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(First Draft)

MEANS OF INTERORGANISATIONAL CO-ORDINATION OF PRODUCTION:

THE ROLE OF TRANSPORT AND TELECOMMUNICATION

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Abstract:

This paper analyses the respective role of travel and telecommunication in interactions between the economic actors involved in particular production systems. We base our theoretical discussion on the well-known distinction between information and knowledge. Codified information can travel through various channels, whereas tacit knowledge is embedded in people and cannot travel independently in space. The choice between the various means of co-ordination (face-to-face contacts, telecommunication, EDI etc.) appears to have three dimensions: a cognitive dimension (tacit vs. articulate knowledge), an organisational dimension (degree of centralisation and interdependence), and a social dimension (interpersonal networks as support for co-ordination). The empirical study compares five industries as to their behaviour in telecommunication and travelling.

1. Introduction

The purpose of this paper is to analyse the respective role of travel and telecommunication in interactions between the economic actors involved in particular production systems. Transportation and telecommunication systems are crucial to the efficient co-ordination and organisation of production systems, and the recent technological and organisational developments in both areas (new technologies of information and communication NTIC, high speed rail etc.) have important impacts on the way that firms organise the circulation of information and people.

Schematically speaking, two very different forms of "immaterial" interactions (i.e. not concerning goods transport) in production systems can be opposed: exchange of codified, standardised information, which is possible over long distances through telecommunication devices, and co-ordination necessitating specific knowledge and collective learning processes. We will base our theoretical discussion on the well-known distinction between information and knowledge, derived from the theory of information. According to this definition, information, as long as it is codified and explicit, can travel through various channels, independently from people. Knowledge, in the sense of tacit, non codified information, is embedded in people and cannot travel in space independently. This distinction thus determines the choice between travelling (in order to establish face-to-face interactions) and telecommunication. The distinction is also important for understanding the need for proximity (permanent or temporary) in networks of producers: interactions involving a high content in idiosyncratic or tacit knowledge usually imply proximity between the participants.

We will compare empirical data on the utilisation of travel and telecommunication in intra- and inter-firm co-ordination from several industries, collected in a qualitative survey of production plants in the North of France. These data allow us to analyse the characteristics of interactions between plants and headquarters and between firms and their suppliers, subcontractors and customers (frequency, duration, nature of information etc.) as well as the means chosen to support these interactions (e.g. meetings, EDI, telephone etc.). The comparison of behaviour in various industries gives interesting insights in sectoral patterns of interactions. We will show that the determinants of choice go beyond the nature of information and include organisational and social dimensions.

2. Elements of a conceptual framework

The objective of the research is to understand the role of transportation (or face-to-face contacts) and telecommunication in the co-ordination of production: co-ordination between a producer and the suppliers, customers and sub-contractors and the use of various means of communication (telephone, fax, EDI, face-to-face contacts etc.). The research question can thus be formulated as follows: Can we predict in which cases, and under which circumstances, information or knowledge can be transferred over long distances (in other terms, be standardised and codified), and in which cases face-to-face exchange is necessary? Is there a sectoral pattern, in other words, can we identify industries (or subgroups of firms) which mainly deal with knowledge and thus need face-to-face contacts, and others where close interaction is not necessary in the co-ordination of production?

2.1. Substitution or complementarity of transport and telecommunication

The question of the role of the development of transport and telecommunication technologies in production systems is not a new one. For the past 20 years, there has been a considerable amount of literature on the role of new technologies of information and communication on spatial patterns of development and the spatial organisation of firms. Two approaches can be opposed.

On the one hand, telecommunication and transportation are considered as intermediate resources for production. This approach usually refers to the neo-classical framework in economics. Technological developments in both fields improve accessibility and lower the cost of overcoming distance in production activities. New technologies of communication create positive network externalities and thus have positive impacts on economic development (Capello, Nijkamp, 1996). This type of approach can, however, be criticised as a model of technological determinism, the development of new technologies of transport and communication changing the spatial patterns and the behaviour of firms in space (Capello, Gillespie, 1994).

A second type of approaches focuses on the co-ordination of production systems and the media that support this co-ordination between actors. Transport and telecommunication are considered as alternative means of co-ordination between the members of the network (Brousseau, Rallet, 1997). The technological developments in both fields are instrumental to, but not the causes of, new organisations of production and new forms of spatial division of labour (Moati, Mouhoud, 1994).

The question then becomes whether transport and telecommunication are substitutable or complementary means of co-ordination. The thesis of substitution between telecommunication and transportation stipulates that virtual interactions will progressively replace face-to-face interaction, as telecommunication techniques and media improve over time and become more efficient and less costly.

The opposite thesis of complementarity considers telecommunication and face-to-face contacts as complementary means for the co-ordination of production (Rallet, 1997). According to this thesis, more intensive use of telecommunication will not replace travelling for face-to-face interactions. The need for proximity will never disappear completely, because certain types of interactions cannot take place without spatial proximity. What is more, the frequency of interactions over long distances and face-to-face go together (Zumkeller, 1997).

We will here develop the approach in terms of complementarity, by analysing the theoretical determinants of choice between communication through media and face-to-face contacts.

2.2. Determinants of choice between face-to-face contacts and communication through media: the cognitive dimension

The choice between face-to-face contacts and communication through media is classically analysed through the distinction between *information* and *knowledge* (Machlup, 1983) and between *tacit* and *codified* knowledge (going back to Polanyi, 1958).

Neo-classical economics generally adopt a more restrictive definition of knowledge: technology, for instance, is considered as a sum of information (private and public). Sociologists, on the opposite, consider knowledge as a social, collective phenomenon. The conservation, reproduction and transfer of knowledge is embedded are collective phenomena.

Heterodox analyses in economics analyse knowledge in a sense closer to the second definition. In the tradition of the evolutionist and institutionalist economics of innovation, the diffusion of innovation is modelled as a learning process, thus not comparable to a process of transmission of information, but of knowledge and know-how, which necessitate close interactions between individuals.

Information is completely codified and explicit and exists independently from people, can be exchanged on a market and travel in space. *Knowledge*, on the other hand, can only be partly standardised and codified. Tacit knowledge is embedded in people and thus cannot travel in space independently from people. Its transmission requires interactions between people.

This distinction on a cognitive basis leads to the assumption that only information and explicit, codified knowledge can be transferred in space through telecommunication media, whereas the transfer of tacit knowledge from one person to another necessitates face-to-face contacts and thus (at least temporary) spatial proximity.

On the basis of Nelson's and Winter's (1982) analysis, we can distinguish between *tacit*, *implicit* and *articulated* knowledge. Parts of knowledge are articulated in "languages" (natural language or others). Another form of knowledge is implicit, but possible to articulate, whereas tacit knowledge is impossible to articulate. Articulated knowledge is obviously easier to transfer in space (at least as far as the "language" is understood). However, even tacit knowledge can be transferred, but only through interpersonal learning.

Mangolte (1997) completes this strictly cognitive analysis by considering the "support" of knowledge. According to this author, knowledge is always embedded: in people, machines, rules, organisations etc.. However, it can, up to a certain degree, be "extracted" from its original support (a specific person) to an external support (e.g. a book, but also a machine, which can be copied, without the incorporated knowledge being articulated).

"Extraction" and "articulation" of knowledge are two different processes. This analysis considers the spatial dispersion of knowledge to be correlated, not only to the strict cognitive dimension of tacit or articulate knowledge, but also, and often even more, to the type of support. Tacit knowledge does not necessarily remain "local". It can also travel in space, but in different forms.

This analysis leads to the following assumptions concerning the opportunity to use the various media of communication:

		<i>Cognitive dimension of knowledge</i>		
		Tacit <i>impossible to articulate</i>	or	Implicit <i>non articulated, but possible to articulate</i>
Support of knowledge	Internal <i>embedded in a specific person</i>	Knowledge transfer is possible only through interpersonal learning (proximity, face-to-face contacts).		Knowledge can be transferred through interpersonal interactions (direct communication: face-to-face, telephone etc)
	External <i>separated from the initial holder</i>	Knowledge transfer is possible through copying. The external support of knowledge can travel in space.		The support can travel in space and be transferred through most media of telecommunication.

Source: adapted from Mangolte (1997)

This analysis shows that, although all forms of knowledge can be transferred, knowledge which is articulated and extracted on an external support travels most easily in space through all kinds of transport and telecommunication means. Telecommunication always implies articulation of knowledge. Transfer in space without direct contact with the initial holder implies extraction of the knowledge on an external support.

2.3. Determinants of choice of communication media in co-ordination: the organisational dimension

Alongside the cognitive dimension of analysis, the use of various media in co-ordination has many organisational aspects, such as the need for flexibility, the possibility for standardisation of interactions, the degree of centralisation and the degree of interdependence.

All telecommunication technologies do not have the same properties regarding the forms of co-ordination that they allow. We have to distinguish between standardised exchange of information, such as electronic data interchange (EDI), where procedures of exchange are completely codified *ex ante*, and techniques such as telephone and fax, which can be used for mutual adjustment. Moreover, we can distinguish media which allow direct, real-time interaction (telephone), and indirect, sequential interaction media such as fax, mail and e-mail.

Törnqvist (1991) analyses the strategic dimension of interactions through a study of the contact networks of universities and makes a distinction between routine interactions and interactions involving uncertainty. Routine interactions can be performed through various media of communication. Personal face-to-face contacts, on the other hand, are required for interactions that involve some degree of uncertainty, such as the development and the renewal of knowledge or negotiations.

Electronic data interchange (EDI) is a special case in this respect. It can be defined as the standardised transmission of information directly between computers of different organisations. The automation of data transmission makes the complete codification of information and transmission procedures necessary *ex ante*. EDI is a non flexible co-ordination technique. In such, it appears to be more appropriate for situations of risk than for situations of radical uncertainty, where mutual adjustment and idiosyncratic interactions are vital.

Brousseau (1994) shows that EDI cannot simply be considered as an alternative means of communication, compared to telephone, fax and e-mail. EDI does not replace other media in the co-ordination of production. It transforms co-ordination and the organisation of production itself. The advantage of EDI for firms is not as much cost reduction or improved efficiency of electronic communication, but the necessary standardisation of co-ordination procedures *ex ante*, which has many impacts on the overall performance of the firms beside cost reduction in communication.

Recent research on EDI implementation between firms shows some basic characteristics of the types of co-ordination for which this form of communication is appropriate. EDI being a non flexible co-ordination technique, which requires investments in codification and standardisation, it tends to be implemented bilaterally more often than multilaterally. Industries where intra-industry relations are more important than inter-industry relations tend to use EDI more often. The same goes for industries that do not have mainly international relations. The codification appears to be easier to implement on a national and an industry basis.

Brousseau and Rallet (1997), by combining Mintzberg's (1979) analysis of the structure of organisations and the transaction cost framework (Williamson, 1985), develop a taxonomy of organisational structures according to the opportunity to use various media in the co-ordination of production. Two dimensions are opposed: the degree of hierarchy and the degree of interdependence. They primarily distinguish between centralised and decentralised organisations: In centralised (hierarchically structured) organisations, information flows frequently and regularly according to standardised procedures, whereas decentralised organisations rely more on mutual adjustment.

The second distinction, the degree of interdependence, opposes specialised production units, where interactions between complementary production phases are necessary for co-ordination, and integrated production units, which have less need for co-ordination.

This analysis leads to the following assumptions on the use of different telecommunication media:

		Degree of hierarchy	
		<i>Centralised organisations</i>	<i>Decentralised organisations</i>
Degree of interdependence	<i>Specialised production units</i>	Standardisation of vertical and horizontal co-ordination =>EDI + intensive use of all telecommunication media	Mutual adjustment using telecommunication and face-to-face contacts
	<i>Integrated production units</i>	Standardisation of vertical co-ordination => EDI possible	Little need for co-ordination Moderate use of telecommunication

Source: adapted from Brousseau/Rallet (1997)

This taxonomy predicts the use of different telecommunication techniques by distinguishing between organisational configurations relying on mutual adjustment and those appropriate for the standardisation of the circulation of information. Brousseau and Rallet (1997) thus conclude that standardised transmission technologies such as EDI tend to be used more frequently in centralised organisations with specialised production units.

However, the taxonomy cannot predict the choice between face-to-face interaction and telecommunication for mutual adjustment. The combination of the cognitive and the organisational dimension results in a more comprehensive framework.

2.4. The role of proximity, interpersonal relations and trust in the quality of co-ordination

Certain types of productive organisation, however, seem to escape from the determinism of the nature of information and the organisational structure. Idiosyncratic forms of co-ordination appear in configurations where trust and interpersonal relations are important for the quality of co-ordination. This applies, for instance, to industrial districts and other forms of localised systems of production, but also to non-territorialised production networks.

The analyses of industrial districts (Beccattini, 1989) and other forms of localised production systems traditionally emphasise the role of the local community, social norms, tacit rules, cultural proximity and informal relations between the members in the coherence and performance of such production systems.

Using Granovetter's (1985) approach on "embeddedness", several authors in this field develop the assumption that interactions in the co-ordination of production are embedded in social networks (see, for instance, Grabher (1993) and Borgatti's et al. (1997) work on governance networks). Interpersonal relationships between the actors of the production network contribute to build trust, and thus improve the quality of co-ordination (Castel, 1997). The trust engendered by personal relations is as well a result as a prerequisite for transactions. The main argument for our purpose is, of course, that interpersonal relationships rely on face-to-face contacts and (at least temporary) spatial proximity.

More recently, analyses of the concept of proximity have shown that the spatial dimension is not a strict constraint. Authors such as Bellet et al. (1993) distinguish between spatial and organisational proximity and show that interactions between the actors of the production process require proximity, but not necessarily spatial proximity. Cultural and organisational proximity are prerequisites, as well as results, of the co-ordination of production. Although such proximity is, in general, more easily attained and sustained on a geographically limited basis, certain types of networks such as professional communities can exist and co-ordinate efficiently without being co-located.

If we make the assumption that the interpersonal relations which are crucial to the development and the sustainability of organisational proximity and trust rely, at least partly, on face-to-face contacts and thus on (at least temporary) spatial proximity, the role of such contacts in the co-ordination of production receives a different theoretical status. We have considered above that face-to-face contacts are necessary because certain forms of knowledge related to production cannot be transferred in space by other means. In this new framework, interpersonal contacts are vital for certain types of productive systems, because they create the

conditions that make co-ordination of production between actors of different organisations possible.

3. Empirical findings

We will now turn to the empirical study of the use of telecommunication and face-to-face contacts in the co-ordination of production, in order to confront these with the determinants of choice considered above from the analytical point of view. We use detailed observations, for a large number of production plants, of effective behaviour concerning exchange and co-ordination with their main external partners (suppliers, subcontractors, customers) as well as internally (headquarters and other production plants). We have information on the frequency of meetings, the use of telecommunication media (telephone, fax, EDI) as well as on the purposes for which the various media are used (cf. methodology in the appendix). We can thus compare the respective roles of telecommunication technologies and travel in 110 production plants in the five industrial sectors: food, textile & clothing, chemicals, machinery and metalworking.

3.1. *The use of electronic communication in the co-ordination of production*

The data of our empirical survey contain information about the use of different means of electronic communication (exchange of data files, intranet, e-mail, EDI etc.) in interactions with the different partners of the plant inside and outside of the firm, the frequency of use and the purposes (see table 2 in the appendix).

Electronic transmission of information is used differently according to the different types of partners. Intra-firm use of electronic transmission is becoming very common: 70 % of the production plants of our sample communicate electronically with their headquarters and other plants of the firm. This is especially the case in the food and chemical industries, where vertical integration and specialisation of production plants explain the need for real-time bulk transmission of data. On the contrary, the intra-firm use of electronic transmission is much weaker than average in the textile and clothing sector, where firms are usually smaller and less vertically integrated.

Electronic modes of interaction are, of course, much less common (about one third of plants) with external partners. As for the relations with customers, more than 30 % of firms use some form of electronic exchange of information. Although the types of customers differ greatly between industries (from distribution companies to production firms), differences between industries are not significant. The metalworking industry is an exception though, since electronic communication is marginal with customers, but quite important with suppliers. Overall, the use of electronic modes of exchange is less frequent in interactions with subcontractors and suppliers. Especially with subcontractors, close interactions and mutual adjustment appear to be more important.

As for electronic data interchange (EDI) strictly speaking, defined as the *automated* exchange of data with *external* partners from machine to machine, an average of 29 % of plants use it with one or several partners. Again, the use of EDI in the food and chemicals industries is above the average. In all industries, the use of EDI appears to be related either to the fact of selling to the automobile industry or the large-scale distribution chains, who impose their

communication standards, or to the existence of one major customer, supplier or logistics provider, with whom the plant works on a long-term basis.

These industry patterns confirm Brousseau's and Rallet's (1997) analysis. The strongest use of electronic exchange of information can be found in the industries where plants are most specialised and the vertical organisation most hierarchical (in our sample, food, chemicals and parts of the metalworking industry).

3.2. The role of face-to-face contacts

The data set contains similar information on the use of face-to-face meetings between each production plants and its partners. Only a small share of the plants of our sample does not make use of face-to-face contacts at all. However, industry patterns appear clearly.

In the food industry, an important share of the plants never meet their customers (over 40 %) and their suppliers (27 %) directly. This is mainly related to the organisational architecture of the large firms in this industry: production plants tend to be very specialised and integrated in a strong hierarchy, where contacts with customers and suppliers are established only at the firm level.

On the contrary, the textile and clothing industry, as well as machinery producers, usually rely strongly on frequent face-to-face contacts with customers. More than half of these plants meet their customers at least once a week.

The textile and clothing industry shows a particular feature as far as face-to-face meetings are concerned. Many firms stress the role of interpersonal relationships, progressively built up through informal meetings in professional exhibits, showrooms etc, as well as through visits without explicit technical or commercial purposes.

Overall, the frequency of meetings appears to be related to the purpose. The frequency of meetings is highest (more than once a week) for co-ordination on technical problems and product conception and definition, whereas commercial negotiation and technical audits require face-to-face contacts less frequently. The correlation between *joint product conception* and face-to-face contacts with customers is particularly important: in only 2 cases, the specification of the product can be made without face-to-face interaction.

Frequency of meetings also change over time: meetings are usually more frequent in the beginning, when a new product is developed or a new partnership established with a customer, supplier or subcontractor. When meetings evolve into more routine interactions, they tend to be less frequent.

3.3. Industry patterns in the choice between various means of co-ordination

We will finally attempt to summarise our empirical findings on the issue of industry patterns in the choice between face-to-face contacts, telecommunication and electronic data exchange. Looking at the overall use of the various media of interaction, we can identify three groups of production plants in our sample.

- The first group of plants (one fifth of the sample) is permanently in contact with customers, suppliers and other plants, through all media of interaction (phone and fax, EDI, meetings). There is no clear pattern here: all industries, except chemicals, are equally represented.
- The second group of plants (also 1/5) is hardly ever in relation with external partners, but strongly related through intra-firms contacts. These plants belong mostly to the food and chemical industry, where plants are strongly specialised and integrated in a centralised organisation.
- The majority of plants (3/5) is frequently in contact with partners through the usual means of interaction (phone and fax, meetings), but makes little use of electronic exchange of information.

The industry patterns observed are, on the whole, coherent with the assumptions developed above. They can be at least partly related to the nature of productive problems and purposes of interactions prevalent in each sector, to the specific structure of production in each industry, but also to conventions and social norms.

Among the factors that determine the need for face-to-face interactions, co-definition of products and the resolution of complex technical problems in production are clearly the most evident. However, the case of the textile and clothing industry illustrates the role of interpersonal relationships in the development of trust and flexibility in intra-industry co-ordination.

The use of EDI and, more generally, of computerised exchange, appears to be related to the structure of organisations: plants which are specialised and belong to a vertically structured organisation tend to use these automated modes of data exchange more frequently.

There is clearly no trend towards substitution of EDI and other electronic forms of information exchange to face-to-face meetings. Moreover, the frequency of telephone (or fax) and face-to-face contacts always go together as well.

4. Conclusions

The objective of this paper was to contribute to the understanding of the respective role of transport and telecommunication in the co-ordination of production. We have examined the literature on co-ordination, organisation and information for determinants of choice between various media of communication and found three important dimensions:

1. A *cognitive* dimension: according to whether knowledge to be transmitted is articulated, implicit or tacit, and embodied in people or in external supports, it can be transferred more or less easily.
2. An *organisational* dimension: depending on the degree of centralisation (hierarchy) and interdependence, the flows of information in or between organisations can be more or less standardised and thus use different techniques of communication.
3. A *social* dimension: interpersonal networks can be an important support for co-ordination and thus rely on face-to-face contacts.

We have then analysed observations of effective behaviour in 110 production plants in order to determine industry patterns of co-ordination and choice of means. We have found that electronic modes of telecommunication are used more extensively in industries where plants are specialised and integrated in a centralised organisational structure. As for the need for face-to-face meetings, we found a strong relation with joint product development and joint resolution of technical problems. However, although differences between industries appear clearly, the different means of telecommunication and face-to-face contacts do not replace each other.

5. Appendix

5.1. Research methodology

The industry survey concerns 110 production plants of more than 20 employees, located in the Nord-Pas-de-Calais region in the following industries:

Table 1: Sample of plants

Food	27
Textile & Clothing	22
Chemicals	22
Machinery	19
Metallurgy & Metalworking	20
Total	110

The survey was conducted through detailed face-to-face semi-directive interviews (1 to 1 ½ hours). The guide for interviews was designed in order to gather quantitative and qualitative information on the following topics:

- general characteristics of the plant and the firm (number of plants, location, employment, organisational structure, diversification)
- products and production process (range of products, equipment, technologies and processes, quality of the labour factor, specificity of resources)
- characteristics of demand (industry structure, type of customers, degree of differentiation / customisation)
- characteristics of intra-firm relations: centralisation of decisions and organisation, autonomy of the plant, computerisation of intra-firm exchanges, circulation of information and knowledge (media used, frequency, organisation and centralisation of flows)
- relations with clients, subcontractors and suppliers: use of communication media and face-to-face contacts (frequency, purposes etc.)
- organisation of goods transportation, inventories and logistics strategy
- location factors

The information collected through the interviews was completed and cross-checked, whenever possible, through multiple sources: professional publications, industry studies, interviews with professional organisations and experts on the two sectors.

5.2. Data from the industry survey

Table 2: Use of electronic transmission of information

<i>(number of plants)</i>	with customers	with suppliers or subcontractors	with headquarters and/or other plants	EDI*
All industries	31 %	18 %	70 %	29 %
food industry	30 %	16 %	88 %	41 %
textile-clothing	33 %	6 %	38 %	23 %
chemicals	38 %	17 %	76 %	36 %
machinery	35 %	22 %	64 %	21 %
metalworking	17 %	30 %	65 %	17 %

* EDI is defined as standardised electronic exchange of data with external partners.

Table 3: Use of face-to-face contacts

<i>(number of plants)</i>		<i>never</i>	<i>some</i>	<i>frequent*</i>
CUSTOMERS	food industry	41 %	50 %	9 %
	textile & clothing	10 %	35 %	55 %
	chemicals	10 %	65 %	25 %
	machinery	5 %	37 %	58 %
	metalworking	0	64 %	36 %
	All industries	15 %	49 %	36 %
SUPPLIERS	food industry	27 %	50 %	23 %
	textile & clothing	6 %	55 %	39 %
	chemicals	20 %	73 %	7 %
	machinery	0	69 %	31 %
	metalworking	8 %	69 %	23 %
	All industries	13 %	62 %	25 %
SUB-CONTRACTORS	food industry	ns	ns	ns
	textile & clothing	7 %	29 %	64 %
	chemicals	Ns	ns	ns
	machinery	8 %	58 %	33 %
	metalworking	Ns	ns	ns
	All industries	13 %	51 %	36 %
HEADQUARTERS OR OTHER PLANTS	food industry	0	55 %	45 %
	textile & clothing	13 %	27 %	60 %
	chemicals	0	70 %	30 %
	machinery	18 %	27 %	55 %
	metalworking	6 %	53 %	41 %
	All industries	6 %	49 %	45 %

* more than once a week

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