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The European Central Bank as Spatial Monopoly

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Introduction

It is well-known that a closed economy's central bank has the position of a total monopoly: only the national bank is allowed – by law – to issue the economy's currency, thus if someone wants to use Forints of British Pounds for whatever it is, he or she is first of all buyer of products offered by the Hungarian National Bank, or by the Bank of England, resp. The same is true for the European Central Bank: the Euro, the common currency of a lot of member states of the European Union, is offered only by the ECB. Consequently, as in the closed

national economies, monopoly profit – the so-called seigniorage – does also exist in the Euro-zone. On the other side, an essential difference has to be considered. In the case of closed national economies the area officially controlled by the national currency is more or less the territory of the country, i. e. the area is determined by the political borders. Considering the Euro as common currency of several countries this is obviously not true, implying the question what is the area controlled by the Euro.

The Spatial Monopoly

From the introductionary remarks it follows that for the present analysis of the ECB's market position requires a spatial approach. Satisfying this requirement it makes sense to use models and results developed in spatial economics. (For details see e. g. SCHÖLER [2005],

Let us assume in a certain area a special good or service is offered by a single firm, the monopoly; the quantity of this good or service is denoted by q. For the sake of simplicity let be the area a line. Consumers demanding this good or service are equally distributed over the area. Consumers' demand can be described by a linear demand function, i.e., $q^D(\hat{p}) = a - b\hat{p}$, where $\hat{p}$ is the market price to be paid for one unit of the good or service.[i] The problem is that the potential consumers are located at different places, i. e., their distance to the monopoly differs from consumer to consumer. But, however, wherever a buyer plans to consume the good, he or she has to cover transportations costs. If the consumer will travel from his or her home to the firm where the product can be bought at mill-price p, he or she has to bear the traveling cost; if, in another case, the product will be sold by represents of the firm or by traders directly at the consumers' home, the market price will exceed the mill-price by the costs for transportation. In any case, the final price consumers have to pay consists of

the mill price and transportation costs. Let r be the distance between the consumers' home

and the firm, and let's denote by t the transportation costs of one unit of the commodity

related to one distance unit, e. g., costs necessary to transport 1 gallon oil over the distance of

one kilometer. Consequently, tr will denote the transportation costs for one commodity unit's

transfer over 1 km. Summing up, the market price to be paid by a consumer living in a

distance of r from the firm is $\hat{p} = p + tr$. Therefore the individual demand of a consumer

living in r distance from the producer is

$$q^D(p) = a - b(p + tr).$$ (1)

To obtain the total demand on the market, Q^D, one has to sum up all individual demands with

respect to the distance, i. e.,

$$Q^D(r) = \int_{-R}^{R} q^D(r) = 2\int_{0}^{R} q^D(r),$$ (2)

or

$$Q^D(r) = 2(a - bp)R - btR^2.$$ (3)

Here R is an assumed maximum distance between the firm and consumers demanding the

good or service the monopoly is offering. The concrete value of R is up to now totally

unknown, it has been assumed only that such a maximum does exist. Later it will be shown

that it is possible to derive an exact value for R, with other words: the value of R to be derived

will determine the market size too. (See Graphic No. 1)
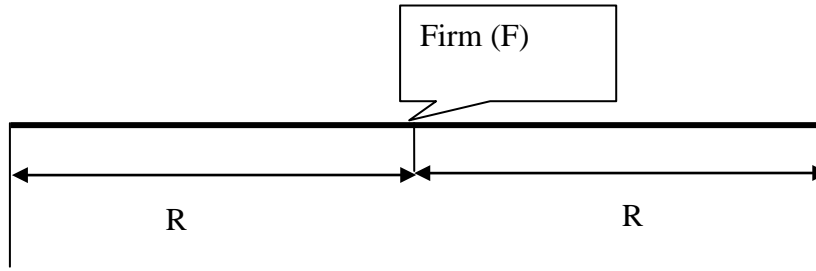
If we assume a linear cost function[ii]

$$K(Q) = kQ + FC, \qquad (4)$$

where k denotes the marginal costs, the profit can be expressed by the following term:

$$\Pi = (p - k)\left[2(a - bp)R - btR^2\right] - FC. \qquad (5)$$

The firm is now setting the mill-price p as that price maximizing the profit. Therefore p has to satisfy the condition $\dfrac{d\Pi}{dp} = 0$, i. e., the firm's optimal mill-price is given by

$$p^* = \frac{2a - btR + 2bk}{4b}. \qquad (6)$$

Substituting this mill-price into the profit equation (5), one can see that the profit depends only on R:

$$\Pi^* = \left(\frac{2a - btR + 2bk}{4b} - k\right)\left[2\left(a - b\frac{2a - btR + 2bk}{4b}\right)R - btR^2\right] - FC.$$

Consequently, the profit maximizing distance value R^* expresses the market size. Therefore, one has to set $\dfrac{d\Pi^*}{dR} = 0$ which is satisfied by

$$R^* = \frac{2(a - bk)}{3bt}. \qquad (7)$$

The economic interpretation of expression (7) can be given as follows: The market size depends on the marginal production cost (k), on the price sensitivity of the consumers (b), and – last, but not least – on the reservation price ($\frac{a}{b}$). The lower are the marginal production costs and/or the lower is the price sensitivity, the higher is R^*. The same effect, the extension of the market, will be observed, if the reservation price would increase. Market size is therefore determined by the behavior of both economic actors, the firm and the consumer(s), and market size will change if at least one of these actors will develop and apply a new strategy.

Monetary distances

In this point the above general model of a spatial monopoly will be applied to the Euro-zone with the European Central Bank as monopoly providing the Euro-zone with money and with the economic actors in the Euro-zone as "consumers". At the first moment, however, it is not very realistic to assume for the Euro-zone an one-dimensional market as it had been done in the general model – the Euro market does quite obviously not exist "along a line". That's right! But, first of all, the analysis of one-dimensional markets is much more easier than the investigation of two-, or higher dimensional markets. It can be shown that the one-dimensional model could be extended to a two-dimensional one. (See SCHÖLER [2005], Fujita – Krugman – Venables [1999]) The only thing one would have to do is to summarize the aggregated demands "along a line" for all possible lines in the two-dimensional surface.[iii] Furtherwise, it has to be taken into consideration that in the present approach distance does not mean the traditional length of a line or of a way between two points in the – let's say – geographical space. More generally spoken, distance is now simply the difference between

values of the same properties different elements of a given set have. (For more examples see e. g. Hevér [2012])

Analyzing monetary problems distance can be interpreted as the difference between interest rates, inflation rates or quantities of money observable at different points (national economies or regions) of the geographical space. Using the expression of distance in this sense, does not mean to find out how far are these national economies or regions from each other in kilometer, but to investigate how close they are to each other in their monetary conditions. Therefore, a national economy may be a neighbor of another national economy, but taking into account monetary characteristics, may be that they are far away from each other if monetary conditions or performances would be considered, and, of course, the opposite may be also true: national economies on different continents can be similar from monetary – or any other – point of view.

The ECB's optimal interest rate

In the following part the more general results about spatial monopolies will be applied to the monetary sector. In 2002 most of the member states of the European Union have introduced the Euro as joint currency. The European Central Bank provides the member states of the Euro-zone with money, and – this makes it possible to apply the above model – this bank is the only institution issuing Euros. On the other side there are economic actors (firms, households, governments, regional authorities, etc.) demanding this money; the number of the economic actors is n. Because of the different economic and social situation of the actors, they are faced with different nominal interest rates – the better is an actor's economic situation the lower is the risk premium and thus, the lower is the interest rate to be paid for loans. Let's denote the individual interest rate of actor i with r_i, the most efficient actors' interest rate is

therefore the lowest one, this will be denoted by r^{min}, the highest nominal interest rate (r^{max}) has to be accepted by the economic actor with the lowest performance. It is obvious, that $r^{min} \leq r_i \leq r^{max}$, for all $i = 1, ..., n$. Since the lowest interest rate does not contain any risk premium, r^{min} can be considered as the ECB's "pure" interest rate (r^{ECB}), similar to the mill price in the case of the spatial monopoly. Therefore the individual interest rate of the ith economic actor can be described by the expression $r_i = r^{ECB} + \rho(y^{max} - y_i) = r^{ECB} + \rho \Delta y_i$, where y^{max} is the income level of the most efficient economy, and y_i denotes income level of economic actor i, the income difference for any individual actor related to the most efficient one is denoted by Δy_i. Verbally expressed this means that the closer is the performance of the individual economic actor to that of the best one, the lower is the risk premium, an increasing difference between these two income levels would imply spreading nominal interest rates.

Money demand of actor i depends on real income and on the nominal interest rate, so the traditional money demand function can be used to describe i's behavior on the money market, or using the linear form[iv]:

$$m_i^D = m_i^D(y_i, r_i) = my_i - kr_i. \tag{8}$$

Taking into account the risk premium, the expression has the form

$$m_i^D = my_i - k(r^{ECB} + \rho \Delta y_i).$$

Total money demand is the sum of all individual money demands whatever is the difference of their individual performances related to that of the best economic actor, i.e.,

$$M^D(\Delta y_i, r_i) = \int_0^\gamma m_i^D(\Delta y_i) d(\Delta y_i),$$

where γ denotes the income difference between the economic actors with the highest and with the lowest performance. Applying this procedure to the individual money demand functions, one obtains for the total money demand

$$M^D\left(\Delta y_i, r_i\right) = \left(my_i - kr^{ECB}\right)\gamma - \frac{1}{2}k\rho\gamma^2. \tag{9}$$

If the European Central Bank would create exactly that amount of money demanded by the economic actors, the total revenue would be

$$TR = r^{ECB}\left\{\left(my_i - kr^{ECB}\right)\gamma - \frac{1}{2}k\rho\gamma^2\right\}. \tag{10}$$

Let's assume a simple linear (total) cost function representing the ECB's costs for creating the M quantity of money

$$TC = \mu M + FC, \tag{11}$$

where μ is the constant marginal cost and FC stands for fix costs. Using eqs. (10) and (11), the ECB's profit can be expressed as the difference between total revenues and total costs, i. e.,

$$\Pi = \left(r^{ECB} - \mu\right)\left\{\left(my_i - kr^{ECB}\right)\gamma - \frac{1}{2}k\rho\gamma^2\right\} - FC. \tag{12}$$

The strategy of the ECB is to find the interest rate maximizing its profit. Therefore one has to calculate $\dfrac{d\Pi}{dr^{ECB}} = 0$. Finally, the result is

$$r_{opt}^{ECB} = \frac{2m - k\rho\gamma + 2\mu k}{4k}. \tag{13}$$

This equation contain behavioral parameters, as μ, k, m, and ρ, but is can also be seen that the income difference (γ) will also influence the optimal interest rate. The bigger are the

income differences in the area the European Central Bank offers its money the lower must be the optimal interest rate. The reason seems to be quite clear: income differences will imply differences in the risk premiums to be paid by the less developed individuals. But lower development and paying risk premiums means huge burdens for these individuals, regions or countries. Therefore, if the European Central Bank would like to provide these actors with the joint currency, the „pure" („mill") interest rate must be kept on a low level.

Accepting this, it has to be seen that the consequence is a special process of counter-selection: To pay the mark-up price, the risk premium, less developed individuals have to pay a relatively higher price for the joint currency than the higher developed part of the region.

The area controlled by the European Central Bank

Using (13) it is possible to characterize the area controlled by the European Central Bank. Substituting the value of the optimal interest rate (13) into the profit function (12), and maximizing this with respect to the income difference γ, i. e., analyzing the condition $\dfrac{d\Pi}{d\gamma} = 0$, for which it can be derived that $3k^2\rho^2\gamma^2 + 8k\rho\mu\gamma - 4my_i k\rho - 4m^2 + 4\mu^2 k^2 = 0$.

This is a quadratic equation in γ with the solution[v]

$$\gamma = \frac{-8k\rho\mu + \sqrt{64k^2\rho^2\mu^2 - 48k^2\rho^2\left(my_i k\rho - m^2 + \mu^2 k^2\right)}}{6k^2\rho^2}. \tag{14}$$

It is not the concrete form of this expression which is of interest, but the message: If the European Central Bank would follow an economically meaningful strategy, the only those economic actors, countries, etc. should be provided with the joint currency, where the income difference in relation to the most efficient economic actors, or countries does not exceed a

certain value. On the other hand, if the joint currency would be offered to economies with an income level differing from the most efficient economy's level by more than γ, the European Central Bank will be unable to fulfill its duties according to the requirements of economic efficiency.

Of course, arguing on the present abstract level it is totally impossible to comment, or even to evaluate the economic or monetary policy followed to stabilize the Euro, this can be done only after intensive empirical research. But, however, the introduction of the currency used by a lot of the EU member states, has had more a political motivation than an economic one. The demonstration of a qualitatively new level in the continent's unification process had been considered as much more important than the integration of the national economies into a European economy. From this point of view it is not surprising that the sovereign debt crisis in several European economies – expressing the level of their economic performance in relation to the so-called European living standard rationally expected by the citizens of these member states – is in a very close connection with the Euro-crisis – expressing that the most important monetary authority of the European Union is unable to bridge the gap between the income levels of regions in the politically unified Europe. With other word: the Euro-zone is to big – to heterogenous – for the European Central Bank, or, as Kenneth Rogoff wrote about the Euro zone: "the optimal single currency area is probably still a country, at least when two or more large countries are involved" (Rogoff [2012].

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[i] Since the above demand function corrsponds to the inverse demand function $\hat{p} = \dfrac{a}{b} - \dfrac{1}{b}q$, it becomes clear that $\dfrac{a}{b}$ represents the so-called reservation price, i. e. that maximum amount of money offered by at least one consumer for one unit of the product, or: nobody is willing to pay more for one unit of the good or service offered by the firm.

[ii] This is equivalent with the assumption of a linearly homogenous technology, i. e. multiplying the factor quantities used in the production process will lead to an increase in output characterized by the same multiplier.

[iii] If the two-dimensional surface would be a simple circle, then the demand described by equation (3) would be the total demand of all consumers located on a line between the center of the circle and a certain point on the circle's line. To obtain the demand of all consumers living inner the circle or on the circle's line the line has to rotate through 360^0. Denoting the angel between the original line and any other line by φ, then φ has to change from 0 till 360, or between 0 and 2π. The total demand of all consumers in the circle is therefore

$$Q_c^D(R) = \int\limits_0^{2\pi} \left(\int\limits_0^R r(a - bp - btr)dr \right) d\varphi$$. From this formula it can be seen that the change from the one-dimensional market to the two-dimensional one does not influence the basic statement about what the market size is depending on; the only effect is a more complex formal expression.

[iv] At the moment it is assmumed that the real income of the ith economic actor is independent on the interest rate he is faced with.

[v] Of course, the quadratic equation has two solutions, but the only this one can be interpreted from economic point of view; the other solution is definitely negative, wich would imply a negative income difference.