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Inflation and Productivity Differentials in EMU.

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DISCUSSION PAPER

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Abstract

The aim of this paper is to find out whether the Balassa-Samuelson effect is important in EMU. We use panel data going from 1970 to 1995 for the current EU members in order to estimate the long run effect of bilateral differences in productivity growth differential between the traded and non-traded goods sector on bilateral inflation differentials. The regression results indicate a significant effect of the productivity differential, as proposed by the theory. According to our regression results, the impact of a productivity shock on the inflation differential can be quite substantial, going up to an 8% increase in the inflation differential.

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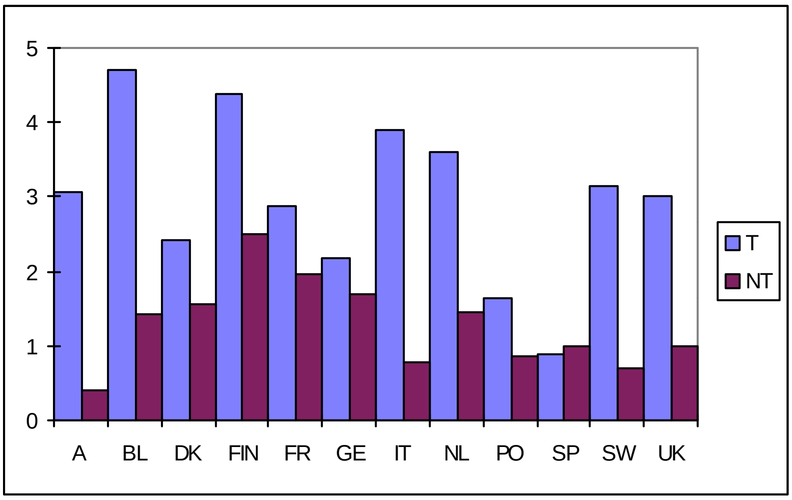
1. Introduction

With the creation of EMU the question arises of how much inflation might still prevail within the union. According to the Maastricht Treaty, price stability is one of the major aims of the ECB. However, as to the Balassa-Samuelson theorem, inflation differentials between countries can be explained through the existence of productivity differentials between the traded and the non-traded goods sectors.[1] This means that between the countries participating in EMU, there might still be subsisting inflation differentials.

Figure 1 Average Productivity Growth (in percent) (1971-95)[2]



Comparing the productivity growth in the traded and in the non-traded goods sectors (figure 1), we find strong evidence for higher productivity growth in the traded goods sector, as proposed by the theory.

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[1] In its initial form, the theorem states that differences in the traded sector's productivity across countries lead to an over- or under-valuation of the real exchange rate between the two countries. In the later literature, it is generally assumed that the productivity difference between the traded and the non-traded sector drive the inflation rate, and therefore the real exchange rate, see for example Canzoneri et al. (1999).

[2] The average is taken over the years for which data were available. Portugal and Spain, for example, have a lot of missing observations, so that the average does not cover the total of the period.

The aim of this paper is to find out whether the Balassa-Samuelson effect is important in EMU. Previous empirical studies have found ambiguous results concerning the effect of productivity differentials on inflation, depending on the sample period, and on the econometric methods used. We will use a sample from 1970 to 1995 for the current EU members. We specify our model in first differences and estimate the long run effect of the productivity growth differential between the traded and non-traded goods sector on inflation, pooling the data for all countries of our sample. In a second step, we estimate the model in a bilateral form, so that we measure the effect of differences in the traded and non-traded goods sectors' productivity growth differentials between two countries on their inflation differential.

The paper is structured as follows: Section 2 gives an overview of previous empirical studies on the link between inflation and productivity differentials, and section 3 will describe the theoretical derivation of the model. Section 4 presents our estimation results, section 5 quantifies how much of the inflation differential is due to productivity differentials, and section 6 contains concluding remarks.

2. Empirical findings in the literature

Most empirical studies on the link between inflation (the real exchange rate) and productivity are based on co-integration tests, in order to focus on the long-run relationship. This procedure is based on the assumption that both inflation and the productivity growth differential between the traded and the non-traded goods sectors are integrated of order one.

Alberola and Tyrväinen (1998) make co-integration tests on the standard and an extended Balassa-Samuelson model. In the latter, they include wage differentials between the traded and the non-traded sectors, assuming that wages between the two sectors do not equalise. They find evidence in favour of this assumption. Their co-integration tests for 11 EU members from 1975-95 confirm a long-run relationship between inflation and productivity differentials for Germany, Spain and Belgium in the standard model, and for all countries but the Netherlands in the extended model.

Canzoneri et al. (1999), for example, test two components of the Balassa-Samuelson model, using panel data on 13 OECD countries for the period 1960-93: the first component is the hypothesis that the relative price of non-traded goods should reflect relative productivity of labour in the traded and the non-trade sectors. They find evidence for a co-integrating relationship between relative prices of non-traded goods and relative productivities in the non-traded goods sector. The co-integration coefficient is generally close to one, as suggested by the theory. The second component they test is the hypothesis that PPP holds for traded goods. Their finding is that there are large long-lived deviations from PPP in traded goods.

Chinn and Johnston (1997) try to find out whether the real exchange rate can be determined through productivity shocks in the traded and the non-traded sector, government spending and inflation. Taking data of 14 industrialised countries for the period 1970 to 1991, they find more evidence in favour of co-integration when analysing panel data, then when analysing the time series of every country separately.

The three previous studies do however not test for the order of integration of inflation and productivity differentials.

Hondroyiannis and Papapetrou (1998) analyse the causality between the price level and productivity in a temporal causal framework with the help of co-integration tests. As all variables but the CPI are I(1), and the latter is I(2) in their sample of low-inflation OECD countries during the period 1960-95, no co-integration is possible. Their conclusion is that according to this finding, there cannot exist any long run relationship. In a second step, they control for output and monetary policy. Applying the Johanson maximum likelihood approach, they can reject the hypothesis of a spurious relationship between the consumer price index and productivity.

MacDonald (1997) uses co-integration tests for real exchange rate data on the US dollar, the DM and the Japanese Yen during the period 1974-93. He finds significant and sensible long run relationships for the real effective exchange rates of these currencies with the productivity differentials between the traded and the non-traded sectors, when controlling for the demand side, fiscal policy, private sector savings and oil prices.

Only a few studies base their analysis on regressions. One of them is a study of Asea and Mendoza (1994) who investigate in how far long run relative labour productivities can explain long run relative prices of non-traded goods, and whether the latter explain cross country real exchange rate differentials in the long run. Their empirical findings for 14 OECD countries from 1970 to 85 are that the Balassa-Samuelson proposition cannot be rejected, and that long-term relative prices are of little help in explaining long term differences in the level of the real exchange rate. Asea and Mendoza use a Hodrick-Prescott filter in order to take only the long-run component of the data into account.

Strauss (1995) uses data for the G7 from 1960 to 1990 to estimate the speed of adjustment of the real exchange rate to changes in non-tradable prices. The regression results based on a co-integrating ECM indicate that the relative price of non-tradable goods significantly influences the real exchange rate in short run. For most economies, the adjustment to equilibrium takes about three years.

De Gregorio and Wolf (1994) run short-term regressions with the real exchange rate and with the relative price of non-traded goods as dependent variables. In both cases, they take as dependent variable the total factor productivity differential between the traded and the non-traded sectors, the prices of imports and exports (alternatively the terms of trade), government expenditure and the GDP per capita. All variables are in first differences. De Gregorio and Wolf take 14 OECD countries over the period 1970-85, using SUR estimates. Sectors for which the exports divided by the value added exceed 10% are classified as tradable goods, whereas the other sectors constitute the non-traded goods sector. In the regressions with the real exchange rate as dependent variable, they find highly significant coefficients for total factor productivity. However, when taking the relative price of non-traded goods as dependent variable, the coefficient of productivity becomes insignificant.

De Gregorio et al. (1994) observe that the correlation of inflation rates has increased within Europe, whereas the correlation of demand and supply side factors have increased for non-core, but decreased for core economies. Furthermore, their data suggest that the relative price of non-tradables has increased almost uniformly. Their regression results show that short-run demand side factors, in particular income growth, have most explanatory power of relative price changes. In the long run, most of the increase in the relative price of non-tradables can be explained by a faster increase of total factor productivity in tradables. Their long run analysis is however based on 1970-85 averages for only 14 countries.

Froot and Rogoff (1991) explain differences in the real exchange rate movements of currencies participating in the European exchange mechanism by different factors. First, shocks to government spending influence the real exchange rates, as government expenditure has a stronger effect on the traded goods sector. The second factor consists of shocks to labour productivity, the third imperfectly credible aggregated demand policy, and the last one debt gaps. They empirically test the influence of these factors and find the government consumption to be statistically significant, whereas the productivity in the traded and the non-traded sectors are not significant. Their regression covers the period 1979-89 for the EMS countries. They do not use bilateral real exchange rates, but rather define the variables of every country vis-à-vis the EMS average.

Hsieh (1992) analyses the real exchange rate of Germany and Japan to their trading partners from 1954 to 1976 and find a significant effect of the productivity differential between the traded and the non-traded goods sector for both countries.

Micossi and Milesi-Ferretti (1996) regress the inflation differential between the traded and the non-traded sector in a country on the labour productivity differential in the two sectors, an EMS dummy, inflation (based on the GDP deflator) and the GDP growth rate for eight EU countries from 1966 to 90. For about half of the regressions, they find a significant influence of the productivity differential on the inflation differential. They also test the relationship in a bilateral regression, where the real exchange rate (based on the GDP deflator) is explained by the real exchange rate (based on unit labour costs) and the productivity differential between traded and non-traded sectors for both countries. Again, the evidence for a significant influence of the productivity differentials is mixed.

Table 1 gives an overview of the main differences between the empirical studies.

Table 1 Empirical Studies on Prices and Productivity Differentials

	Countries	Period	Dep. Var.	Expl. var.	Results
Alberola and Tyrväinen (1998)	EU11	75-95	$\Delta p^T/\Delta p^N$	Δq^T-Δq^N	Co-integrated
Canzoneri et al. (1999)	OECD13	60-73	p^T/p^N	q^T/q^N	Co-integrated
Chinn and Johnston (1997)	OECD14	70-91	ΔRER	Δq^T-Δq^N	More evidence for co-integration when using panel data
Hondroyiannis and Papapetrou (1998)	OECD low infl.	60-95			Long-run relationship only when including output and mon. pol.
MacDonald (1997)	$, DM, Y	74-93	RERR	q^T-q^N	Co-integrated
Asea and Mendoza (1994)	OECD14	70-85	p^T/p^N	q^T-q^N	Significant +
Strauss (1995)	G7	60-90	RER	q^T-q^N	Significant +
De Gregorio and Wolf (1994)	OECD14	70-85	ΔRER $\Delta p^T/\Delta p^N$	Δq^T-Δq^N	Significant + Not significant
De Gregorio et al. (1994)	OECD14	70-85	Δp	Δq^T-Δq^N	CT very small LT sign. +
Froot and Rogoff (1991)	EMS	79-89	RER	q^T, q^N	Not significant
Hsieh (1992)	Germany, Japan	54-76	RER	q^T-q^N	Significant +
Micossi and Milesi-Ferretti (1996)	EU8	66-90	Δp^T-Δp^N	Δq^T-Δq^N	Mixed

3. Theoretical background

The average price level is composed of the price levels in the tradable sector and the non-tradable sector:

$$p = (1-a)p^T + ap^N \tag{1}$$

were p is the average price level, p^T and p^{NT} the price levels in the tradable and non-tradable sectors and a is the share of production in the non-traded sector in total production, all expressed in logarithm.

We will assume that the production functions in both sectors are of the Cobb-Douglas form:

$$Y^T = A^T \left(K^T\right)^{g^T} \left(L^T\right)^{1-g^T} \text{ and } Y^N = A^N \left(K^N\right)^{g^N} \left(L^N\right)^{1-g^N}$$

with Y is the production, L the labour force, K capital, and A the technology, the superscript designing the traded (T) and the non-traded (N) goods sector.

We therefore have:

$$\frac{\partial Y^T}{\partial L^T} = \left(1-g^T\right)A^T\left(K^T\right)^g \left(L^T\right)^{-g} = \left(1-g^T\right)\frac{Y^T}{L^T} \tag{2}$$

$$\frac{\partial Y^N}{\partial L^N} = \left(1-g^N\right)\frac{Y^N}{L^N} \tag{3}$$

Furthermore, we will define $Q^T = \ln\frac{Y^T}{L^T}$ and $Q^N = \ln\frac{Y^N}{L^N}$, with Q the labour productivity.

In a competitive environment where profits have to be zero we have furthermore the following conditions:

$$\frac{\partial Y^T}{\partial L^T} = \frac{W}{P^T} \qquad (4)$$

and

$$\frac{\partial Y^N}{\partial L^N} = \frac{W}{P^N} \qquad (5)$$

where W are the wages. We assume that wages are the same in the traded and non-traded goods sector. The equations state that in each sector, labour productivity equals wages divided by prices.

Dividing equations (4) and (5) by each other, substituting (2) and (3) and taking the logarithm[3], we have:

$$p^N = p^T + \ln\left(1 - g^N\right) + q^T - q^N \qquad (6)$$

Substituting (6) into (1) we obtain:

$$p = p^T + a\left[q^T - q^T\right] + a \ln\left(\frac{1 - g^T}{1 - g^N}\right)$$

Assuming that the elasticities γ^T and γ^N are constant, and defining $c = a \ln\left(\frac{1 - g^T}{1 - g^N}\right)$, we obtain:

$$p = c + p^T + a\left(q^T - q^N\right) \qquad (7)$$

or

$$p - p^T = c + a\left(q^T - q^N\right) \qquad (8)$$

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[3] Small caps will stand for logarithmic variables.

This means that the price level in a country equals the inflation in the traded goods sector plus the share of non-traded goods times the productivity differential between the traded and the non-traded goods production.

The price differential between two countries is therefor defined as follows:

$$p_i - p_j = c_{ij} + \left(p_i^T - p_j^T\right) + a_i\left(q_i^T - q_i^N\right) - a_j\left(q_j^T - q_j^N\right) \qquad (9)$$

or

$$\left(p_i - p_j\right) - \left(p_i^T - p_j^T\right) = c_{ij} + a_i\left(q_i^T - q_i^N\right) - a_j\left(q_j^T - q_j^N\right) \qquad (10)$$

with $c_{ij} = c_i - c_j$.

The price differential between two countries should thus be a function of the differential of traded goods prices between the two countries, and the share of non-traded goods in production multiplied with the productivity differential between the traded and the non-traded goods sector for both countries.

4. Empirical analysis

Our empirical analysis adds to the studies presented above in several ways. First, we analyse the effect of productivity differentials between the traded and the non-traded sectors on prices, and not on the real exchange rate as in many of the studies. This has the advantage that we do not test two hypotheses simultaneously, namely the Balassa-Samuelson theorem and purchasing power parity.

Second, we enter all variables in growth rates and also estimate a bilateral equation, taking the inflation differential between countries i and j as dependent variable. To our knowledge, none of the existing empirical studies uses this method. Beside the fact that we are interested in the inflation differential within EMU rather than in the inflation rate of each individual country, this method has the advantage to increase the number of observations.

Finally, we apply the analysis to the EU, using a data set covering the period from 1971-95 for all present EU members, except Greece and Ireland[4]. We use panel data estimations, taking into account not only variation over time, but also across countries. This should make our estimator more efficient, as it increases the number of observations.

The traded sector consists of the manufacturing sector; the non-traded sector is calculated by subtracting manufacturing, agriculture and mining and quarrying form the total (all sectors together). This means that it is composed of the remaining service sectors: electricity, gas and water; construction; wholesale and retail trade, restaurants and hotels; transport, storage and communication; finance, insurance, real estate, and business services; and community, social and personal services.

The estimated equations are the following:

$$p_{it} = c_i + a_1 p_{it}^{T} + a_2 f_{it}^{N} \left(\Delta q_{it}^{T} - \Delta q_{it}^{N}\right) \tag{11}$$

and

$$p_{it} - p_{it}^{T} = c_i + a_2 f_{it}^{N} \left(\Delta q_{it}^{T} - \Delta q_{it}^{N}\right) \tag{12}$$

for the one-country specification, and

$$p_{it} - p_{jt} = c_{ij} + b_1 \left(p_{it}^{T} - p_{jt}^{T}\right) + b_2 \left[f_{it}^{N} \left(\Delta q_{it}^{T} - \Delta q_{it}^{N}\right) - f_{jt}^{N} \left(\Delta q_{jt}^{T} + \Delta q_{jt}^{N}\right)\right] \tag{13}$$

and

$$\left(p_{it} - p_{jt}\right) - \left(p_{it}^{T} - p_{jt}^{T}\right) = c_{ij} + b_2 \left[f_{it}^{N} \left(\Delta q_{it}^{T} - \Delta q_{it}^{N}\right) - f_{jt}^{N} \left(\Delta q_{jt}^{T} + \Delta q_{jt}^{N}\right)\right] \tag{14}$$

for the bilateral specification, with:

f_{it}^{N} the share of value added in the non-traded goods sector,

[4] For these two countries, no reliable data on sectoral value added were available.

$$\pi = \begin{cases} \Delta CPI \\ \Delta GPI \end{cases} \quad and \quad \pi^T = \begin{cases} \Delta PPIT \\ \Delta XPI \end{cases}$$

We take the growth rate of two different price indices as dependent variable (π): the consumer price index (CPI) and the GDP deflator (GPI). For inflation in the traded goods sector (π^T), we also take two definitions, the producer price index in manufacturing (PPIT), and the export price index (XPI). The productivity growth in the traded and non-traded goods sectors (Δq^T and Δq^{NT}) are defined as the growth rates of the value added by employee in the respective sector.[5] Appendix A gives a description of the data sources.

We multiply the productivity differential with the share of value added in the non-traded goods sector (ϕ_{it}^N). Therefor, we would expect the estimated coefficient to be equal to one in the long run. The advantage of multiplying the differential with the share rather than estimating the share directly is that we allow the shares to differ across countries, which would not be possible otherwise. Remember that we use panel data, so that we obtain the same estimated coefficients across the different cross sectional units, in our case couples of countries.

We impose the same coefficient for the productivity differential for both countries, in order to make sure that the equation is symmetric. In order to relax somewhat this assumption, we also test whether the coefficient of the traded goods sector productivity growth is different from that of the non-traded goods sector. The resulting equations are:

$$\pi_{it} = c_i + \gamma_1 \pi_{it}^T + \gamma_2 \phi_{it}^N \Delta q_{it}^T + \gamma_3 \phi_{it}^N \Delta q_{it}^N \tag{15}$$

and

$$\pi_{it} - \pi_{it}^T = c_i + \gamma_2 \phi_{it}^N \Delta q_{it}^T + \gamma_3 \phi_{it}^N \Delta q_{it}^N \tag{16}$$

for the one-country specification, and

$$\boldsymbol{p}_{it} - \boldsymbol{p}_{jt} = c_{ij} + \boldsymbol{d}_1\left(\boldsymbol{p}^T_{it} - \boldsymbol{p}^T_{jt}\right) + \boldsymbol{d}_2\left(\boldsymbol{f}^N_{it}\Delta q^T_{it} - \boldsymbol{f}^N_{jt}\Delta q^T_{jt}\right) + \boldsymbol{d}_3\left(\boldsymbol{f}^N_{it}\Delta q^N_{it} - \boldsymbol{f}^N_{jt}\Delta q^N_{jt}\right) \qquad (17)$$

and

$$\left(\boldsymbol{p}_{it} - \boldsymbol{p}_{jt}\right) - \left(\boldsymbol{p}^T_{it} - \boldsymbol{p}^T_{jt}\right) = c_{ij} + \boldsymbol{d}_2\left(\boldsymbol{f}^N_{it}\Delta q^T_{it} - \boldsymbol{f}^N_{jt}\Delta q^T_{jt}\right) + \boldsymbol{d}_3\left(\boldsymbol{f}^N_{it}\Delta q^N_{it} - \boldsymbol{f}^N_{jt}\Delta q^N_{jt}\right) \qquad (18)$$

We will first present some insights into the order of integration of the variables of our model. Then, we will present the estimation results of the unilateral and the bilateral equation.

4.1. Stationarity analysis

In this paragraph we want to address the question which is the order of integration of the different variables. As we intend to estimate the equations in first differences, as indicated in equations (11)-(18), we test the order of integration of total inflation, inflation in the traded goods sector, and the productivity growth differential between the traded and the non-traded goods sectors.[6]

The literature on unit root tests in panel data is currently developing, trying to combine findings on unit roots in time series with panel data econometrics. Initially, it has been assumed that unit roots in the individual time series composing panels do not matter for the estimators as the 'spurious' relationship resulting from a unit root would be corrected for by the existence of breaks in the data when switching from one cross-sectional unit to another. However, in the 90s, different tests for unit roots in panel data have been introduced, starting with Levin and Lin (1993).

We will test for a unit root following a more recent paper of Im, Pesheran and Shin (1997), who implement the Dickey-Fuller test for each individual time series composing

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[5] Portugal was excluded from the sample when the producer price index in the traded goods sector entered into the regression, as no data were available for this variable.

[6] Appendix C shows the charts of all variables involved.

the panel, and calculate the test statistic taking the average of these Dickey-Fuller statistics over all individuals. They use Monte-Carlo simulations in order to compute the corresponding critical values. This test has the advantage of being relatively easy to implement, but the feedback is the underlying assumption that the panel to be tested is balanced, i.e. the number of time periods is the same for each cross sectional unit. Table 2 shows the results of this test for the unilateral, as well as for the bilateral specification of the variables, with intercept and with and without time trend. Bold (italic) numbers indicate that the hypothesis of a unit root can be rejected at a 1% (5%) confidence level. In the unilateral specification, we can see that for CPI-inflation, and for GPI-inflation, we cannot reject H_0 of a unit root unless we include a time trend. As the problem seems to be solved when including a time trend, we will include it also into our regression. In the bilateral specification, the test can reject the hypothesis of a unit root for all variables at a 1% confidence level. When taking the difference between total inflation and inflation in the traded goods sector, we can also reject a unit root at 1%.

Table 2 Im-Pesheran-Shin unit root tests for panel data

	Unilateral specification		Bilateral specification	
	τ_μ	τ_τ	τ_μ	τ_τ
ΔCPI	-1,21	*-2,72*	**-2,24**	**-2,58**
ΔGPI	-1,48	**-3,01**	**-2,60**	**-3,04**
ΔPPIT	**-2,28**	**-3,15**	**-3,04**	**-3,36**
ΔXPI	**-2,62**	**-3,68**	**-3,54**	**-3,88**
ΔPRTN	**-3,79**	**-4,16**	**-3,39**	**3,93**
ΔOIL	**-4,94**	**-5,79**		
ΔCPI-ΔPPIT	**-3,65**	**-3,76**	**-3,12**	**-3,26**
ΔCPI-ΔXPI	**-4,03**	**-4,11**	**-3,86**	**-4,01**
ΔGPI-ΔPPIT	**-3,85**	**-3,96**	**-3,62**	**-3,73**
ΔGPI-ΔXPI	**-4,13**	**-4,21**	**-4,13**	**-4,23**

4.2. Estimation results

As we want to analyse the impact of productivity differentials on inflation in the long-run, we use long-run data, taking five year averages for all variables. Due to the large number of missing observations, we are obliged to take an overlapping sample going from 1971-75 to 1991-95. Therefore, a Newey-West error correction is implemented, correcting for heteroskedasticity and autocorrelation.

The regression results of equations (11), (12), (15) and (16) are shown in tables 3 and 4.

Table 3 Empirical results: one-country version (restrained)

Dependent variable: π - equation (11)

	$\pi = \Delta CPI$		$\pi = \Delta GPI$	
TREND	-0,037	-0,085 **	-0,099 **	-0,145 **
DOIL1	-0,708 *	-1,262 **	-0,782 *	-1,146 **
DOIL2	-0,285	-0,266	-0,763 **	-0,685 **
π^T_{PPI}	0,779 **		0,703 **	
π^T_{XPI}		0,639 **		0,571 **
$\phi^N(\Delta q^T - \Delta q^N)$	0,187 *	0,073	-0,032	-0,077
ARSQ	0,930	0,927	0,933	0,926

Dependent variable: π - equation (12)

	$\pi_{CPI}-\pi^T_{PPI}$	$\pi_{CPI}-\pi^T_{XPI}$	$\pi_{GPI}-\pi^T_{PPI}$	$\pi_{GPI}-\pi^T_{XPI}$
TREND	0,044	0,060 **	0,009	0,028
DOIL1	-1,177 **	-2,402 **	-1,410 **	-2,501 **
DOIL2	-0,800 **	-1,377 **	-1,454 **	-2,004 **
$\phi^N(\Delta q^T - \Delta q^N)$	0,295 **	0,149	0,112	0,014
ARSQ	0,502	0,560	0,527	0,532

* significant at 5%; ** significant at 1%

We use fixed effects estimates for panel data, so that we have different intercepts for each cross-sectional unit. Beside a time trend, we also included two dummies for the oil shocks into the equation (DOIL1 and DOIL2). These dummies are equal to one for five years from 1974 (1980) onwards, as we take five year averages for all variables. The coefficients of these dummies are negative and significant in almost all specifications. Traded goods inflation has a significant impact on total inflation, the coefficient being around 0.7 when taking PPI-inflation in manufacturing, and around 0.6 when taking XPI-inflation. This is quite close to one, which is expected by the theory.

The productivity growth differential between the traded and the non-traded sectors yields quite mixed results. The coefficient is significantly different from zero only in the first column, when taking CPI- inflation as dependent variable, and PPI-inflation in manufacturing as inflation in the traded sector. In these cases, it has the expected positive sign, but is much smaller than one, which would be the value expected.

The adjusted R-squared is relatively high in all specifications. In the regression with total inflation as dependent variable (ARSQ ≅ 0.93), this is mainly due to the high significance of traded goods inflation. The differential between total and traded goods inflation also yields a relatively high adjusted R-squared (above 0.5), indicating that the oil price shocks have high explanatory power.

Table 4 Empirical results: one-country version (unrestrained)

Dependent variable: π - equation (15)

	$\pi = \Delta CPI$		$\pi = \Delta GPI$	
TREND	-0,040	-0,091 **	-0,091 **	-0,154 **
DOIL1	-0,709	-1,217 **	-1,217 **	-1,078 **
DOIL2	-0,297	-0,297	-0,297	-0,732 **
π^T_{PPI}	0,778 **		0,634 **	
π^T_{XPI}		0,634 **		0,564 **
$\phi^N \Delta q^T$	0,184 *	0,053	0,053	-0,107
$\phi^N \Delta q^N$	-0,379 **	-0,443 **	-0,443 **	-0,493 **
ARSQ	0,930	0,930	0,936	0,932

Dependent variable: π - equation (16)

	$\pi_{CPI}-\pi^T_{PPI}$	$\pi_{CPI}-\pi^T_{XPI}$	$\pi_{GPI}-\pi^T_{PPI}$	$\pi_{GPI}-\pi^T_{XPI}$
TREND	0,041	0,057 *	0,004	0,022
DOIL1	-1,179 **	-2,377 **	-1,413 **	-2,460 **
DOIL2	-0,813 **	-1,413 **	-1,481 **	-2,063 **
$\phi^N \Delta q^T$	0,293 **	0,134	0,108	-0,011
$\phi^N \Delta q^N$	-0,482 **	-0,456 **	-0,533 **	-0,509 *
ARSQ	0,503	0,565	0,543	0,547

* significant at 5%; ** significant at 1%

The results of equations (15) and (16) look very similar to the previous results for all variables except productivity growth. The coefficient of the productivity growth in the non-traded goods sector is significantly different from zero in all specifications, and has the expected negative sign. It is much closer to one in absolute value than in the results of table 3. In contrary, the productivity growth in the traded goods sector is significant only when we use CPI-inflation in combination with PPI-inflation in manufacturing. The coefficients of the traded and of the non-traded sectors' productivity growth are quite different (in absolute values), which is in contradiction with equations (7) and (8). A possible reason for this contradiction is that data on manufacturing and services are only an approximation of traded and non-traded goods. Another reason could be that there is more competition in the traded goods sector, so that the productivity in this sector is converging among EU countries. This could be caught up by the time trend in our estimation, so that the effect on inflation is very small.

The results of table 4 indicate that the findings in table 3 (few significant results for $\phi^N(\Delta q^T - \Delta q^N)$) are mainly due to a difference in the impact of productivity growth in the traded sector and that in the non-traded sector.

The mixed results of the one-country specification can however also be due to the small amount of observations, combined with a high number of missing values for productivity for some of the countries. We therefor also estimate the equation in a bilateral form, as suggested in equations (13), (14) (table 5), (17) and (18) (table 6).

Again, we use the fixed effects estimator, and include a time trend, as well as dummies for the two oil price shocks into the equation. The time trend is significant and negative in all specifications, indicating that inflation differentials between the EU members declined during the sample period. The oil price dummies are in about half of the cases significant.

Table 5 Empirical results: bilateral version (restrained)

Dependent variable: p_i-p_j - equation (13)

	π = ΔCPI		π = ΔGPI	
TREND	-0,138 **	-0,076 **	-0,107 **	-0,057 **
DOIL1	-1,881 **	-0,437	-1,557 **	-0,225
DOIL2	-1,460 **	-0,279	-1,657 **	-0,609 **
ΔPPI_i^T-ΔPPI_j^T	0,792 **		0,822 **	
ΔXPI_i-ΔXPI_j		0,637 **		0,648 **
$\phi_{it}^N(\Delta q^T$-$\Delta q^N)$- $\phi_{jt}^N(\Delta q^T{}_j$-$\Delta q^N{}_j)$	0,190 **	0,094	0,051	-0,015
ARSQ	0,902	0,887	0,907	0,895

Dependent variable: (p_i-p_j)- (p_i^T-p_j^T) - equation (14)

	π = ΔCPI		π = ΔGPI	
	π^T = ΔPPIT	π^T = ΔXPI	π^T = ΔPPIT	π^T = ΔXPI
TREND	-0,152 **	-0,091 **	-0,120 **	-0,072 **
DOIL1	-2,063 **	-0,314	-1,712 **	-0,106
DOIL2	-1,605 **	-0,003	-1,781 **	-0,342
$\phi_{it}^N(\Delta q^T$-$\Delta q^N)$- $\phi_{jt}^N(\Delta q^T{}_j$-$\Delta q^N{}_j)$	0,269 **	0,193 **	0,117 **	0,081
ARSQ	0,379	0,228	0,461	0,268

* significant at 5%; ** significant at 1%

This time, we do find evidence for a positive effect of the bilateral difference of the productivity growth differentials between the traded and the non-traded sectors on inflation differentials, and in about half of the cases, this effect is significant. In the first form of the model, where the inflation differential between two countries is the dependent variable, the productivity variable is significant only in the specification of CPI-inflation combined with PPI-inflation in manufacturing (with XPI-inflation only at 10%). However, when we take the difference between the total inflation differential and the traded goods inflation differential as dependent variable, we find evidence for a significant effect of the productivity differential in all but one specification. This might suggest that the poor results of the previous regressions were due to some stationarity problem of inflation, despite the fact that the tests rejected a unit root.

The adjusted R-squared is slightly lower than in the unilateral estimations.

Table 6   Empirical results: bilateral version (unrestrained)

Dependent variable: p_i-p_j (equation 17)

	π = ΔCPI		π = ΔGPI	
TREND	-0,127 **	-0,058 **	-0,090 **	-0,034
DOIL1	-1,585 **	0,023	-1,086 **	0,367
DOIL2	-1,316 **	0,002	-1,425 **	-0,249
ΔPPI_i^T-ΔPPI_j^T	0,787 **		0,820 **	
ΔXPI_i-ΔXPI_j		0,645 **		0,661 **
$\phi_{it}^N \Delta q^T$- $\phi_{jt}^N \Delta q^T{}_j$	0,255 **	0,099	0,070	-0,046
$\phi_{it}^N \Delta q^N$- $\phi_{jt}^N \Delta q^N{}_j$	-0,631 **	-0,813 **	-0,673 **	-0,863 **
ARSQ	0,905	0,895	0,914	0,908

Dependent variable: (p_i-p_j)- (p_i^T-p_j^T) (equation 18)

	π = ΔCPI		π = ΔGPI	
	π^T = ΔPPIT	π^T = ΔXPI	π^T = ΔPPIT	π^T = ΔXPI
TREND	-0,142 **	-0,070 **	-0,102 **	-0,046 **
DOIL1	-1,785 **	0,204	-1,256 **	0,539
DOIL2	-1,467 **	0,307	-1,552 **	0,044
$\phi_{it}^N \Delta q^T$- $\phi_{jt}^N \Delta q^T{}_j$	0,350 **	0,204 **	0,150 **	0,054
$\phi_{it}^N \Delta q^N$- $\phi_{jt}^N \Delta q^N{}_j$	-0,712 **	-1,010 **	-0,741 **	-1,052 **
ARSQ	0,391	0,279	0,494	0,344

* significant at 5%; ** significant at 1%

In the unrestrained regression, we again find quite different coefficients for productivity growth in the two sectors. This time, we do however have some evidence for a positive effect of traded goods productivity growth on inflation, which could indicate that there was some data problem in the one-country estimation. Remember that we have a lot more observations in the bilateral version of the model. The coefficient of productivity growth in the non-traded goods sector is now close to one, as expected from the theory.

5. The Inflation differential in a monetary union

According to the model of section 3, and under the assumption that purchasing power parity holds in the long run, the long run inflation differential between two EMU member countries should depend on their respective productivity differentials between the traded and the non-traded goods sectors. This is because the inflation differential in the traded sector should be equal to zero, so that equations (13) and (14) become:

$$\boldsymbol{p}_{it} - \boldsymbol{p}_{jt} = \boldsymbol{b}_2 \left[\boldsymbol{f}_{it}^{N} \left(\Delta q_{it}^{T} - \Delta q_{it}^{N} \right) - \boldsymbol{f}_{jt}^{N} \left(\Delta q_{jt}^{T} + \Delta q_{jt}^{N} \right) \right] \tag{19}$$

and equations (17) and (18) become:

$$\boldsymbol{p}_{it} - \boldsymbol{p}_{jt} = \boldsymbol{d}_2 \left(\boldsymbol{f}_{it}^{N} \Delta q_{it}^{T} - \boldsymbol{f}_{jt}^{N} \Delta q_{jt}^{T} \right) + \boldsymbol{d}_3 \left(\boldsymbol{f}_{it}^{N} \Delta q_{it}^{N} - \boldsymbol{f}_{jt}^{N} \Delta q_{jt}^{N} \right) \tag{20}$$

With our regression results, we can thus calculate what would have been the average inflation differentials if a monetary union had been in place during the period under examination. This can be calculated by multiplying the coefficient β_2 of equation (14) with the productivity differentials multiplied with the respective shares of the non-traded sector, and by multiplying the coefficients δ_2 and δ_3 of equation (18) with the productivity differentials in the traded and the non-traded sector, respectively. We calculate the average for this potential inflation in a monetary union for all countries of our sample, using the estimation results of equations (14) and (18). Moreover, we are interested in the effect of a possible productivity shock on inflation differentials. In this purpose, we take the maximum of the productivity differential (the minimum in case of negative differentials) and multiply it with the corresponding coefficients of equations (14) and (18). Table 7 presents the results for the average CPI-inflation differential.[7]

The numbers in the first four columns represent the average inflation differentials due to the difference of the productivity differential between the traded and the non-traded sectors in country i and country j. This gives us an idea about the inflation that can subsist on average inside EMU, because of productivity differentials between the participating countries.

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[7] We do not present the results for those equations where XPI-inflation is the proxy for inflation in the traded goods sector, as the coefficients were in several cases not significantly different from zero.

Table 7 Inflation differential due to the productivity differential

	Average 1971-95				Maximum 1971-95			
	Results of (14)		Results of (18)		Results of (14)		Results of (18)	
	CPI-PPIT	GPI-PPIT	CPI-PPIT	GPI-PPIT	CPI-PPIT	GPI-PPIT	CPI-PPIT	GPI-PPIT
A	0,176	0,077	0,484	0,515	3,919	1,711	7,840	6,661
BL	0,377	0,165	0,415	0,086	2,509	1,096	4,480	3,383
DK	-0,167	-0,073	-0,333	-0,282	-3,919	-1,711	-7,840	-6,661
FIN	0,047	0,021	-0,320	-0,598	-3,018	-1,318	-5,299	-5,541
FR	-0,183	-0,080	-0,417	-0,394	2,781	1,214	-5,199	-4,864
GE	-0,272	-0,119	-0,430	-0,276	-2,223	-0,971	3,769	3,151
IT	0,354	0,154	0,580	0,392	3,018	1,318	-5,683	-5,243
NL	0,059	0,026	0,048	-0,015	2,090	0,913	-4,347	-4,151
PO	-0,207	-0,090	-0,149	0,082	-2,781	-1,214	-4,924	-4,099
SP	-0,389	-0,170	-0,392	-0,029	2,033	0,888	4,325	3,877
SW	0,189	0,082	0,389	0,340	3,261	1,424	5,133	3,928
UK	0,016	0,007	0,125	0,180	-2,709	-1,183	4,696	3,945

Negative numbers indicate that the country had a negative productivity differential in the year of the maximum, i.e.

$b_2\left[f_{it}^{N}\left(\Delta q_{it}^{T}-\Delta q_{it}^{N}\right)< f_{jt}^{N}\left(\Delta q_{jt}^{T}+\Delta q_{jt}^{N}\right)\right]$ for equation (14), and

$d_2\left(f_{it}^{N}\Delta q_{it}^{T}-f_{jt}^{N}\Delta q_{jt}^{T}\right)< d_3\left(f_{it}^{N}\Delta q_{it}^{N}-f_{jt}^{N}\Delta q_{jt}^{N}\right)$ for equation (18).

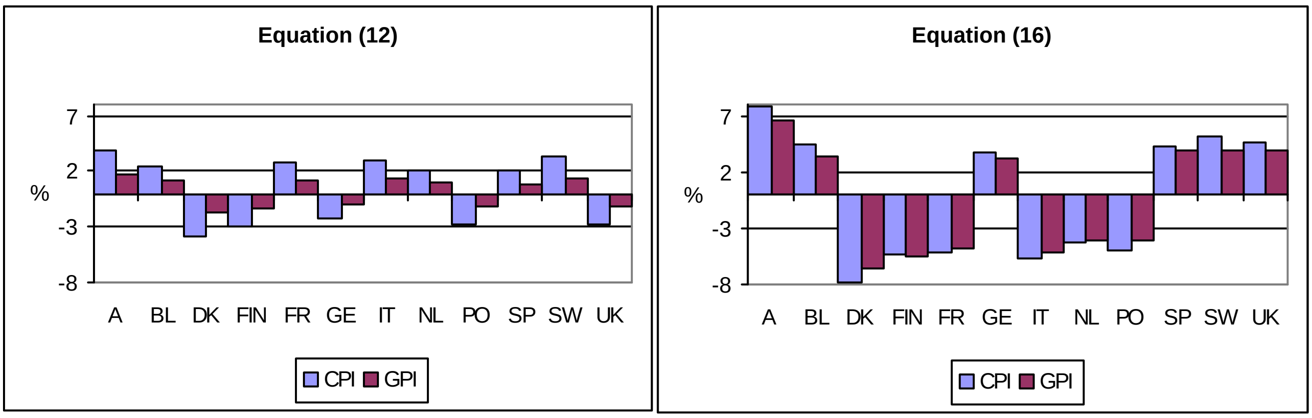
We observe that the average inflation differential due to productivity differentials varies between 0.007 and 0,6% in absolute value. When CPI-inflation is taken as proxy for total inflation, the effect is in most cases somewhat higher then for GPI-inflation. The effect is highest for Belgium, Italy and Spain and lowest for Austria, Denmark, France, Finland and the UK.

The maximum effect (columns 5-8 in table 7) are quite substantial, indicating that differences in the productivity growth differentials between the traded and the non-traded sectors across EU countries can lead to inflation differentials going up to 8% in absolute value. Again, this effect is much stronger when the calculation is based on the results of equation (18).

Figures 2 and 3 shows the average and maximum inflation differentials due to productivity differentials with CPI-inflation and GPI-inflation as proxies for total inflation, both based on the results of equations (14) and (18). We observe more variation when we base our calculation on equation (18). Moreover, there are quite substantial differences across the different EU countries.

Figure 2 Average Inflation Differential due to Productivity Differentials

Figure 3 Maximum Inflation Differential due to Productivity Differentials



6. Concluding Remarks

According to the Balassa-Samuelson hypothesis, the total price level should be driven by the price level in the traded goods sector, and by the productivity differential between the traded and the non-traded goods sectors. The question we analysed in this paper is in how far inflation differentials can subsist within EMU, due to productivity differentials between the participating countries.

In order to test this hypothesis, we use data for 13 of the 15 EU members from 1971-95 and take five-year averages for all variables in first differences. We estimate two unilateral and two bilateral specifications of the model: first, we use as dependent variable total inflation (differentials) and as explanatory variables the difference between total inflation (differentials) and traded goods inflation (differentials), and the (difference between two countries') productivity growth differential between the traded and the non-traded sectors. Second, we put the traded-goods inflation (differential) on the left hand side. We use the consumer price index and the GDP deflator for total inflation, and the producer price index in manufacturing and the export price index for inflation in the traded goods sector. The results of the one-country estimates are quite mixed, in that the productivity growth differential has only in one case a significant and positive effect. In the bilateral version of the model, we find in most cases that there is a significant positive effect of the long-run productivity differential on the inflation differential, as proposed by the theory. The mixed results of the unilateral specification might be due to the number of missing observations.

When we calculate the average inflation differential due to the productivity differential, we find that the average effect goes up to 0,6%. The effect differs according to which indicator is chosen for total inflation. It is somewhat smaller when using the GDP-deflator. The effect of productivity shocks is calculated, taking the maximum of the countries' productivity differentials (minimum in case of a negative value) as a potential shock. The total effect on the inflation differential is quite substantial, going up to 8% in absolute value.

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Appendix A Definition of the variables

Inflation (p):

Consumer price index, 1990=100; Source: OECD Main Economic Indicators

GDP-deflator, 1990=100; Source: OECD Main Economic Indicators

Traded goods inflation (p^{T}):

Export price index (XPI), 1990=100; Source: OECD Main Economic Indicators

Producer price index manufacturing, 1990=100; Source: OECD International Sectoral Database, OECD Main Economic Indicators, and OECD Indicators of Industrial Activity

Productivity (q^T, q^N):

Defined as value added (in constant prices USD) divided by employment in the respective sector; Source: OECD, International Sectoral Database, and OECD National Accounts II

Data from the manufacturing sector are taken for the traded goods sector; the non-traded goods sector is composed by

- electricity, gas, and water
- construction
- wholesale and retail trade, restaurants and hotels
- transport, storage and communication
- financing, insurance, real estate, and business services, and
- community, social and personal services.

We calculated the sum of these sectors from the data on all sectors together and subtracted agriculture, hunting, forestry, and fishing, mining and quarrying and manufacturing from it.

Appendix B   Samples for each country

	π^T = PPIT	π^T = XPI
A	1971,1972 1977,1994 (18)	1971,1972 1977,1994 (18)
BL	1976,1980 1983,1992 (13)	1971,1980 1983,1992 (18)
DK	1976,1995 (19)	1971,1995 (24)
FIN	1971,1995 (24)	1971,1995 (24)
FR	1978,1995 (17)	1971,1975 1978,1995 (21)
GE	1971,1993 (22)	1971,1993 (22)
IT	1982,1995 (13)	1971,1976 1979,1995 (21)
NL	1972,1995 (23)	1971,1995 (24)
PO	(0)	1987,1993 (6)
SP	1971,1971 1974,1975 1987,1992 (6)	1971,1971 1974,1975 1987,1992 (6)
SW	1971,1978 1981,1994 (20)	1971,1978 1981,1994 (20)
UK	1971,1990 (19)	1971,1990 (19)

As there are no missing observations for CPI- and GPI-inflation, the samples only differ according to the proxy for traded goods inflation (PPI in manufacturing, or the XPI). The number in brackets is the number of observations for each country.

Appendix C Charts of Inflation and Productivity