SHIPPERS' MODE CHOICES AND LOGISTIC CONSTRAINTS

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ABSTRACT

Modal approach is a recurring topic in literature. The supply approach is useful to understand technical specificities and economic characteristics of different modes and to emphasize competition and complementarities.
Our approach is somewhat different. Our investigation is driven by the following postulate that the type of products to transport and the economic characteristics of a mode are not sufficient to explain mechanisms of modal choice. Indeed, they result from stakeholders' choice. Stakeholders opt for a mode according to transported good, but also according to economic constraints of production. Data from a national survey on freight transport ("ECHO Survey") carried out in 2004 among 3,000 French establishments are particularly geared to deal with the demand-supply interactions.
Environmental concerns are becoming increasingly important in transportation practices. Thus what is the real potential of "sustainable" modes? Modal choice will be analysed from two points of view: the first one, differences in the hierarchy of criteria modal choice and the second one, the real possibilities of shift between modes and conditions.
Indeed, we see that production constraints are not the same according to what mode of transportation is used. The integration of the production system is increased and transport takes part in it. This suggests that there is a concerted process to choose how transport shipments involve shippers and their different economic partners. It is shown that the forms of modal choice are an indication of the involvement of economic actors.
The main lessons about modal practices of shippers are firstly, that the possibilities of shift are scarce and secondly, that these shifts are mainly internal to road. Consequently, the potentialities of "sustainable" modes (rail, waterway, sea) are low. The survey reveals an important inertia of modal choice thus demonstrating that the technical and economic characteristics of modes are not the only factor that would explain the modal split.

Keywords: Freight, Mode choice, Transport demand, Production systems

INTRODUCTION

Modal split is a central question in transport policy. It has become even more important due to environmental and energy concerns surrounding transportation, and especially road transport, which is considered to be the most polluting mode. In 2006, transportation accounted for 31.5% of European Union's (EU-27) final energy consumption in tonnes of oil equivalent. Road transportation is responsible for 82% of this figure. Within road transport, freight transport is responsible for 39.4%. Thus, this particular mode is responsible for 10.2% of final energy consumption (Eurostat, 2009). Current data show that this figure is growing despite falling unit consumption. On one hand, freight traffic continues to grow (+35% in tonne-kilometres between 1995 and 2006, for all modes in EU-27). On the other hand, the share of road shipping has increased from 42% to 46%. This mode's dominance is particularly evident if we consider only the land modes, i.e. road, rail, and inland waterway. Within land modes, road transport was used for 77% of freight in 2006 and 72% in 1995.

These figures explain why public authorities have placed so much emphasis on the development of alternative modes. In 2001, modal shift was already a political priority in European White paper on transport policy for 2010 (European commission, 2001). The initiatives that followed generally targeted transport supply with actions such as trans-European transport schemes, subsidies for intermodal services, or progressive liberalization and harmonization of competition. Halfway through this period, the White paper was revised to insist on a more general concept: decoupling the positive effects of mobility from its negative environmental effects (European commission, 2006). Modal shift was increasingly addressed in terms of co-modality. The intent was to reconcile economic growth and sustainable development objectives by encouraging the optimal use of all modes, whether separately or in combination. This concept is controversial, as it seems to weaken the modal shift objectives, but new measures continue the effort to promote rail. Sea and waterway shipping are also stressed, as is the intelligent pricing of freight infrastructures and logistic activities.

Despite strong political will, these measures have yielded mixed results. Road traffic is constantly growing in both absolute and relative terms. This article will examine the failure to achieve modal shift by going to the source of transport activities: transport demand. Our reasoning begins with two basic postulates. First, each mode of transport has its own market segment, whose specific characteristics make mode substitution difficult. Second, transport demand is a fundamentally derived demand. Changes in production systems, which are structural, lead to significant changes in transport demand, and consequently affect mode share. Thus, action that only affects transport supply is insufficient.

These two postulates are not original in and of themselves. In the literature (Quinet et Vickerman, 2004; Blauwens et alii, 2002; Winston 1983, 1985; Allen, 1977) transport and mode share are certainly analysed from the supply side, but also increasingly from the demand perspective, as we will see later in this article. Mode choices are not only based on a simple correspondence between the nature of products to be transported and the economic characteristics of a mode. These choices are situated further upstream, at the

interface between the production system and the transport system. It is necessary to better understand this production system, the constraints it imposes, and how it has changed to ensure the effectiveness of measures promoting modal shift and alternative modes. There is much in the literature dealing with the aspect of transport demand (Baumol, Vinod, 1970; Swenseth et al., 1990; Colin et al., 1983; Savy, 1986; Tyworth, 1991; Burmeister, 2000; Woodburn, 2003).

To understand the link between transport demand and logistics constraints, we will use the results of a French shipper survey carried out by the Transport Ministry and the INRETS in 2004 (Guilbault, 2008). The objective of this survey (called ECHO) was to explain shippers' transport practices by comparing the industrial and logistic characteristics of shippers, the physical, economic, and spatial characteristics of their shipments, and the transport chains through which these shipments pass. This survey involved 3,000 shippers with 10 or more employees in the manufacturing, wholesale, and warehousing sectors. The general term "shipper" designates economic agents who have goods to transport, and which are at the origin of the demand for transport. These agents can be entire firms, establishments, or even individuals. The observation level used in the survey is the "establishment", defined as one single geographic site of a firm. The choice of the establishment allows us to discern better the origins and destinations of transport flows, and analyse the decision process in a more precise level.

Variables related to the shipper include its overall characteristics, economic environment (clients, service providers), conditions of production, and declared transport and logistics choices. For each surveyed shipper, a sample of three recent shipments was selected for complete tracing from departure to arrival at their final destination. Shipment variables include those that are typically considered to affect transport choices (weight, value, and distance), but also "logistic" properties (e.g. time constraints, frequency, or type of recipient). Shipment tracing allows us to reconstruct two chains: the physical chain composed of a series of modes and paths, and the organisational chain of stakeholders. Around 10,000 shipments and transport chains were studied and reconstructed in this way, up to the borders of the old 15-member European Union.

This survey presents a wealth of information related to mode choice. In our first section we study decision making processes, determining at which level they are made and under what conditions they may contribute to shipment and mode choice optimisation, from a sustainable development perspective. Second, we will characterize the supply of transport, and the differences and similarities in the hierarchy of criteria that shippers used to explain their freight mode choices. The third section examines the true latitude of shippers in mode choice decisions. We will demonstrate that shipments with certain characteristics are "captive" to a given mode, and that mode choice policies show a certain inertia. Opportunities for modal shift in the near to medium term are few. This final point is then discussed in terms of economic and logistic structural changes, which impose constraints on shippers. There are strong trends toward spatial and temporal fragmentation of freight flows, and the resultant low shipment weight favours road transport. This helps to explain why less and less shippers even occasionally use alternative modes.

1. DECISION PROCESSES AND MODE CHOICE

Decision processes are among the factors that influence mode choice. There is a great difference between decisions made by the shipper alone, more general strategies involving the shipper's parent firm or group, and logistic plans worked out with the recipient or designed by a third-party logistics provider. These three different levels of cooperation do not yield the same results in terms of mode choice, nor the same opportunities for employing heavier shipments and alternative modes. In the ECHO survey, shippers were questioned about both their shipments and the various potential stakeholders in the shipping decision process: the shipper itself, its parent firm or group in the general sense (financial or economic), and third-party service providers or shipment recipients. This survey provides information confirming that integrated decision processes are important for both arranging more substantial shipments and permitting the use of modes other than road shipping. However, it also shows that the necessary level of integration is still far from being achieved, and that decision-making remains very atomized, with most decisions being made by the shipper alone.

1.1 The atomization of decision making

Changes in production systems have affected decision processes in several ways. Large, highly integrated, hierarchical businesses have given way to structures where production processes are more fragmented. The number of small and medium enterprises is growing, and very small businesses are also common: out of 2.9 million businesses in France in 2007, 93.3% are small businesses with less than 10 employees, while only 0.1% of businesses have more than 500 employees[1]. On the other hand, businesses are increasingly interconnected. New cluster-type organisations composed of small businesses, service providers, or subcontractors are developing alongside large multinational or network-type firms with integrated subsidiaries and supply chain functions. Financial interconnectedness is also common. A retrospective analysis done by the French National Statistics Office (Chabanas, 2002) reveals a major increase in the number of groups and subsidiaries, but it also shows that most of this growth is among micro-groups with less than 500 employees, a fact which is relatively little-known. Advances in information and communication technologies (ICT) have also played a major role in these new types of organization, promoting decentralized coordination.

These changes are typical of an increasingly fragmented, yet coordinated and interdependent economy (Soppé, Guilbault 2009), and one might suppose that transport decisions are also subject to greater coordination. However, what was actually observed in this survey is an "atomization" of the decision process. The shipper most often makes these decisions alone, rather then involving its parent firm or other partners. Here, the coordination effect has been overpowered by fragmentation of the productive fabric. The shipper participates in freight transport mode choice for 87% of shipments. The shipper's parent firm or group was mentioned for only 6% of shipments, and the recipient for 7%. Third parties,

[1] Statistics from the French National Statistics Office (INSEE) not including agricultural and financial businesses.

such as freight brokers and logistics providers have only a marginal role (1%) in this decision, despite growing freight outsourcing in recent years. Moreover, mode choice decisions are often made individually: coordination between multiple decision makers took place for only 1% of shipments.

1.2 Conditions and stakes of decision structuring

1.2.1 Decision level and shipment weight

The greater involvement of partners in mode choice decisions for heavier shipments supports the hypothesis that more structured decision-making (where the shipper cooperates with other partners) can help optimize transport. When expressed in tonnage rather than number of shipments, participation by shippers' partners in transport mode choice is more significant, and happens for around one third of tonnes shipped: the group participates for 11% of tonnes, and the recipient for 22%. Transport service providers participate for only 1% of tonnes - their role is just as minimal as before.

Thus, the rates of involvement presented throughout this article will be expressed in terms of tonnage, in order to better reveal participation in decision making by shippers' partners. The individual rates are calculated for each given partner as the percentage of tonnes for which the partner is mentioned as having participated in mode choice while the total "rate of external involvement" will refer to the share of these tonnes for which at least one of the shipper's partners (firm or group, recipient, transport service provider) participated in the decision. The "rate of coordination" refers to the share of tonnage or shipments for which at least two actors (shipper and/or external partners) participated. These cases of coordination explain why totals presented by category of stakeholder may exceed 100%. These last two indicators (rate of involvement and rate of coordination) allow us to determine the level of "decision structuring", which is considered to be higher when these indicators are higher.

We see in the Figure 1 that firm/group and recipient rates of involvement increase with shipment weight. In sum, the overall rate of external involvement rises from 10% of tonnage for shipments of less than 300kg to 62% for shipments over 30 tonnes, while cases of coordination between the establishment and/or its partners become more frequent, rising from 1% to 15% of tonnage. The strategic nature of much heavier shipments explains this higher level of coordination. But we suggest that the causality can be seen as bidirectional, with more integrated decision processes also favouring heavier or more consolidated shipments.

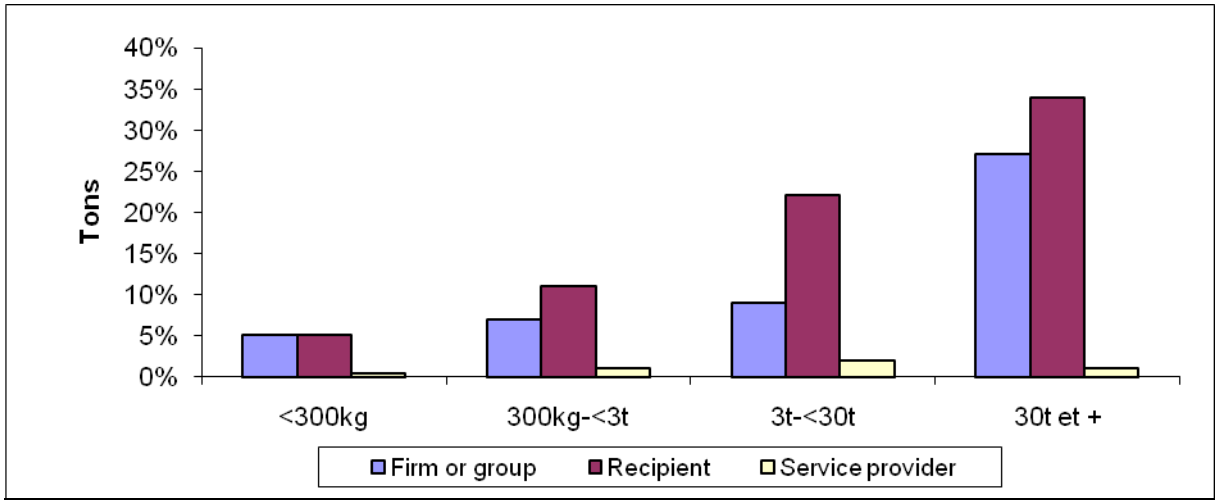

Figure 1 - Weight of shipments and rates of external partner involvement (% of tonnage). ECHO survey 2004, © INRETS

1.2.2 Decision level and shipper type

The level of decision structuring appears to vary greatly by economic sector, showing no real distinct trends. However, the size of the shipping establishment is a determining factor, and clearly has different effects on the participation of different partners (Figure 2). In particular, parent firm or group participation grows with the size of the shipper, showing that larger companies have more integrated transport and logistics policy. On the other hand, recipient participation decreases with the shipper size, as the shipper's (or its group's) traffic structuring is already sufficient.

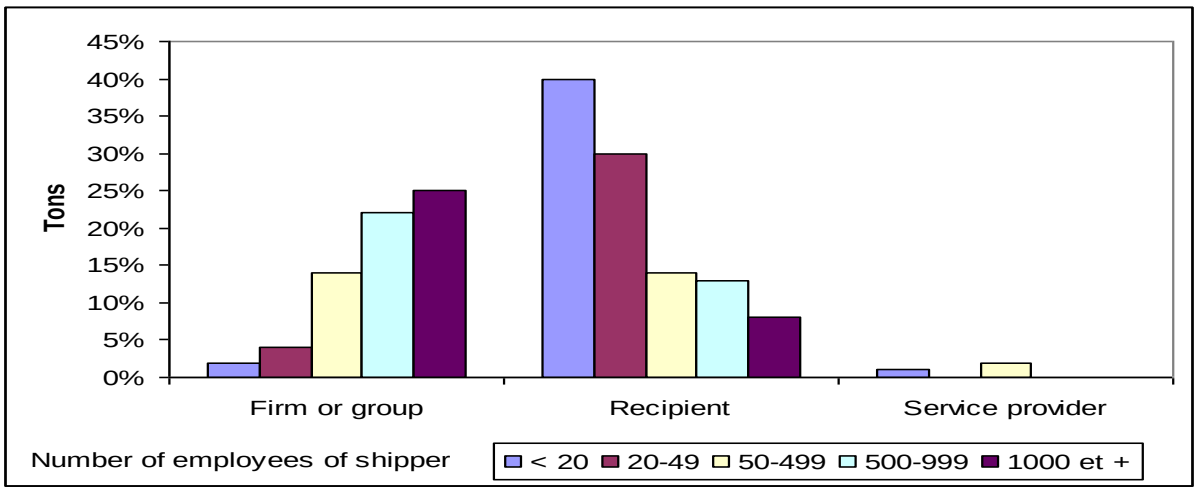

Figure 2 - Size of shipping establishment and involvement rate for external partners (% of tonnage). ECHO survey 2004, © INRETS

If we instead consider the recipient establishment's size, we find that as recipient size grows so does its participation, as well as that of the shipper's firm/group, whose involvement appears to increase when it is dealing with more strategic partners. Different-sized shippers maintain different relationships and balances of power with their various partners, and also

have different opportunities related to their traffic volume. The annual tonnage between a given shipper/recipient pair also appears to strongly structure the decision.

1.2.3 Decision level and chosen freight transport mode

Finally, in order to illustrate the importance of decision structuring we shall describe the relationship between the level of coordination in decision-making and the transport mode that is chosen. We find that road shipping (both own-account and third-party) is most often chosen by the shipper alone. This is in stark contrast with other modes, for which the rates of external involvement and coordination are much higher (Figure 3). The overall involvement of partners rises from 41% of tonnage for third-party road transport (4% for own-account) to 59% for rail, 76% for combined rail-road, and 79% for inland waterway transport. Examples of coordination are almost inexistent for road transport and very low for waterway shipping, but reach 12% of tonnage for combined rail/road transport and 21% for rail. This involvement is again mostly by the recipient or the shipper's firm/group. The share of service provider participation is a bit more significant, but only for the combined rail/road mode (5% of tonnage).

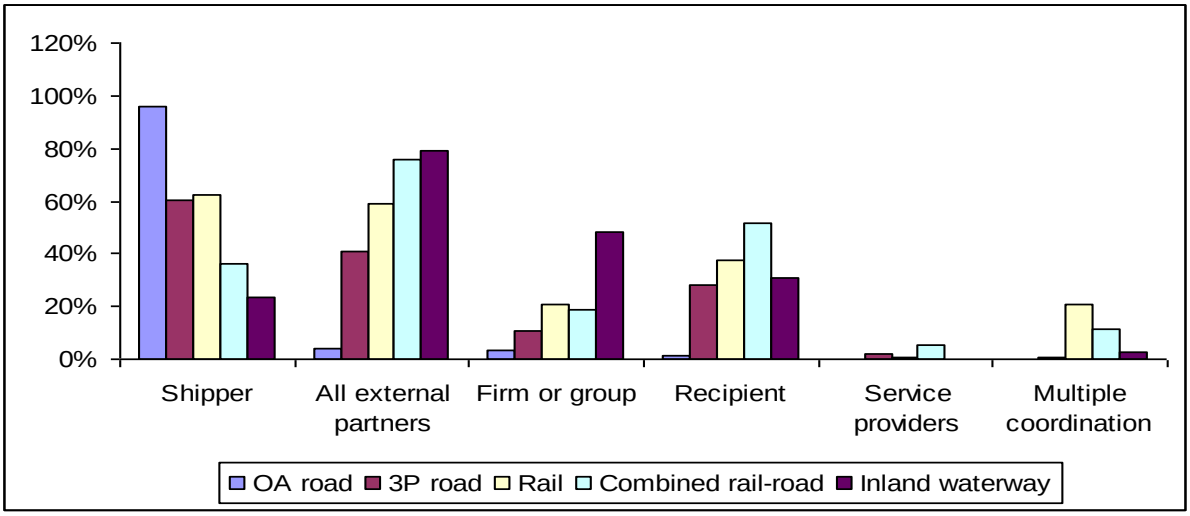

Figure 3 - Transport mode and partner involvement rate (% of tonnage). ECHO survey 2004, © INRETS

Thus, participation by shippers' partners in decision processes is seen to be one of the conditions favouring more massive shipments and the use of multimodal shipping or alternative shipping modes. However, such decision structures are uncommon, occurring for 16% of shipments and 34% of tonnage on average. They continue to be characteristic of large organizations that send high-tonnage shipper/recipient links. Involvement of service providers in decision-making is particularly weak, and is only significant in certain market segments such as combined rail/road transport or export shipments outside Europe. However, unlike other partners, third-party providers participate for rather lightweight shipments. This observation cannot necessarily be extrapolated to other countries. For example, similar exploratory surveys carried out on export shipments in France and the Netherlands show that Dutch shippers delegate upstream transport organization to professionals much more than their French counterparts (Tardieu, 1999).

2. TRANSPORT SUPPLY AND MODE CHOICE CRITERIA

The question of mode choice is of course related to the attractiveness of different transport options, based on their economic and technical specificities (Quandt and Baumol, 1966; Gray 1982). The market is segmented such that different modes can be in competition yet complementary (Niérat, 1997; Bernadet 1997). In this section, we will examine mode choice decisions for the shipments studied in the ECHO survey through criteria cited by the shippers. For reasons related to questionnaire design, we will present the land mode decision criteria separately from those for sea and air shipping. This distinction is justified by the fact the latter modes are often part of more complex intercontinental logistic chains, and cover much longer distances.

2.1 Land modes: the position of road and rail shipping

Table 1 presents the hierarchy of criteria that was obtained for shippers' land mode choices. The first two columns concern all land modes (road, rail, combined rail-road and inland waterway) and are based on a sample of 8,800 shipments. For each of the criteria proposed in the questionnaire, these columns give the percentage of shipments and tonnage for which the shippers stated the criterion had a significant role in mode choice. Total percentages may exceed 100%, as several criteria could be specified for each shipment. Considering the dominant role of road shipping (97% of shipments and 87% of tonnage), these results essentially reflect the choices associated with this mode. The last two columns separately present the results for rail and combined rail/road shipping, with only percentages in terms of number of shipments. They are based on the observation of 135 shipments for rail and 137 shipments for combined rail-road. Because of the low number of waterway shipments (70 shipments), the results for this mode are not presented.

Table 1 - Mode choice criteria for land modes

	All land modes		Rail	Combined Rail-Road
	% shipments where mentioned	% tonnage where mentioned	% shipments where mentioned	% shipments where mentioned
Cost of transport	60	52	82	88
Reliability of shipping times	47	33	9	51
Shipping duration	35	28	59	52
Network accessibility	34	32	22	9
Flexibility	21	25	4	54
Schedules	20	14	52	4
Frequencies offered	18	9	4	5
Safety of goods	14	10	10	44
Door-to-door service	13	14	9	22
Quality of commercial contacts	12	10	4	11
Safety of transport	7	10	9	35
Supply of auxiliary logistic services	4	3	1	1
Legal constraints	3	2	3	< 0,5
Availability of transport equipment before shipment	3	6	4	2
Clarity of services offered	3	2	< 0,5	2
Carrier provides specialized equipment	2	10	7	2
Environmental concerns	1	2	2	6
Management of own-account fleet	6	10	-	-

Source: ECHO survey 2004, © INRETS

The preferences revealed in this table can be grouped into four general categories. The first is the economic criterion of transport cost, which remains the most common determining factor, cited for 60% of shipments and 52% of tonnage. These percentages are even higher for the two rail modes, with price being mentioned for up to 88% of combined rail/road shipments. Cost, and therefore pricing policy, is thus an essential way to promote modal shift.

The second category includes the temporal criteria which reflect the fact that shippers must integrate freight transport into their systems of production under competitive conditions. The reliability of shipping times is particularly important in a system where mastering flow synchronisation and connecting distant production phases has become necessary to avoid costly production standstills. This criterion comes in second place (mentioned for 47% of shipments). Though transport duration is also important to ensure rapid response to demand, it comes in third, at 35% of shipments. Flexibility, schedules, and frequencies are also

solutions to temporal constraints, with each being mentioned at a rate of around 20%. An examination of these time criteria for the rail and combined rail/road modes shows that the duration of transport is not always a disadvantage. This criterion is the second or the third: mentioned for 59% of shipments for the rail, and 52% for the rail/road. Reliability and flexibility seem also to be recognized as advantages of combined rail/road transport when this mode is used (mentioned for 50% of shipments). Nevertheless, schedules and frequencies are rarely mentioned (less than 5%) and can be seen as inadequate for this mode. In the case of rail, schedules seem better adapted (cited for 52% of shipments) while the other temporal quality of service elements work against this mode, particularly the reliability of shipping times (9% of mentions versus 47% for all modes and 51% for combined rail/road), flexibility (4% versus 21% and 54%) and frequencies, a handicap shared by rail and combined rail/road (4% versus 18% and 5%).

Network access is a unique criterion, and forms a separate third category. It is mentioned as a factor in mode choice for one third of land-mode shipments, and also for one third of tonnage. Geographic network coverage must be taken into account when analyzing responses for the rail and combined rail/road modes. Network access is already rarely mentioned for rail (22% versus 34% for all modes), as the network has shrunk over the last few years due to freight station closings. This criterion is even less present for combined rail/road, whose network is still not widespread (9% of mentions). A 1999 French survey of 600 shippers in the Nord Pas-de-Calais region showed that for 28% of them, the major combined rail-road transport axes were geographically irrelevant for all of their shipping needs, and for an additional 13% of establishments the share of their traffic that could be shipped by this mode was too small to consider using it (Guilbault, Piozin and Rizet, 2000). In the 2004 ECHO study (which covers all of France) shippers were not asked this specific question, but we note that for 34% of the surveyed shipments transporters or freight organizers stated that they had no access to combined shipping services.

The final category includes the other heterogeneous criteria that were mentioned for less than 14% of land mode shipments or tonnage. Among these, some are rarely mentioned for road shipping, but are considered more important for rail. This is the case for goods safety and general transport safety, as well as door-to-door service, all of which stand out in favour of the combined rail/road mode (safety mentioned for 44% and 35% of combined shipments versus 14% and 7% for all land modes, door-to-door service 22% versus 13%). Environmental concerns are rarely mentioned (1% of shipments for all land modes), though they are a major target of transport policy and an increasingly publicised element of business policy. They are somewhat more present for combined rail/road (6% of mentions). These shipper criteria give a generally favourable image of combined rail/road, with its principal shortcomings being network density and schedule or frequency. Among other factors that are rarely mentioned but sometimes make a difference, we note that rail shipping benefits from carriers providing specialised equipment (7% of mentions for rail versus 2% for all modes).

2.2 Choice criteria for air and sea shipping

The air and sea modes are quite distinct from the land modes, due to their often international scope and specific cargo characteristics, particularly in terms of weight and value: small high-value shipments for air, and high-tonnage, low-value shipments for sea. These specificities can also be seen in the next mode choice criteria hierarchy. It is organized by primary mode, but shippers took the entire transport chain into account, including primary mode, pre- and post modes, and ports or airports. Table 2 gives the percentage of shipments for which each criterion was mentioned, for these two modes and for road shipping.

Table 2 - Choice criteria for air, sea, and road modes (% of shipments where mentioned)

Choice criteria	% air shipments where mentioned	% sea shipments where mentioned	% road shipments where mentioned
Cost of transport	59	87	60
Reliability of shipping times	54	36	47
Shipping duration	61	42	35
Flexibility	14	8	21
Schedules	27	8	20
Frequencies offered	10	19	18
Safety of goods	28	7	14
Door-to-door service	21	12	13
Quality of commercial contacts	12	14	12
Safety of transport	32	13	7
Supply of auxiliary logistic services	< 0,5	1	4
Availability of transport equipment before shipment	< 0,5	6	3
Clarity of services offered	2	3	3
Carrier provides specialized equipment	< 0,5	< 0,5	2

Source: ECHO survey 2004, © INRETS

2.2.1 The air mode: both time and cost are important

Air transport's hierarchy of criteria reveals the importance accorded to time. The duration of transport is the most important criterion (61% of mentions) whereas the reliability of shipping times also appears more often than for the other modes (54%). This is coherent with the air mode's characteristics: it is rapid and well adapted to long distances, and times can be guaranteed more easily than with other modes. These criteria are particularly important for high-value products and perishable goods, which account for a large share of air freight traffic. This explains also why transport and goods safety criteria are more important for air transport than for other modes, while the complexity of the air-based chains explains the importance given to door-to-door service.

However, cost of transport is still an important criterion, and comes in second position (mentioned in 59% of cases), just behind duration of transport. This result may seem surprising, as this mode has a reputation for being expensive. Here we see that economic cost is always an essential concern for businesses, but this cost is perceived relative to the value of the products being shipped, as well as the distances covered. When confronted with obstacles that are difficult to cross or pass around (oceans, mountains) air transport can still be competitive, at least relative to road transport. Finally, air freight is subject to a certain rigidity, as evidenced by the fact that frequency and flexibility are considered to be less important.

2.2.2. The sea mode: the importance of cost, and the uniqueness of short-sea and container traffic

For sea modes, cost is once again the most important criterion, and is mentioned just as often as for rail or combined rail/road transport (87%). Time-based criteria seem to be less important than for air freight, especially timing reliability, as it is difficult to exactly predict the arrival of a boat to the nearest day or half-day. However, these figures vary depending on the type of maritime traffic. When traffic is categorized into *short-sea* and *deep-sea*,[2] we find that the duration and time reliability criteria are more important for short-sea. While these criteria are still mentioned less often than for air freight, they are cited more frequently than for road shipping (Tables 2 and 3).

Like air freight, the sea modes are relatively rigid: flexibility is mentioned at a rate of 8% for sea, but 21% for road shipments. Again, there are nuances when we consider the nature of the traffic, separating it into containerized and non-containerized (Table 3). Flexibility and frequency are important criteria for containerized traffic, mentioned at a rate comparable to that for road shipping. Again, the complexity of containerized supply chains favours door-to-door transport service, as for air freight.

[2] According the definition from the European Commission, short sea refers here to the maritime transport between ports situated in geographical Europe or between those ports and ports situated in non European countries having a coastline on the enclosed seas bordering Europe. Deep-sea refers to the maritime transport between European ports and ports of non European countries without seafront on an inland sea bordering Europe.

Table 3 - Mode choice criteria for sea supply chains, by shipment characteristics (% of shipments where mentioned)

	Destination		Treatment	
Mode choice criteria	Short sea	Deep sea	Container	Other
Cost of transport	81	89	93	81
Reliability of shipping times	49	30	29	41
Shipping duration	52	30	55	31
Network accessibility	8	9	18	1
Flexibility	15	3	5	10
Schedules	16	23	34	7
Frequencies offered	10	6	14	2
Safety of goods	5	18	24	2
Door-to-door service	21	11	19	10
Quality of commercial contacts	8	17	26	2
Safety of transport	<0,5	1	2	0
Supply of auxiliary logistic services	14	1	1	10
Availability of transport equipment before shipment	<0,5	5	6	<0,5
Carrier provides specialized equipment	<0,5	1	1	<0,5

Source: ECHO survey 2004, © INRETS

3. TRANSPORT DEMAND AND SHIPPERS' TRUE LATITUDE

The difficulties encountered by modal shift policies can be explained in part by the non-substitutability of transport modes. The configuration of networks and their technical and economic characteristics (port capacity, commercial speed, etc.) imply specific market segments and explain the "marginality" of competition, which rarely happens except "at the edges of each mode's area of intervention"[3] (Bernadet, 1997). In the ECHO survey, this point is illustrated by shippers' responses about which alternative modes they could envisage using for the surveyed shipments. Most often, they state that there is no alternative. However, this "captivity" is asymmetrical, and is primarily observed for road shipments. We obtain a similar result when looking at the long term, asking senders about "significant mode changes" in their general freight operations that have occurred in the past. We find that modal shifts are rare, and again are often in the direction of road shipping.

This inertia can also be explained by the characteristics of transport demand. The physical and economic characteristics of shipments largely predetermine the available mode choices, and these characteristics are themselves constrained by changes in production systems. The fragmentation of firms and the productive fabric (discussed above in the context of atomised decision making), as well the emergence of just-in-time logistics, have spatially and temporally fragmented flows. This implies progressively smaller and lighter shipments, which are not conducive to changes in mode. In this final section, we will demonstrate the effect of

[3] Translation done by the authors

these changes on freight transport and the interest of situating reflection on transport demand further upstream.

3.1 A perceived absence of modal alternatives

After being questioned about mode choice criteria for the studied shipments, shippers were next asked to specify which mode they would have chosen if their first choice was not available. This question was only asked for land-mode shipments, and the possible responses included all modes: own-account road, third-party road, rail, combined rail/road, inland waterway, sea, and air, with the possibility to state that no alternative mode was acceptable. The responses, which are summarized in Table 4, thus reflect the shippers' perception of the relative competitive position of these modes. This notion of "perception" is important here, because these responses are subjective and based on the shippers' (incomplete) knowledge and appreciation of each mode and network. They were expressed in terms of existing surveyed shipments, so the shippers did not necessarily consider upstream reorganization that might allow them to use another mode more easily.

Notwithstanding these remarks, we observe that road shipments are quite "captive", when compared to all other non-road alternatives. Alternatives to road shipping remain the exception, and are only considered by shippers for 2% of their road-based shipments (column 2 in Table 4). In 77% of cases they consider that there is no alternative, and for 22% there is indeed an alternative, but it is road-based: usually a switch from own-account to third-party road shipping.[4]

This modal "captivity" is also observed for waterway and rail shipments (columns 6 and 4 in Table 4) but is less pronounced: shippers consider there to be no alternative in 57% and 58% of cases. The counterexample is combined rail/road transport, which is almost always considered to have an acceptable substitute (column 5 in Table 4). In all of these cases, the transfer is essentially toward the road, which is mentioned for 39% of rail shipments, 98% of combined rail/road shipments, and 43% of waterway shipments. Thus, we observe an asymmetry in the relationship between road shipping and other modes, which unfortunately acts in the direction opposite that of sustainable development objectives. Road freight transport has almost no non-road alternative, but can on the contrary serve as a substitute for the non-road modes. The possibility for transfer among non-road land modes also seems extremely limited, again revealing specific market segments associated with given shipment characteristics.

[4] For more information on the different choice criteria between own-account and third-party road shipping, see: Cruz, Guilbault, Gouvernal, 2008

Table 4 - Alternative modes declared by senders (% of shipments where mentioned)

	Own-account or third-party road		Alternative modes, rail, combined rail/road, or waterway	Rail	Combined rail/road	Inland water-way
Road (own-account or third-party)	22%		67%	39%	98%	43%
Rail	2%	<1%	-		-	-
Combined rail-road		<1%	1%	3%		-
Inland waterway		<1%	<1%	<1%	-	
Air		<1%	<1%	-	<1%	-
Sea		-	-	-	-	-
No alternative	77%		31%	58%	1%	57%
Total	100		100	100	100	100

-: no observation. Source: ECHO survey 2004, © Inrets

3.2 Mode choice inertia

In the same survey, the preceding analysis is complemented by questions on "significant changes" in mode that shippers might have made over the previous five years. These significant changes, which we will designate in the following section by the shorter term "jumps", are strategic business decisions as opposed to punctual mode changes like those imagined in the previous section. The results show that these modal jumps are rare. Only 3.4% of the shippers in the study had gone through this kind of mode change, or around 500 establishments per year. Here, we observe that modal practices have strong inertia. If we consider modal jumps of this kind to be an essential individual contribution to general modal shift, we find that this is at best a long-term possibility.

Figures 4 and 5 nevertheless allow us to identify a few trends among the observed jumps, and their positive or negative direction. Figure 4 indicates the jump frequency for each mode, calculated as total number of positive and negative jumps (*i.e.* toward or away from this mode), and expressed relative to the total number of jumps for all modes. They are also expressed as a percentage of shipments and tonnage for the establishments concerned. This does not give an exact measure of volume transferred, as this question was not specifically asked in the survey, but rather an idea of the sort of establishments affected, in terms of the amount of traffic they generate. The results reveal the strong presence of road shipping in the observed jumps. 83% of jumps are toward or away from own account (OA) or third party (3P) road shipping, and these account for 91% of tonnage and 65% of shipments potentially involved in a jump. Rail is the second most prevalent mode, with 30% of jumps and 74% of tonnage potentially involved.

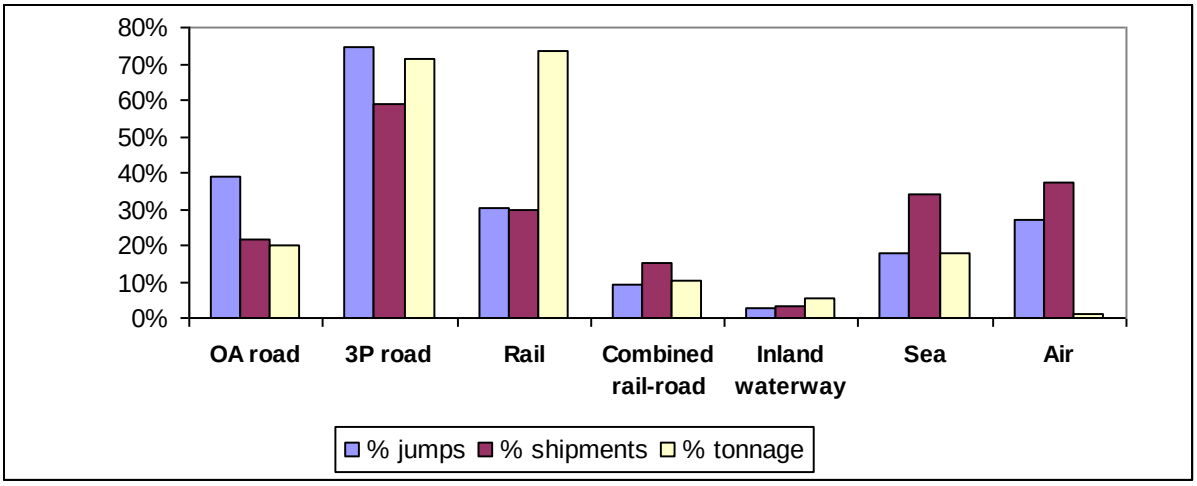

Figure 4 - Jump frequency by mode as % of total jumps, and % of potential volume (number of shipments and tonnage) for the involved shippers. ECHO survey 2004, © INRETS

The balances presented in Figure 5 are calculated differently, with negative jumps subtracted from positive jumps for each mode, but once again expressed out of the sum of all jumps for all modes. They allow us to see the positive or negative direction of the jump balance, and the relative weight of modes. As in Figure 4, they are also represented as a percentage of shipments and tonnage generated by the establishments involved. Their sums are in all cases equal to 0.

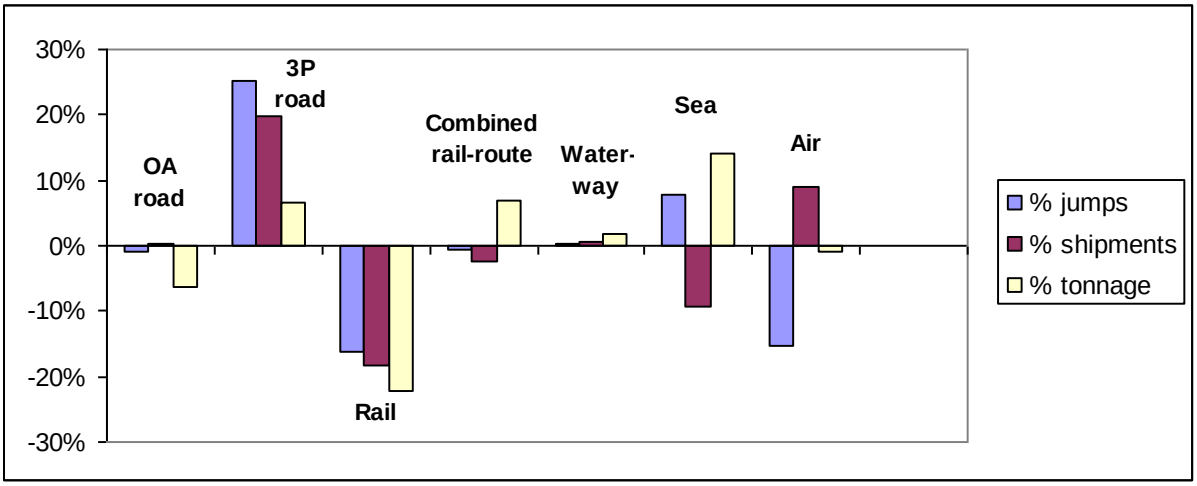

Figure 5 - Balance of jumps by mode, as % of jumps affecting all modes, and % of volume (in shipments and tonnage) for the involved shippers. ECHO survey 2004, © INRETS

They show that third-party (3P) road freight is the major winner in the jumps observed, whereas the rail mode is the primary loser, even for establishments generating the highest tonnage. These are strong trends, visible in both units of measure. For the other modes, the observed effects are weaker, and differ depending on which units are used. We observe particularly contrasting results for the sea and air modes. The jumps toward sea shipping are generally positive in number of shifts and tonnage, but negative in number of shipments. Inversely, air transport jumps are negative in terms of number of shifts and tonnage, but positive in the number of shipments. Rather than a shift, we could speak of these two modes "repositioning" toward shippers that generate more tonnage (in the case of sea) or more

shipments (in the case of air freight). Combined transport also shows contrasting changes, which seem (like sea freight) to indicate a repositioning toward high-tonnage shippers. Results are positive overall in either unit for inland waterway, but movement is quite small.

We will not go into detail here about the different types of shift, by mode pair. Rather, we will underscore the importance the "traffic change" criterion in promoting jumps. Our analysis of reasons for jumps employed the same criteria used above on surveyed shipment mode choice. However, in this part of the survey an additional complementary criterion was introduced which encompassed changes in the establishments' traffic, either in terms of destination or size of shipments. The intent was to test the effect of changes in the establishment's distribution flow structure in a more dynamic context. The hierarchy that was obtained (Table 5) is similar to that presented above for the surveyed shipments. It reiterates the importance of transport cost relative to temporal criteria, but places the new "traffic change" criterion among the most important ones. Traffic change was mentioned in 25% of cases, just behind time reliability (30%) and flexibility (27%).

Table 5 – Comparative hierarchy of criteria explaining mode jumps and mode choice for the surveyed shipments (% of shipments for which mentioned)

Choice criteria	% jumps for which mentioned	% shipments for which mentioned
Cost of transport	61%	60%
Reliability of shipping times	30%	47%
Flexibility	27%	21%
Traffic change (destination, size of shipments…)	25%	Not asked
Shipping duration	14%	35%
Schedules	14%	20%
Safety of goods	12%	14%
Network accessibility	8%	8%
Quality of commercial contacts	8%	12%
Door-to-door service	6%	13%
Frequencies offered	5%	18%
Other criteria	≤ 5%	≤ 7%

Source: ECHO survey 2004, © INRETS

3.3 Modal shift and structural changes in production systems

This final section will help us to illustrate the strong effect of shippers' production and distribution constraints on mode choice. Transportation is closely linked to production systems, of which it is a derived demand; it can even be a totally integrated element of the production process. Changes in modal practices are not only influenced by the characteristics of the various transportation systems. They also reveal a deeper mutation in the entire economic system, and the production methods upon which it is built. Transportation system performance is said to depend on its ability to adapt to increasingly

complex demand, as well as its integration into supply chain management strategies (Christopher, 1992; Rodrigue, 2000, 2006). It is at the heart of a flow-based economy centred on the intensive use of transport (Besson *et al.* 1988, Veltz 1996, Savy 2006). The ECHO survey, focussed on the production characteristics of shippers and their demand for transport, is also full of lessons. A comparison with the previous national shipper survey conducted in 1988 (Guilbault, Soppé, 2009) reveals economic and logistic changes that favour road transport, and a use of alternative modes that is restricted to a few core establishments.

3.3.1 Spatial and temporal fragmentation of freight flows

One of the principal results drawn from these surveys is probably a growing fragmentation of freight flows, as shown by the fact that the number of shipments is growing much more rapidly than the number of tonnes: between 1988 and 2004, the number of shipments grew by 77% (for the common areas of the two surveys), whereas the number of tonnes grew by only 54%. Transport flows appear to be more divided, both in space and time. On one hand, the productive fabric is breaking up into an ever greater number of small businesses, while at the same time intermediary and inter-firm network and group functions are developing, implying more numerous flows and more complex architecture. On the other hand, firms' logistic practices are evolving with the development of just-in-time logistics and zero-delay methods, leading to production that is increasingly pulled by downstream demand, with more frequent and thus more fragmented shipments.

Among the economic changes, we shall of course mention the decline of the heavy industry and raw materials transport, but also a strong decline in the number of large firms which began in France in the 1980s, affecting all sectors including manufacturing. In the scope of the two surveys, the number of firms with 500 or more employees in 2004 was almost half that in 1988: less than 800 firms in 2004, of which less than 200 have more than 1000 employees. The effect on transport is significant, in that these large firms are the most likely to make heavy shipments. This point is illustrated in Table 6, which shows the structure of the firm population and their shipping traffic in tonnes and number of shipments, according to the size of firm. The tonnage/shipments ratio can be interpreted as an indicator of flow fragmentation and shows that most fragmented flows come from the smallest firms, which have been increasing in number, while the most massive shipments are produced by large firms, which are increasingly rare.

Table 6 - Share of number of shippers, tonnage and shipments versus firm size

	Number of shippers	Tonnage	Shipments
Small shippers (10-49)	80%	40%	47%
Medium shippers (50-499)	20%	49%	47%
Large shippers (500 et +)	1%	11%	6%

Source: ECHO survey 2004, © INRETS

As for logistic changes, we will cite the example of the share of tonnage produced on demand, which represents firms' flow management choices and pressure exercised by downstream demand. These figures, only available for the year 2004, show that this practice

is quite common. 66% of shippers produce essentially on demand (at least 70% of their tonnage).

3.3.2 An increasing number of small shipments

The repercussions of these changes on transport demand are many, and have in particular led to a decrease in shipment weight. The average weight observed in 2004 was 1.3 tonnes for the entire field studied, which includes manufacturing industries and wholesale or warehousing operations, but excludes raw material extraction and agriculture. Heavier traffic including raw minerals and mineral ores, and a bit more than half of agricultural products are excluded from the analysis. The study's scope is nonetheless significant, because of the economic importance of the surveyed sectors (which are those that are growing most) and the fact that they produced 47% of the total tonnage sent from France in 2004 (domestic and export traffic).

This average weight of 1.3 tonnes is well below the technical limits of the heavy modes (35 to 60 tonnes for a rail car, 700 to 2500 tonnes for a full train, or 3000 to 4000 tonnes for push barge convoys), and even below the capacity of lorries, which is on the order of 10 to 28 tonnes. This phenomenon of small shipments was already mentioned in 1988, and has grown even stronger because of the changes described above.

The phenomenon is particularly visible if we compare the distribution of shipment weights for the two study years. The logarithmic x axis of Figure 6 shows unit shipment weight, from the survey minimum of 1kg up to 10,800 tonnes, the heaviest shipment observed in the 2004 survey. On the y axis is the cumulative percentage of shipments whose weight is less than or equal to that indicated on the x axis.

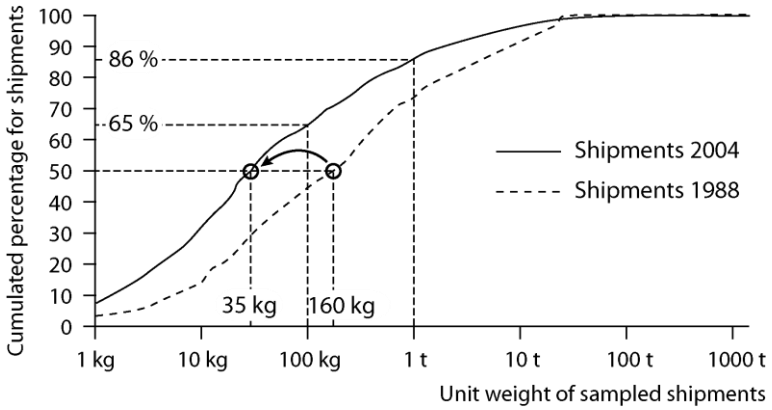

Figure 6 - Cumulative distribution of shipment weights in 1988 and 2004. 1988 shipper survey and 2004 ECHO survey with 1988 scope. © Inrets

The changes in median (represented by the bold arrow) and distribution are significant. Half of the shipments studied in 1988 weighed less than 160kg, and in 2004 half of them weighed less than 35kg: median weight was divided by 4.5. 65% of the 2004 shipments weighed less than 100kg, and 86% less than one tonne.

3.3.3 Use of non-road modes is limited to a small core group of shippers

These changes and their consequences for freight flows, quality of service, and shipment weight all favour increases in road shipping, and statistical data on mode share reveal that road freight is indeed increasingly present. Our next indicator reveals the modes that shippers even occasionally declared using for their shipments that year. For each mode, it shows the percentage of shippers concerned and these shippers' share of total annual shipments and tonnage generated, confirming that use of non-road modes is extremely limited (Table 7). 70% of shippers used only road freight. 23% also used sea or air shipping, but this diversification is often imposed by overseas export. Finally, only 7% of them declared use of rail, combined rail/road, or inland waterway transport, even occasionally.

Table 7 - Modes that shippers declared using for their 2004 shipments

Mode use type	Shipper	Tonnes	Shipments
Road only	70%	53%	70%
Road + sea/air without other land modes	23%	15%	23%
At least one land mode besides road	7%	32%	7%
Total	100%	100%	100%

Source: ECHO survey 2004, © INRETS.

The use of "sustainable" land modes is thus limited to a small core group of shippers (around 7%), who account for 7% of shipments generated and 30% of tonnage. These shippers have very distinct economic and productive characteristics that are described in Table 8.

Table 8 - Characteristics of shippers using rail, combined rail/road, or inland waterway freight transport

Shipper characteristics	**Users of rail, combined rail/road, or inland waterway modes**	**All shippers**
Number of employees (shipper)	126	61
No. of employees (parent firm)	552	302
Rate of membership in multi-establishment firm or group	78%	61%
Annual tonnage per shipper	65 237	14 228
Annual number of shipments per shipper	10 293	655
Annual average tonnage per shipper-receiver link	1 106	398
% tonnes intra-regional	26%	46%
% tonnes export	33%	13%

Source: ECHO survey 2004 © INRETS

The dominant traits are a larger numbers of employees, and above all particularly high annual tonnage: over 65,000 tonnes per year per shipper, whereas the average for all shippers is around 14,000 tonnes. These flows are also very concentrated, with annual tonnage per recipient far above the average: 1100 tonnes versus 400 and up to 1900 tonnes if we consider only those destinations for which the non-road modes are actually used. These shippers' geographic range is large (33% of tonnage is exported, and only 26% of

tonnage stays within the region). Finally, these are highly integrated organizations, with 78% belonging to a multi-establishment firm or an economic or financial group.

Unfortunately, the 1988 survey does not allow us to directly follow changes in the characteristics of shippers using alternative modes. The analyses presented above nevertheless show that characteristics underlying use of these modes are becoming less common, especially establishment size and annual tonnage per shipper-receiver link. Another indirect indicator of change is the number of shippers who make heavy shipments over 30 tonnes, which may be assumed to imply use of rail or inland waterway modes. Observations are unequivocal, showing a decrease in the share of this kind of shipper from 5% in 1988 to only 3% in 2004. Fragmentation of the productive fabric, in terms of site size and freight flow distribution, reduces the alternative modes' number of potential users; the integration of these shippers into more structured networks is insufficient to compensate for this fragmentation.

CONCLUSION

Overall, these trends are very unfavourable to the possibility of transfer toward non-road modes, and explain why public policy has met with much difficulty. The *structural* changes observed in transport demand lead to changes in the frequency and dispersion of flows, the size of shipments, and shipping deadlines, all of which favour road transport. These changes are imposed by an economic model whose productivity and complexity depend on intensive use of transport, leaving shippers with little individual latitude in mode choice. The results are quite clear on this subject, showing that shippers are captive to the road-based modes. The rail and waterway modes are only considered to be viable alternatives for less than 2% of road shipments studied, while inversely road shipping can be substituted much more easily for the other modes. We observe the same effect when studying significant long-term changes in mode. These are very rare (0.6% of shippers per year) and reveal strong modal inertia. When there is change, it is again most often toward road shipping.

At present, there is no "invisible hand" or virtuous market mechanism that can eliminate this dominance. Very few establishments have a diversified modal policy involving rail or waterway shipping. In France, they are but 7% of shippers within the scope of these studies (manufacturing industries and wholesale). The volume potentially concerned is greater (30% of tonnage) but the characteristics associated with shippers who use these modes are becoming less and less common. These are large establishments producing substantial, concentrated flows (65,000 tonnes on average, with more than 1,000 tonnes per recipient per year, and almost 2,000 tonnes per recipient for whom rail and waterway shipping are actually used). All indicators available in both the 1988 shipper and 2004 ECHO surveys converge, showing that over the period of 16 years between the two surveys, the number of such establishments decreased by about one half.

In this context, more strong political reactions are necessary. Actions targeting supply and market regulation are essential. Our analysis of shippers' mode choice criteria shows the importance of cost, which is certainly a fundamental means of transport policy action, but

also carries the risk of lost competitiveness for firms. The quality of freight transport, particularly its reliability, rapidity, and flexibility is also extremely important, and requires technical and commercial responses. We have also shown the importance of accessibility to networks and their configuration. Reduced rail use in France can also be explained by the closing of numerous stations (262 stations no longer accepting isolated rail cars in 2007 – Dablanc *et al*., 2009), which the rail sector justified from an economic perspective. Within rail, combined rail/road transport is still the mode with choice criteria closest to those of road shipping, which probably makes this mode the next most accessible. The planned measures in favour of combined rail/road transport and the creation of new services and infrastructures intended to enlarge this network are thus important, but the surveys also show that combined transport suffers from a lack of frequency and poor schedules. Solving these problems will require axes with sufficient potential traffic, which are currently rare. We have also shown that when combined services exist shippers do not always know about them, so effort is probably also needed to build awareness.

However, these offer-oriented measures are not sufficient. The scale of economic change, particularly the spatial and temporal fragmentation of flows and the shrinking size of shipments (50% of shipments leaving the establishments are less than 30-35kg) makes it necessary to shift reflection further upstream, toward our models of production and consumption themselves. On a pragmatic level, measures targeting the configuration and structure of flows should also be envisaged. More generally, an integrated approach to territorial development seems necessary. One possible theme to explore is the role of freight platforms in the concentration and massification of flows. Solutions can also be organisational. Freight operators were very poorly represented in mode choice decision-making, and should probably be more involved, as they are most capable of consolidating dispersed flows. The creation of rail operators in ports is a step in this direction, but there is progress to be made concerning short-range operators in less-served areas (Chauvineau, 2006).

Shippers also have a role to play in this reorganization. Though production constraints generally leave them very little latitude in mode choice, we have shown that firms and groups who have structured transport strategies seem more capable of massifying their shipments and using alternative modes. Shippers could be given incentives to plan and coordinate their internal transport strategies or increase cooperation and mutualisation among close economic partners. Spontaneous mutualisation and coordination initiatives exist, such as shared supply management (Perraudin, 2007) or mutualised hub and spoke networks, but unfortunately these are rare. Such practices could also be encouraged within *supply chain* firms.

Many different actions can be imagined, targeting transport supply, but also demand. One of the principal results of freight research carried out over the last few years, including the ECHO survey used here, is to show how strong the constraints imposed by transport demand are, as well as the necessity of taking them into account in public policy. Though under certain conditions the market is an efficient mechanism for adapting supply and

demand and helps guarantee productivity, it is no substitute for careful long-term development involving these various actors.

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