SIMULATION OF REGIONAL DYNAMIC PROCESSES IN THE ECONOMY

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Abstract

Economical interactions between countries or regions of countries become more and more important for the economy of nations, the EC and the whole world. Nevertheless, there are only few attempts to model these processes, because most of the classical economic models are too unhandy or too stiff to be extended on regional effects. My approach to this problem is bases upon the dynamic choice theories developped by G. Haag and W. Weidlich from the University of Stuttgart. It describes the behaviour of demand, supply and prices due to the choice behaviour of consumers and producers. It is built up modular, so that it can easily be fit to the requirements of single branches or products. Thus it cannot be applied to political economics as a whole but it can teach us some astonishing effects in parts of them.

Key Words

Spatial economics - Stochastic choise processes - Synergy effects

1. Introduction

Economical interactions between countries or regions of countries become more and more important for the economy of nations, the EC and the whole world. Nevertheless, there are only few attempts to modell these processes, because most of the classical economic models are too unhandy or too stiff to be extended on regional effects. This approach is based upon the dynamic choice theories developed by G. Haag and W. Weidlich [9] from the University of Stuttgart. It describes the behaviour of demand D, supply S and price P due to the choice behaviour of consumers and producers. It is built up modularly, so that it can easily be fit to the requirements of single branches or products. And it is built up discretely, which means, that we will first model the economy in every single region. In the second step we will combine these regions by permitting an exchange of demand and/or supply.

2. Equations of motion

Let us consider a person in a certain state, for example, a customer, who demands a certain product, or a supplier, who supplies a product. With a transiton rate \$w\$ this person will change his state and demand or supply one more, no more or an other product. If $D_i = 1$ means, that the corresponding product \$i\$ is demanded by a customer in the quantity 1, the change of demand by time can be written as

$$\frac{dD_i}{dt} = \sum_j \left(w_{i;j}^{D} - w_{j;i}^{D}\right) + w_i^{D+} - w_i^{D-} \qquad (1)$$

By writing this we cover explicitly all possible kinds of changes, which are redistribution, birth and death processes. For supply and price we get :

$$\frac{dS_i}{dt} = \sum_j (w_{i;j}^S - w_{j;i}^S) + w_i^{S+} - w_i^{S-} \qquad (2)$$

$$\frac{dP_i}{dt} = w_i^{P+} - w_i^{P-} \qquad (3)$$

For the prices only birth and death processes are sensible. This is because in our model one unit of price unlike of demand and supply is not related to one person but can be fixed by the supplier.

For the transition rates w we use an exponential ansatz, which can be motivated by a comparison with the multinomial logit modell [5] and Fechners laws [2] :

$$w_{ij} = \begin{cases} v_{ij} \cdot x_j \cdot e^{u_i - u_j} & \text{for } (0,\dots,(+)_i,\dots,(-1)_j,\dots,0), \\ 0 & \text{for all other} \end{cases} \qquad (4)$$

and

$$w_i^{+/-} = \begin{cases} v_i^{+/-} \cdot x_i \cdot e^{u_i^{+/-}} & \text{for } (0,\dots,(+/-1)_i,\dots,0), \\ 0 & \text{for all other} \end{cases} \qquad (5)$$

The variables u_i are the subjective utility or attractivenes of the state i, the v_i's are the flexibilities of the individuals, and x_i stands for D_i, S_i, P_i respectively. The essential part of our work will be to model this variable and its dependence on the sizes D, S, and P.

3. Attractiveness

3.1. Demand

3.1.1. Frequency dependence

Detailed analysis of the frequency dependence of economical proceedings have been done by Arthur [1]. An extension and an adaptation to this model was made by the author [2].

There are various reasons for a positive or negative feedback of the frequency of demand and supply on the attractiveness of a product :

- network externalities,
- improvement and/or improved handling of a product,
- deterioration of a product and/or deteriorated handling of a product,
- existence of complementary technical or human infrastructure,
- availability of products,
- information,
- psychological effects,
- exhaustion of resources.

The exact dependence is very sensitive to the kind of product and must at least be specified from case to case. But for many products, one can observe, that the subjective utility of a product increases with its frequency for small and middle values and decreases with even higher frequency. Thus we can write as a good assumption for these products :

$$u_i^D(D,S) = [a_i^D \sqrt{\sum_j \alpha_j D_j} + b_i^D (\sum_j \beta_j D_j)^2] + [m_i^D \sqrt{\sum_j \gamma_j S_j} + n_i^D (\sum_j \delta_j S_j)^2] \qquad (6)$$

for

$$a_i^D, m_i^D > 0 \,;\, b_i^D, n_i^D < 0 \,;\, \alpha_j, \dots, \delta_j > 0 \text{ and } a_i^D \gg |b_i^D|, m_i^D \gg |n_i^D| .$$

By the weights $a_j, \ldots, d_j$ we take into account the different importance of different products. The coefficients a_i, b_i, m_i and n_i give us the desired shape of the dependence.

3.1.2. Price dedendence

The most simple ansatz is a negative feedback : $u_i^D(P) = c_i^D \cdot P_i$ and $c_i^D > 0$ (7)

Of course this ansatz will not succeed for example for prestige products. But, because of the modular build-up of our model, it can easily be modified for these cases.

3.1.3 Regional effects

The additional material and immaterial effort in order to demand a product in an other region than the one the customer inhabits is given by a distance term E_i^D , which gives a negative contribution to the attractiveness.

3.2. Supply

3.2.1. Frequency dependence

The final claim here will be the equality of supply and demand (cf. [6, 4]). This yields to the subjective utility :

$$u_i^S = a_i^S \cdot (D_i - S_i) \qquad (8)$$

The coefficient a_i^S will depend on the strategy of every firm and therefore be a function of profits, losses etc.

3.2.2. Price dependence

The price dependence of the supply will be modelled implicitly in the price section.

3.2.3 Regional effects

Regional economics make very different statements according to what products are observed (cf. [8, 2]). Because of this on this, general level of modelling there is no sense to take into account special regional effects on the supply side.

3.3. Price

3.3.1. Price policy

The calculation of prices orientates itself on an inverse S-shaped cost function and the common price policy of enterprises. We obtain :

$$u_i^{P+} = a_i^P \cdot S_i^2 + b_i^P \cdot S_i + c_i^P + \frac{F_i}{S_i} - P_i = -u_i^{P-} \qquad (9)$$

Here, F_i is the fixed capital, and the coefficients a_i^P, b_i^P and c_i^P result from the sum of the two mentionened influences.

3.3.2. Regional effects

A linear coherence with the distance, which seems to be the most usual in previous times, is most unlikely today (cf. [7]). Section 3.2.3 is accordingly valid.

4. Simulation

In the Simulations we consider only redistribution processes on the demand side and only birth and death processes on the supply side. We choose a system consisting of three regions and two products. Thus we obtain from (1) to (3) a 30-dimensional set of differential equations for 18 variables D_i (inhabitants of three regions demand two products in three regions), six variables S_i (two entrepreneurs supply their products in three regions), and six variables P_i. Further we choose a cheaper calculation function (9) for the first product in the first and second region, while the second product in all regions as well as the first one in region three have the same less favourable calculation function.

For the first simulation (figure 1) we isolate the three regions by setting the flexibility n_i to zero for demand in foreign regions : no inhabitant of one region demands any product in an other region. In region 1 and 2, first, product 1 wins because of the smaller negative price feedback. But by reason of the chosen shape of the calculation function, the prices increase at large quantities of supply. The supply follows the demand with a delay and therefore the price for product 1 increases until product 2 becomes more attractive. Demand for product 2 increases and later its price, which makes it less favourable again etc. All in all we obtain an oscillating behaviour in the regions 1 and 2. In region 3 nothing happens because of identical conditions for both products.

In the following simulations we allow demand in foreign regions. But we will start with a large distance term $E = 2$ (figure 2), which makes it uncomfortable to demand in an other region. Now region 3 is affected by the oscillations too. As we can see, it oscillates in phase, a so called lock-in process has taken place.

The third simulation (figure 3) was done with $E = 0$, which means one common market. The oscillations have totally disappeared. Because of the more degrees of freedom on the huge market everyone can satisfy his interests at the same time and the whole system can achieve a stable state.

Figure 1 : Isolated regions. The first index characterizes the region, the second the product

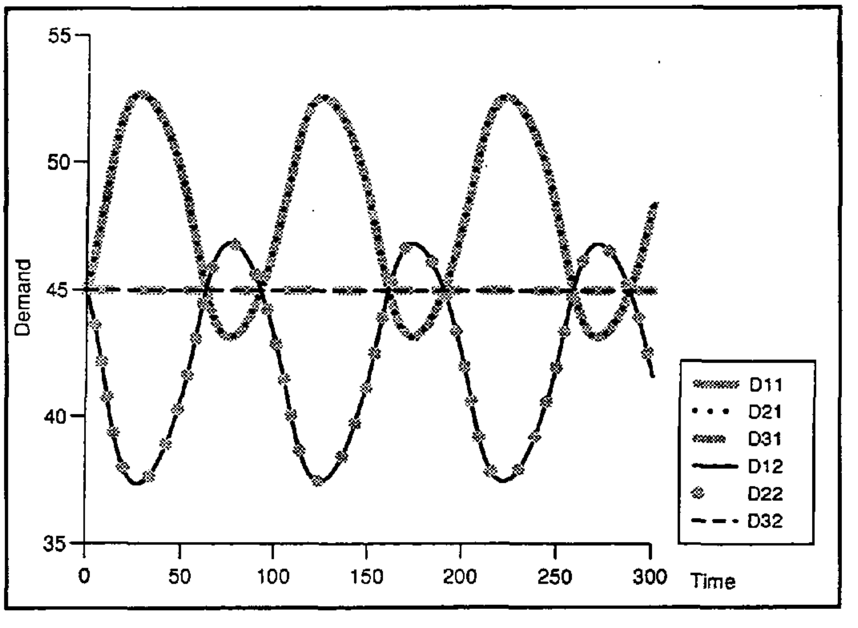


Figure 2 : Distinct regions : E = 2

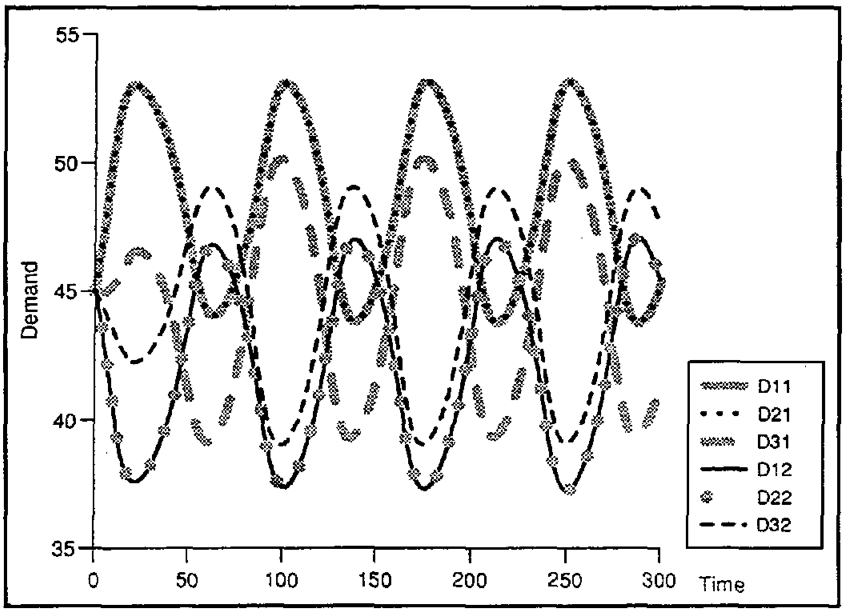
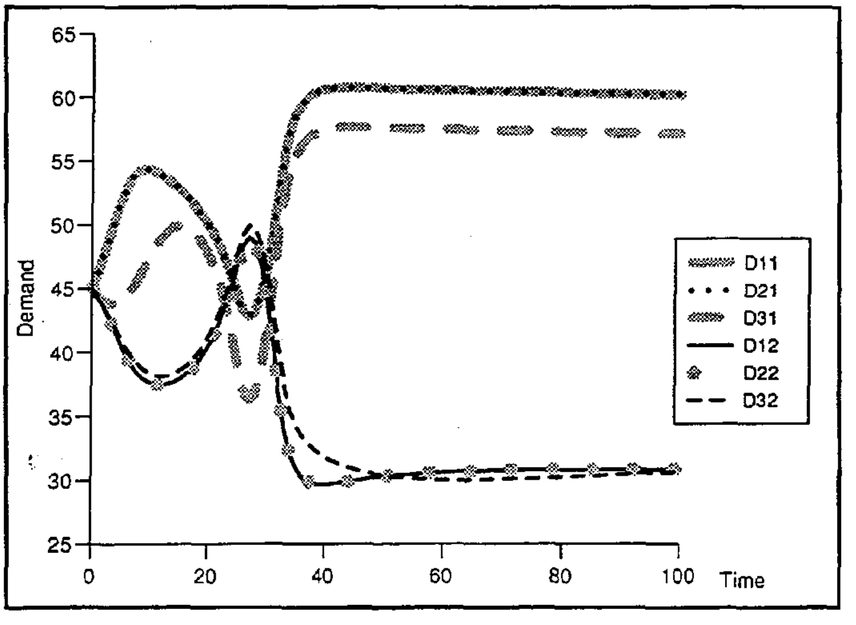


Figure 3 : Common market : E = 0



5. Economic conclusions

The aim of our work is to build a tool for the understanding and simulation of effects in regional economies. For that we build a modular dynamic choice model with the quantities demand, supply, and price. We tested it under the most probable choice behaviours in order to obtain a valid statement not only for specified products or branches but for economies as a whole. In summary our numerical simulation has shown two remarkable effects :

– The consolidation of distinct economies yields to lock-in processes in their oscillating behaviour. This fact has been proved empirically by [3]. Moreover, even more complicated processes than in-phase oscillation (figure 2) occur, which could not be shown here by reasons of space.

– Consolidation also yields to a decrease of oscillation frequency or even disappearance of the oscillation. This effect has not yet been investigated empirically and could in fact be covered by interregional unification of customers or entrepreneurs, which would restrict the freedom of choice again.

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