

**NOMADIC FIRMS IN A GLOBALIZING ECONOMY:
A COMPARATIVE ANALYSIS AND POLICY PERSPECTIVES**

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Abstract:

The location behaviour of modern multinational multi-plant firms appears to exhibit increasingly a flexible mobility pattern with a strong tendency towards footlooseness. The spatial-economic dynamics - often across the border - of such firms is sometimes encapsulated in the term 'nomadic firms'. This paper addresses the issue of nomadic behaviour of firms against the background of globalisation trends. After a critical discussion of globalisation phenomena and a review of the literature on nomadic entrepreneurial behaviour, the paper sets out to formulate a series of relevant hypotheses of spatial relocation behaviour of international firms in a globalising network economy.

The analytical framework is tested by means of empirical data originating from a field study among actual or potential nomadic firms, in both The Netherlands and abroad. Infrastructure quality and geographical accessibility appear to play an important role in spatial relocation decisions, but also opportunity seeking behaviour of multinational firms has a prominent place in nomadic behaviour. The results of the structured interview rounds among various international firms are next more rigorously analysed by using a recently developed method for qualitative classification and explanation, viz. rough set analysis. The results from the latter method confirm to a large extent our previous findings. The paper concludes with lessons for infrastructure policy

1. Setting the Scene

The past decade has witnessed an avalanche of changes in industrial organisation, both locally and globally. The face and position of modern industry has drastically altered. Business linkages have since the 1980's increasingly assumed the form of internationally (or interregionally) operating industrial networks (see for a review Von Raesfeld Meyer 1997; Schachar and Öberg 1990). The drive towards a network economy has exerted a profound impact on the volume and structure of international trade and service delivery (containerisation, outsourcing, back to core business etc.). In addition to shifts in the internal-external network configurations of modern firms, we also observe that the role of transaction costs for intermediate deliveries and intra-firm decision-making is gaining much more importance (see Williamson 1979).

The economic organisation of modern industries can, in principle, be characterised by three alternative arche-types, viz. **market**, **hierarchy** and **networks** (see Lagendijk 1993; Nijkamp and Vermond 1996). A market configuration takes for granted that a firm buys its necessary inputs in a competitive way from other producers as intermediate goods on the market, thus incurring high risks and transaction costs of ad hoc contracts. A hierarchy is an organisational structure where (a significant part of) the industrial production is carried out under the control or inside the own corporation. And finally, a network is an organised industrial structure characterised by exchange relations between actors based on business interactions and mutual linkages (see for an extensive description Hakansson 1987). In recent years we have seen a significant shift towards network structures.

Network theory and analysis have recently become also a fashionable research topic in geography and regional science. Networks are essentially an intermediate form between the market and the hierarchical industrial structure (see Davidson 1995). The benefits of a network to the actors involved originate from synergy as a result of economic complementarity in the activities of firms and their interactions (see also Nijkamp and Reggiani 1998). Efficiency is then enhanced by a combination of both competition and cooperation inside the network, supported by high quality communication potentials and regular interactions among interdependent partners (see also Kamann 1993). Thorelli (1986) and Hakansson (1987) emphasise in particular the long-lasting structural effects of a network, even though the individual firms' position in a network may change; this position is a market asset built up by investments in manpower, communication time and scarce financial means (see also Hinterhuber and Levin 1994). It should be added here that networks may exhibit different structural forms: vertical, horizontal or diagonal, depending on the firm's internal organisation and competence as well as on the external market conditions.

The drive towards an industrial network economy has been accompanied by a drastic change in the spatial-economic position of cities, regions and nations all over the world. There has been a

complex and turbulent movement induced by indigenous growth and spatial connectivity, which has influenced the internal functioning of cities and regions and which has also placed network infrastructure in the centre of spatial dynamics (see also Castells 1985). Consequently, structural change and differential dynamics (a simultaneous occurrence of slow and fast motion) have become a major feature of modern economies at all spatial levels, while stability is nowadays increasingly substituted for spatial-temporal transformation (cf. Omrod 1990).

After the era of the Industrial Revolution in the second part of the last century which was marked by new ways of organising production and transport on the basis of new technological innovations favouring large-scale production for an opening world market, we observe in the last part of our century a new phase in the history of our developed world, viz. a **Network Revolution** marked by interconnected modes of production and by transport and communication processes favouring neo-Fordist types of production (see Lagendijk 1993). As a result, we observe nowadays drastic changes in the spatial-economic, sectoral and organisational structures of modern industries, especially in sectors dominated by technological innovation (cf. also Dicken 1986; Storper, 1996; Thwaites 1978).

Fluidity and mobility have become the landmark of modern networked firms in a Schumpeterian era, where innovation and economic transformation are the characteristics of competitive opportunity seekers. As a result, research in industrial dynamics has gained much popularity in the past decade (see for a review also Bertuglia et al. 1997).

Especially in a European context this industrial transformation process has a pronounced meaning, as the European unification process and the opening up of Central- and Eastern-Europe as low wage countries have shaped the conditions for a mobile and fluid network economy. The increasingly free exchange of persons, commodities and capital has far reaching implications for intra-European trade and transport. The introduction of the European Monetary Union will reinforce the tendency toward further spatio-economic integration (see Fischer and Nijkamp 1999). Recent policy documents show that trade and transport in Europe may be looked at from three partly complementary, partly competing policy angles: the need for **competitive efficiency**, the need for **geographical accessibility** of all regions in Europe, and the need for an **environmentally sustainable development** (see also Reggiani et al. 1997). These three issues will now succinctly be discussed.

Competitive efficiency is at the heart of current European transport policy, where massive investments in Trans European Networks (TENs) and in missing European links serve to support the goal of economic and geographical integration. But also at local, metropolitan and regional scales formidable investment efforts are foreseen in order for main players to survive in a competitive world market based on global networks. Efficiently operating transport networks in the former

segmented European space-economy are critical success factors for the competitive edge of Europe in a global setting. This European network policy will undoubtedly stimulate more mobility, both of persons and of goods.

There is also a major concern on geographical accessibility of less central regions in Europe. The low density of transportation in many rural and peripheral areas has been a permanent source of concern for public authorities, from the viewpoint of both the service quality offered by public transport operators and the objectives set for regional development. A look at the historical development of European infrastructure networks (road, rail, air, waterways) makes immediately clear that the most important links were first constructed between major centres of economic activity. The connections with rural and peripheral areas were in all cases delayed and usually less developed. This situation still holds true for most Central - and East - European regions. This is a clear case where efficiency motives and equity motives are in conflict with one another. In the emerging European welfare states however, the rights of the rural and peripheral areas have been recognised as legitimate claims, even though the economic feasibility of such low density connections was often debatable. Clearly, the equity argument - often reinforced by the 'generative' argument (i.e. an infrastructure - once constructed - will attract new activities) - has played a major role in the political debate on subsidies for transport for the 'mobility deprived' in remote areas.

And finally, there is a more recent major policy concern on the question of whether transport will be devastating for environmentally sustainable development. Our mobile society fulfils many socio-economic needs, but calls at the same time for social and political change in order to attain sustainable mobility (see for a review Nijkamp et al. 1998). Both passenger and goods transport have increased rapidly in the past years, and for the time being there is no reason to expect a change in this trend. Some European scenarios even forecast a doubling of transport flows in one generation. This development provokes intriguing questions on the external (social) costs of transport, such as congestion, pollution and safety issues (see Verhoef 1996). Apart from local problems such as congestion or noise, the global environmental implications of transport are increasingly becoming a source of major concern (see Nijkamp et al. 1998).

After the above sketch of the scene which shows that industrial dynamics and transport policy are increasingly marked by network configurations of a material and immaterial nature, the question arises: what is the likely mobility pattern of modern industries in the era of innovation, globalisation and networking? Will fluidity and mobility become a dominant feature in spatial industrial networks? The present paper will address the issue of spatial relocations of firms from the viewpoint of internationalisation of business life. The aim of this paper is to trace and investigate the origins of nomadic location behaviour of firms and to analyse the possible implications of this nomadic tendency for Dutch - and European - infrastructure policy. In particular, this research concentrates

on two policy concerns: i) what are the locational motives of nomadic companies; and ii) how can they be encouraged to locate and stay in The Netherlands by means of an improvement of the supply of infrastructure facilities?

It seems likely that significant consequences for infrastructure use (e.g. transport flows) may be expected if these nomadic companies would choose to leave the country in large numbers in favour of a location elsewhere.

Important in the relationship between nomadic relocation decisions and infrastructure policy is the question whether a spatial shift of nomadic companies - often comprising the most critical, foot-loose, internationally operating, and cost-sensitive companies - offers an early signal to infrastructure planners that (part of) the transport or communication infrastructure in the overall location profile of a region or country might be sub-optimal compared to locations abroad. The relocation behaviour of nomadic firms may also offer strategic information about future developments in the volume and direction of transport flows, about the transport modes used, and at the end about structural changes in industrial heartlands. From a careful monitoring and analysis of such trends it may be possible to identify the need for new infrastructure investments.

After these introductory background observations, we will start our paper with a concise review of evidence on nomadic (re)location behaviour of firms (Section 2) and then proceed with a macroeconomic analysis of international capital and trade flows (Section 3), followed by a microeconomic-based survey of foreign companies in The Netherlands as well as of Dutch firms with subsidiary plants abroad (Sections 4 and 5). Based on this information, the relationship between nomadic behaviour and infrastructure is analysed in greater detail using rough set analysis (Section 6). And finally, we end the paper with some relevant policy lessons (Section 7) and general conclusions (Section 8).

2. Nomadic Firms in a Global Economy: a Survey

'Nomadic location' behaviour is not a generally accepted or widely used expression in the scientific literature. Nevertheless, several basic principles of nomadic location behaviour can be found in the recent globalisation literature and in related publications (such as network theory). It is commonly recognised that the most important reasons why firms move abroad or establish subsidiary plants elsewhere are market expansion (preferably in emerging markets) and cost reduction (in competitive markets). World-wide deregulation and technological harmonisation trends have greatly simplified the possibilities of entering new foreign markets. However, it is also noteworthy that firms are increasingly confronted with foreign competitors on their own home markets. To survive in this global race characterised by international competition, firms are forced to economise and to grow in order to benefit from scale and scope advantages. Large firms are, for instance, able to

reduce the share of their R&D expenditure per product by allocating them over larger product volumes (economies of scale). In view of severe competition, firms have to optimise also their production process by strict cost reduction strategies. This optimisation of the production process may also prompt a relocation of activities over space. International firms appear to reallocate nowadays increasingly their activities on a world-wide level as a result of competitive strategic behaviour. In this relocation process, firms are of course restricted by source-related and market-related activities, but an increasing number of activities becomes more and more foot-loose and can, in principle, be located almost anywhere between the source and the market place. Such foot-loose activities are eligible candidates for adopting nomadic location behaviour. Significant cost reductions can, for instance, be realised by outplacement of labour-intensive production processes towards low wage countries such as East-European countries and various Asian countries (see also Amin and Thrift 1994).

In the context of market-related activities, significant cost reductions can often be achieved by introducing a large scale distribution network such as European Distribution Centres (EDC). These activities may clearly show nomadic location behaviour; to reduce the logistics costs, the geographical location and mobility in the European infrastructure networks will then be of critical importance.

Nomadic firms will in general not deeply be rooted in a given area; such activities need not necessarily be regionally embedded. As a consequence, new fixed capital investments in a given place (which will usually reduce geographical mobility) will be kept at a minimum. This means that a company often prefers to start a new subsidiary instead of entering a market by a take-over or merger. It often also prefers to rent rather than to buy real estate. Finally, the company is usually less interested in offering its products for the local or regional market concerned (cf. Suarez-Villa 1989).

In summarising the literature on nomadic behaviour, we find that international relocation behaviour may be considered to be 'nomadic', when:

- it is a temporary (re)location;
- few durable investments of a fixed or lumpy nature are involved;
- there are clear cost reductions at stake in the (re)location;
- the (re)located activities are foot-loose;
- the company is not clearly embedded in the local or regional economy;
- the company is part of an international industrial network producing for the international market.

Thus, nomadic companies can be characterised as 'spatial opportunity seekers'. To make a clear distinction between a nomadic (re)location and other international (re)locations, the following typology of nomadic (re)locations may offer a meaningful analytical framework (see Table 1):

Table 1 A typology of nomadic firms vis-à-vis other firms

Nomadic relocation	Other relocation
- foot-loose company	- regionally-oriented company
- foot-loose activities	- source and market-related activities
- relocation across the border	- local, regional or national relocation
- creation of a new company or division	- take-over or merger
- cost reductions	- penetration into emerging market
- low capital investments	- high capital investments
- labour-intensive production	- capital-intensive production
- production for international market	- production for local / regional market
- international network orientation	- local / regional network orientation
- international transport flows	- local / regional transport flows

In summary, the characteristics of nomadic relocations can be categorised in a few prominent, mutually related attributes. The first aspect may be referred to as **foot-loose**. A limitation in the freedom to relocate at any time may stem from either large investments in real estate, education etc. (high sunk costs), or from the specific nature of the production process (source- or market-related). A second feature centres around the notion of **regional embeddedness**. Nomadic companies tend to prevent regional embeddedness not only - as mentioned above - by low capital investments, but also by a low administrative or institutional embeddedness. They often prefer to start a new company or division instead of a local or regional take-over or merger, as the latter strategy may have significant legal consequences (often constraints) in case of a next relocation. The third aspect concerns **cost reduction**. In contrast to the desire to penetrate emerging markets, cost reduction in a competitive environment is the decisive factor to relocate - part of - the company. For example, labour-intensive production processes are relocated towards low wage countries, or the assembly of final products may be concentrated in one particular location in each continent. By these means, standard products can be adjusted to continental standards (e.g. value added logistics in European Distribution Centres). And finally, there is the aspect of the **international** dimension. The firm is usually part of an internationally operating network of firms aiming at producing for a global market (see also Rietveld and Bruinsma 1998).

Clearly, the above typology of attributes is not entirely unambiguous. First, there is a number

of **imprecisely demarcated classes**; a number of the characteristics is mutually related. Furthermore, most characteristics are not such pure contrasts as suggested in the above typology. For instance, the category 'cost reduction' is placed opposite to 'emerging markets'. In reality, a relocation may be caused by a mixture of both factors. Although cost reductions will usually be the driving relocation factor for a nomadic firm, that company will also respond to the advantages that emerging markets offer.

A second problem is the **timing of activities** in the process of international relocation decisions. In general, a company starts penetrating a market by hiring a local agent. After a number of sequential steps (outplacement of representatives, starting a sales and/or distribution network), in a final step (part of) the production activities of the company are relocated. It seems reasonable to assume that also nomadic companies will use a similar strategy, while it seems unrealistic to expect that nomadic firms will spontaneously start up a new company in a completely unknown environment.

After this general exposition on the typical features of nomadic firms, we will in the next section address more empirically the question whether there have been such significant changes in patterns of international trade and transport, that nomadic behaviour may be regarded as a major new development in a globalising economy.

3. Analysis of Trade and Capital Flows

Statistical information on location behaviour of nomadic firms is scanty if not absent. At best, we may distil some evidence from macro-economic statistics. In this section we will look at some macro-economic trade figures related to The Netherlands in order to examine whether statistically nomadic behaviour clearly shows up in this small open economy. The regions of origin and destination of the trade flows to and from The Netherlands are quite diverse, but there is a clear common pattern in terms of the demand for dedicated infrastructure. The freight flows to and from the whole of Europe (North, East, West and South) are predominantly transported by lorries. For The Netherlands, this implies a strong demand for well accessible connections with the European road network. However, the trade flows with other continents predominantly take place by deep or short sea shipping (low value goods) or aviation (high value goods). This implies also a clear demand for a large-scale international hubs, such as a seaport and airport.

Table 2 Import and export of goods of The Netherlands (expressed as a percentage of the total value of The Netherlands)

	West- Europe	East- Europe	America	North- America	Latin- America	Asia	Australia Oceania
1975	72,1	2,3	4,4	7,1	2,8	10,9	0,5
1977	71,3	2,1	4,9	6,7	2,6	12,0	0,4
1979	72,9	2,3	4,9	6,3	2,6	10,6	0,4
1981	70,4	3,0	4,9	6,9	2,7	11,7	0,4
1983	71,9	3,5	5,1	7,2	2,5	9,4	0,5
1985	73,5	3,0	4,2	7,3	2,7	8,7	0,5
1987	77,3	1,9	3,0	6,4	1,9	9,0	0,5
1989	76,9	2,0	2,6	7,2	1,9	8,9	0,5
1991	78,2	1,7	2,4	6,3	1,7	9,3	0,4
1993	75,4	2,4	2,1	6,4	2,1	11,1	0,4
1995	77,0	2,6	1,8	6,0	2,1	10,1	0,3

Source: Bruinsma et al. (1997)

Seen from a macro-economic perspective, import and export relations (expressed in terms of the value of the traded goods), appear to show a rather steady increase between West-European countries and The Netherlands over recent decades (see Table 2). Clearly, these figures do not immediately lead to the conclusion that more attention should be paid to the road network and less to the Dutch mainports of Rotterdam and Schiphol, as here the difference between volume and value is at stake. The trade with West-European countries mainly concerns high-value consumer products, whereas trade with developing countries in particular concerns low-value raw materials. The value of the trade does not tell much about the volume of the transport flows. Nevertheless, the trend is clear: the annual value of the Dutch international trade flows has increased from 175 billion to nearly 600 billion Dutch guilders over the period 1975-1995. Admittedly, these figures are given in current prices, but also the rise in trade in fixed prices (i.e. corrected for inflation) remains still considerable. In conclusion, these figures suggest a growing international orientation of the Dutch economy. However, whether this growth can (partly or entirely) be explained by nomadic tendencies remains to be seen, as this requires more meso- and micro-based research (see Section 4).

Furthermore, it should be noted that import and export flows are only partial indicators for globalisation phenomena (see also Kleinknecht and ter Wengel 1998). In addition to exports and imports, it is also necessary to pay attention to international capital and communication flows. The development of the international inward and outward capital flows - foreign direct investments - shows for The Netherlands to a large extent the same pattern in volume growth and spatial direction as described above for the trade flows. The flow of foreign direct investments towards low wage countries (like, for instance, developing countries) is relatively small and increasing at a low growth

rate. Seen from the viewpoint of the structural and substantial export surpluses, it is no surprise that The Netherlands is a net exporter of capital. Information on international transfer of information and on communication flows is unfortunately missing, so that the picture is incomplete.

Summarising, many empirical facts demonstrate that the share in trade and capital flows of The Netherlands with respect to other European countries is by far the largest and increasing at a fast rate. There are no clear indications of a dramatic orientation of the Dutch economy towards the American, Asian or East-European markets. Inspired by the ideas of globalisation, many recent research efforts on international firm relocations have focused attention on the location of American, Japanese and Korean companies in The Netherlands, but our findings suggest that it is more meaningful to address the relocation patterns of firms at the intra-European level rather than at the global level outside of Europe. Therefore, in the next section we will pay in particular attention to intra-European relocation behaviour of multi-plant firms.

4. Some Empirical Facts on Nomadic Firms

As suggested above, the existence and order of magnitude of nomadic behaviour cannot properly be identified and investigated by means of macro-economic indicators. One needs to investigate more thoroughly the determinants of firms' relocation behaviour from a micro perspective. This is the subject of the present section, in which first a systematic selection mechanism of nomadic firms is offered. The analytical framework is based on the observation that for meaningful relocation research on nomadic firms both the country of origin of the firm and its country of destination have to be considered (see Table 3).

The first quadrant (I) concerns Dutch firms relocating within The Netherlands and is of no interest for the present research endeavour focused on multinational nomadic firms. Moreover, in the past years, abundant knowledge has already been gathered on such intra-country relocations. The second and the third quadrant concern Dutch companies moving towards a location abroad and foreign firms locating in The Netherlands, respectively. Not all these relocations are necessarily nomadic. For example, we might have a single relocation leading to a fixed settlement of the firm, and not necessarily followed by another cross-border relocation in a foreseeable period of time. This restriction does not hold for quadrant IV, which contains foreign firms migrating into The Netherlands but relocating after some time out of the country again. It should be noted however, that in our empirical research we were able to trace only one such dynamic company belonging to this quadrant.

Table 3 Relocation of firms by country of origin and destination

country of destination ↓ origin of firms	→	The Netherlands	Abroad
Dutch companies		I	II
Foreign companies		III	IV

After the description of the analysis framework in Table 3, we will now proceed with our empirical work. To examine the impacts of the relocation of foreign companies into The Netherlands and of Dutch companies abroad on cross-border transport flows and related infrastructure demand of these firms, various companies have been identified and interviewed. By using a structured questionnaire, a wealth of relevant systematic information could be collected. The following distribution of nomadic firms has been deployed for our empirical analysis (see Table 4).

The firms listed in Table 4 belong to quadrant II or III of Table 3. They have been selected from the general business register of the Chambers of Commerce in The Netherlands. All selected companies were characterised by a recent relocation (after 1990). Clearly, the sample does not cover the whole population of nomadic firms, but contains at least important decisions, e.g. from American and Japanese firms and for Dutch firms moving to East-Europe. The foreign companies in The Netherlands (i.e., quadrant III) appear to be service-oriented firms located in the central urban area of The Netherlands (Randstad) and industrial firms located in areas in the vicinity of the Randstad (cf. also Nijkamp and Rienstra 1998). First, they were asked to fill out a survey questionnaire in which they could express their views on the importance of some 40 locational factors for their company as well as the attractiveness score for The Netherlands as a whole on these factors. The scores were given on a five-point scale, for both the time period of their initial location decision in The Netherlands and for the actual present situation. This double check was made, since the importance of some of the locational factors for the firm's activities might have changed since its location in The Netherlands. The same holds for the score of The Netherlands as a whole on these location factors. After the survey questionnaires were returned, the firms were personally interviewed. In the interviews the following items were in particular addressed: general company characteristics, the company network structure, location motives, development of transport flows (inward and outward), and the infrastructure use and demand by the company.

Table 4 List of interviewed nomadic firms

Foreign companies in The Netherlands

- 4 North-American service-oriented companies
- 2 North-American manufacturing companies
- 3 Japanese service-oriented companies
- 3 Japanese manufacturing companies

Dutch companies abroad

- 3 trade companies in Poland
 - 2 transport companies in Poland
 - 2 service-oriented companies in Poland
 - 1 service-oriented company in England
 - 1 service-oriented company in Ireland
-

For quadrant II of Table 3, the attention was in particular focused on Dutch firms in Poland, as this country is recently often regarded as a new spring board for Central - and East-Europe. The Polish pilot study was conducted to analyse the impact of Dutch firms relocating toward a region abroad. In addition, also some control interviews were held by telephone with a foreign company (a truly nomadic company) recently relocated from The Netherlands to England and a Dutch firm that had decided to relocate the majority of its activities to Ireland.

All Dutch companies interviewed in Poland are located in the Warsaw urban area, which is the major booming area in Poland. These firms were asked to fill out a similar questionnaire on the importance of 40 locational factors comparable to those completed by the foreign firms concerned in The Netherlands. The only difference is that they were asked to give the relevant scores for both The Netherlands and Poland for all relevant factors at the time of relocation. In the personal interviews the same items were the subject of discussion, but greater emphasis was here laid on the changes in transport flows (volumes and directions related to The Netherlands) caused by the firm's relocation to Poland.

Both the survey questionnaires and the structured interviews generated a wealth of relevant information, partly of a quantitative and partly of a qualitative nature. The main results will now be discussed in the next section.

5. Results of the Company Surveys

In our presentation of the results of both the survey questionnaires and the interview rounds we will address in particular three issues, viz. the company structure, the transportation factors and the (re)location motives, successively.

5.1 Company structure

Seven of the twelve foreign companies located in The Netherlands and investigated in our empirical analysis appeared to concern European headquarters of the company. In Poland none of the Dutch firms under consideration is a European headquarter, although for six of the seven companies, the Dutch parent company forms the European headquarter.

Table 5 offers some interesting empirical insights. The network structure of all foreign companies is at least European; however, only two of the Dutch companies in Poland are part of a world-wide company network. From both types of firms in our survey (i.e., quadrant II and III from Table 3) it turned out that the companies are completely new subsidiaries. Only one case concerns a take-over of an already existing company. Another common feature of firms in class II and III is the preference for rented premises. Only some 25 percent of the firms possesses its own accommodation and real estate. These companies are either manufacturing companies or transport companies. It seems from our empirical investigation that more land-extensive companies tend to possess their own company real estate. The land-intensive companies however, needing e.g. office buildings seem to prefer to rent real estate.

Table 5 Distribution and features of nomadic firms

Company structure and feature	Foreign companies in The Netherlands	Dutch companies in Poland
European headquarters	7	0 (6)*
European network	12	7
world-wide network	12	2
new company	11	7
rented premise	8	5

* In six cases the Dutch parent company is the European headquarter

Most relocations are apparently the result of an expansion of existing activities abroad. This does not necessarily mean however, that those activities were discontinued in the country of origin. It is important to mention that firms from both classes (II and III) show that only minor adjustments are made to accommodate the product to the demands of the new market. Those minor adjustments consist mainly of regrouping, re-packing or adding guidelines for use in the correct languages.

A major difference between classes II and III is that foreign firms in The Netherlands have hardly changed their activities, whereas Dutch companies in Poland have increased the range of

their activities to a large extent. Foreign companies in The Netherlands have to serve apparently a mature European market, whereas the emerging East-European market in transition offers many unexploited opportunities. The wish of many Dutch companies to have their own - Dutch - management available to them and working with them in Poland, seems largely instigated by their wish to exploit these new opportunities which might not be judged to be sufficiently and effectively ensured by local managers in the host country.

5.2 Transport systems

Regarding the transport flows and the use of transport systems, both types of classes in an survey point in the same direction. Intercontinental freight transport flows are transported either by sea or by air. The distribution within Europe takes place by road, except for special deliveries, high value products, and/or spare materials which are often transported by air. Rail and inland waterway infrastructure seem to be of marginal importance for nomadic firms according to the results of our surveys. However, one should remember that none of the companies surveyed generates flows of low-value bulk products; for such products, rail and inland waterway infrastructure are often used.

There are however, a number of differences between foreign companies located in The Netherlands and Dutch companies located in Poland. Whereas American and Japanese firms in The Netherlands generate largely their own activities and trade flows, Dutch companies in Poland are strongly linked to and dependent on their Dutch parent company. American and Japanese companies appear to develop their own trade flows for independent producers outside of their network structure. The Dutch companies in Poland however, are dependent on goods flows which are generated and directed by the parent company. Dutch parent companies appear to collect almost all inputs and components and distribute next those goods to their subsidiary firms in Poland. This spatial pattern of collection and distribution by the parent company can partially be explained by the explicit company policy to keep stocks in Poland low, in particular since taxes and customs duties must be paid immediately at the Polish border.

Another important difference between American and Japanese companies in The Netherlands on the one hand and Dutch companies in Poland on the other is that the market area of the first class comprises all of Europe, whereas the market area of the latter is mainly in Poland and its East-European neighbours. Only in the long-term do the Dutch companies in Poland intend to expand their activities by opening new subsidiary firms in, for instance, Russia. Clearly, it is noteworthy that, in general, it may be difficult to attract and maintain internationally operating firms in The Netherlands, since the market area exceeds clearly the small size area of The Netherlands. The large consumer markets for those internationally operating firms are predominantly Germany, France and the United Kingdom. However, a number of companies stated that from a strategic point of view, it

is an advantage to be located in a relatively small consumer market in Europe: none of the large consumer markets can claim that the company is competitively located in their home markets; and even more importantly, none of the large consumer markets can complain that the company is located in another large consumer market instead of their own home-market. Thus, from a strategic competitive viewpoint a small country may also have advantages for a nomadic firm.

5.3 Location motives

In both case studies related to quadrant II and III of Table 3 the main aim of the companies investigated to relocate across the border is to expand their activities in an emerging market. All companies stated that both the expansion and the entrance into the new market have been successful; so there is apparently a low tendency to relocate soon the subsidiary firm once more again. Apparently, nomadic tendencies are mitigated by market success.

The entrance of companies into the North-western European market is of a different magnitude compared to the entrance into the East-European market. The North-western European market is a developed, mature market close to the point of saturation for standard products, whereas the East European market is a young, undeveloped market in a phase of rapid transition. The particular advantages of the Polish market are the relatively stable economic and political climate. The Polish market is also a good frontier market for expanding into other East-European markets, although the recent recession in Russia tends to make Western firms more hesitant.

The entrepreneurial demands concerning the location profile of a region are rather diverse in the case studies related to quadrant II and III. In Poland the entrepreneurs require a stable political, economic, financial - notably currency exchange - climate and low wages. The underdeveloped infrastructure network, inefficient customs facilities and bureaucratic legislation etc. do not severely restrain Dutch companies from locating in Poland. In regard to the second class of case studies, i.e., a location in The Netherlands, the prerequisites of American and Japanese companies are more stringent. They indeed make their locational choice based on a favourable locational profile like legislation, accessibility to various types of infrastructure networks, fast customs facilities offered, etc. Clearly, when The Netherlands would not be able to fulfil such wishes, these companies would decide relatively easily to relocate to another country within North-western Europe. The decision to relocate from The Netherlands to countries such as Belgium, Luxembourg, Germany, and even France and the United Kingdom, seems to be easier than the decision to relocate from Poland to a Baltic state, Russia or the Ukraine.

In conclusion, locational motives of nomadic firms are rather diverse. There are common elements (such as market expansion and cost-minimising behaviour in a competitive global economy), but there are also country-specific, site-specific and sector-specific motives. This

analytical issue will be further addressed in Section 6.

6. A Rough Set Analysis for a Comparison of Locational Determinants of Nomadic Firms¹

The sample of nomadic firms investigated in our field work is rather small (21). Furthermore, many of their statements on the importance of infrastructural and other factors of their locational decision - as expressed during intensive interview rounds - appeared to be rather 'soft' in nature. As a consequence, standard statistical techniques (such as logit analysis) cannot be applied here. And therefore, we will resort to a rather new mathematical approach which has recently also been used for another comparative study of 'soft' locational factors (see Nijkamp and Rienstra, 1998).

Rough set analysis is essentially a decision support tool from operations research which tries to formulate decision rules of an 'if...then' nature. Based on a multidimensional survey table of objects (alternatives, individuals, phenomena), it aims to find out which combinations of a classified set of values characterising these objects are consistent with the occurrences of a class value of a response variable. Clearly, there may be multiple decision rules that fulfil this consistency requirement. So rough set analysis seeks to trace these decision rules (based on some sort of combinatorial logic) and to identify which background variables (or attributes) are showing up in these decision rules and with which frequency. These variables are then the critical determinants of the phenomenon under investigation. More details on rough set analysis can be found in Annex 1.

In the framework of our empirical research we start with the specification of the multidimensional information table (see Table 6), which we have constructed on the basis of the survey questionnaires and interviews among all nomadic firms. The variables x_1 to x_{10} are the 'explanatory' factors (attributes) which for each nomadic firm determine its response variable, viz. the degree of footlooseness (in contrast to source- or market-orientation) as an indicator for the question whether the firm concerned is in principle nomadic in nature. The total number of interval classes per item is 2, 3 or 4. Clearly, for each firm in our sample this information table can now be filled out by using the qualitative ('soft') information from the survey questionnaires and the interviews.

¹ The authors wish to thank Maurice Ursum for his statistical support in the rough set analysis.

Table 6 Multidimensional information table on the attributes of 21 nomadic firms

		Class 1	Class 2	Class 3	Class 4
country of origin	x1	US	Japan	Netherlands	Other
economic sector	x2	services	industry	trade	transport
investment level	x3	---/--/-	+	++/+++	
new versus take-over/merger	x4	take-over	new		
cost reduction versus market penetration	x5	---/--	-/0	++/+++	
labour intensity	x6	-	0	+ /+++ /++++	
international production	x7	--	0	+ /++	+++
international network	x8	0/+	++	+++	
international trade	x9	---/--/-	+ /++	+++	
goods flows	x10	---	+	++/+++	
footloose character	y	---/--/-	+	++/+++	

Table 7 Data table on the occurrence and composition of minimal sets in rough set analysis

Minimal sets			
{1, 6, 9, 10}	{1, 3, 5, 9, 10}	{1, 2, 6, 7}	{1, 2, 4, 6, 9}
{1, 5, 7, 10}	{1, 3, 6, 7, 10}	{1, 2, 5, 7}	{1, 2, 3, 4, 5, 9}

Following the rough set approach (see Annex 1), we can now draw up the table containing all information on the minimal sets (see Table 7). The country of origin appears to show up in the core of the decision rules, so that this is a common explanatory variable for nomadic behaviour in all cases. Other variables with a high frequency in the decision rules are the sector comprising the firm concerned, the size of goods flows, the labour intensity and the degree of international production (see Table 8).

Table 8 Results of the rough set analysis

		minimal set	variable value in decision rule	average per set	nr. of classes
country of origin	x1	8 (core)	86	10.8	4
economic sector	x2	4	51	12.8	4
investment level	x3	3	13	4.3	3
new versus take-over/merger	x4	2	5	2.5	2
cost reduction versus market penetration	x5	4	20	5.0	3
labour intensity	x6	4	25	6.3	3
international production	x7	4	25	6.3	4
international network	x8	0	--	--	3
international trade	x9	4	23	5.8	3
goods flows	x10	4	32	8.0	3

Table 9 Frequency of explanatory variables values included in the rough set decision rules

		y = ---/--/-				y = +				y = ++/+++			
		1	2	3	4	1	2	3	4	1	2	3	4
86	country	17		25			12			13	5	6	8
51	sector	8	5	4	3		2			25	4		
13	investments	1	1	5						1	2	3	
5	new / take-over						2			2	1		
20	costs / market	6	4	5						5			
25	labour	2	8	4						3	7	1	
25	international production			2	4			4		2	2	7	4
0	international network												
23	international trade	1	5				2	2		3	4	6	
32	goods flows		2	8			2	2		12		6	

Although the country of origin is the core variable in the model, it appears to need on average quite a few decision rules for each set to explain the variance in the footlooseness of firms (as is the case for the economic sectors). In other words; there seems to be no simple and straight

forward relationship between the country of origin and footlooseness. More information about the underlying relationships can be derived from Table 9 by looking at the values of the explanatory variable included in the decision rules. For instance, it appears that quite some American companies are either footloose or not at all. This might be explained by the fact that approximately half of the American firms is industrial in nature, while the other half is service-oriented. As can be seen from the sectoral findings, the industry is rather inert from a spatial mobility perspective, whereas services are highly footloose. The Dutch firms in Poland appear to be rather inert as well. This can also be explained by the sector composition: the Dutch firms in Poland are mainly trade and transport sector companies.

Another interesting result is that market-oriented firms are inert and that firms that produce no goods are footloose. This last result implies that the infrastructural needs of footloose companies are low from the viewpoint of the inflow and outflow of goods.

Table 10 Frequency of firms affected by variable values included in the rough set decision rules

		y = ---/--/-				y = +				y = ++/+++			
		1	2	3	4	1	2	3	4	1	2	3	4
141	country	25		41			32			16	9	6	12
72	sector	8	9	12	6		2			31	4		
13	investments	1	1	5						1	2	3	
5	new / take-over						2			2	1		
27	costs / market	6	10	5						6			
33	labour	2	11	8						3	8	1	
40	international production			2	4			16		2	2	10	4
0	international network												
34	international trade	1	7				6	2		4	4	10	
46	goods flows		2	9			6	2		20		7	

The results of Table 9 appear to show up even more pronounced in Table 10, in which the frequency of firms affected by the specific variable values included in the decision rules are given. For instance, it can easily be seen that the American, Dutch and market-oriented firms are more inert and Japanese firms, service sector firms and firms producing no goods are more footloose than Table 9 showed. Some additional findings are that labour-intensive firms are relatively

established, while firms operating in an international trade network are more nomadic.

The results of the rough set analysis confirm largely our findings (see Table 1) about the relationships between footlooseness and the characteristics of firms. Having now discussed in mainly qualitative terms the findings from our empirical investigation of nomadic firms, it is important to suggest policy-relevant conclusions. This will be the subject matter of the next section.

7. Nomadic Relocation and Infrastructure Lessons

7.1 General observations

The relationship between nomadic companies and transport infrastructure has to be seen from two angles. The supply side of infrastructure is of critical importance in convincing and attracting foreign firms to locate in a specific country. The infrastructure supply in The Netherlands is relatively favourable from a European point of view. More important however, is the fulfilment of the business demand for efficient transportation of goods. Foreign companies locating in The Netherlands will generate transport flows and the input and output flows of these companies will have The Netherlands as their home base. This creation of new transport flows by foreign companies located in The Netherlands will have significant impacts on the volume and the direction of the total transport flows and the efficient use of transport modes in The Netherlands. The reverse effects may show up when companies decide to relocate outside The Netherlands, for instance, towards Eastern-Europe or Asia. The related transport flows may then shift in terms of direction of flows (e.g., more flows passing through the eastern part of The Netherlands towards Eastern-Europe, or more exports instead of imports in Dutch seaports), but they may also affect the choice of different transport modes (e.g., road instead of inland shipping or rail) or they may even bypass The Netherlands (i.e., then goods are directly transported from the United States towards Poland without trans-shipment in The Netherlands). This might then also lead to an under-utilisation of the existing and/or planned Dutch infrastructure networks.

For an efficient handling of the input and output of transport flows of internationally operating companies, the quality of interregional and international infrastructure networks are apparently of critical importance. Admittedly, for commuting trips, business services and daily deliveries, the local - urban - infrastructure networks are also of primary importance. Although the quality of local infrastructure networks did not receive particular attention in our case studies, a number of Japanese and American companies appeared to state that the accessibility of urban areas is of utmost importance for their decision to stay in The Netherlands. In particular, metropolitan accessibility seems to be a critical location factor in the severely congested Randstad area in The Netherlands.

7.2 *Dutch infrastructure policy*

There are two main targets of infrastructure policy in The Netherlands. First, within the rather strict Dutch environmental sustainability conditions, the mainports Rotterdam and Amsterdam should be given sufficient opportunities to grow. And second, there is a preferential policy concerning transport flows on the main corridors from these mainports towards the hinterland. These corridors should as much as possible be freed from congestion.

This policy is in line with the demands of the Japanese and American companies located in The Netherlands. Their goods must be imported by the Dutch mainports and distributed throughout Europe, mainly by road. The combination of a seaport and an airport located nearby is especially seen as a strategically important location factor. Apart from the Randstad, this combination of two entry ports within Europe is found only in Belgium and Northern Germany. Nevertheless, the location of Japanese and American companies in The Netherlands is not necessarily destined forever; several of these companies appear to constantly evaluate critically their geographical location and accessibility with a view to their access to European markets.

The trade flows of Dutch companies in Poland continue to be directed by the parent company in The Netherlands. The transport flows to Poland use mainly the road network, even-though the Polish road infrastructure is of a poor quality. Only high-value goods are transported by air. However, the Dutch parent companies often buy their inputs on the world market, while the distribution towards the subsidiary companies abroad then takes usually place afterwards by road transport. This observation underlines the importance of efficient road transport corridors from The Netherlands towards the rest of Europe.

Most firms interviewed in our field work intend to expand their activities in Central- and Eastern-Europe in the near future, assuming that the 'Russian disease' will not affect trade significantly. If the transport flows continue to be organised by parent companies, one might expect a rapid increase in the volume of the transport flows towards Central- and Eastern-Europe; these flows may especially pass through the eastern area of The Netherlands.

We may thus conclude that both foreign companies in The Netherlands and Dutch firms abroad highlight the importance of an effective Dutch infrastructure policy, in which much emphasis is laid on the quality of mainports and their hinterland connections.

7.3 *European infrastructure policy*

The European infrastructure policy as developed by the European Commission has a clear emphasis on the construction of Trans European Networks (TEN's) for road and high speed rail connections. Along with the TEN's, the European Commission supports deregulation in aviation and rail transport to increase the efficiency achieved in those networks.

Both case studies related to quadrant II and III of Table 3 show the importance nomadic companies attach to the development of the European road network. Only to a minor extent is aviation used for the European distribution of goods. The train and inland waterways play no important role. From a company perspective, in the short-term the further development of the road network seems to be of utmost importance. It should be added however, that in our empirical work no heavy industries were included, since these are not foot-loose. It is highly possible that for such industries, inland waterways and rail may also be important transport modes (next to pipelines).

We may thus conclude that from a European perspective, The Netherlands has a high interest in being well connected to the TEN's as advocated by the European Commission. Seen from this perspective of multinational nomadic firms, it seems thus desirable to secure its relatively accessible position within the European transport infrastructure networks.

8. Conclusions and Policy Strategies

In general, companies attach much importance to two types of network infrastructure: (i) long-distance transport infrastructure (TEN's, railroads, highways, aviation, inland waterways, and sea shipping) with a view to interregional and international transport, and (ii) high-quality local/metropolitan infrastructure (light railways, hybrid railway systems, orbital motorways, parking facilities etc.) with a view to the daily distribution of commuting and service traffic. Both types of infrastructure improve the access to - and accessibility of - locations and are therefore important locational factors for firms. The weights attached to these factors by firm appear to differ and to depend on the sector concerned, the economic activity, the geographic location and the market.

An interesting finding is that really foot-loose or nomadic companies exist only rarely in a pure form. There will always be some kind of physical linkage to existing transport infrastructure. Relocation of activities is only desirable when the costs of a new location - in terms of infrastructure costs - are lower than those at the old location. Next to this, the transition and sunk costs caused by the relocation might be prohibitive. Therefore, in reality there will only be a small fraction of companies operating in a purely contestable market with zero entry and exit costs which might instigate a frequent relocation of company activities. The chance of finding nomadic companies that are both foot-loose and have negligible transition and sunk costs is thus small. This means that even in an international economy, pure nomadism will probably not become a phenomenon of considerable size in terms of entire physical company relocations. However, a development that may be expected is a flexible relocation in several phases. Firms may open subsidiary companies which, over time, expand their activities and gain in economic importance. In the longer term, this process will have the impact of a nomadic relocation, and can only be measured in an evolutionary sense. Research on relocations should therefore pay more attention to those incremental relocation

processes. In other words, it is at the end not the question whether pure nomadism exists that is important, but rather to which extent - given a number of relocations of certain activities - there is a process of nomadic tendencies.

Finally, transport infrastructure is only one of the important determinants of relocation decisions and of nomadism, next to other location factors, such as quality of life, labour market conditions, cost levels, etc. Even though in some cases it may seem that the quality of the transport infrastructure network is of decisive importance, the actual location decision is normally based on a broad set of locational factors which determine the entrepreneur's choice. In a saturated competitive market, 'soft' location factors such as local image and local policy might be particularly important. It might be attractive in such a market to link infrastructure advantages of a given geographical site to economic and psychological image factors of that location.

In the light of the previous findings, it is from a policy perspective also important to understand that infrastructure comprises more components than only roads and harbours. It concerns an integrated package of services offered by networks of several categories, which explains that a company located at a certain place is sometimes able to generate more benefits - or market opportunities - than a company at some other location with the same infrastructure quality would achieve. This implies that from the viewpoint of internationally operating companies the identification of weak links in the logistic chain and of bottlenecks in an integrated package of transport infrastructure services is of critical importance.

References:

- Amin, A., and N. Thrift (eds.), *Globalisation, Institutions and Regional Development in Europe*, Oxford University Press, Oxford, 1994.
- Baaijens, S., and P. Nijkamp, Meta-analytic Methods for Exploratory and Explanatory Research, *Journal of Policy Modelling*, 1998 (forthcoming).
- Bergh, J.C.J.M., van den, K. Button, P. Nijkamp and G. Pepping, *Meta-analysis in Environmental Economics*, Kluwer, Dordrecht, 1997.
- Bertuglia, C.S., S. Lombardo and P. Nijkamp (eds.), *Innovative Behaviour in Space and Time*, Springer-Verlag, Berlin, 1997.
- Bruinsma, F.R., C. Gorter and P. Nijkamp, *En de Karavaan Trok Verder...*, Adviesdienst Verkeer en Vervoer, Rotterdam, 1997.
- Button, K., and P. Nijkamp, Environmental Policy Assessment and the Usefulness of Meta-analysis, *Socio-economic Planning Sciences*, vol. 31, no.3, 1997, pp.231-240.
- Castells, E. (ed.), *High Technology, Space and Society*, Sage, New York, 1985.
- Davidson, P., *Netwerkvorming in de Vliegtuigindustrie*, Master's Thesis, Dept. of Economics, Free University, Amsterdam, 1995.
- Dicken, P., *Global Shift*, Harper & Row, London, 1986.
- Fischer, M.M., and P. Nijkamp (eds.), *European Monetary Integration and Regional Industrial Development*, Springer-Verlag, Berlin, 1999 (forthcoming).
- Hakansson, H. (ed.), *Industrial Technological Development; A Network Approach*, Croom Helm, Andover, Hants, 1987.
- Hinterhuber, H.H., and B.M. Levin, Strategic Networks, *Long Range Planning*, June, 1994, pp. 43-58.
- Kamann, D.J. and P. Nijkamp, Technogenesis, *Technological Forecasting and Social Change*, vol. 39, 1993, pp. 35-46.
- Kleinknecht, A., and J. ter Wengel, The Myth of Economic Globalisation, *Cambridge Journal of Economics*, vol. 22, no. 5, 1998, pp. 637-647.
- Lagendijk, A., *The Internationalisation of the Spanish Automobile Industry*, Thesis Publishers, Amsterdam, 1993.
- Matarazzo, B., and P. Nijkamp, Methodological Complexity in the Use of Meta-analysis for Empirical Environmental Case Studies, *Journal of Social Economics*, vol. 34, nos. 7-9, 1997, pp. 799-811.
- Nijkamp, P., and A. Reggiani, *The Economics of Complex Spatial Systems*, Elsevier, Amsterdam, 1998.
- Nijkamp, P. and S. Rienstra, *Internationalisation and Localisation*, Research Paper, Department of Spatial Economics, Free University, Amsterdam, 1998.
- Nijkamp, P. S. Rienstra and J. Vleugel, *Transportation Planning and the Future*, John Wiley, Chichester/New York, 1998.
- Nijkamp, P., and N. Vermond, Scenarios on Opportunities and Impediments in the Asian Pacific Rim, *Studies in Regional Science*, vol. 11, no. 3, 1996, pp. 1-46.
- Omrod, R.O., Local Context and Innovation Diffusion in a Well-connected World, *Economic Geography*, vol. 66, no. 2, 1990, pp. 109-122.
- Pawlak, Z., *Rough Sets*, Kluwer, Dordrecht, 1991.
- Raesfeld Meyer, A. von, *Technological Cooperation in Networks*, Ph. D. Thesis, Twente University of Technology, 1997.
- Reggiani, A., P. Nijkamp and S. Bolis, The Role of Transalpine Freight Transport in a Common European Market, *Innovation*, vol. 10, no. 3, 1997, pp. 259-275.

- Rietveld, P. and F. Bruinsma, *Is Transport Infrastructure Effective?: Transport Infrastructure and Accessibility; Impacts on the Space Economy*, Springer-Verlag, Berlin, 1998.
- Schachar, A., and S. Öberg (eds.), *The World Economy and the Spatial Organization of Power*, Avebury, Aldershot, UK, 1990.
- Slowinski, R., *Intelligent Decision Support*, Kluwer, Dordrecht, 1992.
- Storper, M., Innovation as Collective Action, *Industrial and Corporate Change*, vol. 5, no. 3, 1996, pp. 761-790.
- Suarez-Villa, L., *The Evolution of Regional Economics*, Preager, New York, 1989.
- Thorelli, H.B., Networks: Between Markets and Hierarchies, *Strategic Management Journal*, vol. 7, 1986, pp. 37-51.
- Thwaites, A.T., Technological Change, Mobile Plants and Regional Development, *Regional Studies*, vol. 12, 1978, pp. 445-461.
- Verhoef, E., *The Economics of Regulating Road Transport*, Edward Elgar, Cheltenham, UK, 1996.
- Williamson, O.E., *Markets and Hierarchies*, Free Press, New York, 1979.

Annex 1

Concise Description of Methodology of Rough Set Analysis

The total number of cases investigated in our study is 21 potentially nomadic companies. Clearly, this sample is not sufficient for applying standard statistical methods. Therefore, a recently developed nonparametric statistical method concerning data analysis is used. This is rough set analysis, developed by Pawlak (1991) and Slowinski (1993). We will offer here a concise introduction to rough set theory (for further details we refer to van den Bergh et al. (1997), Matarazzo and Nijkamp (1997), Baaijens and Nijkamp (1998) and Button and Nijkamp (1998)).

A rough set is a set for which it is uncertain in advance which objects belong precisely to that set, although it is in principle possible to identify all objects which may belong to the set at hand. Rough set theory takes for granted the existence of a finite set of objects for which some information is known in terms of factual (qualitative or numerical) knowledge on a class of attributes (features, characteristics). These attributes may be used to define **equivalence** relationships for these objects, so that an observer can classify objects into distinct equivalence classes. Objects in the same equivalence class are - on the basis of these features concerned - **indiscernible**. In case of multiple attributes, each attribute is associated with a different equivalence relationship. The intersection of multiple equivalence relationships is called the indiscernibility relationship with respect to the attributes concerned. This intersection generates a family of equivalence classes that is a more precise classification of the objects than that based on a single equivalence relationship. The family of equivalence classes that is generated by the intersection of all equivalence relationships is called the family of elementary sets. The classification of objects as given by the elementary sets is the most precise classification possible, on the basis of the available information.

Next, we will introduce the concept of a **reduct**. A reduct is a subset of the set of all attributes with the following characteristic: adding another attribute to a reduct does not lead to a more accurate classification of objects (i.e., more granules), while elimination of an attribute from a reduct does lead to a less accurate classification of objects (i.e., less granules).

Finally, the **core** of a set is the class of all indispensable equivalence relationships. An attribute is indispensable if the classification of the objects becomes less precise when that attribute is not taken into account (given the fact that all attributes have been considered until then). The core may be an empty set and is, in general, not a reduct. An indispensable element occurs in all reducts. The core is essentially the intersection of all reducts.

Based on the previous concepts, rough set theory is now able to specify various decision rules of an "if then" nature. For specifying decision rules, it is useful to represent our prior knowledge on

reality by means of an information table. An information table is a matrix that contains the values of the attributes of all objects. In an information table the attributes may be partitioned into **condition** (background) and **decision** (response) attributes. A **decision rule** is then an implication relationship between the description of the condition attributes and that of a decision attribute. Such a rule may be exact or approximate. A rule is exact, if the combination of the values of the condition attributes in that rule implies only one single combination of the values of the decision attributes, while an approximate rule only states that more than one combination of values of the decision attributes corresponds to the same values of the condition attributes. Decision rules may thus be expressed as conditional statements ('if then').

In practice, it is possible to use both decision rules implied by the data contained in the information table and, if necessary, in further rules supplied and suggested by experts. The former may be accompanied by an indicator of their "strength", for example, the frequency (absolute or relative) of events in agreement with each decision rule. Moreover, both the former and the latter rules may be based on suitable and different sets of condition attributes, containing a larger or smaller number of attributes (even a single attribute). This latter case implies that the value assumed by an attribute is sufficient to guarantee that the decision attribute (or attributes) will assume certain values, whatever the values of the other condition attributes.

Decision rules, that constitute the most relevant aspects of rough set analysis, may be directly applied to problems of **multi-attribute sorting**, that is, in the assignment of each potential object (action, project, alternative, etc.) to an appropriate pre-defined category according to a particular selection criterion. In this case, the classification of a new object may be usefully undertaken by a comparison between its description (reflected in the values of the condition attributes) and the values contained in the decision rules. These are more general than the information contained in the original information table and permit also a classification of new objects more easily than would be possible by using a direct comparison between the new and the original objects. In general, decision rules in rough set analysis allow to make conditional transferable inferences, as the 'if' conditions specify the initial conditions, while the 'then' inference statements highlight the logical valid conclusions for cases outside of the initial set of objects. In this way, rough set analysis can also be used as a tool for conditional transferability of results from some case study to a new situation.