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Labor-Cost Effects on Relative Prices between Regions of a Monetary Union: Implications for the EMU

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Econometrics

Labor-Cost Effects on Relative Prices between Regions of a Monetary Union: Implications for the EMU

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Three industrial organization (IO) models suggested by Dornbusch (1987) are here adapted to study the labor-cost effects on relative prices of tradable goods between the regions of a monetary union. The assumption of imperfect and segmented goods and labor markets makes the analysis best suited for a monetary union such as the present European EMU. We find that in this context the type and extent of the effects studied depend on the different degree of competition in the same industry of different countries, the different absolute or relative number of foreign and domestic firms in the market of each country, and the product substitutability. Very simple simulations show the potentiality of IO models in a dynamic framework. (JEL D43, E31, F15, L16)

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1. - Introduction

The issue of price level divergence and inflation differentials[1] between regions of a monetary union became truly relevant only in 1999 with the birth of the European Economic and Monetary Union (EMU) because of the important implications that its presence and persistence could have for the Union itself. "[...] If one country were to show a sizeable, growing and unsustainable divergence in inflation from the level in other euro area countries [...]" (European Central Bank, ECB (2000)) that country may decide that the lack of national monetary independence has consequences so negative for the national economy that it may be desirable to leave the Union. Since participation is not mandated by a Constitution as it is in the Unites States, this possibility, albeit extreme, is always open. National authorities and the Union as a whole, then, have to concern themselves with possible ways to prevent such a situation. This fact is even more relevant if it is considered that the EMU structure seems to be unable to tolerate a very high level of divergence of inflation rates. First, indeed, the ECB's statute states that "[...] the primary objective of the ESCB[2] shall be to maintain price stability. Without

[1]Even if the two concepts are different, however they are strictly related each other. In particular, it is worth to note that most theories that provide an explanation of price level divergence within a monetary union also permit the description of the evolution of inflation differentials. Notwithstanding, in the following every reference to the two concepts will always be made being aware of their differences.

[2]ESCB is the European System of Central Banks which is composed of the European Central Bank (ECB) and the national central

prejudice to the objective of price stability, it shall support the general economic policies in the Community [...]". In the implementation of its monetary policy, then, it is very difficult for the European Central Bank to pay attention to regional imbalances. Moreover, fiscal adjustment is currently restricted by the Stability and Growth Pact (SGP), the main objective of which is to reduce the incentive for member countries to have a permissive fiscal policy because of the distribution over all the EMU countries of the cost of monetary tightening. In reality, though, by strongly limiting the functioning of automatic stabilizers, there is a further factor of rigidity in case the presence and persistence of inflation differentials go along with the persistence in the relative ranks of the inflation rates of EMU countries for a long period[3]. Nor does the structural adjustment in goods and labor markets seem to be able in the EMU context to eliminate possible divergences between member countries within a short time. Finally, it is important to add to all of this that there is not a centralized fiscal authority in the EMU able to implement regional transfers to offset possible regional shocks to prices (as instead happens in the United States) and that "since third party arbitrageurs operating outside of the monetary union will ensure equalization of nominal interest rates on debt of identical default risk, heterogeneity of inflation rates may imply vastly dif-

banks (NCBs) of all EMU member States.

[3]However, if correctly interpreted, the SGP could diminish the problem of inflation differentials. The strong effort required by the Pact to achieve a budgetary position in surplus or in balance, indeed, should guarantee the correct functioning of automatic stabilizers.

ferent real interest rates and hence sizable differentials in real tax liabilities in the servicing of that debt across nations" (Cecchetti, Mark, and Sonora, 1998, p. 7). In such an economic context, then, it is even possible that the ECB single monetary policy would cause the divergences to grow and inflation rates to continue and even become larger if this effect is not counterbalanced or exceeded by the anticyclical effect caused by the relative loss of competitiveness of countries with higher inflation rates.

The real problem is thus not only the presence of price level divergence and inflation differentials within the EMU area - that, to a certain extent, is to be expected - but also the insufficient way in which the flexibility of fiscal policy and that of labor and financial markets are really able to compensate for different economic developments, asymmetric shocks and a non optimal monetary policy. Therefore, the knowledge of the factors responsible for the differentials of price levels and inflation differentials in the EMU is very important to allow authorities to understand the real danger related to this phenomenon and, possibly, to implement policies to control it.

The aim of this paper is to study the relevance of a potential cause of price level divergence and/or inflation differentials within a monetary union. The labor-cost effects on relative prices in the presence of imperfect and segmented goods and labor markets are analyzed in Section 3 by adapting to the context of a monetary union the industrial organization (IO) models used in another framework by Dornbusch (1987)[4]. Before doing this, in the next Sec-

[4]The attention of Dornbusch (1987) is focused on explaining the

tion a synthetic overview of the theories on regional price divergence within a monetary union is presented in order to correctly introduce the relevance and contributions of the IO analysis. In Section 4 the potentiality of these models in a dynamic framework is shown through very simple simulations and some considerations about further research are drawn out. Concluding remarks follow.

2. - Sources of Regional Price Divergence within a Monetary Union

A simple, but useful method to understand the magnitude of inflation differentials in the EMU is comparing them with those of the United States, a much more integrated and long-standing monetary union. Table 1 shows that, from its official inception, inflation dispersion in the European monetary union does not appear having been very high: the average of the high-low range and the average of the standard deviation in the EMU, indeed, are of the same size than those of the United States. Moreover, the empirical evidence in Rogers (2001) and Arese-Visconti (2002a) suggests that the current path of inflation differentials in the EMU is probably mainly caused by a process of price level convergence under way[5], exactly as economic theory suggests it should happen in new monetary unions where

adjustment of relative prices to exchange rate movements.

[5]I am aware of the fact that a possible reason for differing price levels among EMU countries could be that the exchange rates chosen at the outset were not equilibrium levels.

initial regional price levels differ.[6]

Table 1: Comparison between regional inflation dispersion in the EMU and in the USA

	EMU[1]	USA[2]
Average range high-low	2.93	3.83
Average st. deviation	0.90	0.84

[1] Calculations based on annual inflation rates derived from the Consumer Price Index (CPI) of 11 EMU countries (Greece excluded) over the period 1999-2001. The source of data is the IMF's World Economic Outlook Database (September 2002). [2] Calculations based on CPI-based annual inflation rates of 26 areas of United States over the period 1999-2001. The source of data is the Bureau of Labor Statistics of the U.S. Department of Labor (http://www.bls.gov).

All this, though, does not mean that a full convergence of price levels will be achieved and that inflation differentials within the EMU will disappear. There are many explanations of why this may not necessarily happen.

The first factor which researchers have focused on to explain divergences of price levels within a monetary union has been the existence of *transportation costs* that create a band in which prices in different places can freely fluctuate without any possibility of making arbitrage.[7] Furthermore,

[6] Theories that explain this phenomenon are the Heckscher-Ohlin-Samuelson model, the new growth theory, and the Balassa-Samuelson model.

[7] For a formal discussion on how transportation costs affect both price level divergence and inflation differentials see, for instance, Arese-Visconti (2002b).

transportation costs can provoke such divergences even in case of very tradable products if they contain significant nontraded components.[8]

Other reasons why regional price levels can diverge arise when aggregate indices are considered. Divergences of price levels could derive, indeed, from different weights used in the regional indices: in this case, even if the price of each commodity is everywhere equal, a change in their relative price will cause the indices to diverge. Another problem of aggregation is that price data are all relative to a base-year. In order to study relative prices, thus, it has to be assumed either that in the base-year they were equal to one or to focus on their variation in time, requiring it to be equal in all regions considered - concept known in literature as 'relative' Purchasing Power Parity (PPP).[9]

A further possible explanation for regional price level divergence and inflation differentials within a monetary union is provided by the Balassa-Samuelson (BS) model.[10] Its basic idea is the following. Suppose that products can be di-

[8]Components that cannot be traded because of excessively high transportation costs such as labor in a supermarket, taxes and rent (on the building)[See Rogoff (1996)].

[9]Formally, 'relative' PPP requires that $p_t^A/p_{t-1}^A = p_t^B/p_{t-1}^B$, where p_t^A and p_t^B are, respectively, a general price index in region A and B at time t. 'Relative' PPP, thus, simply states that the changes in the regional indices over a certain period are equal. 'Absolute' PPP, instead, requires that that at any time t, $p_t^A = p_t^B$. This should be the case if for a large number of commodities prices are equal, thus guaranteeing the regional indices to be highly correlated.

[10]For a in-depth discussion of the model see Balassa (1964) and Samuelson (1964) or, for a more formal discussion, Alberola and Tyrväinen (1998) and Arese-Visconti (2002b).

vided into the category of commodities traded (Tradeable Goods, TG) and the category of commodities that cannot be traded because of excessively high transportation costs (Nontradeable Goods, NTG)[11]. This means that TG are exposed to competition, while NTG are not. Since both categories are present in the price indices, different growth paths in the NTG prices lead price indices to divergence. A common assumption made in most empirical studies on the BS is that, once transportation costs are taken into account, price levels in the TG sector as equal. The correctness of this hypothesis, though, is very doubtful and need to be empirically evaluated. In this regard, useful insights can be again obtained from the evidence on the United States.

Using a panel of prices[12] for 51 final goods from 48 cities in the United States over the period 1975:1 through 1992:4 (quarterly data), Parsley and Wei (1996) test for stationarity of relative price levels, estimate rates of convergence to their parity, and investigate possible factors that can affect the convergence rates. Their evidence points to an overall rejection of nonstationarity of the series considered and to a fast reversion to the parity of regional prices, with stronger results for the TG. With reference to the third purpose, both the effects of transportation costs and of possible non-

[11]Examples of TG are the manufactured products, while examples of NTG are many personal services.

[12]Their source is the *Cost of Living Index* published by the American Chamber of Commerce Researchers Association (ACCRA). This index contains comparative average prices, thus allowing, in theory, to overcome the problems related to the use of price indices. The series considered are the logarithm of prices of each city relative to those of the benchmark city (New Orleans).

linearities on the rate of convergence to the parity of price levels are found to be statistically significant, but do not allow to completely explain the divergence of prices among different locations.

The paper of Parsley and Wei (1996), though, presents several important problems in reference to the data used and the methodology applied.[13] In order to overcome some of these problems, Cecchetti, Mark, and Sonora (1998) use a panel of annual observations on the aggregate CPI for 19 cities over the period 1918-1995[14] to reach the same goals as Parsley and Wei (1996). Also in this case the hypothesis of nonstationarity of the series considered is strongly rejected, but the speed of reversion to the parity of regional prices is much slower. Furthermore, distance is found to be not significantly different from zero - even if it has the expected sign - and there is moderately strong evidence in favor of nonlinearities in the convergence to the PPP. Also the effect of NTG[15] in the price index is detected: surprisingly, the deviation from the parity is quite persistent for TG prices, while it is not for the prices of services.

This last result is confirmed also in different frameworks. With monthly data for 29 U.S. cities (Dec. 1986 - June

[13]With regard to the first point, see Cecchetti, Mark, and Sonora (1998) and Engel and Rogers (2001). As for the second, the problems are those of the panel unit root test used in their study, that is the test proposed by Levin and Lin (2002) (LL) - see Maddala and Wu (1999).

[14]The source of these data is the Bureau of Labor Statistics (BLS) and they are the basis for the construction of the national CPI.

[15]Here commodities are taken as TG, while services are taken as NTG.

1996) from the BLS, Engel and Rogers (2001) aim at explaining the variability of prices of similar goods across U.S. cities by measuring the standard deviations of changes in the logarithm of the relative prices. A very interesting result refers to the fact that the weighted-average value of standard deviation is much higher for TG than it is for NTG. Moreover, even taking distance into account, the "city effects" in the data are found to be very important.

Interesting insights arise also from the study of O'Connell and Wei (1997). They investigate the nonlinear dynamics of deviations from the parity of regional price levels arising from transportation costs[16] by fitting a Threshold AutoRegression model[17] (TAR) to relative prices. The basic idea is to test if relative prices are nonstationary in the band produced by transportation cost and stationary outside. The findings obtained with this method are compared with those of the *GLS* panel unit root test. Contrary to Parsley and Wei (1996), the evidence from this last test shows that for goods grouped by commodity type nonstationarity can be rejected only in a few cases both when products are grouped by commodity and when products are grouped by location. This results could arise from the nonlinear dynamics of the deviations from the regional price-levels parities: in the large majority of the cases, indeed, the AR(1) model is rejected in favor of the TAR model. Very interesting is also the fact that the estimated thresholds are quite high

[16]Their data set is substantially the same as that used in Parsley and Wei (1996)

[17]For further details on the TAR model see, for instance, Tong (1993).

for the majority of the products and the majority of the cities.[18]

Overall, from the evidence provided so far it would appear that even in a long-standing, highly-integrated monetary union such as the United States relevant price level divergences can occur and that this seems to be true even for the TG sector. Another important conclusion that can be drawn from the preceding empirical results is that transportation costs alone are not enough to completely explain the movements of relative regional TG prices. This means that supplementary theories on this phenomenon are needed in the context of a monetary union. This is the object of the analysis in the next Section.

3. - Relative Tradable-Goods Prices within a Monetary Union: the Industrial Organization Approach

A relevant feature of the European EMU is that, even though many efforts have been made so far to deepen the economic integration of its current members, their goods and labor markets are still imperfect and segmented. Under these conditions, scope for price level divergences and inflation differentials in the TG sector does exist.

From a "demand-side" point of view, oligopolistic firms facing different elasticities of demand in different locations can realize price discrimination between destinations. As suggested by Kravis, Lipsey, and Kalter (1977) with ref-

[18]Both when goods are grouped by commodity and when they are grouped by location, in most cases thresholds are equal to or higher than 10%.

erence to the international context, indeed, this practice can arise from "[...] the existence of product differentiation both in terms of physical characteristics relating to appearance and performance, and in terms of various service elements such as before-and-after-sale advice and service, credit terms and speed of delivery" [p.2]. A condition for price discrimination to take place is that "the constellation of rivals differs from market to market". This theory, then, probably does not fit the United States, but can be applied to the EMU quite well.

Price level divergences and inflation differentials in the TG sector within the EMU could also arise from a "supply-side" point of view. With reference to countries with different currencies, Dornbusch (1987) suggested four static IO models in which the extent of the adjustment of domestic-foreign relative prices to exchange rate movements depends on market structure, product substitutability and the relative number of domestic and foreign firms. It turns out that his basic setup can be exploited and adapted to the case of a monetary union deriving price and/or inflation divergences as a consequence of flexible relative labor cost across countries.

For sake of space, let us concentrate on three of these IO static models[19] where an oligopolistic market is allowed to have, respectively, perfect substitution between alternative suppliers (Cournot) and imperfect substitution without

[19]Also the Salop model has been applied to the monetary case by the author, but it is not reported for sake of space. In any case, the findings are in line with those of the IO models presented in this paper. Details are available from the author upon request.

(Dixit-Stiglitz) or with (extended Dixit-Stiglitz) strategic interaction.

Assuming that firms in any industry have a linear technology, with labor as the only input, the effect on industry equilibrium prices of flexible relative labor costs in member countries is studied. In particular, for simplicity, we analyze the impact that an increase of labor cost in only one out of the two countries considered has on the common equilibrium price of the industry in each nation. The interest in studying this case arise also from the fact that scope for labor costs to differ in the EMU does really exist. First of all, indeed, EMU countries have very different labor market structures and traditions. Moreover, there is a strong consensus that, overall, European labor markets are very rigid with varying degree of rigidity from country to country. One way to offset this inflexibility could be cross-national migration, but at present this is currently very low and is expected to grow only very slowly.[20]

3.1 *The Cournot Model*

Let us consider a homogeneous product sold in an oligopolistic market and assume that every firm maximizes its profit by taking the other firms' sales as given. Furthermore, let us assume that there is an effective spatial separation between the product and labor markets in the two countries considered (A and B), members of a monetary union. With these hypotheses it is possible to analyze the

[20]See, for instance, Björkstén and Syrjänen (1999) and Eichengreen (1998).

effect of a change in unit labor costs on the equilibrium price of the industry in the two nations. We start by considering the country A. For simplicity, suppose the demand function is linear:[21]

$$Q_d = a - bP_A, \tag{1}$$

where Q_d represents the quantity demanded, a is a constant which contains all the nonprice determinants, b is a positive coefficient and P_A is the common price of the industry. The n producers of country A and the n^* producers[22] of country B produce each, respectively, quantities q and q^*. As a consequence, aggregate sales will be

$$Q = nq + n^*q^*. \tag{2}$$

Profits for the generic firm of country A and B, then, are equal, respectively, to

$$(P_A - \frac{w}{\pi})[a - bP - (n-1)q - n^*q^*]$$

and to

$$(P_A - \frac{w^*}{\pi^*})[a - bP - nq - (n^* - 1)q^*],$$

where w and w^* are, respectively, the wages in A and B, and π and π^* are, respectively, the labor productivity in A and B. Let's define $(w/\pi) = \omega$ and $(w^*/\pi^*) = \omega^*$.

[21] It will be shown in a subsequent footnote that the use of the generic inverse demand function $P = F(Q)$ does not change the substance of the results reached by using the linear demand function.

[22] n and n^* can be interpret not only as mere 'number' of producers, but also as share of market controlled, respectively, by the firms of A and B.

Assuming that firms maximize their profits by taking the other firms sales as given, the quantities produced by firms of country A and country B are, respectively,

$$q_i = b(P_A - \omega) \tag{3}$$

and

$$q_j^* = b(P_A - \omega^*).$$

Substituting expression (3) in (2) and then in (1) we reproduce Dornbusch's result about the the common equilibrium price in the industry of country A, that is equal to

$$P_A = \frac{(n\omega + n^*\omega^*)}{N} + \frac{a}{bN};$$

$$N \equiv n + n^* + 1.$$

We can exploit these results to investigate what the price reaction to a change in relative labor costs will be. Supposing, for instance, that in country B there is an increase of the unit labor cost and that, for simplicity, the unit labor cost in country A remains constant, firms of country B will reduce their production thus causing an increase in the common equilibrium price and in the quantities sold by domestic firms. The opposite effect will be provoked by a reduction in the unit labor cost in country B: in this case firms of country B will raise their production and both the common equilibrium price and domestic firms' sales will fall. The same reasoning can be made in order to analyze the consequences of a change in the unit labor cost in A keeping constant, for simplicity, that of B.

We are now interested in knowing the intensity of the effect of unit labor costs movements on the common equilibrium price in the industry of country A. In order to achieve this result, it is sufficient to calculate the elasticities of the equilibrium price with respect to the unit labor cost in countries A and B. These, respectively, are equal to

$$\epsilon_A = \frac{n}{N}\frac{\omega}{P_A},$$

$$\epsilon_B = \frac{n^*}{N}\frac{\omega^*}{P_A}. \tag{4}$$

Note that these elasticities have two determinants: the share of domestic and foreign firms of the total number of firms in the market and the ratio of the marginal cost to the common equilibrium price in the industry of country A for domestic and foreign producers. This means that the impact of a change in the unit labor cost in A and/or B on the common equilibrium price of A's industry will be higher the more competitive the industry is - that is, the smaller the mark-up of price over marginal cost - and the higher the share of domestic and/or foreign firms of the total number of firms in the market of A. Consider now the same industry in B. If it is supposed, for simplicity, that the demand function is equal to that in A and n' and $n^{*\prime}$ are, respectively, the number of firms of A and B, then the same reasoning made before allow us to calculate the elasticities of common equilibrium price of the industry in B with respect to the unit labor cost in the two countries that are

$$\epsilon_A^* = \frac{n^{*\prime}}{N^*}\frac{\omega^*}{P_B} \tag{5}$$

for B and

$$\epsilon_B^* = \frac{n'}{N^*}\frac{\omega}{P_B},$$

for A. The common equilibrium price of B is P_B. Also in this case the determinants of the elasticities are the level of competition in the industry and the share of firms of each nation of the total number of firms in the market.

These results enable us to analyze the impact that a change in the unit labor cost of a country has on common equilibrium prices in A and B. Suppose, for instance, that there is an increase in the unit labor cost in B. The common equilibrium price in B relative to A's will rise if and only if[23]

$$\frac{n^*}{N}\frac{\omega^*}{P_A} < \frac{n^{*\prime}}{N^*}\frac{\omega^*}{P_B},$$

that is if the market competition is higher in B than it is in A and if the relative number of firms of B in the market of A is lower than the relative number of firms of B in the market of B.[24]

[23] In the case of the generic inverse demand function $P = F(Q)$ (4) and (5) become, respectively, $\epsilon_B = (n^*/(N-\theta))(\omega^*/P)$ and $\epsilon_A^* = (n^{*\prime}/(N^*-\theta^*))(\omega^*/P^*)$, where θ and θ^* represent, respectively the elasticity of the price with respect to demand in A and B. Assuming that in the EMU θ and θ^* are not very dissimilar, the substance of the results achieved by using the linear demand function does not change.

[24] Two possible intuitive reasons why this is true for the majority of the industries in the EMU are constituted by the high level of

3.2 *The Dixit-Stiglitz Model*

This model emphasizes imperfect substitution between alternative suppliers. Consider the case of two countries (A and B) that are members of the same monetary union, but with goods and labor markets separate and imperfect. For simplicity, assume that in both countries there is the following separable utility function with convex indifference surfaces:

$$u = U[z, V(\underline{x})],$$

where z and $\underline{x}$ are two different commodities and $\underline{x} = (x_1, x_2, x_3, \ldots, x_\omega)$ with x_1, x_2, x_3 ... being different brands of the same commodity. For simplicity, suppose also that V is a symmetric function and that all the brands of the product $\underline{x}$ have equal fixed and marginal costs and unit income elasticities. The fact that income distribution problems are neglected allows us to interpret U either as representing Samuelsonian social indifference curves or as a multiple of a representative consumer's utility - if the appropriate aggregation conditions are fulfilled.[25] Product diversity, then, can be regarded either as different consumers using different varieties or as diversification on the part of each consumer.

In country A, n firms of A and n^* firms of B supply

market segmentations present in the past among European countries which allowed domestic firms to impose themselves on the domestic market and the fact that, in order to be able to enter a foreign market, one country's firms have entry costs higher than those of domestic firms, such as higher information costs, that make it harder to build a distribution network or a reputation abroad.

[25]For an in-depth discussion see Dixit and Stiglitz (1977).

some variant of the commodity $\underline{x}$ exactly as happens in B where the firms of B are $n^{*\prime}$ and those of A are $n^{\prime}$. Assume that

$$V(\underline{x}) = (\sum_{\iota=1}^{\omega} x_{\iota}^{\gamma})^{1/\gamma}$$

with $0 < \gamma < 1$ for concavity and in order to allow a situation where several of the variant of $\underline{x}$ are zero.

The demand for the product of each firm in the market of $\underline{x}$ in A is obtained by maximizing the utility function:[26]

$$x_i = x\left(\frac{P_A}{p_i}\right)^{\kappa}; \quad \kappa = \frac{1}{(1-\gamma)}. \tag{6}$$

The price index of the variants of $\underline{x}$ is

$$P_A = [(\sum_{i=1}^{n} p_i^h + \sum_{j=1}^{n^*} p_j^h)]^{1/h}; \quad h = -\frac{\gamma}{(1-\gamma)}. \tag{7}$$

In equation (7), p_i denotes the price of a variant produced in A and p_j denotes the price of an imported brand. If every firm faces a demand function like that in equation (6) and assumes it is sufficiently small so that its price changes will not affect the industry price P, its profits will be

$$\pi_i = (p_i - \omega)x_i$$

and its price will be

$$p_i = \mu\omega; \quad \mu = \frac{1}{(1-1/\kappa)}, \tag{8}$$

[26]For further details, see Dixit and Stiglitz (1977), pp. 298-299.

with μ representing a constant mark-up which depends inversely on the elasticity of substitution among variants. If we suppose that the industry structure is symmetric, every domestic and foreign firm sets its price with the same mark-up. This means that the price fixed by the foreign firms will be

$$p_j = \mu\omega^*. \tag{9}$$

Equations (8) and (9) allow us to reach two interesting conclusions. First, it is found that the relative price of domestic and foreign variants in A depends uniquely on relative unit labor costs, that is

$$\frac{p_i}{p_j} = \frac{\omega}{\omega^*}.$$

Also in this case the analysis can be conducted as to allow us to verify what the effect of a relative labor cost change is on the prices set by domestic and foreign firms in each market. In order to reach this result, it is sufficient to calculate the elasticity of the industry price with respect to unit labor costs of domestic and foreign firms. In A these, respectively, are

$$\epsilon_A = n\left(\frac{\mu\omega}{P_A}\right)^h$$

$$\epsilon_B = n^*\left(\frac{\mu\omega^*}{P_A}\right)^h. \tag{10}$$

Consider now the market of $\underline{x}$ in B. Suppose, for simplicity, that the utility function is the same as A.[27] Rea-

[27]This assumption it is not far from the truth if it is considered that, overall, in the countries member of the EMU the consumption patterns are, at present, very similar.

soning in the same way we did above, then, we can calculate the elasticities of the industry price in B ($P_B = [\sum_{i=1}^{n^{*\prime}} (p_i^*)^h + \sum_{j=1}^{n'} (p_j^*)^h]^{1/h}$) with respect to the unit labor costs of domestic and foreign firms that, respectively, are

$$\epsilon_A^* = n^{*\prime} \left(\frac{\mu \omega^*}{P_B} \right)^h \tag{11}$$

$$\epsilon_B^* = n' \left(\frac{\mu \omega}{P_B} \right)^h .$$

As in the Cournot model, it is now possible to compare the changes of the industry prices in each country following a modification in relative labor costs. Suppose, for example, that in B there is an increase in the unit labor cost. From (10) and (11) we know that the industry price in B will grow more than that of the same industry in A if and only if

$$\epsilon_B^* > \epsilon_A,$$

that is, if and only if

$$n^{*\prime} \left(\frac{\mu \omega^*}{P_B} \right)^h > n^* \left(\frac{\mu \omega^*}{P_A} \right)^h .$$

Unlike the Cournot model, then, what is important here is not the share of a nation's firms of the total number of firms in a market, but rather its absolute number. This result is due to the fact that, because of product diversity and the lack of strategic interaction, only the prices of the firms of the country where unit labor costs have grown increase, while those of the others remain constant. In any case, the substance of the conclusions reached through this model are

the same of those obtained by means of the Cournot model: the divergence of the unit labor costs growth rate causes the divergence of inflation rates; this divergence will be higher the greater the separation between the two markets.

3.3 *The Extended Dixit-Stiglitz Model*

The lack of strategic interaction between firms in the previous IO model is a major shortcoming because it is clearly not a realistic assumption. As a consequence, the overcoming of this limitation could strongly improve the robustness of the analysis. The simple solution proposed by Dornbusch (1987) is to assume that all firms react to a one percent change of the industry price by modifying their price in the same direction by a fraction σ $(0 < \sigma < 1)$. In this way, in country A the markup pricing equations for the individual domestic and foreign firms become

$$p_i = \mu_A \omega; \quad \mu_A \equiv \frac{1}{1 - \frac{1}{\kappa(1-\rho_A)}}$$

$$p_j = \mu_B \omega^*; \quad \mu_B \equiv \frac{1}{1 - \frac{1}{\kappa(1-\rho_B)}} \,,$$

where

$$\rho_A = \frac{dP_A}{P_A}\frac{p_i}{dp_i} = \frac{1}{\sigma + (1-\sigma)[n + n^*(p_j/p_i)^h]} < 1 \qquad (12)$$

$$\rho_B = \frac{dP_A}{P_A}\frac{p_j}{dp_j} = \frac{1}{\sigma + (1-\sigma)[n^* + n(p_i/p_j)^h]} < 1$$

are the elasticities of the industry price with respect to, respectively, the prices of individual domestic and foreign firms.[28]

We think that it is instructive to extend the graphical approach by Dornbusch (1987) in an analytical direction. As customary, let us consider the effect on industry prices in A and B of an increase in the unit labor cost of B. Supposing, for simplicity, that the utility function and the σ in B are the same of A, the industry price in A and B are, respectively,

$$P_A = [(\sum_{i=1}^{n} p_i^h + \sum_{j=1}^{n^*} p_j^h)]^{1/h}$$

$$P_B = [(\sum_{r=1}^{n^{*\prime}} p_r^h + \sum_{q=1}^{n^{\prime}} p_q^h)]^{1/h} \quad .$$

As a consequence, the markup pricing equations for individual domestic and foreign firms in country B are, respectively,

$$p_r = \lambda_B \omega^*; \quad \lambda_B \equiv \frac{1}{1 - \frac{1}{\kappa(1-\eta_B)}}$$

$$p_q = \lambda_A \omega; \quad \lambda_A \equiv \frac{1}{1 - \frac{1}{\kappa(1-\eta_A)}} \ ,$$

where

[28] Equations (12) are obtained with reference to a single firm assuming that $\sigma = \frac{dp_i}{P_A}\frac{P_A}{p_i} = \frac{dp_j}{P_A}\frac{P_A}{p_j}$ for all firms with the exception of that firm.

$$\eta_B = \frac{dP_B}{P_B}\frac{p_r}{dp_r} = \frac{1}{\sigma + (1-\sigma)[n^{*\prime} + n^{\prime}(p_q/p_r)^h]} < 1$$

$$\eta_A = \frac{dP_B}{P_B}\frac{p_q}{dp_q} = \frac{1}{\sigma + (1-\sigma)[n^{\prime} + n^{*\prime}(p_r/p_q)^h]} < 1.$$

It is now necessary to compute the elasticities of the markup of firms of A and B with respect to the unit labor cost of B. In country A these are, respectively,

$$\delta_A = \frac{d\mu_A}{\mu_A}\frac{\omega^*}{d\omega^*} = -\frac{n^* h(1-\sigma)(p_j/p_i)^h(\rho_A)^2\mu_A}{\kappa(1-\rho_A)^2}(1+\delta_B) \tag{13}$$

$$\delta_B = \frac{d\mu_B}{\mu_B}\frac{\omega^*}{d\omega^*} = \frac{nh(1-\sigma)(p_i/p_j)^h(\rho_B)^2\mu_B}{\kappa(1-\rho_B)^2 - nh(1-\sigma)(p_i/p_j)^h\mu_B(\rho_B)^2},$$

while in country B these are, respectively,

$$\psi_B = \frac{d\lambda_B}{\lambda_B}\frac{\omega^*}{d\omega^*} = \frac{n^{\prime}h(1-\sigma)(p_q/p_r)^h\lambda_B(\eta_B)^2}{\kappa(1-\eta_B)^2 - n^{\prime}h(1-\sigma)(p_q/p_r)^h\lambda_B(\eta_B)^2} \tag{14}$$

$$\psi_A = \frac{d\lambda_A}{\lambda_A}\frac{\omega^*}{d\omega^*} = -\frac{n^{*\prime}h(1-\sigma)(p_r/p_q)^h\lambda_A(\eta_A)^2}{\kappa(1-\eta_A)^2}(1+\psi_B).$$

It is now possible to calculate the elasticities of the industry price in A and B with respect to unit labor costs of firms of B, defined, respectively, as ϵ_A and ϵ_B^*:

$$\epsilon_A = \frac{np_i^h\delta_A + n^*p_j^h(1+\delta_B)}{(P_A)^h}$$

$$\epsilon_B^* = \frac{n^{*\prime}p_r^h(1+\psi_B) + n^\prime p_q^h\psi_A}{(P_B)^h}.$$

As a consequence, the industry price in B will grow more than that of the same industry in A if and only if $\epsilon_A < \epsilon_B^*$. This is true if and only if

$$[n\delta_A + n^*(\frac{p_j}{p_i})^h(1+\delta_B)](\frac{p_i}{P_A})^h < [n^{*\prime}(1+\psi_B) + n^\prime\psi_A(\frac{p_q}{p_r})^h](\frac{p_r}{P_B})^h. \tag{15}$$

In order to simplify the analysis, we make the assumption that $p_i = p_j$, $p_r = p_q$, $n = n^{*\prime}$ (hereafter n), and $n^\prime = n^*$ (hereafter n^*). These imply that $\eta_B = \eta_A = \rho_A = \rho_B$ (hereafter η), $\lambda_B = \lambda_A = \mu_A = \mu_B$ (hereafter λ), $\omega = \omega^*$, and, then, that $p_i = p_j = p_r = p_q$ (hereafter p). Thus, the inequality (15) becomes

$$n^*[1 + (\delta_B - \psi_A)] < n[1 + (\psi_B - \delta_A)] \ . \tag{16}$$

By substituting equations (13) and (14) in (16), we obtain that condition (16) holds if and only if

$$(n - n^*)\{[\kappa(1-\eta)^2]^3 - h\lambda\eta^2[\kappa(1-\eta)^2]^2(1-\sigma)[n + n^*]\} +$$

$$+[n^*n^2 - n(n^*)^2][\lambda\eta^2(1-\sigma)h]^2\kappa(1-\eta)^2 > 0 \ .$$

that is true if and only if

$$n > n^* \quad .$$

The results obtained by the simpler version of the Dixit-Stiglitz model are, thus, confirmed.

4. - Possible Extensions of Industrial Organization models

The most important feature of the IO models presented is their flexibility. Besides the major case analyzed above, indeed, they can be applied to many other situations. Think, for instance, of the case in which the firms of a country control not only the majority of the domestic market, but even the majority of the foreign market, or of the situation in which there is an equal increase of labor costs in all countries.

The flexibility of IO models also arises from the fact that they can be also inserted in a dynamic framework. An easy way to do this, for instance, is to impose the realistic condition that the number (market share) of firms of a country increases (decreases) in a market as a consequence of the gain (loss) of competitiveness due to the reduction of their prices relative to foreign. The dynamic description of the labor-cost effects on relative price levels and inflation rates, thus, can be obtained by applying the IO models sequentially, the link between different periods being represented by the changes in the number (market share) of firms on markets.

With the only aim of providing an example of how this insertion of IO models in a dynamic framework could work

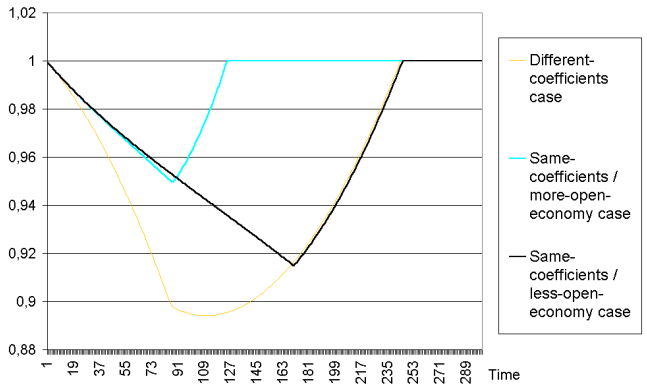

Figure 1: Price of country B relative to price of country A obtained by simulating the Cournot model. Three cases are considered: in the first, the economy of a country is more open than that of the other, but in each market domestic firms react the same than foreign firms to changes of relative price; the other two are a more-open-economy version and a less-open-economy version of the case in which firms in both markets react the same way to changes of relative price.

in practice, we carry out some very simple simulations on the Cournot model. Further details are in the Appendix. We consider the effects on the dynamics of price level and inflation differentials of diverging labor costs in two countries (A and B). In particular, we we make the unrealistic hypothesis that the labor cost of A grows more than that of B forever. Two main cases are considered: first, the economy of a country is more open than that of the other, but in each market domestic firms react in the same way as foreign firms to changes of relative price; second, firms in both markets react the same way to changes of relative

price. We study a more-open-economy version and a less-open-economy version of this last case. The final condition is that the total number of firms in each market is maintained equal in every period. Figure 1 shows the relative prices obtained for all the situations considered. Results are as expected: after a period of divergence of price levels, these converge as a consequence of always more similar market structure (share of firms of country B in the two markets); furthermore, the more open an economy is, the faster is the convergence of price levels; third, having different or equal reaction coefficients in the two markets affects just the shape of convergence and not the length of time needed to reach the parity; finally, the most interesting result of this exercise is that in a dynamic framework relative prices and inflation differentials cannot diverge forever even in the extreme case of labor costs continuously diverging.

Apart from these conclusions, perhaps the most important feature of these simple simulations is that they allow us to draw some important considerations about further research on the IO models. First of all, the real potential of these models can be fully expressed only in a formal dynamic framework which should be analytically studied. In particular, in this context many other factors may be considered: think, for instance, about the inclusion of a certain degree of labor mobility in the models or about a change in the relative employers-employees bargaining power affecting labor costs caused by the gain/loss of competitiveness of their firms. Another interesting development could be combining the IO models with others such as the BS. Finally, an empirical investigation of these IO models should

be performed.

Conclusions

An industrial organization approach is used in this paper to study the relevance of a potential cause of tradable-goods-price level divergence and inflation differentials in a monetary union with special reference to the European EMU. The labor-cost effects on relative prices in the presence of imperfect and segmented goods and labor markets are analyzed by adapting the static IO models used in another framework by Dornbusch (1987) to the context of a monetary union. The attempt is to provide a robust description of the TG price adjustment in each country following a change in the relative labor cost in countries member of a monetary union by considering three of these IO static models where an oligopolistic market is allowed to have, respectively, perfect substitution between alternative suppliers (Cournot) and imperfect substitution without (Dixit-Stiglitz) or with (extended Dixit-Stiglitz) strategic interaction. This, indeed, is a very interesting case in the EMU context due to the very different labor market structures and traditions in the national economies of the European monetary union. Many other cases, though, can be easily described by the IO models.

The main conclusion is that the type and extent of the labor-cost effects on relative TG prices between the regions of a monetary union depend on the different degree of competition in the same industry of different countries, the different absolute or relative number of foreign and domestic

firms in the market of each country, and the product substitutability.

It is very important to note that the fact that results do not crucially depend on the type of oligopolistic market considered, but are qualitatively always the same, means that it is possible to extend the conclusions reached for individual industries to whole TG sectors if it is assumed that, in the majority of the cases, the conditions that cause the divergence of price levels and inflation differentials of the countries of a monetary union hold.

Very simple simulations have also been carried out in order to illustrate the how these models can be extended to a dynamic framework. The main considerations that arises from this exercise show that the real potentiality of these models can be fully expressed only in a dynamic framework - that, therefore, should analytically studied - and combining them with other models such as the BS. These extensions could be the object of further research.

APPENDIX

In this appendix some details on the simulations of the Cournot model described in Section 4 are presented. We remember that the only aim of this exercise is providing an example of the potential of IO models in a dynamic framework.
In the linear demand function we impose

$$a = 1; b = 0.8 \ .$$

The initial values of ω and ω^* are 100. The growth functions of unit labor costs in country A and B, respectively, are

$$\omega_t = \omega_{t-1} + 0.6$$

and

$$\omega_t^* = \omega_{t-1}^* + 0.2 \ .$$

The initial values of n, n^*, $n^{*\prime}$, and n', respectively, are 100, 70, 70, and 100 (symmetric case). We impose that
if $p_{rel_t} = P_{B,t}/P_{A,t} > 1$, then

$$n_t = n_{t-1} + cp_{rel_t};$$

$$n'_t = n'_{t-1} + fp_{rel_t};$$

$$n^{*\prime}_t = n^{*\prime}_{t-1} - f\frac{1}{p_{rel_t}};$$

$$n^*_t = n^*_{t-1} - c\frac{1}{p_{rel_t}};$$

if $p_{rel_t} = P_{B,t}/P_{A,t} = 1$, then

$$n_t = n_{t-1};$$

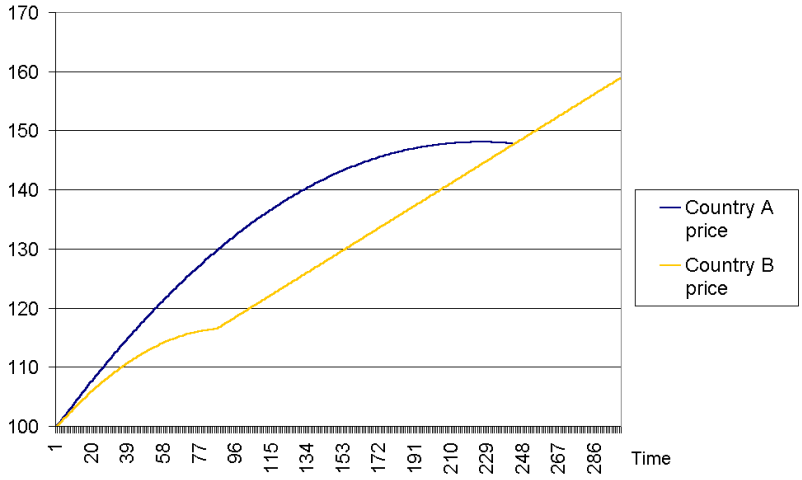

Figure 2: Price levels of countries A and B obtained by simulating the Cournot model. A is the less open economy and in each market domestic and foreign firms react the same to changes of relative price.

$$n'_t = n'_{t-1};$$
$$n^{*\prime}_t = n^{*\prime}_{t-1};$$
$$n^*_t = n^*_{t-1};$$

if $p_{rel_t} = P_{B,t}/P_{A,t} < 1$, then

$$n_t = n_{t-1} - cp_{rel_t};$$
$$n'_t = n'_{t-1} - fp_{rel_t};$$
$$n^{*\prime}_t = n^{*\prime}_{t-1} + c\frac{1}{p_{rel_t}};$$
$$n^*_t = n^*_{t-1} + f\frac{1}{p_{rel_t}}.$$

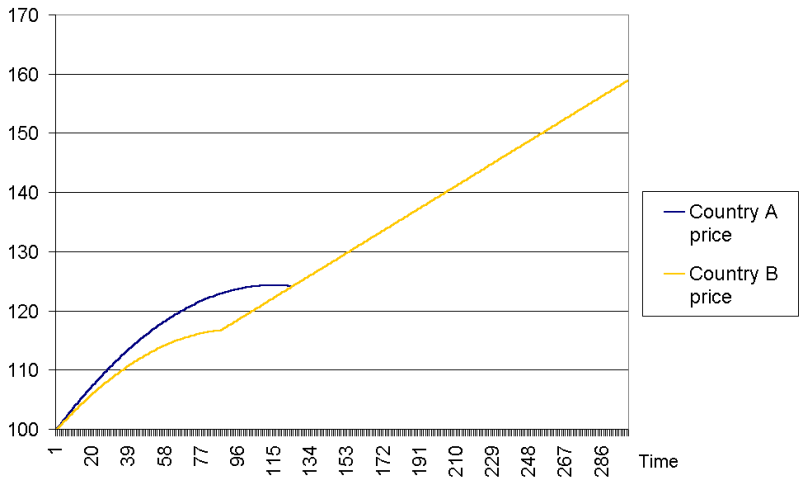

Figure 3: Price levels of countries A and B obtained by simulating the Cournot model. Firms in both markets react the same way to changes of relative price: more-open-economy version.

The cases considered are:

1. The economy of a country is more open than that of the other, but in each market domestic firms react the same than foreign firms to changes of relative price (Figure 2).

2. Firms in both markets react the same way to changes of relative price: more-open-economy version (Figure 3).

3. Firms in both markets react the same way to changes of relative price: a less-open-economy version (Figure 4).

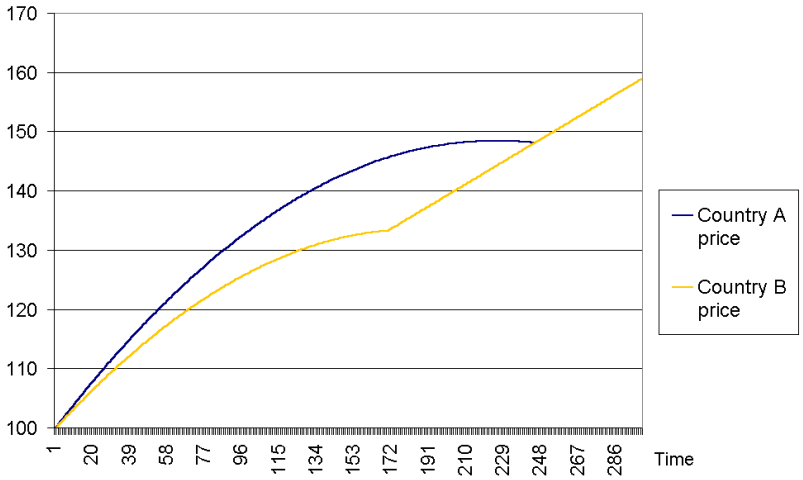

Figure 4: Price levels of countries A and B obtained by simulating the Cournot model. Firms in both markets react the same way to changes of relative price: less-open-economy version.

In the first case the values of c and f, respectively are 0.4 and 0.8; in the second case the values of c and f are both 0.8; in the third case the values of c and f are both 0.4. Notice also that the total number of firms in each market is maintained fixed always.

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