WINNERS AND LOSERS IN THE EUROPEAN MONETARY UNION

A Neural Network Analysis of Spatial Industrial Shifts

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Abstract

The forthcoming creation of a single European currency area will likely have far reaching impacts on the competitive position of European industries, as a result of a decline in transaction costs and currency risks for intra-European trade. These impacts will take place independent of the question whether the 15 EU countries form an Optimum Currency Area or not. The generally expected gains of trade from an integrated European market may therefore not be Pareto-optimal, as a monetary union may have significant distributional impacts on individual countries and regions. Then there will be winners and losers.

This paper addresses the welfare impacts of a single European currency area by investigating industrial changes and shifts in location that may take place after the introduction of the EURO, based on the idea that fixed exchange rated in the EMU will
be reflected in a decline in transportation costs and industrial clustering. The empirical analysis uses an extensive data set on industrial production, interest rates and exchange rates in the various European countries.

Two policy scenarios are envisaged, with a retrospective (backcasting) scenario on the likely effects of (i) a fixed exchange rate in the past and (ii) a fixed exchange linkage with the US dollar. Next, a neural network analysis is developed to trace for the two above mentioned scenarios the foreseeable and likely welfare effects of a single monetary union. It is concluded that the introduction of the EMU- according to the two past scenarios – would have worsened for most European countries the industrial competitiveness.

1. Prologue

The European integration is not a single and simple event taking place at one moment in time, but a long lasting evolutionary process with many ups and downs (see for an interesting survey Jones 1996 and Swann 1996). The first integration plans date back to the early post-war period, while the development of European integration will likely stretch far into the next century. European integration encompasses more than market integration; it incorporates also social, political, technological and monetary harmonization. After the completion of the internal market and the steps towards opening up the European economic space towards Central- and Eastern-Europe, much debate has in recent years centered around the challenges of transforming the European Monetary System (EMS) into the Economic and Monetary Union (EMU) (see e.g. Loureiro 1996). The EMS - already some twenty years in existence - was put in operation to ensure monetary stability in European Community countries and acted as a 'laboratory experiment' which might lead to a complete European monetary unification.

Such an integrated financial market would favour economic efficiency and would discourage national exchange rate policies aiming to achieve country-specific economic goals, while also some financial discipline would be imposed on high-inflation countries (see Eichengreen et al. 1995; De Grauwe 1994; Kenen 1995).

The road towards the EMU has been full of obstacles (see e.g. Alders et al. 1996). The EMS system - with the European Currency Unit (ECU) as a central accounting unit - has shown various tidal movements, and it has lasted until the Maastricht Treaty (1991) before a decision was taken by the European member countries to pave the road towards the EMU. In contrast to the EMS, the countries did not only commit themselves to a stable exchange rate, but - more importantly - also to full monetary integration. The Maastricht Treaty has formulated several strict convergence criteria to be fulfilled in order to qualify as an EMU member. The most important criteria - which would encourage intra-EU convergence - are: a public budget deficit of less than 3% of GDP (apart from very exceptional cases), a government debt of at maximum 60% of GDP, and an inflation rate that is at maximum 1.5% higher than the average of the lowest three EU countries. Such conditions would not only serve as entry conditions, but would also have to be met during the stage of actual monetary integration. The so-called Stability Pact stipulates that EU-countries jeopardizing the stability of the EMU by inappropriate budgetary policies may be subject to a penalty. In this context, the European Central Bank would become a very powerful agency (see also Canzeroni et al. 1994); it would also be responsible for maintaining a stable, low and single European interest rate for the European currency, the Euro.

A historical decision was reached on May 1 and 2, 1998, when the eleven EU countries which would qualify and were willing to join the EMU were named. These countries have agreed on an irrevocable conversion rate between their currencies and the single European currency. These eleven participants represent an important market of a substantial critical mass (some 290 million consumers). The non-participating countries are: Great-Britain, Denmark, Sweden and Greece. The reasons for their non-entry are different: Great-Britain and Denmark have for the time being insufficient domestic support for the Euro, Sweden has additionally not yet met the exchange rate requirement, and Greece has by far not met any of the budgetary entry requirements.

The EMU will have significant consequences for EU macro-economic policy, e.g. fiscal policy, tax harmonization, socio-economic expenditure policy, stabilisation policy etc. It seems also plausible that in the near future important issues like fiscal federalism (i.e., the question of allocation of taxation and public expenditure rules across different levels of government) will come to the fore (see Van Aarle et al. 1997). Although thus far the main interest has been in nominal convergence in the EU (reflected inter alia in inflation convergence, exchange rate stability and low fiscal deficits), there is an increasing awareness

of the uncertainties involved in real convergence, such as in the industrial sector and the labour market (see also Heylen and Van Poeck 1995 and Jaeger and Parkinson 1994).

The expected benefits of the European economic and monetary integration have been widely praised in recent years: free trade of goods, capital and labour; absence of exchange rate risks among the EU countries; significant reduction of transaction costs for the industry. These conditions would clearly favour the competitive position of Europe's industry. But some evident questions still remain: what is the order of magnitude of these benefits and how are they distributed across sectors, countries and regions? More than a decade ago, the well-known Cecchini report (1988) was published which tried to assess the efficiency gains of a single European market. This report formed the economic basis for decision-making on the completion of the internal market and offered the necessary quantitative foundation for integration policies in Europe which would stimulate industrial development (see also Bangemann 1992 and Nicolaides 1992). Such quantitative estimates are at present lacking for the industrial effects of the EMU. Clearly, the gains of the EMU will mainly depend on entrepreneurial response in Europe, e.g., in terms of flexibility, international orientation and marketing. The business community has at present a portfolio of new opportunities offered by an integrated and homogeneous European monetary market system.

The main question however, will be whether such a uniform market with entirely free mobility of capital, labour and goods is likely to emerge in a European context. In contrast to the USA, for instance, there is not a homogeneous culture, there are many language barriers, and there is only a limited mobility of labour. This inertia may form serious impediments to the achievement of full gains of European economic and monetary integration. In this framework also the Optimum Currency Area (OCA) theory may provide important analytical insights into the opportunities and barriers of monetary integration between different countries (see Section 2).

In the light of the previous observations, this paper seeks to offer a critical assessment of the expected benefits of economic and monetary integration for European industries. The literature suggests that the success of integration policies depends largely on the existence or emergence of an Optimum Currency Area (OCA) after monetary integration of distinct countries. If the OCA conditions are not met, a non Pareto-optimal monetary union may result with serious equity impacts on individual industries, regions or countries. After a survey of relevant literature, the paper then moves on and seeks to identify possible win-lose situations in a single European currency area for European industries as a result of locational shifts that are likely to take place after the introduction of the Euro. Since obviously no historical data on the impacts of the Euro do exist, the assumption is made that the Euro will create efficiency gains in terms of transportation costs and industrial scale economies. Then, in a retrospective sense, two scenarios are developed and assessed, addressing the question

what would have happened in the past, if there would have been (i) a fixed European exchange rate and (ii) a fixed exchange linkage with the dollar. The research methodology is based on training methods incorporated in neural network analysis. The information base for our empirical analysis comprises detailed data on industrial production, interest rates and exchange rates in the various European countries. In this way, the foreseeable and likely efficiency and distributional effects of a monetary union can be traced.

The paper has the following structure. Section 2 will introduce the theory of optimum currency area and critically discuss its formulations and implications for Europe. In Section 3 the attention is focussed on trade theory and industrial location theory in order to offer the basis for our analysis of the distributional impacts of a single currency - as a result of a decline in transaction costs - on industrial concentration in the various member countries. Since a formal operational model for assessing such impacts does not exist, we argue in Section 4 that a neural network approach may be a fruitful analytical framework for empirical research in this area. After a discussion of the database, we present in Section 5 various results of 'what...if...' scenarios for individual countries in Europe, while the paper is concluded with a few reflective remarks.

2. Pareto Optimality in an Optimum Currency Area

A critical success factor for a single European currency area is price stability of the Euro. The maintenance of price stability will be the main competence and task of the independent European Central Bank. In the Maastricht Treaty (1991) already stringent entry conditions for participating countries were stated, in particular on the convergence of various macro-economic indicators. The necessity of independence of monetary authorities in achieving price stability is clearly explained by the political economic theory of stable macro-economic policy. The theory of central bankers' independence sets out that independent monetary policy is a *sine qua non* for welfare gains of the participating countries. Seen from this perspective, a strong Euro - under the supervision of a competent European Central Bank - would lead to a fair distribution of welfare gains to all participating countries (see for more details Blackburn and Christensen 1989; Prast 1996). This would then be a nice example of 'club externalities'.

The independent central bank approach however, fails to recognize sufficiently the costs of introducing a single currency, particularly in terms of political acceptance costs in convincing candidate countries to join. The goal of price stability would then have to be traded-off against other policy objectives, such as a fair distribution of integration benefits. Precisely the latter point is a source of concern, as the gains of integration will only lead to an equitable outcome among all participants in case of equal competitive conditions with free mobility of capital, goods and labour. In the current heterogeneous European situation - with

a great many cultural-linguistic barriers and significant welfare discrepancies among the EU countries - these conditions are not met. Consequently, in the short to medium term a Pareto-optimal allocation will not materialize; there will be winners and losers.

In this context, the theory of Optimum Currency Area (OCA) plays an essential role in the current debate on the welfare benefits of the introduction of the Euro. This theory argues that a monetary union among different countries may be efficient, if the result of a single currency in the whole area is about equal. This is based on the assumption that free exchange of goods, capital and labour will create gains of trade and will improve macro-economic performance (in terms of inflation rate, employment e.g.) due to the exclusion of internal fluctuations in exchange rates and interest rates. Even countries characterized by high macro-economic disparities in terms of production or employment may benefit from a single currency area, if these countries have an entirely free factor mobility. Thus, a clever combination of different countries may lead to significant macro-economic benefits for all players involved, caused by a decline in transaction costs, information costs and exchange costs. The result will be a rise in international trade - and hence gains of trade - between the participating countries (see e.g. Mundell 1961, 1998; Tavlas 1993).

On the other hand, if macro-economic adjustments among different countries forming a single currency area are largely asymmetric (and thus also country-specific), then the price and wage flexibility is insufficient to meet the conditions of labour mobility and automatic stabilisation by federate taxation and government expenditure policy (cf. Heylen and Van Poeck 1995).

Against this background, two analytical questions now emerge: (i) has the OCA theory a sufficient theoretical and empirical validity, and (ii) does the newly created EMU fulfil the conditions of an OCA?

In regard to the first question, a long debate has taken place after the first publication on an optimum currency area among different countries by Mundell (1961). In the literature particular attention has been given to the conditions specified by the OCA theory and the distribution of costs and benefits of a single currency area. The OCA theory takes for granted a trade-off between a reduction in transaction costs and unfavourable macro-economic effects in a monetary union due to the elimination of exchange rate risks. The gains are mainly meso-economic in nature and accrue to the international industry; the costs are mainly macro-economic adjustment costs to tackle shocks in the economy (e.g., in terms of employment), while some countries may also lose because of seignorage capacities (De Grauwe 1994). Clearly, a necessary condition for an OCA is that the gains be higher than the costs. In a currency area with high labour mobility the adjustment costs will be lower than in an area with wage and labour rigidity. Thus an OCA has the highest net monetary integration benefits

in combination with a maximum factor mobility.

In subsequent discussions on the validity of the OCA theory various extensions have been added, such as the degree of openness of the constituent areas (see McKinnon 1994), the degree of product diversification (cf. Kenen 1989, the degree of financial integration and the degree of similarity in inflation rates (see Masson and Taylor 1993). In recent years, it has also been argued that macro-economic shocks will cause in particular severe problems in a currency area when these are a-symmetric (in other words, when the countries concerned have dissimilar economic structures) (see also Eichengreen 1993).

Therefore, it can be argued that the net gains of a currency area are largely determined by country-specific conditions. According to some estimations undertaken by the European Commission, the cost savings after the introduction of the EMU may amount to some 1 to 1.5 per cent of GDP of the participating countries as a result of a decline in transaction costs (see Gros and Thygesen 1995). In addition, there may be dynamic (e.g. generative) benefits caused by endogenous growth which may far exceed that static allocative integration benefits and which may amount to 4.5 to 6.5 percent of GDP (see Baldwin and Venables 1995).

In conclusion, the findings from the long lasting debate on the OCA theory have not yet led to unambiguous conclusions. In particular, the country-specificity of monetary integration benefits make the OCA theory a conditional growth theory, where the gains are dependent on a-symmetric developments that are largely determined by historical, cultural and geographical factors of participating countries.

The second question whether the EMU forms an OCA is in principle easier to answer. Given the low level of factor mobility among European countries, smooth adjustments will likely not take place. A-symmetric shocks may cause high macro-economic disadvantages (see Masson and Taylor 1993). Seen from this perspective, the EMU is certainly not an OCA.

It is however, a different question whether a given country should participate in a single currency area; the costs of non-participation may also be high. De Grauwe (1996) has argued that there are three reasons why the OCA theory cannot answer the latter question: (i) one has to estimate also the positive effects of a single currency area and not only the costs; (ii) there is no benchmark to measure the critical level of adjustment costs beyond which countries would better stay alone; (iii) the role of the exchange rate in relation to the adjustment of the economies in case of a-symmetric shocks is ambiguous, as many shocks appear on the sectoral or micro level. In fact, none of the tradition OCA-criteria can determine the optimal size of the set of participating countries in a single currency area, because these criteria are only selective instruments to minimize the costs due to a-symmetric shocks. In addition, it should be mentioned that the shocks may also be endogenous; for instance, Frankel and Rose (1996) argue that the correlations between the business cycles of

distinct countries are dependent on the level of integration of trade activities.

The reason for the failure of the OCA theory to offer conclusive answers is probably best expressed by Mélitz (1995): "*Yet the only visible advance in the (OCA-) theory since Mundell is the proposal of new criteria for determining the optimal size of a currency area. The subject will remain in the same informal state in which Mundell left, and any effort to delve into the matter soon reveals the absence of agreement about some of the most elementary questions regarding the theory... [The fault] lies in the professions' unwillingness to adopt a formal analysis of the subject divorced from the policy aspects*".

This ambiguity may perhaps also explain the current situation in Europe, characterized by a dual speed introduction and acceptance of the EMU. There is still much uncertainty about the likely impacts of the introduction of the EMU, not only from a macro-economic perspective but also from a meso-micro (industrial) perspective. In the next section we will pay in particular attention to the latter category of effects.

3. The Regional-Industrial Dimension of Monetary Integration

In a single currency area exchange rate adjustments are ruled out, but as a consequence serious impacts may emerge in the real economy (e.g., shifts in employment). An OCA does not necessarily mean an area with an optimum level of social welfare.

In the present section we will conceive of monetary integration as a reduction in transportation costs for international trade. The decline in trade costs can be further analyzed by making a reference to international trade theory and to regional growth theory. Changes in transportation costs will have consequences for industrial location and for agglomeration economies. In our analysis we will take a look from a different perspective than the OCA-theory: in contrast to the assumption that differences in economic structure cause high adjustment costs as a result of a-symmetric shocks, we assume that the economic structure of a country is not entirely exogenous, but is also endogenously determined through changes in the currency system.

To address this point, we will first discuss the static role of a single currency for industrial development based on the theory of international trade and regional integration. Then we will pay attention to the consequences of a single currency by using Krugman's new theory on economic geography by assuming that a single currency manifests itself as a reduction in transportation costs (see Krugman 1994).

The conventional international trade theory argues that trade activity between countries increases welfare because of comparative cost advantages of each country, which leads to product specialisation. Following the Hecksher-Ohlin theory, we also know that the supply of production factors affects international trade patterns: a country with abundant cheap labour would export those products which are labour intensive, because the factor

rewards will be higher in this case. More recently, much attention has been focused on trade in homogeneous goods; in this context, it has been pointed out that also monopolistic competition and scale economies may generate substantial welfare increases emerging from international trade as a result of market expansion and rising choice opportunities of consumers (see Kenen 1989; Krugman 1994).

The current real-world trade patterns are still strongly hampered by trade barriers, both nature-given and man-made. Regional integration then emerges, if such barriers are removed, e.g. through the creation of a customs union or a common market. The impacts of trade liberalisation can be analyzed by using the model developed by Baldwin and Venables (1995). This model starts off from the following expenditure equation:

$$E = wL + rK + X\,[(p+t) - a\,(w,r,x)] + tm - I \qquad (3.1)$$

with:

- E: total consumer expenditures
- L: labour
- K: capital
- X: total domestic product
- I: investments
- p: price
- t: unit trade (transport and transaction) cost
- w: wage rate
- r: interest rate
- a: average product cost (depending on factor payments and average product volume per firm)
- tm: revenues from trade barriers accruing to domestic population

The following utility function is assumed for a representative member of society:

$$V = (p + t, n, E) \qquad (3.2)$$

with:

- n: product variety

Next, by taking the total differential of the utility function and by dividing this result by the marginal utility of expenditures, we obtain:

$$dV/Ve = tdm - md\,[t - \alpha t] - mdp + [p + t - \alpha]\,dX - X\alpha dx + (Vn/Ve)\,dn + (r/s - 1)\,dI \qquad (3.3)$$

with:

s: social rate of discount

Expression (3.3) allows now to decompose the welfare effects of trade liberalisation into 7 successive factors:

(i) volume effect: trade liberalisation influences trade volumes between countries, leading to a rise in international trade.

(ii) trade cost effect: the advantages of international trade have to be corrected for a term αt representing the leakage effects of trade duties for domestic agents.

(iii) terms of trade: welfare changes cause a shift in exchange rates between the countries concerned.

(iv) output effect: a welfare effect due to a change in industrial output of firms where the price is not equal to average costs.

(v) scale effect: changes in average costs as a result of a rise in industrial scale.

(vi) variety effect: welfare effect caused by a rise in the variety of consumer products.

(vii) trade-off effect on welfare between investments and consumption: investments will negatively affect consumption, but the fruits of investments may be higher returns in the future (depending on the ratio of the interest rate vs. the social rate of discount).

These various components can in particular be used to trace the effects of trade liberalisation, but they may also be useful in assessing the impacts of a monetary union. The Baldwin-Venables models treats changes in prices and trade costs as determinants of welfare. If a monetary union leads to a decline in transaction costs and if such costs are conceived of as component of trade costs (Mélitz 1993), then this model may be used to estimate the welfare implications of monetary integration. In particular, this model is then able to show that changes in the following variables may be expected: the trade volume, the prices and the terms of trade in case of perfect competition; and the industrial output, the scale economies and the product variety in case of imperfect competition. And finally, there will be investment changes as an indirect effect resulting from the previous six factors which impact on welfare.

In addition, a monetary union will lead to more price stability, but the impact of this phenomenon will depend on the price elasticity of the various goods. As a consequence, a monetary union will have different effects on different industrial sectors, not only in terms of the above mentioned factors, but also in terms of their location (including the scale economies). This is supported by Ricardian comparative cost theory which would argue that changes in relative cost structures of goods would affect their comparative advantage, so that changes in product specialisation and hence also in industrial location will take place. The analysis of these effects will now be undertaken with reference to recent studies on the trade

and location aspects of economic geography (see Krugman 1991, 1994).

Economic geography and international trade theory offer two complementary analytical frameworks; economic geography investigates the locational behaviour of industries (as a result of production costs, transportation costs (including trade barriers) and agglomeration benefits), while international trade theory focuses attention on the quantitative and qualitative dimensions of commodity flows between different countries. A full integration would mean that impediments to international trade vanish, so that only the location of production in space remains as a possible response of economic actors. Seen from this perspective, a reduction in transportation (and transaction) costs in a given country is not necessarily favourable, as the decisions where to locate a given activity will be co-determined by the relative production costs, transportation costs and agglomeration advantages. Especially in case of monopolistic competition industrial scale advantages tend to lead to large-scale concentrations of international industry. The nature of these scale advantages is determined by two types of linkages, viz. forward (demand) and backward (supply) linkages. The first category refers to a situation where a clustering of industries in a given area leads to overall benefits for all industries through a rise in the demand for their products. The second category of linkage effects emerges from the supply side through cost savings mechanisms of all industries.

The latter reasoning has far reaching implications for the question whether trade liberalisation will favour social welfare (and hence for the question whether the EMU will increase welfare of the European citizen). It is noteworthy that the generally accepted wisdom is that the european economic and monetary integration will stimulate a convergence of the economies of the participating countries, that the economic structure of these countries will become more homogeneous and that it is beneficial for the less wealthy European counties to join the 'EMU-club'. However, the above sketched analytical framework points out that economic and monetary integration may easily lead to more diversification in the economic structure of these countries, as a result of regional concentration of the industry caused by scale economies in a monopolistic competition market.

Furthermore, there is no guarantee that weaker economies would benefit from integration. According to Krugman and Venables (1990) it is very well possible that a new industrial economic structure will emerge after integration, through which the competitive position of peripheral regions (caused e.g. by low wages) is eroded, since multinational industries may prefer a location in central areas in order to benefit from scale economies and better access to large consumer markets, so that peripheral areas may become the losers.

Against the background of the previous political-economic expositions on economic and monetary integration effects, we will next in the second part of this paper test the hypothesis whether monetary integration (or at least a system of fixed exchange rates) in an

economic union will lead to industrial concentration and hence to unequal benefits for participating countries. This empirical analysis will be presented in the next sections.

4. Analysis Framework

In this section we will concisely describe our methodology for testing the hypothesis whether a common currency area tends to favour industrial concentration in geographically accessible (usually central) areas. Clearly, for the time being there is no formal model to describe the complex relations between commodity flows associated with international trade and industrial (re)location behaviour of internationally-oriented firms. Neither a simple regression model nor a complex spatial equilibrium model would be able to capture the complex causal relationships between various trade and location factors. Furthermore, the limited data set would hamper a multi-dimensional path analysis. Seen from this perspective, the use of neural network (NN) analysis seems to be appropriate.

NN analysis is both an exploratory and explanatory research method with the capacity to generalize from experience, without fixing - a priori - any behavioural rule or model among variables (see e.g. Himanen et al. 1998). Sometimes NNs are also coined artificial neural networks (ANNs). NNs may be defined as "*richly connected networks of single computational elements. The fundamental tenet of neural computation (or computational by ANNs) is that such networks can carry out complex cognitive and computational tasks*" (see Merah and Wah 1992). NNs have become a popular research methodology, as they are able to imitate the rich human brain functions based on a system of dendrites. Like the human brain, the structure of NN analysis is formed by a large number of neurons which form an interconnected network. The connectivity between neurons is based on weights, also known as synapses. The major feature of NNs is that they can learn through the supply and processing of empirical data (also coined patrons), so that by means of successive learning experiments the weights can be approximated. In other words, NNs learn about real-world linkages through the patrons supplied to them. The result of the learning phase is the computation of weights, based on the repeated application of training experiments leading to analysis rules (see also Chester 1993; Nijkamp and Reggiani 1998). NNs have a micro, a meso and macro structure, through which the interdependent relationships can be depicted. This structure determines also the connectivity framework of neurons, in particular the way the weights between the neurons will be computed and processed. An important distinction in the structure of NNs is between feedforward and feedbackward NNs. A feedbackward NN allows for cyclical connections between the neurons (like bidirectional connections), while a feedforward NN does not. A typology is given in Figure 1.

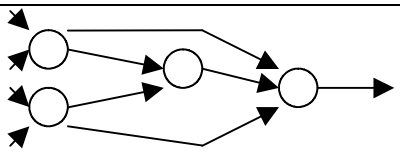
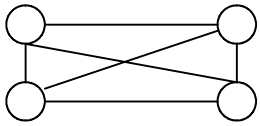
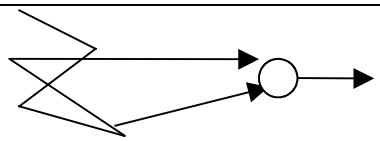
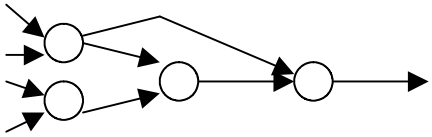
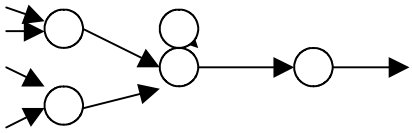
Connectivity pattern	Graphical illustration
Feedforward	
Bidirectional connections	
High-order connections	
Recurrent connections	
Self-connections	

Figure 1.Types of connections between neurons, source: Mehra and Wah (1992, p. 50)

After the structure of the NN is determined, the next step is to train the network. This is done by a learning algorithm which "*seeks to adapt a network's parameters (usually its weights) and/or its structure in order to make future outputs more desirable*" (see Mehra and Wah 1992). This learning is essential, as then the basic information on the environment at hand is provided by preparing the NN to recognize and classify the underlying patterns.

There are different ways to train the network and to use learning algorithms for solving NN problems. In our analysis, we will use a so-called backpropagation NN, which is a basic NN model. The features of this model are: (i) the presence of at least one hidden layer; (ii) a feedforward structure; (iii) a learning algorithm which uses the the bias between the computed and the real output during the computing stage of the weights (see Kasabov 1996).

A multilayer NN structure has inter alia the following properties: (i) a precise approximation via a goodness-of-fit based on multiple hidden layers (and multiple neurons in these layers); (ii) the use of multivariate nonlinear regressions models.

After the exposition of the research methodology based on NN analysis, we will now concisely describe our empirical framework. The main objective is to trace the expected effects of fixed exchange rates in an economically integrated market on the international location patterns of industries, with a particular view to concentration tendencies in central areas. As a rough indicator for industrial concentration we will use here the relative size of the industry in a given country in a joint currency area.

From all countries under consideration the following common data base has been constructed based on a time series for the period 1975-1996 for the input data:

- (changes in) the interest rate on quarterly government bonds
- (changes in) the exchange rate with respect to the US dollar,

and for the output data:

- total industrial production in each of the 15 EU countries (and Norway) as well as the EU as a whole (based on the OECD statistics from the electronic databank Datastream).

These data are available in index figures, based on nominal values of the variables corrected for the exchange rate with respect to the US dollar. The base year is 1990. All these data have multi-causal connectivity structures. In order to test now our basic hypothesis we will use a feedforward, multi-layered NN model (on the basis of the so-called generalized delta-rule learning algorithm). This backpropagation NN model will be applied here using the so-called Neuralyst softwareprogramme (running under Excel).

Based on the above data base, the total number of neurons is equal to 22 (exchange rate, rate of interest, change in exchange rate, change in rate of interest, a time dummy variable and 17 dummies for the countries (15 for all EU countries, 1 for Norway and 1 for the EU as a whole). The total number of patrons would then be 22 * 12* 17 = 4,488. However, as a result of the backpropagation mechanism using both input and output variables and as a result of a mismatch between the two input variables and the output variable in terms of time period, the total number of patrons is at the end 3,691. From this number, a total of 811 is used as a validation set. The remaining set is randomly distributed as a test and training set in the proportion 1 to 4, respectively. The next section will now be devoted to the

empirical analysis.

5. Empirical Analysis

Given the NN methodology outlined above and the empirical data described, the application of the NN model took place in two stages.

In the first stage, the training was carried out, based on a gradient descent learning algorithm. Clearly, several problems inherent in a backpropagation procedure had to be coped with, such as local minima, convergence and overfitting. In our case, different numbers of neurons and hidden layers were used. The test statistic for the performance of the NN experiments is based on the Average Relative Variance (ARV), defined as:

$$ARV = \frac{\sum_{n=1}^{N} (y_n - \hat{y}_n)^2}{\sum_{n=1}^{N} (y_n - \bar{y})^2} \qquad (5.1)$$

where y_n is the observed value of the dependent variable (i.e., industrial production), $\hat{y}$ is the computed value of this variable and $\bar{y}$ the average value. The closer ARV is to zero, the higher the goodness-of-fit of the NN model.

In our empirical analysis, the value of ARV turned out to lead to very favourable outcomes, viz.:

ARV (validation set) = .032

ARV (test and training set) = .053

Given the confidence in the overall NN goodness-of-fit, we may now move to the second stage, viz. the further investigation of policy options on the introduction of a single currency for industrial production and location. If we take for granted that in the past two policy options have existed, viz. fixed exchange rates and flexible exchange rates, and that the economic performance of the various European countries was (partly) the result of flexible exchange rates, we may raise the question: what would retrospectively have happened if these countries would have decided to have fixed exchange rates? This 'what... if...' question can be investigated by using a backpropagation NN approach. In this way we would also be able to test our hypothesis on the link between a single currency area and industrial concentration.

In our analysis we take for granted two retrospective policy scenarios for the above question, viz. (i) the introduction of a common currency area within Europe itself, and (ii) the establishment of a fixed link between the European currency and the US dollar.

In the first scenario we have fixed exchange rates in Europe, but still fluctuations with respect to the dollar. This case is studied by fixing the exchange rates of the European countries with respect to the German Mark (DM) in the first year for which our data for all countries concerned were available (i.e., 1975). For the EU as a whole this base year was 1984. Thus, in our approach the DM acts as some sort of 'numéraire'.

The empirical results of this scenarios experiment are depicted in Figures 2 to 4. These figures show that the impact of fixed exchange rates on industrial production is indeed significant, viz. a monthly positive effect ranging from .007 percent to .2 percent.

The positive effects of a common currency appear to be rather evenly distributed. For the Italian industrial production high gains are to be expected, whereas for Germany and The Netherlands even negative economic impacts are computed. It is also interesting to observe that the gains of industrial trade and location are fairly neutral for the Belgian economy. Thus, it is clear that the EMU will have substantial distributional impacts on individual countries and regions as a result of cumulative effects of fixed exchange rates on industrial production and relocation. A common currency area may thus worsen the competitive position of those countries which have had a strong industrial profile. It is also evident that under such conditions the EMU is definitely not forming an OCA. It has to be added of course, that in a very long term perspective the EMU shocks may be better absorbed by the individual countries, so that then they may also reap the fruits of an OCA.

The second scenario assumes that the exchange rates are fixed in the year for which for the first time the data are available for each individual country. As shown in Figures 5 to 7, these results lead to a more complex picture. The industrial production in Italy gets a positive shock from 1992 onwards (i.e., the completion of the internal European market), but negative effects in previous years. For The Netherlands and Germany - and also for the EU as a whole - the net effects are again not very promising. Belgium shows in this case wild fluctuations. Thus, there are clearly winners and losers in Europe. Therefore, we may conclude that policy scenario 2 cannot boost a high economic benefit for most EU countries.

We may conclude that *ex post* a single European currency would have had great impacts on individual countries, but the impacts are unequally distributed. Thus we may formulate the tentative conclusion that the introduction of the EMU will likely lead to a significant change in the industrial development in the various member countries.

6. Concluding Remarks

The introduction of the Euro incorporates both costs and benefits. The nature of the costs is not known, as we do not have experimental results on the convergence effects of a single European currency area. NN analysis may offer a methodological framework for analyzing retrospectively the foreseeable effects, based on historical data. In our empirical work two policy scenarios were investigated, which both showed substantial distributional

impacts on individual countries and a doubtful effect on the EU as a whole. The EMU is certainly not an OCA and this condition will show up in future industrial developments, especially during the first decade of the monetary transformation and integration.

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