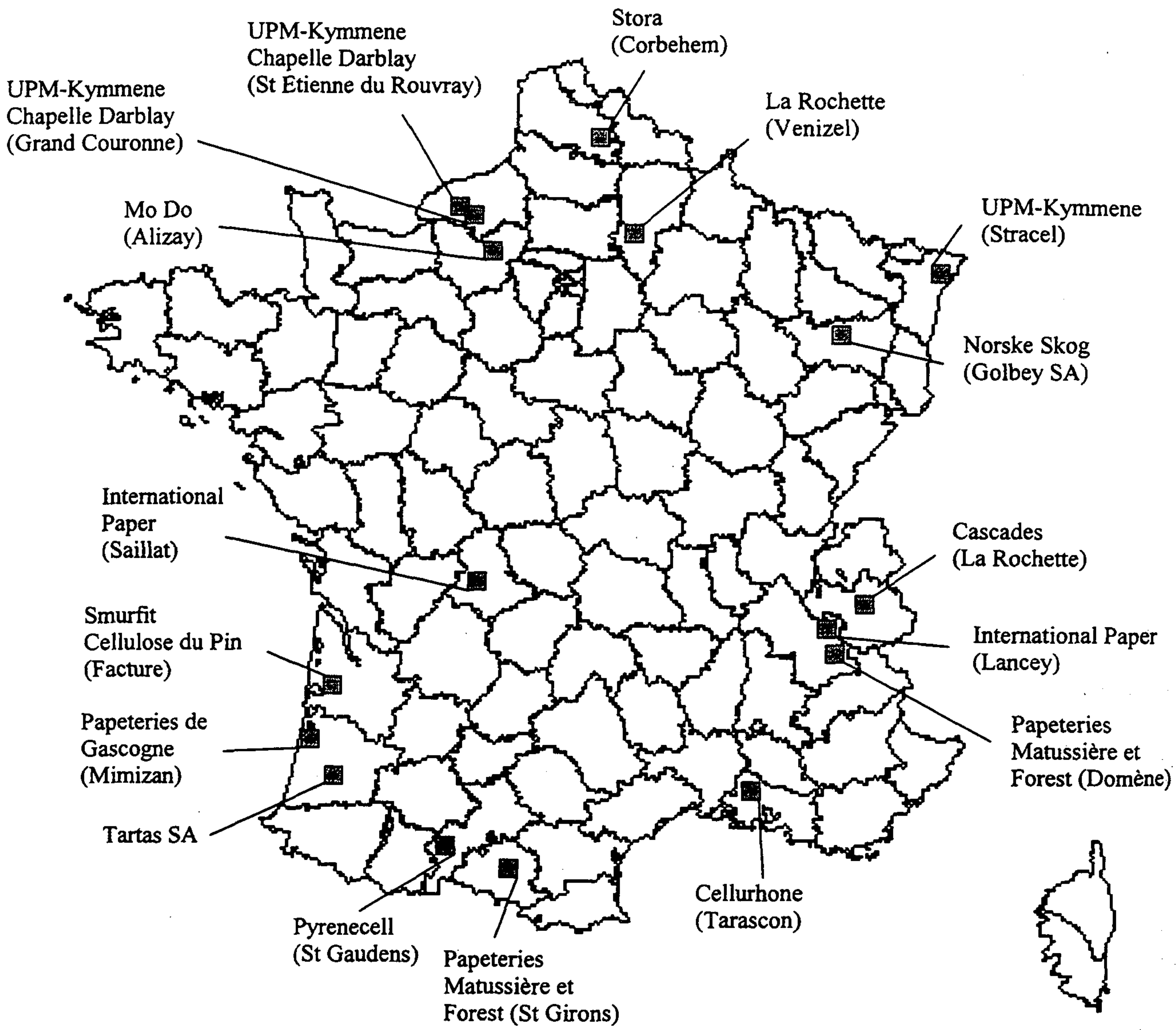
Ce travail de modélisation ne permet pas de tirer plus d'éléments sur l'évolution des flux d'un point de vue géographique. Mais il pourrait être une porte ouverture sur un travail complémentaire portant sur une dimension spatiale. Pour cela, une étude sur les perspectives d'évolution des diverses régions papetières doit être menée, en considérant les potentialités des usines situées dans ces mêmes régions, autrement dit une analyse micro-économique est indispensable. Selon les divers scénarios, on pourra ensuite tenter de répartir les volumes de bois entre les massifs forestiers et les usines, la pâte à papier entre les ports d'importation ou les usines de pâte et les régions papetières... peut-être de la manière la plus efficace possible.
Ce type de travail est tout à fait envisageable et réalisable, et peut offrir une approche différente de la modélisation à moyen terme.

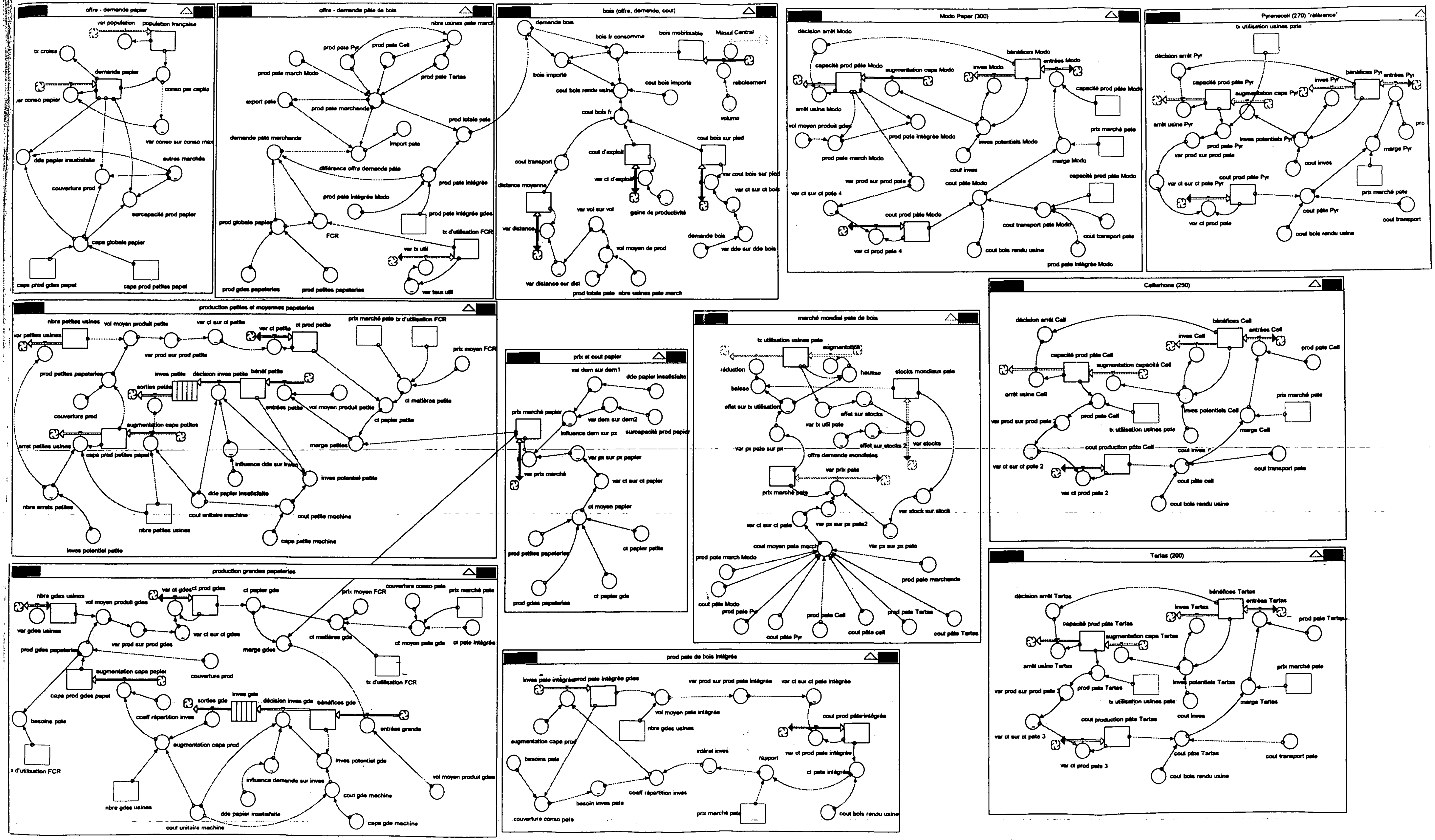
CONCLUSION

Les scénarios proposés dans ce rapport ne constituent que quelques exemples. L'utilisateur peut envisager de nouveaux scénarios « en jouant » sur les variables.

Ce travail de modélisation ne permet pas de tirer plus d'éléments sur l'évolution des flux d'un point de vue géographique. Mais il pourrait être une porte ouverture sur un travail complémentaire portant sur une dimension spatiale. Pour cela, une étude sur les perspectives d'évolution des diverses régions papetières doit être menée, en considérant les potentialités des usines situées dans ces mêmes régions, autrement dit une analyse micro-économique est indispensable. Selon les divers scénarios, on pourra ensuite tenter de répartir les volumes de bois entre les massifs forestiers et les usines, la pâte à papier entre les ports d'importation ou les usines de pâte et les régions papetières... peut-être de la manière la plus efficace possible.
Ce type de travail est tout à fait envisageable et réalisable, et peut offrir une approche différente sur la modélisation à moyen terme.

LOCALISATION DES USINES DE PATES A PAPIER




offre - demande papier
offre - demande pâte de bois
bois (offre, demande, cout)
Modo Paper (300)
Pyrenecell (270) "référence"
production petites et moyennes papeteries
prix et cout papier
marché mondial pate de bois
Cellurhone (250)
Tartas (200)
production grandes papeteries
prod pate de bois intégrée