Preliminary and incomplete.
Comments and suggestions most welcome.

Exchange Rate and Inflation Differentials

With Imported Intermediate Inputs.

A Factor-Specific Model with International Fragmentation of Production

Antonella Liberatore*
Fabio Sdogati*

Paper to be presented at the Italian Trade Study Group meeting
Roma, 20-21 November 2008

Abstract and Summary of Conclusions

JEL Ref numbers:
Inflation in Open Economies
International Fragmentation of Production
Exchange Rates and Inflation

* Politecnico di Milano, Department of Management, Economics and Industrial Engineering. <antonella.liberatore@it.ibm.com>, <fabio.sdogati@polimi.it>

Introduction

Over the past ten years the European Central Bank succeeded in reaching and maintaining medium-run price stability in the Euro Area[1]. Nevertheless, though inflation rates converged (and decreased) during the stage II of EMU, since 1999 inflation *differentials* among the member countries have been increasing (Busetti *et al.* 2006).

To be sure, inflation differentials among countries belonging to a monetary union are a natural adjustment mechanism to local shocks; nevertheless, inflation differentials among EMU countries, especially because of their policy implications, have been raising a growing concern among European economists. Before the Euro began circulating, the well-known Balassa-Samuelson effect was a common explanation for this phenomenon: different growth rates between tradable and non-tradable good sectors produce a real appreciation of the exchange rate which has to be balanced with higher inflation rates. Showing a relevant growth in productivity, Ireland was regarded to be the best example of the Balassa-Samuelson effect. Since the introduction of the Euro, as soon as inflation differentials began to increase, a variety of empirical studies have been addressing the issue, considering cyclical reasons, the role of national policies (fiscal policy above all), and demand behaviour among the possible causes of this phenomenon (Rogers *et al* 2001; Blanchard 2001; ECB 2003).

Another branch of literature considers instead the effects of "globalisation" on inflation rate: appearance of emerging countries on the world trade scene and growing trade integration contributed, according to some economists, to maintain a low and stable inflation rate in most industrialised countries. Nevertheless, not everybody shares such point of view: low-cost imports from emerging countries do not affect the inflation rate automatically, as international trade only affects relative prices, not the aggregate price level[2]. The main result of most studies, however, is that low-cost imports could have an effect on inflation dynamics only in the short run (IMF 2006).

Though extremely important toward our understanding of the issue of what determines inflation differentials, the two strands of literature referred to above heavily discount two issues: the role of the exchange rate as an independent originator of inflation, and the role of structural variables in the emergence of country-specific differences in the reaction of the aggregate price level to exchange rate shocks. Indeed, a debate focusing on the structural reasons of the phenomenon, namely the structural differences among member countries and their different degree of exposure to extra-EMU trade, is only recently emerging in the literature, and then with attention

[1] This statement does not apply to the whole period beginning July 2007, which has been characterized as one of 'credit crunch' or, even, 'credit panic.'

[2] For two opposite visions, see Rogoff (2005) and Ball (2006).

being paid to differential effects of exchange rate movements on national inflation rates (ECB, 2003; Honohan and Lane, 2003).

This paper aims at analyzing the differential impacts of exchange rate changes on national inflation rates both theoretically and empirically. It differs from previously published work in several respects. First, we are interested on the effects of a change in the price of intermediate imports, and not of the imported finished products, on the aggregate price level. This channel is important because intermediate inputs affect domestic production costs directly: to our knowledge such channel has not been studied to the extent we believe it deserves. Consequently, we are interested in analysing the effect of a change in the price of intermediate imports both at country and at industry level: we expect different price dynamics for different degrees of integration of industries (and countries) in the global value chain. Secondly, we model the link between exchange rate and inflation by considering the role of internationally integrated production processes, beside openness to trade. The importance of this channel is self-evident: imported intermediate inputs affect domestic production costs directly. We do not know of any paper addressing the issue this way. Finally, we look for the *net* effect of an exchange rate shock on the inter-country inflation differential, that is, for the effect of the shock on both the import and the export side: the import-side effect of the shock will depend in our model upon the degree of *integration* of the national production structure on the world's, whereas the export-side effect will depend upon the degree of *exposure* of the home country to the world's change in demand for domestic products due the exchange rate shock.

The paper is organised as follows. The first paragraph lays the theoretical foundations of the model as a whole drawing on both the Scandinavian model of inflation for a small open economy and the recent literature on international fragmentation of production processes. These two strands of literature constitute the basic framework for our model and allow us to identify precisely the core of our interest, namely the link between prices of intermediate products and prices of final ones. In the second paragraph we build a model in which the aggregate price level of a small open economy depends both on its degree of integration in the world production process and on in exposure to trade on the export side: the first link is ensured by an elastic domestic demand for imported intermediate inputs, the second by an elastic foreign demand for domestic exports of final manufacture products. Empirical testing of the theoretically derived relations follows in paragraph three: we test the predictions of the model using a sample of eleven countries belonging to the European Economic and Monetary Union and we use panel data models (*pooled OLS* and *Fixed Effects* models) to estimate the impact of integration ad exposure on inflation rate. Empirical testing is carried out at the industry level as well. Paragraph four summarizes the main results.

1. Theoretical and Empirical Foundations

Aiming at analysing the phenomenon of inflation differentials both theoretically and empirically, our work needs to be founded in both theoretical and empirical literature.

From the theoretical point of view, our work has important affinities with the Scandinavian model of inflation, which relates the inflation rate of a small open economy to different productivity growth rates between tradable and non-tradable good sectors (Aukrust, 1977). The core feature of this model, borrowed in our framework, is the distinction between an *exposed* sector, which suffers international competition, and a *sheltered* sector, not competing in the international market but linked to the exposed sector by the perfect mobility of labourers. This structural, cost push approach assumes great importance in explaining inflation differentials if monetary causes are left out by definition.

The other main branch of theoretical literature on which our work is founded is related to international fragmentation of production processes. Jones and Sanyal (1982) published the first main contribution in this field, where ntermediate products are finally let enter a general equilibrium model. During the nineties various contributions analysed the international fragmentation of production within the traditional international trade models: the international division of labour enhances the comparative advantage principle and amplifies the benefits of productive specialization. (Arndt, 1996, 1997, 1998; Deardorff, 1998, 2001; Jones, Kierzkowski, 2001). Due to historical reasons, most contributions focused on the implications of international fragmentation on factors' rewards and employment; nevertheless, this literature allowed us to point out the link between prices of intermediate products and prices of final goods[3].

The animated debate about causes and implications of the observed inflation differentials among Euro Area countries, instead, is mostly empirical. Alberola (2000) published the first empirical work on this issue, identifying two possible causes of the differentials: on one hand, the Single Market drives price level convergence, implying temporary differences in inflation rates; on the other hand, these differentials may be consequences of country-specific shocks. In the following years a number of empirical studies followed the one published by Alberola, trying to explain the possible causes of the phenomenon. The first possible cause is linked to the role of domestic demand, i.e. the presence of asymmetric consumption patterns (or different elasticities of substitution) in different countries. Government policies can also affect HICP inflation through

[3] From a strictly theoretical point of view, we borrowed the basic framework of the well-known specific factor model (Jones, 1971), in turn derived from the general equilibrium framework set by Jones (1965).

changes in administered prices and indirect taxes and thus such national measures may add to inflation dispersion within the euro area. Neither domestic demand nor institutional reasons, however, seem to have had a major impact on inflation differentials (ECB, 2003). Cyclical reasons, instead, certainly contributed to explain, at least partly, the presence of inflation differentials among member countries, especially in the case of Ireland[4] (Rogers et al, 2001; Blanchard, 2003).

The most traditional explanation for the phenomenon is the so-called Balassa-Samuelson effect, which relates high inflation rates to large productivity differentials between tradable and non tradable sector. A paper by De Grauwe and Skudenly (2000) shows that this explanation is quite convincing, even if it is worth considering the difficulty to be found when attempting to isolate the Balassa-Samuelson effect from other factors[5] (ECB, 2003).

The last group of possible causes considered in the literature has an international dimension, and refers to external factors like oil price or exchange rate: if Euro Area countries show different degrees of dependence from oil imports, different degrees of extra-EMU trade or different pass-through coefficient, for instance, the impact of similar shocks (the same variation in the price of oil or the same exchange rate movement) may have differential effect on national inflation rates. Such "external" factors seem to have contributed to the increase of inflation differentials, especially for countries like Netherlands, Greece and Portugal, whose inflation rate, during the first years after the introduction of the Euro, seemed to have been affected by the depreciation of the currency (ECB, 2003).

The "external" factors explanation appears to us to be the most suited to explain the phenomenon, and we would certainly subscribe to a statement to the effect that the "exchange rate is a major factor in explaining inflation divergence", as exchange rate movements are the most important source of the variation of import prices (Honohan and Lane 2003). The authors conclude that countries whose nominal effective exchange rate depreciates more than the European average will have higher inflation rate. This result was confirmed a few years later: if the Euro's depreciation contributed the rise of inflation in the most exposed (to extra-EMU trade) countries, the appreciation that followed contributed to reduce inflation differentials, driving a sharp fall in inflation rate in the more externally oriented member countries (Honohan and Lane 2005).

The above mentioned literature, even though emphasizing the importance of the exchange rate in explaining inflation differentials among Euro Area countries, neglects the role that *intermediate imports* may play, since it regards the different degrees of exposure to external trade in *finished goods* as the unique channel through which the exchange rate may influence prices in an open economy. In an internationally integrated production process, instead, any exchange rate change

[4] But also Portugal, Greece and, to a lesser extent, Spain and Netherlands.
[5] Monetary factors, for instance.

causes also a variation in the prices of intermediate products, thus affecting national production *costs* directly.

2. A Specific-Factor Model with International Fragmentation of Production

2.1 Basic Structure of the Model

Consider a small, perfectly competitive economy producing two commodities, manufacturing (M) and services (S). The manufactured good is traded in the world market at a given price (p_M^W). Services are, instead, non tradable. The economy employs three factors of production: each sector makes use of a specific factor -capital, K, in the service sector, and intermediate product I in manufacturing, along with labour (L), which is free to move across industries to equalise the value of its marginal product. Neither labour nor capital are internationally mobile.

Endowment of capital and labour are given and treated as parameters. Specific factor I, instead, is imported from the rest of the world at a given price, p_I^W , assumed constant in world currency. Technology, with variable coefficients, is described by the columns of the A matrix[6]:

$$A = \begin{bmatrix} a_{LM} & a_{LS} \\ a_{IM} & a_{KS} \end{bmatrix}$$

where a_{ij} indicates the number of units of input *i* required to produce one unit of commodity *j*. Each input coefficient a_{ij} is a function of the relative cost of factors (ex. $a_{IM} = f\left(\frac{w}{p_I}\right)$), and it is chosen among all the possible combinations of factors (represented by the unit isoquants) in order to minimise unit production costs.

The following relationships show the full employment conditions for the three factors of production:

$$a_{LM} M + a_{LS} S = \bar{L} \qquad [1]$$

$$a_{KS} S = \bar{K} \qquad [2]$$

[6] The formulation of the model is borrowed from Jones (1965).

$$a_{IM} M = I \qquad [3]$$

Equation [1] and [2] represent the full employment of the two factors the economy is endowed with; equation [3], instead, is the economy's demand for the intermediate product I, imported from the rest of the world and employed to produce an amount M of manufactured product, given its price p_I in domestic currency. Being p_I^W the intermediate product's price in world currency, in fact, we have that $p_I = p_I^W e$[7].

The manufactured product's price, p_M, is determined in the world market; the price of services, p_S, instead, is endogenous. Equations [4] and [5] represent the maximum profit conditions in a competitive equilibrium:

$$a_{IM} p_I + a_{LM} w = p_M \qquad [4]$$

$$a_{KS} r + a_{LS} w = p_S \qquad [5]$$

where w represents the nominal wage, r is the return of capital, p_I, p_M and p_S represent the prices of intermediate input, manufactured product and services, all expressed in domestic currency.

Trade balance is defined by equation [6]: the value of the country's exports (a share of M production, M_{EXP}) equals the value of imports of intermediate input I:

$$M_{EXP} p_M = I \, p_I \qquad [6]$$

Combining eq. [6] and [3] we obtain the percentage of total production of M the country exports:

$$\frac{M_{EXP}}{M} = \frac{p_I \, a_{IM}}{p_M} \qquad [7]$$

As expected, the share of manufactured product the country sells in the world market depends on the terms of trade, p_M / p_I, and on the intensity with which intermediate input is employed per unit of output, a_{IM}. Note that $\frac{p_I \, a_{IM}}{p_M} = \vartheta_{IM}$, i. e. the distributive share of factor I on the price of the manufactured product; consequently, trade balance implies the equality between the percentage of

[7]As usual, we indicate with the etter e the domestic currency price of foreign exchange.

M exported and the distributive share of the intermediate input on the price of the manufactured product:

$$M_{EXP} = \vartheta_{IM}\, M \qquad [7']$$

We finally define the elasticity of substitution between the two commodities, manufactured product and services:

$$\sigma_D = \frac{\hat{M}_C - \hat{S}}{\hat{p}_S - \hat{p}_M} \qquad [8]$$

where $\hat{M}_C$ indicates the percentage of M consumed within the economy.

2.2 Effects of a Change in the Terms of Trade

Consider an exogenous fall in the price of the imported intermediate input due to an appreciation of the domestic currency: if the price of the manufactured good is assumed, as for now, constant in domestic currency, the shock improves the country's terms of trade.

The maximum profit condition for the exposed sector becomes:

$$a_{IM}\, p_I^W e + a_{LM}\, w = p_M \qquad [4']$$

Any movement of the exchange rate (consider, in this instance, an appreciation of the domestic currency) generates a change in the factor price ratio $\left(\frac{w}{p_I^W e}\right)$ in the manufacturing sector. Consequently, the coefficients a_{LM} and a_{IM} will change, together with the allocation of labour in the two sectors. The variation of the input coefficients depends on the elasticity of substitution between the factors of production in the two sectors: firms, indeed, will substitute labour with intermediate input, whose price decreased. Being the wage equal, the reduction of the price of the imported factor will generate extra profit in the manufacturing sector, if the price of M is held constant. This is shown in relation [6], which represents the equation of change of the maximum profit condition for the manufacturing sector:

$$\vartheta_{IM}\hat{e}+\vartheta_{LM}\hat{w}=0 \quad [9]$$

Let the symbol "^" indicate the relative change of the variable below and ϑ_{ij} the distributive share of factor *i* on the price of commodity *j* [8]:

$$\vartheta_{IM}=\frac{a_{IM}\,p_I^W e}{a_{IM}\,p_I^W e+a_{LM}w};$$

$$\vartheta_{LM}=\frac{a_{LM}w}{a_{IM}\,p_I^W e+a_{LM}w}.$$

The reduction of p_I (in domestic currency) allows the country to import a greater amount of intermediate input and the manufacturing sector to expand its output, which is consistent with the increase in the "endowment" of the specific factor of that industry. The expansion of the output attracts labourers from the service sector, and the percentage increase in salary which restores the equilibrium is given by eq. [9]:

$$\hat{w}=-\hat{e}\frac{\vartheta_{IM}}{\vartheta_{LM}} \quad [9']$$

The bigger the distributive share of the intermediate input on the price of M, the stronger is the growth in nominal wage following an appreciation of the domestic currency. If ϑ_{IM} is greater than ϑ_{LM} wages increase, in percentage terms, more than the exchange rate itself.

The perfect mobility of the labour force permits the transmission of the exchange rate shock from the manufacturing sector to the services and drives the equalisation of nominal wage in the two industries. The adjustment of the marginal productivities takes place through the reallocation of workers and the consequent variation of the amounts of M and S produced. If the total labour force is given, equation [10] must hold:

$$\lambda_M\hat{L}_M+\lambda_S\hat{L}_S=0 \quad [10]$$

[8] The distributive shares are considered constant in both sectors.

The previous expression is obtained differentiating equation [1]; $\hat{L}_M$ and $\hat{L}_S$ represent the relative change in the workers allocated in the manufacturing and service sectors, respectively, while the coefficient λ_j is the fraction of labourers allocated in the *j* sector (for example, $\lambda_M = \dfrac{a_{LM}M}{a_{LM}M + a_{LS}S} = \dfrac{L_M}{L}$).

We can express eq. [1] in function of the percentage variation of the amount produced of M and S and of the $\hat{a}_{ij}$, namely the variations of the input coefficients:

$$\lambda_M(\hat{a}_{LM} + \hat{M}) + \lambda_S(\hat{a}_{LS} + \hat{S}) = \hat{L} \qquad [10']$$

The coefficients $\hat{a}_{ij}$ vary in function of the changes in the factors' price ratio; given the elasticities of substitution in both sectors, σ_M and σ_S, we can write[9]:

$$\hat{a}_{LM} = \vartheta_{IM}\sigma_M(\hat{e} - \hat{w});$$
$$\hat{a}_{IM} = -\vartheta_{LM}\sigma_M(\hat{e} - \hat{w});$$
$$\hat{a}_{LS} = \vartheta_{KS}\sigma_S(\hat{r} - \hat{w});$$
$$\hat{a}_{KS} = -\vartheta_{LS}\sigma_S(\hat{r} - \hat{w}).$$

From equation [8], known that $\hat{M} = \hat{M}_{EXP} = \hat{M}_C$ [10], we obtain the percentage variation in the amount of M produced, if $\hat{p}_M = 0$:

$$\hat{M} = \hat{S} + \sigma_D \hat{p}_S \qquad [8']$$

Differentiating eq. [3.2] we obtain the percentage variation in the amount of services produced:

$$\hat{S} = -\hat{a}_{KS} \qquad [11]$$

[9] The equation is derived from the definition of elasticity of substitution between factors of production and from the maximum profit condition.

[10] Since $M = M_C + M_{EXP}$, we have $\hat{M} = \vartheta_{IM}\hat{M}_{EXP} + \vartheta_{LM}\hat{M}_C$. Solving for M_C and substituting into [8], we obtain [8'].

Substituting in equation [10'] the expressions found for $\hat{M}$ and $\hat{S}$, together with the percentage variation in salary, we obtain the percentage variation in the return of capital depending on the exchange rate variation:

$$\hat{r} = -\hat{e}\frac{\vartheta_{IM}}{\vartheta_{LM}}\left[1 - \frac{\lambda_M(\sigma_D - \sigma_M)}{\lambda_M \vartheta_{KS}(\sigma_D - \sigma_S) + \sigma_S}\right] \qquad [12]$$

The effect of an appreciation of the domestic currency on the return of capital, then, depends on the value of the ratio $\frac{\lambda_M(\sigma_D - \sigma_M)}{\lambda_M \vartheta_{KS}(\sigma_D - \sigma_S) + \sigma_S}$, i.e. on substitution possibilities between the factors of production and on the elasticities of substitution on demand's side. Call A the ratio $\frac{\lambda_M(\sigma_D - \sigma_M)}{\lambda_M \vartheta_{KS}(\sigma_D - \sigma_S) + \sigma_S}$: the effect of an appreciation on the return of capital will depend on this term. Four main scenarios might occur:

1. If the elasticity of substitution in the manufacturing sector is bigger than σ_D, A is negative. This can happen, for instance, if $\sigma_D = 0$: in this case consumption (and production) of the two commodities varies in the same proportion; if domestic currency appreciates the production of both M and S increases, and the return of capital will grow more than the wage itself.

2. The case $A = 0$ occurs if we assume that both consumer preferences and production functions in the two sectors are Cobb-Douglas. If that, the production of services will not change, while the percentage increase in manufacturing production will equal the rise in salary, and the return of capital in the service sector will increase by the same amount, too.

3. If the value of A falls between 0 and 1 the percentage variation in the return of capital will be smaller than the variation in salary. This occurs, for instance, if substitution possibilities in the manufacturing sector are small (or even zero): the increase in M production attracts labourers in the manufacturing sector, while the reduction in the amount of services produced dampens the increase in the return of capital.

4. Finally, the percentage variation of *r* is negative $(A > 1)$ if consumer demand is very elastic to the relative price of the two commodities: the reduction of output in the service sector is such as to reduce the marginal product of the specific factor in that sector.

The effect of an exchange rate shock on the final price of services is described by eq. [13], equation of change of the maximum profit condition in the service sector:

$$\vartheta_{KS}\hat{r} + \vartheta_{LM}\hat{w} = \hat{p}_S \qquad [13]$$

Substituting the expressions found for $\hat{r}$ and $\hat{w}$ in the previous expression, we can write the percentage variation in the price of services depending on the variation of the nominal wage:

$$\hat{p}_S = \hat{w}\left(1-\vartheta_{KS}A\right) \qquad [13']$$

or depending on the exchange rate variation:

$$\hat{p}_S = -\hat{e}\frac{\vartheta_{IM}}{\vartheta_{LM}}\left(1-\vartheta_{KS}A\right) \qquad [13'']$$

Once again, the effect of an appreciation of the national currency on the final price of services will depend, both in direction and in size, on the value of the A coefficient. As $\hat{p}_S$ is a weighted average of the variations of wage and return of capital, the price of services decreases only if the reduction of r more than compensates the increase in w[11].

The following table summarises the results obtained:

Table 1. Effects of an appreciation of the national currency on relative return of factors, production and price of services as a function of A

	$\frac{\hat{r}}{\hat{w}}$	$\hat{M}$	$\hat{S}$	$\hat{p}_S$
$A<0$	$\frac{\hat{r}}{\hat{w}}>1$	$\hat{M}>0$	$\hat{S}>0$	$\hat{p}_S>0$
$A=0$	$\frac{\hat{r}}{\hat{w}}=1$	$\hat{M}>0$	$\hat{S}=0$	$\hat{p}_S>0$
$\lvert 0<A<1$	$\frac{\hat{r}}{\hat{w}}<1$	$\hat{M}>0$	$\hat{S}<0$	$\hat{p}_S>0$
$A>1$	$\frac{\hat{r}}{\hat{w}}<0$	$\hat{M}>0$	$\hat{S}<0$	$\hat{p}_S>0,\ A<\frac{1}{\vartheta_{KS}}$ $\hat{p}_S<0,\ A>\frac{1}{\vartheta_{KS}}$

[11] Actually, a high elasticity of substitution in demand would be quite unconvincing, the two commodities being manufactured products and services.

An appreciation of the national currency determines an increase in the production of M for any value of the A coefficient, i.e. independently from both demand and technology. This is consistent with the fact that, if the country imports more intermediate input, the total “endowment” of the country for that factor increases, and so does the production of the sector which employs that factor as specific. The percentage increase in the amount of M produced is greater the bigger is A, that is the stronger are the substitution possibilities between factors in the manufacturing sector and the more elastic is consumer demand. On the contrary, the percentage variation in the production of services decreases as A increases, and the same occurs to the price of services.

2.3 Effects of an Appreciation of the Domestic Currency

Consider now an appreciation of the national currency that has an impact on both the import and the export side. That is, the appreciation makes the imported intermediate input cheaper but, at the same time, causes a loss in international competitiveness, as a part of the manufacturing production M_{EXP}, is traded in the world market. The economy is still price taker in the international market for manufactured products, but the price of M, p_M^W is given (and constant) in world currency.

The full employment conditions for the factors of production do not change; the maximum profit condition for the manufacturing sector, instead, becomes:

$$a_{IM}\, p_I^W e + a_{LM}\, w = p_M^W e \qquad [4'']$$

while in the service sector is the same as before:

$$a_{KS} r + a_{LS} w = p_S \qquad [5]$$

Trade balance implies that the imports of intermediate factor equals, in value, the amount of manufactured product sold in the world market:

$$M_{EXP}\, p_M^W e = I\, p_I^W e \qquad [6]$$

that is:

$$\frac{I}{M_{EXP}} = \frac{p_M^W}{p_I^W} \qquad [6']$$

where the share of manufacturing sector's production the country exports equals, as before, the distributive share of the intermediate factor in the price (or cost) of M:

$$M_{EXP} = \vartheta_{IM} M \qquad [7']$$

The internal demand elasticity is now defined as follows:

$$\sigma_D = \frac{\hat{M}_C - \hat{S}}{\hat{p}_S - \hat{e}} \qquad [8]$$

remembering that $\hat{p}_M = \hat{p}_M^W + \hat{e}$, and the world price of M is assumed constant.
The effect of an appreciation of the national currency in the M sector is obtained differentiating eq. [4'']:

$$\vartheta_{IM}\hat{e} + \vartheta_{LM}\hat{w} = \hat{e} \qquad [17]$$

from which we derive the percentage variation in nominal wage that maintains the equilibrium in the manufacturing sector:

$$\hat{e} = \hat{w} \qquad [9'']$$

In this case an appreciation of the national currency *reduces* nominal salary in the same percentage: if the manufactured product becomes more expensive for foreign consumers, the entrepreneur is forced to cut the costs of production to remain active in the world market.

The variation in salary is transmitted from the manufacturing to the service sector and generates once again a reallocation of labourers between the two industries. The full employment condition (in differential terms) permits to determine the variation in the return of capital following the shock in the exchange rate:

$$\lambda_M \left(\hat{a}_{LM} + \hat{M}\right) + \lambda_S \left(\hat{a}_{LS} + \hat{S}\right) = 0 \qquad [10']$$

The percentage variation in the amount of services produced is directly derived from eq. [2] (the total endowment of capital is fixed):

$$\hat{S} = -\hat{a}_{KS} = \vartheta_{LS}\sigma_S(\hat{r} - \hat{w}) \qquad [11]$$

While production in the manufacturing sector varies according to eq. [8], remembering that $\hat{M} = \hat{M}_C = \hat{M}_{EXP}$. Substituting into [10'] the previous expressions we obtain the percentage variation in the return of capital, which equals the variation in salary and exchange rate:

$$\hat{r} = \hat{e} = \hat{w} \qquad [17]$$

An appreciation of the domestic currency generates a reduction of nominal wage and of the return of capital identical, in percentage terms, to the exchange rate variation. Consequently, relative prices of factors in the two sectors do not change: both technological coefficient and the amount produced of M and S are not altered by the shock. The reduction of the nominal return of factors generates the fall in the price of services:

$$\hat{p}_S = \hat{e} \qquad [18]$$

Thus, the appreciation of the domestic currency has a deflationary effect.

2.4 An Intuitive Explanation of Our Analytical Results: the Role of Integration and Exposure

Before moving on to empirically test the predictions of the model, we want to we want to briefly discuss the properties of this theoretical framework. In our version of the specific-factor model, imported intermediate inputs are not an input as energy might be: rather, they are manufactured goods and can substitute for labour in the production of the home manufactured good. This property allows for a specific role of the relationship between degree of international fragmentation of production and degree to which domestic prices react to exchange rate shocks. In the baseline scenario in which the home country produces two goods, only one of which requires the imported intermediate input in production and is at same time the only exported one, a shock to the domestic currency price of the intermediate input yields a direct impact on the structure of costs of the industry producing the manufactured goods. Yet, inter-industry labour mobility ensures that the shock will indirectly affect the other industry as well, even though the imported good is not an input in its production process. It follows that the final, net effect on the good's price depends on the degree to which the changing imported input price generates a terms of trade change. Indeed, a change in imported input prices leading to a terms of trade improvement requires that nominal labour reward increases, which induces in turn an increase in the non-tradeable good's price: the aggregate inflationary effect will be the higher, the larger the share of the imported input on the manufactured, tradeable good's price.

Consider now the case of a Euro area country exporting the manufactured good to another Euro area country. In this instance, an appreciation of the home currency will reduce the home currency price of the imported input without affecting the terms of trade, that is, without any effects on the price of the exported good: Manufacturing firms will be compelled to cut domestic production costs, which will induce a fall in both wages and the price of the non-traded good. The final aggregate effect on the home economy will be deflationary , and the more so the more integrates the manufacturing industry is integrated in the world's production network. To put it more straightforwardly: the effect of the home currency appreciation will be inflationary if firms are price takers in the home currency, whereas it will be deflationary if the price takers in foreign currency prices. The degree of *integration* of domestic manufactures in the global value chain does not generate, *per se*, inflation or deflation: a variation of the *price* of the imported intermediate input (or an exchange rate movement) triggers a transmission mechanism that, through the labour market, produces a change in the price of final goods. The *direction* of the variation, that is, whether there will be an inflationary or deflationary bout, depends upon the degree to which national producers are able to set the price of the manufactured good independently of any exchange rate variation. Intuitively, an entrepreneur who exports a large share of output to the world market will suffer exchange rate variations more than an entrepreneur who only sells in the home market. This is what we mean by *exposure,* and propose to measure with the country's export performance.

The *extent* of the variation, instead, depends on the degree of *integration* of the economy in the world production process.

Now, it is apparent that as far as EMU countries are concerned exports toward another country of the area is tantamout to selling to a different area of the same country, since the single currency does not leave room for the effects of exchange rates on price competitiveness. This is the reason why we treat *external exposure*, that is, extra-UEM export performance, and *internal exposure*, or infra-UEM exposure, separately both in the model and in our empirical work. If a country's exports are shipped within the Euro area, then an appreciation of the Euro will induce a terms of trade improvement insofar as imported (from the Euro area) intermediate inputs will be available at a lower domestic currency price but will have no detectable effect on the price of exports. It follows that the effect of the shock on wages and inflation will be, if negative, PERCHE' 'IF NEGATIVE?'

rather weak. On the other hand, exports shipped to a country not belonging to the area will be less price-competitive after the appreciation of the domestic currency: the home country gains from the appreciation on the import (cost) side, but loses on the export (revenue) side. Under such conditions we expect that appreciation will lead to lower wages and, accordingly, deflation.

3. Testing the Model's Predictions

This paragraph aims at empirically testing the relationship between an economy's degree of integration in the global value chain and its inflation rate.

In our theoretical model a change in imported intermediate price (or an exchange rate movement) triggers a transmission mechanism which changes the overall price level, the direction and the extent of this variation depending on the degree of exposure to external trade and on the degree of dependence on imported intermediate inputs. The latter variable is measured using the ratio of intermediate imports coming form extra-EMU countries on total production; as for the former, we consider the ratio of exports on total production, distinguishing between intra-EMU and extra-EMU exposure.

We tested empirically the results of the model using a sample of eleven countries belonging to the European Economic and Monetary Union (Austria, Belgium, Spain, Germany, France, Italy, Greece, Ireland, Finland, Netherlands and Portugal). Using data covering the period 1995-2005, we investigated the role of international division of labour in explaining, al least partly, inflation differentials among EMU countries.

We use panel data models (*pooled OLS* and *Fixed Effects* models) to assess the impact of integration[12] and exposure on the domestic inflation rate. The analysis was also carried out individually for the following industries: Textiles, Chemicals, Metal Products and Machinery, Electrical and Optical Equipment, Transport Equipment, Services.

Formally, we submit to empirical testing two separate statements:

1. An appreciation of the national currency generates a *variation* in the general price level; the greater is the distributive share of the intermediate input on the total price of the traded finished product (i.e., the more the economy is *integrated* in the world production process), the bigger is the variation of the country's aggregate inflation rate.

[12] The variable "integration" used for estimation includes the exchange rate's contribution:
$$integration = imported\ intermediate\ input\ ratio \times exchange\ rate\ variation.$$

2. The direction of the variation in the inflation rate depends on the degree of external *exposure* of the economy: we expect that an appreciation of the domestic currency is *deflationary* for countries (and sectors) whose *exposure* to extra-EMU trade is higher.

The econometrical model we used to verify the above hypotheses is the following:

$$p_{ijt} = \beta_0 + \beta_1 (prod_{ijt}) + \beta_2 (int\_extra_{ijt}) + \beta_3 (esp\_extra_{ijt}) + \beta_4 (esp\_intra_{ijt}) + \varepsilon_{ijt}$$

where *i* refers to countries, *j* to sectors and *t* to time period (year).

Variables are defined and measured as follows:

p_{ijt}: growth rate of purchaser's prices in sector *j* for country *i* (source: Eu Klems).

$prod_{ijt}$: labour productivity growth rate for sector *j* in country *i*; i. e. value added for hour worked[13] (index, source Eu Klems).

$int\_extra_{ijt} = cambio_t \times \vartheta_{ijt}$: this term measures the joint effect of a movement of the exchange rate and of a variation in the degree of integration of the economy in the world production process. We need to measure the *combined* effect because an high (or low) value of the variable integration has no effect, *per se*, on the inflation rate: in our model the change in the price of the imported intermediate input (which is captured, in our case, by the exchange rate movement) causes a variation of the overall price level; the integration variable, instead, determines the magnitude of the effect. $cambio_t$ is the percentage variation in the nominal effective exchange rate of the Euro[14], (the sample contains countries belonging to the Euro Area); the index is calculated considering the 44 most important trade partners (source: Eurostat).

esp_extra_{ijt}: measure of the degree of exposure to extra-EMU trade: $\frac{(X\_extra-UEM)_{ijt}}{(produzione)_{ijt}}$

where the total exports of sector *j* are divided by the total output (in value) if the same sector. (source: Eurostat, OECDstat[15]).

esp_intra_{ijt}: measure of the degree of exposure to intra-EMU trade:

$\frac{(X\_intra-UEM)_{ijt}}{(produzione)_{ijt}}$ (source: Eurostat, OECDstat).

ε_{ijt}: error term.

[13] The indicator is borrowed from IMF (2006).
[14] Data before 1st of January 1 are proxies calculated by ECB. Source: Eurostat.
[15] Data base OECDstat was used only for services.

The equation is estimated on a panel of data of 66 cross section units (sector *j* in country *i*) observed for 11 periods (1995-2005). The countries we considered are Austria, Belgium, France, Finland, Germany, Greece, Ireland, Italy, Portugal, Netherlands, Spain; the sectors considered are Textiles, Chemicals, Machinery, Electrical and Optical Equipment, Transport Equipment, Services.

We estimated three different panel data models:

1. *pooled OLS* : baseline model.
2. *LSDV1*: fixed-effects model (*Least Square Dummy Variable*), with sector and country dummies.
3. *LSDV2*: fixed-effects model with joint dummies (sector-country).

We estimated the equation using the full sample first, than on eleven country sub-samples (with sector dummies) and finally on six sector sub-samples (with country dummies).

The results of the estimates are shown in table 2, 3 and 4.

Table 2. Estimates from the full sample

	OLS	**LSDV1**	**LSDV2**
prod_growth	-0.1282 *** (0.0051)	-0.1163 *** (0.0414)	-0,1028 *** (0,0372)
ext_integration	-3.7741 *** (0.7745)	-3.9337 *** (0.8210)	-3,8386 *** 0,8142
ext_exposition	-0.0022 (0.0081)	-0.0018 (0.0043)	-0,0503 (0,0345)
int_exposition	-0.0023 (0.0029)	0.0052 *** (0.0019)	0,0104 (0,0114)
Sector dummies	NO	YES	JOINT
Country dummies	NO	YES	
N obs.			
Adj. R-squared	0.1217	0.2249	0,2191
F	20.4374 ***	9.5651 ***	3,68541 ***

Table 3. Estimates from six sector sub-samples

	VARIABLE	COEFFICIENT	P-VALUE	
TEXTILES	prod_growth	-0,5594	0,0505	*
	ext_integration	-2,2439	0,0029	***
	ext_exposure	-0,0884	0,6634	
	int_exposure	-0,0690	0,6738	
CHEMICALS	prod_growth	-0,1047	0,2032	
	ext_integration	-11,8987	<0,00001	***
	ext_exposure	-0,1122	0,0001	***
	int_exposure	0,1409	0,3163	
MACHINERY	prod_growth	-0,1589	0,1100	
	ext_integration	-3,3764	<0,00001	***
	ext_exposure	0,3116	0,2002	
	int_exposure	-0,0052	0,1018	
ELECT. OPTICAL EQUIPMENT	prod_growth	-0,0657	<0,00001	***
	ext_integration	-1,6850	0,0064	***
	ext_exposure	0,0465	0,5168	
	int_exposure	0,0340	0,0557	*
TRANSP. EQUIPMENT	prod_growth	-0,0601	0,0000	***
	ext_integration	-0,6503	0,1962	
	ext_exposure	-0,1639	0,2222	
	int_exposure	0,0999	0,2571	
SERVICES[16]	prod_growth	0,0336	0,1357	
	ext_integration	0,0674	0,8382	
	ext_exposure	1,9988	<0,00001	***

[16] Data on internal exposure are not available for the service sector.

Table 4. Estimates from eleven country sub-samples

	VARIABLE	COEFFICIENT	P-VALUE	
AUSTRIA	prod_growth	-0,0286	0,4760	
	ext_integration	-1,7992	0,1087	
	ext_exposure	0,1320	0,0742	*
	prod_growth	0,0349	0,0179	**
BELGIUM	prod_growth	-0,1998	0,0366	**
	ext_integration	-3,2719	0,0720	*
	ext_exposure	0,0533	0,6703	
	prod_growth	0,0287	0,1573	
SPAIN	prod_growth	-0,0563	0,2999	
	ext_integration	-3,9447	0,0162	**
	ext_exposure	0,4250	0,0879	*
	prod_growth	0,2160	<0,00001	***
FINLAND	prod_growth	-0,1555	0,0982	*
	ext_integration	-7,4658	0,0041	***
	ext_exposure	-0,0802	0,1839	
	prod_growth	-0,1189	0,5282	
FRANCE	prod_growth	-0,0504	0,0582	*
	ext_integration	-5,9771	0,0335	**
	ext_exposure	-0,0786	0,4723	
	prod_growth	0,0288	0,6907	
GERMANY	prod_growth	0,0849	0,0995	*
	ext_integration	-2,4284	0,0150	**
	ext_exposure	-0,0303	0,9011	
	prod_growth	0,2079	0,6067	
GREECE	prod_growth	-0,3549	0,0185	**
	ext_integration	-5,1348	0,1476	
	ext_exposure	-0,1717	0,6849	
	prod_growth	-0,1371	0,5681	
IRELAND	prod_growth	-0,0683	0,2514	
	ext_integration	-3,8422	0,0014	***
	ext_exposure	-0,0126	0,9565	
	prod_growth	-0,0003	0,9441	
ITALY	prod_growth	-0,5623	0,0204	**
	ext_integration	-9,7747	0,0058	***
	ext_exposure	-0,1192	0,7901	
	prod_growth	0,0573	0,6177	
NETHERLANDS	prod_growth	-0,0372	0,3909	
	ext_integration	-2,9546	0,1833	

	ext_exposure	-0,0795	0,3432	
	prod_growth	0,0589	0,1613	
PORTUGAL	prod_growth	-0,0418	<0,00001	***
	ext_integration	-10,5044	0,0325	**
	ext_exposure	-0,0888	<0,00001	***
	prod_growth	0,1366	0,0705	*

The integration coefficient is statistically significant in the first model: the affect of an appreciation of the national currency is deflationary. In the LSDV1 model the internal exposure is significant, too, and shows the expected positive sign. The last model controls for the joint time-invariant effects of sectors and countries: the coefficient of integration is again negative and significant, while the exposure coefficient is statistically zero. Table (??) shows the results of the estimates for the sector sub-samples, calculated with country dummies. The table shows interesting results: the integration coefficient is significant for Textiles, Machinery and Chemicals. For this last industry, in particular, the estimated parameter value is -11.9. External exposure is never significant (except for the service sector); the exposure to intra-EMU trade, instead, seems to affect prices in the expected positive sign.

The results of the estimates on the country sub-samples (with sector dummies) are shown in table 4. The integration coefficient is significant (at least 10% of confidence) for eight over the eleven countries considered. In all cases, including the non-significant ones, the coefficient has negative sign and appears relevant: for Portugal and Italy, for instance, the estimated beta is approximately -10. The variables appear significant and show the expected sign only for Portugal. For Spain and Austria, instead, both intra and extra-EMU exposure seems to positively affect inflation.

Overall, the results obtained reveal some anomalies (???): the integration coefficient, as expected, is quite always negative and significant, thus confirming that an appreciation of the national currency has deflationary effect, the more the economy is integrated in the international value chain. If we exclude Portugal, however, the country-level analysis does not reveal a significant impact of all the variables on the inflation rate at the same time.

We thus performed a further analysis on four sub-samples, splitting the full sample according to the values of the variables of *external integration* and *extra-EMU exposure*. We estimated an equation in which the dependent variable is the inflation rate, including only the exchange rate variation among the regressors (productivity growth serves as control).

Table 5. Estimates from four *exposure-integration* sub-samples

	Low Exposure			High Exposure		
Low Integration	*var.*	*coeff.*	*p-value*	*var.*	*coeff.*	*p-value*
	Prod_growth	-0,058101	<0,00001***	Prod_growth	-0,10192	0,06488*
	Ex_rate_var	-0,069883	-0,06988***	Ex_rate_var	-0,13827	0,05744*
High Integration	*var.*	*coeff.*	*p-value*	*var.*	*coeff.*	*p-value*
	Prod_growth	-0,470912	0,00667***	Prod_growth	-0,11647	0,00101***
	Ex_rate_var	-0,287731	0,00355***	Ex_rate_var	-0,23664	0,00007***

In the four sub-samples an appreciation of the domestic currency is deflationary and the estimated coefficient associated to the exchange rate variation is always statistically significant. As predicted by our theoretical model, a high degree of integration in the world's production process magnifies the deflationary effect of the currency's appreciation: the estimated *beta* of the exchange rate is always bigger (in modulus) in the second row of the matrix. The weakest effect, as expected, is associated with low values of both *integration* and *external exposure*. Moreover, for high values of *integration* the effect of an appreciation on inflation rate is almost the same for high and low values of *external exposure*[17], thus stressing the relevance of *integration* as a determinant factor in explaining inflation rate in an open economy.

5. Concluding remarks

Literature on the effects of exchange rate fluctuations on national inflation rates is not particularly abundant. Furthermore, much of it deals with the issue within a framework where traded goods are 'final', i. e., goods entirely produced in one country. In this framework inflation can be observed either because of an increase in the domestic currency price of imported consumption goods or because of an increase of the domestic currency price of energy and raw materials. Finally, domestic inflation is rarely modelled as the effect of a change in the degree of competitiveness of domestic output due to exchange rate changes.

[17] The distance between the two coefficients is about one standard deviation.

In this paper we address the question of why domestic currency prices react as much as they do to a given exchange rate change. Clearly, an answer to this question ought to highlight the reason behind different reactions of ‘domestic’ prices in different ‘countries’, such as those we insist calling ‘members of the European Economic and Monetary Union.’ Large portions of contemporary literature on inflation differential within the EMU consists of econometric exercises conducted at a very high level of methodological sophistication, but makes no reference to the role of common external shocks such as it might be one coming from the external valuation of the Euro. The model we adopt in this paper is very straightforward. Building mostly on research on specific-factor models pioneered by Jones, we posit that the home country is producing and consuming two goods, a manufactured one and a service. The manufactured good is produced through domestic labor and an imported intermediate input, which the world supplies at a given foreign currency price for any amount demanded; labor and imported input are substitutes in production. The service good is produced through domestic labour and domestic capital; neither labour nor capital are traded internationally. Finally, the manufactured good is produced for exports as well as for domestic consumption, whereas all services produced are shipped to the home market.

There are two features of this model we have exploited in this paper. First, by letting the imported intermediate input enter as such in just one industry, we are able to derive the differential impact that a change of its domestic currency price has on the two industries, the one producing the traded good and the one producing the non traded one. This opens the way to empirical testing of the differential impact of exchange rate changes at the industry level within any given country. Secondly, we can study the very same issue under two different conditions: first, by assuming that the exchange rate change has no effect on a country’s competitiveness on the export market via the domestic currency price of the exported good, we study the within-EMU trade effects of the shock. But in a second scenario we allow for extra-EMU trade, so that the exchange rate shock hits the domestic economy by altering the foreign currency price of its manufactured exports.

It follows that an exchange rate shock will affect a given industry (in any country) the more the higher the degree of integration of that industry in the world <u>production</u> structure; and that it will affect a given industry differently in countries where it is differently integrated in the world production network. Just the same is to be expected about the effects of exchange rate changes on the export side of the economy: different degrees of <u>exposure</u> of an industry to competition on the export market will generate different reallocation of resources on the domestic economy.

The model yields the results we reported in Tables 1-5.

We then moved to econometrically test the analytical results. We obtain a number of results which not in the least contradict the a priori according to which integration and exposure, as we mean these expression in this paper, seem to play a relevant role in the determination of the inflation rate of an open country. In particular, the coefficient of the variable capturing integration is negative and statistically significant in most cases, both for the whole sample and for the sub-samples (countries and sectors). Intra-EMU and extra-EMU exposure appear significant in some cases, but the sign of the coefficient is not always consistent with our expectations. In order to understand the role of this two variables we use a model of the inflation rate including only the exchange rate and the productivity growth rate as independent variables. We estimate this model on four separate subsamples, classified according to the values ('high"'and 'low', the median being the threshold) assumed by the variables of integration and external exposure. In this way we are able to distinguish the contribution of exchange rate from the one of integration. In all subsamples the exchange rate coefficient is negative and significant: an appreciation is always deflationary. For low values of integration and exposure the effect is weaker, while for higher values of integration the effect of the appreciation is relevant, both for high and low values of external exposure.

Overall, empirical evidence is coherent with the results of the theoretical model, highlighting the importance of the intermediate imports channel to explain inflation differentials among EMU countries.

References

ALBEROLA, E., *Interpreting inflation differentials in the Euro Area*, Economic Bulletin, p. 61-70, April 2000.

ARNDT, Sven, *Globalization and the open economy,* North American Journal of Economics and Finance, Vol. 8, No. 1, pp. 71-79, 1997.

ARNDT, Sven, *Super-specialization and the gains from trade*, Contemporary Economic Policy 16 (4), October 1998.

AUKRUST, Odd, *Inflation in the Open Economy, a Norwegian Model*, in L. B. Krause, W. S. Salant, eds, "Worldwide Inflation – Theory and Recent Experience", the Brookings Institution, 1977.

BALL, Lawrence M., *Has Globalization Changed Inflation?*, NBER Working Paper No. W12687, 2006.

BLANCHARD, Olivier, *Country Adjustments within Euroland: Lessons after two years*,

BUSETTI et al., Inflation Convergence and Divergence within the European Monetary Union, WP No. 574, January 2006.

DEARDORFF, Alan V., *Fragmentation in simple trade models*, North American Journal of Economics and Finance, 2001.

DEARDORFF, Alan V., *Fragmentation across cones*, in S. Arndt and H. Kierzkowski (eds.), "Fragmentation, New Production Patterns in the World Economy", Oxford University Press, 2001.

DE GRAUWE, Paul, and Frauke SKUDELNY, , *Inflation Differentials in EMU*, Center for Economic Studies Discussions Paper Series (DPS) 00.15, 2000.

ECB, *Inflation Differentials in the Euro Area: Potential Causes and Policy Implications,* September 2003.

HONOHAN, Patrick and Philip R. LANE, *Divergent inflation rates in EMU*, Economic Policy 18 (37), 2003.

HONOHAN, Patrick and Philip R LANE, *Exchange Rates and Inflation under EMU: An Update*, IIIS Discussion Paper No. 31, 2005.

IMF, *How has Globalisation Affected Inflation?*, in IMF, "World Economic Outlook", 2006.

JONES, Ronald W., *Simple General Equilibrium Models*, The Journal of Political Economy 73, No. 6, December 1965.

JONES, Ronald W., *A Three-Factor Model in Theory, Trade and History*, in "Trade, Balance of Payments and Growth", edited by Jagdish Bhagwati, Ronald W. Jones, Robert Mundell, and Jaroslav Vanek. Amsterdam: North-Holland, 1971.

JONES, Ronald, and Henryk KIERZKOWSKI, *A framework for fragmentation*, in S. Arndt and H. Kierzkowski (eds.), “Fragmentation, New Production Patterns in the World Economy”, Oxford University Press, 2001.

JONES, Ronald W. and Kalyan K. SANYAL, *The Theory of Trade in Middle Products*, The American Economic Review, Vol. 72, No. 1 pp. 16-31, Mar., 1982.

KIERZKOWSKI, Henryk, *Theoretical Foundations of the Scandinavian Model of Inflation*, The Manchester School of Economic & Social Studies, vol. 44(3), pages 232-46, September 1976.

ROGOFF, Kenneth S., *Impact of globalization on monetary policy*, Proceedings, Federal Reserve Bank of Kansas City, pages 265-305., 2006.

Appendix A

A1. Estimated Values of *External Integration*

COUNTRY	SECTOR						
	Textiles	Chemicals	Machinery	Elect. Optical Equipment	Transport Equipment	Services	Country Average
Austria	0.0482 (0.007)	0.0491 (0.008)	0.0463 (0.007)	0.0452 (0.008)	0.0553 (0.010)	0.0310 (0.006)	0.0459 (0.010)
Belgium	0.0826 (0.008)	0.0839 (0.011)	0.0803 (0.008)	0.0725 (0.010)	0.0911 (0.009)	0.0578 (0.006)	0.0780 (0.014)
Spain	0.0329 (0.005)	0.0349 (0.006)	0.0310 (0.005)	0.0333 (0.006)	0.0369 (0.006)	0.0198 (0.003)	0.0315 (0.008)
Finland	0.0410 (0.005)	0.0489 (0.007)	0.0477 (0.007)	0.0444 (0.005)	0.0461 (0.007)	0.0288 (0.004)	0.0428 (0.009)
France	0.0319 (0.004)	0.0360 (0.005)	0.0310 (0.004)	0.0327 (0.004)	0.0382 (0.005)	0.0198 (0.003)	0.0316 (0.007)
Germany	0.0439 (0.007)	0.0439 (0.008)	0.0399 (0.007)	0.0399 (0.007)	0.0472 (0.009)	0.0260 (0.005)	0.0401 (0.010)
Greece	0.0558 (0.011)	0.0704 (0.013)	0.0660 (0.014)	0.0613 (0.011)	0.0364 (0.007)	0.0284 (0.006)	0.0530 (0.019)
Ireland	0.0451 (0.008)	0.0422 (0.008)	0.0469 (0.011)	0.0584 (0.009)	0.0502 (0.010)	0.0374 (0.006)	0.0467 (0.011)
Italy	0.0344 (0.006)	0.0369 (0.007)	0.0335 (0.005)	0.0326 (0.005)	0.0379 (0.006)	0.0222 (0.004)	0.0329 (0.007)
Netherlands	0.0890 (0.016)	0.0972 (0.020)	0.0853 (0.015)	0.0976 (0.018)	0.0971 (0.016)	0.0569 (0.011)	0.0872 (0.021)
Portugal	0.0348 (0.004)	0.0398 (0.006)	0.0336 (0.005)	0.0377 (0.006)	0.0400 (0.005)	0.0222 (0.003)	0.0347 (0.008)
Sector Average	0.0491 (0.020)	0.0530 (0.022)	0.0492 (0.021)	0.0505 (0.021)	0.0524 (0.022)	0.0319 (0.014)	0.0477 (0.022)

A2. Estimated Values of *Internal Integration*

COUNTRY	SECTOR						
	Textiles	Chemicals	Machinery	Elect. Optical Equipment	Transport Equipment	Services	Country Average
Austria	0.1025	0.1045	0.0985	0.0962	0.1176	0.0658	0.0975
	(0.008)	(0.008)	(0.008)	(0.009)	(0.011)	(0.007)	(0.018)
Belgium	0.1791	0.1817	0.1742	0.1570	0.1974	0.1252	0.1691
	(0.011)	(0.019)	(0.013)	(0.017)	(0.014)	(0.009)	(0.027)
Spain	0.0581	0.0614	0.0546	0.0586	0.0650	0.0350	0.0555
	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)	(0.002)	(0.011)
Finland	0.0545	0.0648	0.0632	0.0592	0.0610	0.0383	0.0568
	(0.003)	(0.003)	(0.002)	(0.005)	(0.003)	(0.002)	(0.010)
France	0.0572	0.0645	0.0556	0.0587	0.0686	0.0355	0.0567
	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.002)	(0.011)
Germany	0.0548	0.0548	0.0499	0.0498	0.0589	0.0325	0.0501
	(0.006)	(0.007)	(0.006)	(0.006)	(0.008)	(0.004)	(0.010)
Greece	0.0658	0.0830	0.0773	0.0729	0.0431	0.0334	0.0626
	(0.010)	(0.013)	(0.010)	(0.013)	(0.008)	(0.005)	(0.021)
Ireland	0.0687	0.0642	0.0710	0.0889	0.0763	0.0570	0.0710
	(0.011)	(0.011)	(0.014)	(0.012)	(0.014)	(0.008)	(0.015)
Italy	0.0393	0.0420	0.0382	0.0373	0.0432	0.0253	0.0376
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.006)
Netherlands	0.0987	0.1074	0.0946	0.1081	0.1079	0.0630	0.0966
	(0.005)	(0.006)	(0.004)	(0.006)	(0.005)	(0.003)	(0.017)
Portugal	0.0877	0.1001	0.0846	0.0948	0.1009	0.0561	0.0874
	(0.004)	(0.006)	(0.004)	(0.005)	(0.002)	(0.003)	(0.016)
Sect. Average	0.0788	0.0844	0.0783	0.0801	0.0855	0.0516	0.0764
	(0.038)	(0.038)	(0.036)	(0.033)	(0.043)	(0.027)	(0.038)

Source: Eurostat, Eu Klems. Standard deviation in brackets.

A3. Estimated values of *External Exposure*

COUNTRY	SECTOR						
	Textiles	Chemicals	Machinery	Elect. Optical Equipment	Transport Equipment	Services	Country Average
Austria	0.1492	0.2392	0.2811	0.3279	0.3000		0.2595
	(0.018)	(0.049)	(0.032)	(0.078)	(0.053)		(0.079)
Belgium	0.1838	0.2783	0.2118	0.3110	0.2219	0.0421	0.2278
	(0.018)	(0.090)	(0.024)	(0.053)	(0.042)	(0.001)	(0.083)
Spain	0.0447	0.0646	0.0905	0.1161	0.1128		0.0857
	(0.010)	(0.008)	(0.008)	(0.006)	(0.018)		(0.030)
Finland	0.1011	0.1159	0.2242	0.3084	0.5390	0.0566	0.2410
	(0.016)	(0.021)	(0.012)	(0.037)	(0.068)	(0.016)	(0.168)
France	0.0879	0.1260	0.1624	0.2159	0.2469	0.0372	0.1550
	(0.015)	(0.011)	(0.010)	(0.028)	(0.015)	(0.002)	(0.070)
Germany	0.1996	0.1623	0.2345	0.2248	0.2200	0.0336	0.1910
	(0.023)	(0.018)	(0.034)	(0.046)	(0.022)	(0.003)	(0.064)
Greece	0.0322	0.0696	0.1612	0.2414	0.1669	0.1237	0.1334
	(0.012)	(0.012)	(0.016)	(0.066)	(0.044)	(0.019)	(0.080)
Ireland	0.1057	0.4158	0.1898	0.3273	0.0918	0.1257	0.2162
	(0.042)	(0.117)	(0.030)	(0.047)	(0.037)	(0.017)	(0.138)
Italy	0.0575	0.1229	0.1631	0.1352	0.1656	0.0234	0.1185
	(0.008)	(0.017)	(0.013)	(0.015)	(0.012)	(0.002)	(0.051)
Netherlands	0.2426	0.2939	0.2277	0.5467	0.2553	0.0661	0.2889
	(0.038)	(0.065)	(0.032)	(0.221)	(0.055)	(0.012)	(0.168)
Portugal	0.0355	1.8797	0.0770	0.1499	0.0690	0.0265	0.4013
	(0.007)	(0.355)	(0.005)	(0.058)	(0.027)	(0.001)	(0.716)
Sect. Average	0.1127	0.3426	0.1839	0.2641	0.2172	0.0589	0.2115
	(0.072)	(0.512)	(0.063)	(0.140)	(0.129)	(0.039)	(0.253)

Source: Eurostat, Eu Klems. Standard deviation in brackets.

A4. Estimated Values of *Internal Exposure*

COUNTRY	SECTOR					
	Textiles	**Chemicals**	**Machinery**	**Elect. Optical Equipment**	**Transport Equipment**	**Services**
Austria	0.2427	0.2599	0.2059	1.0638	0.5511	0.4647
	(0.007)	(0.021)	(0.045)	(0.079)	(0.058)	(0.330)
Belgium	0.5651	0.6822	0.3569	2.3163	1.1186	1.0078
	(0.020)	(0.120)	(0.062)	(0.330)	(0.118)	(0.725)
Spain	0.0810	0.1140	0.0975	0.4675	0.4527	0.2425
	(0.007)	(0.017)	(0.010)	(0.056)	(0.022)	(0.182)
Finland	0.1232	0.1246	0.2198	0.2876	0.3526	0.2216
	(0.024)	(0.026)	(0.057)	(0.059)	(0.046)	(0.101)
France	0.1300	0.2003	0.1691	0.4396	0.3705	0.2361
	(0.008)	(0.011)	(0.024)	(0.052)	(0.032)	(0.143)
Germany	0.1821	0.1985	0.1433	0.4391	0.3024	0.2531
	(0.012)	(0.022)	(0.021)	(0.029)	(0.011)	(0.110)
Greece	0.0537	0.0594	0.0510	0.5915	0.0475	0.1606
	(0.004)	(0.026)	(0.007)	(0.086)	(0.015)	(0.221)
Ireland	0.3612	0.6606	3.5852	0.0665	0.3395	1.0026
	(0.057)	(0.131)	(1.012)	(0.026)	(0.120)	(1.389)
Italy	0.0671	0.1053	0.0632	0.5443	0.2865	0.2133
	(0.007)	(0.015)	(0.007)	(0.039)	(0.021)	(0.187)
Netherlands	0.5217	0.4806	1.0606	1.0698	1.0722	0.8410
	(0.086)	(0.021)	(0.208)	(0.198)	(0.176)	(0.318)
Portugal	0.0973	0.1293	0.3203	0.3866	0.6463	0.3160
	(0.011)	(0.019)	(0.040)	(0.095)	(0.081)	(0.208)
Sect. Average	0.2205	0.2741	0.5703	0.6975	0.5036	0.4487
	(0.178)	(0.224)	(1.039)	(0.601)	(0.326)	(0.595)

Source: Eurostat, Eu Klems. Standard deviation in brackets.

Appendix B

Description of Industries

INDUSTRY	NACE	SITC	DESCRIPTION
TEXTILES	D17t19	5	Textiles, leather goods
CHEMICALS	D23t25	65	Chemicals, rubber, plastic and fuel
MACHINERY	D27t29	67t69 71t74	Machinery and mechanical equipment
ELECTRONICAL AND OPTICAL EQUIPMENT	D30t33	75 77	Electical, electronical and optical machinery
TRANSPORT EQUIPMENT	D34t35	78t79	Automobiles; aircrafts and other vehicles
SERVICES	GtK	na	Wholesale and retail trade, hotels, transport services, telecommunications, financial services and real estate, other business services