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**INTERREGIONAL TRADE FLOWS IN FINLAND:**  
Research Methods and Some Empirical Evidence.

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## **Abstract**

The aim of this paper is to discuss about the relationship between economic growth and patterns of interregional trade flows. The research question is: What are the differences in patterns of commodity flows between different industries and different regions, and how do these patterns differ from the Finnish average level? The goal is to learn to understand the spatial dynamics of regional specialisation in relation to demand, supply and interaction networks. This paper examines the pattern of economic interactions between Finnish provinces (NUTSIII -level regions in the EU) using trade flow data on nearly 4000 companies. They were asked about the destination of their sales and the origin of their purchases.

Special attention is paid to the multiregional trade models, such as Input-Output models and Gravity-type models. Furthermore, Graphical models and Neural Network models, which are not traditionally used in analyzing trade flows between different regions, are introduced. Differences between these models are, also, discussed. Finally, some empirical results from the trade flow distributions are introduced. These results show, for example, that home region is the most important region both in sales and purchase. Thus, approximately 40 per cent of total sale is intraregion sale and, furthermore, the purchase from home region is also significant.

**Keywords:** Economic networks, commodity flow distributions, and spatial interaction models

## **1. Introduction**

Economically successful regions and areas have often little in common due to the differences in industrial structure, etc. (Perry, 1999, p. 1). There are, however, some factors in production which all of these places competes. These factors are land, labour, capital and technology. They are considered as entry factors, inputs to economic activity in a certain region. They, furthermore, determine output levels the economy or the region is able to produce. The output, on the other hand, determines the economic activity of the region in question. While region with high level of output attract more financial investments, which further attracts firms to relocate or start their businesses there further attracting skillful workforce with good job opportunities and vice versa. These further promote region's economic activity and output levels and, thus, attract trade partners i.e. promote interregional interaction.

The aim of this study is to learn to understand the spatial dynamics of regional specialisation in relation to demand, supply and interaction networks between Finnish provinces. The research question is: What are the differences in patterns of commodity flows between different industries and different regions, and how do these patterns differ from the Finnish average level.

Trade flow is defined by data in this context. Statistics Finland has collected data on postal survey from nearly 4000 Finnish companies (Piispala, 1999; and Kauppila, 1999). They were asked about the shares of destination of their sales and the shares of origin of their purchases. While, for example, the turnover of a particular firm is known and, among other things, the total turnover of a particular industry is known, it is possible to estimate the direction and magnitude of interregional interaction between Finnish provinces. Additional data, such as flows of commercial wood, etc., are also used in order to avoid bias in inferences.

Section 2 contains discussion about relationships between spatial interaction and economic development. In section 3 some aspects concerning network dynamics is touched. Different methods for analysing and estimating interregional trade flows are introduced in section 4. Finally, a brief description about data, discussion about quality of data, and some empirical results are revealed in section 5.

## **2. Spatial Interaction and Regional Economic Development**

A substantial number of definitions have been done to handle the question of defining a region in the context of regional economics. One dimension of such definition is the concept of a functional region (e.g. Karlsson & Nilsson, 1999; and Bailey). It can be defined according to the operational structures of its activities. It can also be considered as an economically active and economically self-sufficient region where people lives and works at a same time. The functional region consists of one or more urban centers surrounded by the peripheral hinterland. Dicken et al. (1990), furthermore, outlines that the different social and economic processes characterize regions. Such a process is, for example, interaction between other regions. Interaction inside the functional region is often of a higher magnitude than between regions due to the higher interaction costs. Despite of the fact that the best estimate to the functional region in Finland is often considered to be NUTSIV –level, the NUTSIII-classification system is used due to the level of aggregation of data.

Increase in production efficiency and in demand promotes – together with accumulation of capital and technological knowledge – economic development (Teubal & Zusckovic, 1994, p. 15). According to Fotheringham and O’Kelly (1989, pp. 1-2) economic development is, furthermore, driven by the increased specialisation. The necessity for that specialisation is spatial interaction. These processes of spatial interaction (e.g. interregional trade, transport systems, migration systems, industrial production systems or diffusion of technologies and innovations) does not occur in isolation but are generated by particular forces. There are three fundamental bases (forces) for all spatial interaction. Firstly, in order interaction to take place between two regions, they must complement each other. Secondly, intervening opportunities have to be, also, available. And finally, if the cost of movement is too great, interaction might be even absent. The last one implies not only to the distance but, also, to the transport costs of different goods. It is, furthermore, related to the varying movement characteristics of different goods and services because some products are more sensitive to distance than others. (Dicken et al., 1990; Fellman et al., 1995)

All these systems have a several features in common. Firstly, the point of origin differs spatially from the point of destination. The difference between these points could be from several meters (in production line) up to thousands of kilometres (in international trade) depending on the system under study. The separation between a set of points could be, also, measured in terms of cost or time spent in order to overcome that separation. Secondly, correlation between the points of origin and destination is related to the distance between them. While geographical distance between any pair of points increases not only the interaction between them but also, the bilateral influence which they share decreases. This leads to the ideas of friction of distance or distance decay, and spatial autocorrelation, respectively. Finally, the spatial level (e.g. point vs. area) from which the data are collected have a major affect on the inference drawn upon the information at hand. If the data are collected from very aggregated level some primary information about the structure of that system might be, and probably is, lost and therefore analyses done and inferences drawn could be biased (MAUP – Modifiable Areal Unit Problem, see e.g. Anselin, 1988; Haining, 1990; and Bailey & Catrell, 1995). Thus, the original data should be as disaggregate as possible in order to fully understand the system in question. On the other hand, a very detailed disaggregation of data causes the problem of reliability if the sample sizes are too small. Results are usually presented in a more aggregate level than original data in order to get clearer picture of that particular system and overall patterns of interactions.

### **3. Economic Networks**

The basic elements of a network are nodes and arcs; node is a agent (i.e. a firm, a city, a region or a nation), in the network, and arc is a link between two nodes or agents. These agents can be connected to networks which works at different levels (Perry, 1999). Karlsson & Westin (1994, p. 3) defines that economic link between two nodes contains a tangible or intangible element of capital. They proceeds that, there is a reason why economic links are durable; they are created by means of investments. Economic link is destroyed if it is not maintained. The change is, furthermore, needed in order to brake stability of an active and maintained link between two nodes. Dutta & Mutuswami (1997), on the other hand, highlight that there might, but not necessarily, be a conflict between network stability and network efficiency. One major source of changes, which breaks the stability, are innovations, which gives a third node superiority over others.

This changes demand structure in the network because third node attracts others in terms of cheaper, differentiated or even whole new goods and services.

Diffusion of innovations can be distinguished into two major (spatial) processes. The process of the movement of new ideas, technologies and products exists either between center and peripheral areas around it, or between two centers which are strongly connected no matter how great the distance between them is. The rate of diffusion declines crucially when distance increases from the center of origin toward the periphery. Furthermore, the importance of means of communication in diffusion process cannot be over-emphasized due to the importance of information. There is, however, a risk concerning transfer of innovation. Risk is related to the lack of information concerning income and expenditure levels. The knowledge about the nature of the alternatives at hand may also be limited. (Shefer & Frenkel, 1998, pp. 189-190) Johansson & Westin (1987, pp. 4-5), on the other hand, outlines that "prerequisite for a node to function as a frequent birth place of a new products is a rich network of import channels". They proceed that second prerequisite for new innovations is the adoption rate the industry is capable of adapting new technological solutions. Furthermore, authors see the gathering of information about new products and technologies as third prerequisite for innovations.

Economic networks are characterised by risk reducing mechanisms. Frequent information exchange in the network itself works as such mechanism. Another form of such mechanism is priority structure, which is set by the network; thus, each agent is given priority (hierarchy) between members and non-members of the network. (Teubal & Zuscovitch, 1994, p. 15) This is, of course, inconsistent with the assumption of a perfect competition in international economics. But it might be true in the real world.

Active and often spatially concentrated industrial network is called a cluster. Clusters are also found in a wide variety of traditional industries. Thus, it is not only recent development of high-tech industries which tries to benefit from others. Companies join into the clusters in order to increase their competitive advantage. High-tech firms are still more and more increasing geographical concentration of their activity despite of the fact that it is easy to pass information over long distances because of the recent development of the information technology. (Swann & Prevezer, 1998, p. 1) Thus,

regions and cities are investing technology parks in order to attract high-tech firms to relocate or start their businesses there. These technology parks are usually situated near universities. Fujita et al. (1999), for example, offers a broad discussion about industrial clustering.

Another important aspect concerning functioning of a network is its synergy and performance. With network synergy Nijkamp and Reggiani (1998) means that structure of a network together with connectivity has an affect to the performance of that network. Thus, network synergy between actors is caused by the increase in performance of network through non-linear development further leading to higher benefits for actors involved. Network performance, which is related to the potential of each link in a network, has two background factors: network coverage and network connectivity (ibid. 151-152). Network coverage implies to the number of agents connected to the network. Network connectivity, on the other hand, implies to the quality of links between nodes in a particular network as a result of network synergy and the structure of that network.

#### **4. Research Methods**

There are several methods which are used in analysing interregional trade flows (Nijkamp, 1986; Batten & Westin, 1989; Fotheringham & O'Kelly, 1989; Haining, 1990; Bailey & Catrell, 1995; & Susiluoto, 1999). Batten and Westin (1989) outlines that there are four types of methods which are used in trade context: 1) Gravity and entropy models, 2) Input-Output models, 3) Spatial Price Equilibrium models, and 4) Interregional Computational General Equilibrium models. Authors proceeds that when all four models are appropriately formulated, they may be regarded as equilibrium models. Susiluoto (1999), furthermore, offers a comparative discussion between three models: 1) Input-Output models, 2) Input-Output models integrated (or combined) with econometric models, and 3) general equilibrium models. He outlines that integrated Input-Output and econometric models might be appropriate in many circumstances.

All above-mentioned methods have their pros and cons. Gravity-type and. Input-Output frameworks, for example, have weak representation of location processes and price formation (Johansson & Westin, 1987, p. 2). According to Batten and Westin (1989, p.



7) Spatial Price Equilibrium models, on the other hand, suffers from their underlying assumptions, namely that: 1) trade is in homogenous, transport sensitive goods; 2) commodity markets are perfectly competitive; and 3) each buyer has completely and reliable information. Authors proceed that assumption of product homogeneity and spatial price equilibrium precludes the possibility of cross-hauling (intra-industry trade). Observed trade patterns, however, shows the opposite; the volume of cross-hauling has increased at least in the national level.

In this paper Gravity-type (chapter 4.1), Input-Output models (ch. 4.2), biocomputing or Neural Network applications (ch. 4.3), and finally, Graphical models (ch. 4.4) are briefly discussed.

#### 4.1 The Gravity Model

The estimate of total flow between two nodes, origin  $i$  and destination  $j$ , is  $\mu_{ij}$  and the distance between those nodes is  $d_{ij}$ . There are, however, other factors affecting to interaction decisions. For example, larger places tend to attract people and economic activity more than smaller ones. The model which takes customer expectations – the potential of different nodes – into account is the Gravity model (Fellman, et al., 1996; Batten et al. 1986; etc.):

$$I_{ij} = k \frac{P_i P_j}{d_{ij}^b},$$

where  $I_{ij}$  = amount of interaction between place  $i$  and  $j$ ,  
 $P_i P_j$  = product of some measure of “mass” (population, etc.) of the two places  $i$  and  $j$ ,  
 $d_{ij}$  = distance separating place  $i$  and place  $j$ ,  
 $b$  = frictional effect of distance, and  
 $k$  = an empirical constant.

Thus, the model predicts the amount of interaction to be proportional to the product of the origin and destination size and inversely proportional to distance between those two nodes.

Some problems might arise when using the Gravity model according to Yamashita, J. 1995, pp. 17-20. First, the Gravity models estimates might be, and often are, distorted in a way that estimated number of flows are not exactly the same as known number of flows. Second, the Gravity model estimates interaction just between city pairs – not multiple interactions which is the case in reality: cities and regions interact with several other cities. Third, Gravity model has no concrete theoretical basis in every socio-economic context. Fourth, there is no logical connection between micro and macro level behavioral in the Gravity model. And finally, interpretation of parameter estimates might be difficult.

In doubly constrained model, which deals with the first problem mentioned, it is possible to estimate exactly the total observed flow. This is possible to do in two stages: first, to fit model to the observed model, and then estimate own parameter, both to origin and destination, by including the covariance structure of the process into the model. Furthermore, it should always investigate how well the fitted model fits to observed pattern of flows. This is done by comparing local differences (residuals) between estimated and observed flows. (e.g. Fotheringham & O’Kelly, 1989)

## **4.2 Input-Output Models**

Input-Output models are widely used in regional science (e.g. Hewings, 1986; Susiluoto, 1997, 1999; Sonis et al. 1998; and Forssell, 1999). One of the main reasons for that is that it allows high level of sectoral disaggregation in the analysis. Another is that it is quite easy to adapt despite the fact it requires quite comprehensive amount of data concerning the economy or functional region in question. According to McGregor et al. (1996) Input-Output models are a single general equilibrium system which has a fixed coefficient technologies. It is, also, assumed that capacity constraints are absent and labor supply is infinitely elastic. Furthermore, it is usually used as an short-term estimation tool but in some circumstances it allows a long-run estimation which can be used as a benchmark for other long-term methods used. Forssell (1999) outlines that with Input-Output analysis, it is possible to analyze and adapt different kind of inputs for example, knowledge and know-how of the labor, and R&D to the model. He proceeds that it is easy to formulate a clear picture about economic dependencies and structures within the particular economy using Input-Output methods.

### **4.3 Neural Network Applications**

The development of computer power has made it possible to adapt Neural Network applications into spatial interaction context. Instead of introducing Neural Networks in detail only some literature is referred (e.g. Nijkamp et al. 1997, 1998, 1999; & Berqvist & Westin, 1997; Fischer & Leung, 1999). Only their pros and cons are briefly discussed.

According to Nijkamp et al. (1997, pp. 414-415) Neural Network applications has two features which makes them suitable tool for statistical data analysis. First, they do not need a priori information about exact statistical model (e.g. in the case of a large quantity of data). Secondly, they can learn and forecast on the basis of noisy, fuzzy and even incomplete data. Furthermore, unlike Gravity-models, it is possible to capture not only aggregate phenomena but also individual behaviour with the Neural Network applications. Thus, Neural Networks are a effective tool for the computational problems, when there is a large amount of data. They, for example, gave better forecasts than logit-models in the Italian transport mode (rail vs. road) context (ibid. 427).

The structure of the network should be, however, properly defined and the application should also be sufficiently trained in learning phase. Also a comparative analysis between different architectures/algorithms and different software packages should be done in order to make sure that inferences drawn are not biased or wrong (ibid. 428). Similarly Berqvist & Westin (1997) found that Neural Network with back propagation learning algorithm has the best performance in the estimating phase, but the forecasting was completely biased.

### **4.4 Graphical Models**

To change the idea of trade flow measured in money to the idea of which flows are more likely to take place in the network at particular time. This idea relates to probability distributions introduced in statistical and probability theory. Furthermore, the fundamental notion in the theory of probability is the conditional independence which can be used in describing multivariate dependencies, like commodity flows

between different nodes in the network. There are several different methods for the analysis of multivariate data sets. The models which are probably most likely to fit with the concept of trade flow data are those of Graphical models.

Graphical modelling is a form of multivariate analysis that uses graphs to represent models both in spatial and non-spatial cases. They provide a concise and informative summary of multivariate interactions. These models consists of families of log-linear models, Gaussian models, and mixed models for discrete and continuous data. The fundamental idea underlying Graphical models, is the concept of conditional independence which means in the network context that everthing what happens in a single node is independent with other nodes condtional to itself and its neighbours. In other words, the probapility of a particular outcome or event in a node is only related to that particular node and its neighbours – not to "neighbours neighbours".(Lauritsen, 1999; Cox & Wermouth, 1996; Whittaker, 1990; and Eriksen, 1999)

Whittaker (1990) presents the benefits Graphical models have compared to other statistical multivariate methods:

1. It is quite easy with the Graphical models to explain and describe multiple relationships between different variables through conditioning some other variables. He outlines also that the global Markov property which gives theoretical framework for interpreting the independence graph (network) in the way that it does not eliminate any association between variables.
2. The process of model selection have become much easier since Graphical models have been adapted. This is because they are so easy to fit and interpret.
3. With Graphical models it is possible to unify continuos data (through correlation matrix) and categorical data (through contingency table).

Eriksen (1999), furthermore, applies Graphical models into context specific interaction models where a rich class of operational models and effective computational algorithms can be adapted. Lauritsen (1999) provides a comprehensive discussion about the causal inference of the Graphical models.

I am going to implement Graphical models into trade flow context. I refer to previous discussion in order to justify my decision despite of the fact that these methods are not straight comparable. In the context of multilayer and hierarchical network such method, which is able to take into account that hierarchical structure, is needed. Of course, I will have to benchmark my results somehow. Thus, I needed to do, at least, part of the analyses in a additional method in order to compare inferences drawn. Such a method could be for example Gravity models or logit (discrete choice) models (for discussion about logit models see e.g. Nijkamp, 1986).

## **5. Data**

Statistics Finland carried out the trade flow survey using postal questionnaire for a sample of companies. The total number of questionnaires sent was nearly 10 000 in which over 4000 answered. Thus, the respondent rate was over 40%. These establishments were asked about the regional destination of their total sales in 1996 covering both the foreign trade and the domestic trade. The origin of their purchases was, also, questioned. Industry was classified using TOL95 classification, where the economy is split into 75 industries. Thus, the information is in the total purchase/sales level, not in the commodity level. (Piispala 1999a, 1999b; Kauppila 1999)

The sample contained only 5.4% of companies, and still, the responses did cover over 40% of the total turnover (Piispala, 1999a, p. 18). Thus, the inferences drawn could be considered to be correct. The intention is, however, to use additional data, such as wood flow studies (Ylitalo et al. 1990; and Västilä et al. 1997) and information about regional transportation flows with different modes of transportation (various sources), in order to get even more accurate results.

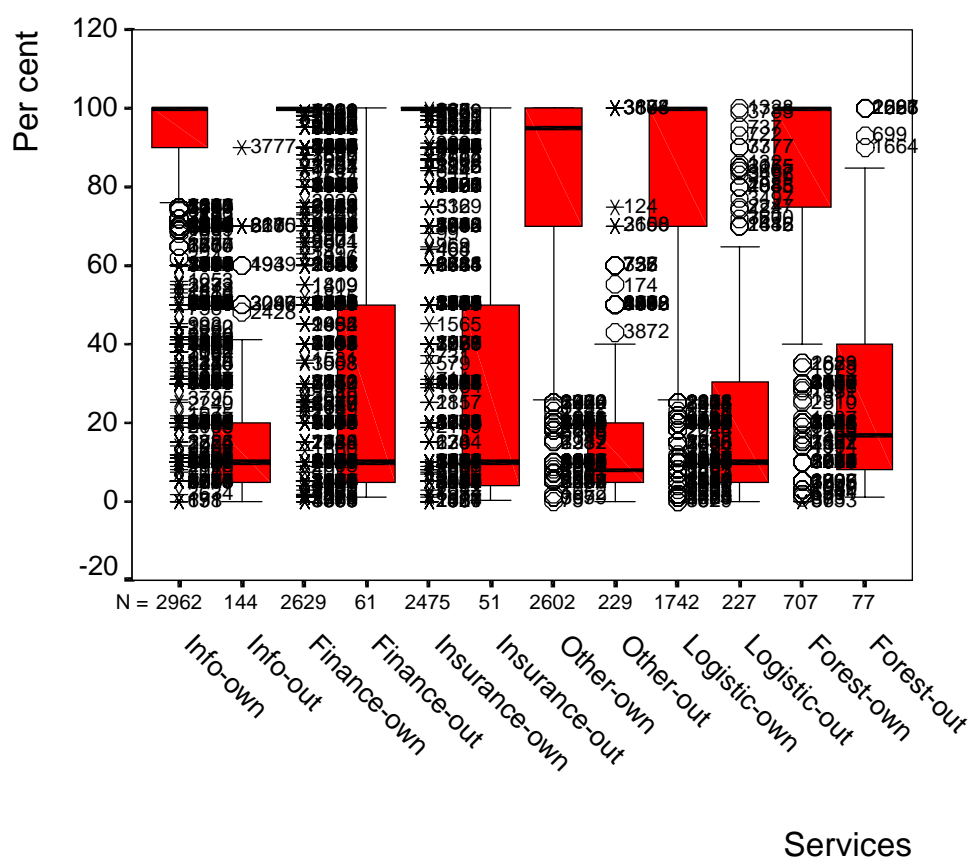
In order to estimate total trade flows between different regions, other indicators are also used. These indicators, which are presented at a regional (NUTSIII-level), are, for example, GDP, number of inhabitants, number of firms per industry, number of employees per industry, the total turnover per industry, investments in R&D, and number of patents. These indicators are needed because the original data implies only to the share of a particular interaction, not into exact volume of different flows.

## 5.1 Some Results

The differences in economic structures among the provinces in Finland are great. For example, Uusimaa (the capital region) have a relatively high service sector while the share of manufacturing industries, and primary industries is only about 20 per cent of the GDP. The share of agriculture and forestry, on the other hand, is great in the eastern and western provinces of Finland. (Piispala, 1999a, p. 4)

These results show, for example, that home region is the most important region both in sales and purchase. Thus, approximately 40% of total sale are intraregion sale. Also the share of international sale is huge; the average is 48%. The regional difference varies considerably between regions; the variation is from 20% up to 62%, Southeast Finland being strongest driven by paper industry. The total export volume is, however, greatest in Uusimaa, Varsinais-Suomi and Pirkanmaa. That is also the area where greatest interregional flows appear. (Piispala, 1999b)

The purchase from home region is also at significant level. Table 1 shows that the median ( $\cong$  mean) of the information services (info-) bought from home region (own) are 100%, while services bought outside (out) home region is around 10%. The situation is approximately same with another services. For example, the finance and insurance services act in the same way although there are some differences in distributions.



**Table 1.** The share of services bought in Finland

The distributions of services bought in Päijät-Häme are presented in the table 2. The distributions look closely the same as they are in the table 1. Although, it should be mentioned that there are too few observations in all those services – except maybe logistic services – bought outside home region in order to make any statistical conclusions. One might, however, want to compare them to the Finnish level (table 1.) in order to get some idea about similarities in the distributions.





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