The enlargement of the euro area: differences in relative inflation

Lukasz W. Rawdanowicz*
(lukaszr@case.com.pl)

May 2005

Abstract

This paper investigates the structural determinants of relative inflation (i.e. inflation of non-tradables vs. tradables) in the context of overall inflation differentials in the EU. The analysis is based on the theoretical model developed by Bergstrand (1991). This framework incorporates three alternative hypotheses of relative inflation (Harrod-Balassa-Samuelson, relative factor endowment, and demand effects). Due to the lack of reliable data on capital stocks only a curtailed version of the model is tested here empirically. The various specifications of the model are estimated using the panel group mean FMOLS estimator developed by Pedroni (2000) for an unbalanced panel including the majority of EU countries. In general, econometric estimations support the Bergstrand model and corroborate the findings of other studies indicating that relative labour productivity and demand factors are important determinants of relative inflation. In addition, differences in relative price determination between new and old EU Member States are found. They seem to be consistent with theoretical considerations and the transition phenomenon. The paper also discusses policy implications for overall inflation stemming from relative price models.

Keywords: relative inflation, Bergstrand model, panel estimations, euro area enlargement

JEL codes: E31, C23, E58

Acknowledgments

This research was supported by a grant from the CERGE-EI Foundation under a program of the Global Development Network. Additional funds for grantees in the Balkan countries have been provided by the Austrian Government through WIIW, Vienna. All opinions expressed are those of the author and have not been endorsed by CERGE-EI, WIIW, or the GDN.

I would like to thank Prof. Peter Pedroni for providing me with the RATS code for the panel group mean FMOLS procedure, and participants of the CERGE-EI workshop in Prague and Wojciech Paczynski for their valuable comments. All remaining errors are mine.

* When writing the paper the author was working at CASE (Center for Social and Economic Research) in Warsaw. He is currently an economist at the European Central Bank. The views expressed in this paper do not necessarily reflect those of either institution.

Contents

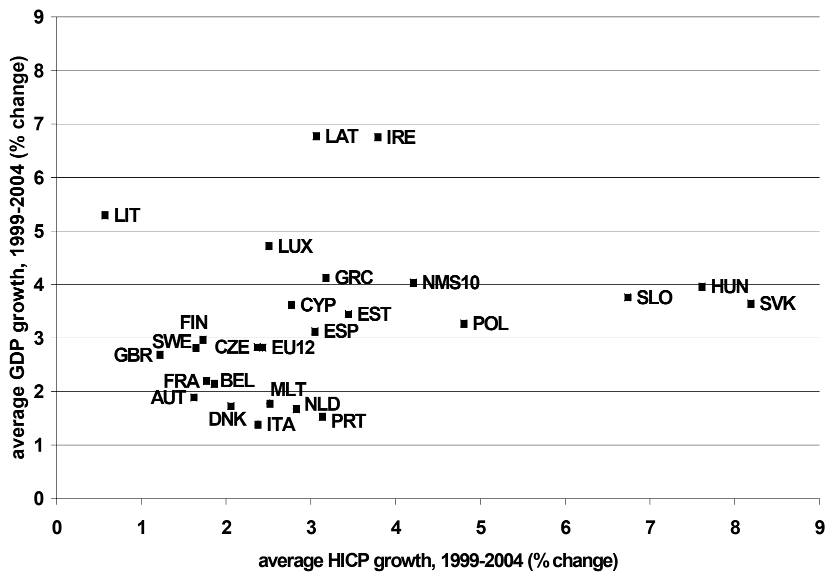
List of tables

List of figures

1. Introduction

There has been a relatively high degree of diversity in terms of economic performance among the euro area countries. This is evident in particular in inflation and GDP growth rates (see Figure 1). Such conditions may make conducting a single monetary policy difficult given that the European Central Bank (ECB) can only tackle inflation and growth developments at the area-wide level and does not have any instrument to address member-specific problems. Economic performance becomes even more diversified when the prospective euro area members are added to the picture. After EU enlargement in May 2004 the ten new EU Member States became EMU members with a derogation (i.e. they are obliged to adopt the euro at some later stage). Six new Member States (NMS) – Estonia, Lithuania, Slovenia, Cyprus, Latvia, and Malta[1] – have already joined the ERM II and others are expected to follow suit soon. Thus, if everything goes smoothly, by 2007-2008 the euro area could be enlarged by at least six new members.[2] The question arises as to whether the accession of NMS will cause economic tensions in the euro area and further complicate the conduct of single monetary policy?

Figure 1. Average GDP and HICP growth rates in the EU, 1999-2004



Source: Eurostat.

Inflation differentials in the euro area and in the EU have recently become a popular research topic and a variety of approaches have been formulated – see, for instance, OECD (2002), ECB (2003) and Egert, Ritzberger-Grunwald and Silgoner (2003). One needs to acknowledge that the sources of inflation differentials can be very diverse. They can stem from long-term structural factors, temporary factors (like such policy measures as administered prices, indirect taxes, etc.), different cyclical positions over the business cycle, different exposure to external shocks (primarily in terms of the commodity and currency structure of foreign trade), structural characteristics of labour and product markets (including the degree of wage and

[1] The first three countries joined the ERM II on 27 June 2004, and the latter three on 29 April 2005.
[2] The Treaties stipulate at least two years in the ERM II prior to joining the euro area.

price rigidities, different degrees of competition in key domestic markets), as well as technical issues related to measurement of inflation.

One of the most common approaches to dealing with structural inflation differentials is to analyse relative inflation, i.e. inflation between non-tradables and tradables. This is generally undertaken in the Harrod-Balassa-Samuelson (HBS) framework. In this model, under the assumption of perfect competition, international capital mobility and sectoral labour mobility at the national level, relative inflation arises due to the different pace of relative sectoral productivity growth and is purely a supply-side phenomenon. Although models of relative prices do not provide clear indications about specific price levels or overall inflation rates they can be used for making simulations of aggregate inflation.

Models of relative price determination, and more generally of real exchange rates, have been extensively tested for developed countries (for instance, Asea and Mendoza (1994), De Gregorio, Giovannini and Wolf (1994), Canzoneri, Cumby and Diba (1996), Chinn and Johnston (1996), and Alberola and Tyrvainen (1998)), and also more recently for Central and Eastern European countries (CEECs) (for example De Broeck and Slok (2001), Dobrinsky (2001), Halpern and Wyplosz (2001), Egert *et al.* (2003), MacDonald and Wojcik (2003), and Rawdanowicz (2004)). These models focus primarily on the HBS effect or its internal mechanism (i.e. the Baumol-Bowen effect – see Section 3). In addition to this simple framework, many authors test simultaneously other explanatory variables, including demand-side factors. Overall inflation simulations based on the model estimates are also conducted in some studies. In particular, Alberola and Tyrvainen (1998) undertake such an exercise for eight EMU members and Egert *et al.* (2003) for selected CEECs. Generally, all of the above studies corroborate the link between, on the one hand, relative inflation and on the other, relative productivity and the demand effect, as well as point to its inflationary consequences. A comparison of the exact magnitudes of this effect is complicated by the adoption of different theoretical frameworks, model specifications, definitions of variables, countries and time samples and estimation methods.

Against this background, this paper attempts to contribute to the empirical literature by testing, in a coherent manner, alternative hypotheses of relative inflation determination based on the Bergstrand (1991) model. The adopted model explains relative inflation with a sectoral productivity differential, demand effect and relative capital-labour endowments. As such, the focus is solely on structural effects. The paper applies a standardised approach to the current and prospective euro area members (in terms of model specification, definition of variables and estimation methods) and investigates differences between these two country groups.

The remainder of this paper is organised as follows. Section 2 surveys the empirical literature dealing with the structural determinants of relative inflation and the ensuing inflationary consequences for the euro area countries and CEECs. In Section 3, the Bergstrand (1991) theoretical model is described. Section 4 discusses definitions and sources of data. In Section 5, the results of econometric estimations are outlined. The related policy issues are overviewed in Section 6, followed by conclusions in Section 7.

2. Literature survey

Structural factors determining relative inflation in developed countries have been the subject of numerous studies. In this strand of the literature, Alberola and Tyrvainen (1998) estimate and test the internal HBS model for eight euro area countries[3] in the context of overall inflation differentials in the euro area.[4] They perform tests in the cointegration framework on a country-by-country basis. While estimating the HBS model they not only test the existence of a cointegration vector, but also its economic identification (i.e., consistency of estimated parameters with the theoretical model). The investigation shows that the data do not support the standard HBS model for five out of the eight countries (in one case due to a failure of finding a cointegration vector and in four other countries due to wrong economic identification). Alberola and Tyrvainen argue that this could be attributable to the fact that the assumption of wage equalisation is rejected by the data. Consequently, they estimate an augmented HBS model which incorporates not only relative productivity but also relative wages. This specification renders more robust results and cointegration vectors for seven countries where proper economic interpretation is found. They also perform simulations of potential differences in overall inflation. This exercise assumes identical inflation of tradables and is based on past trends for explanatory variables. Consequently, the analysis indicates an inflation differential among EMU members of around 2 percentage points.

Simulation-based inflation differentials for EU countries are also calculated by Canzoneri, Cumby and Diba (2001). According to their estimates of the HBS effect, the inflation differential for hypothetical monetary union would amount to roughly 2-3 percentage points. These figures are derived based on past trends in relative labour productivity and prices (value-added deflators) for ten EU countries[5] over the period 1973-1997. Using panel unit root tests they demonstrate cointegration between relative prices and labour productivity.

A similar approach is applied by a number of other authors. These studies focus generally on developed countries and analyse additional determinants of relative prices.[6] Asea and Mendoza (1994), based on a dynamic two-country general equilibrium model, test evidence for the internal and standard HBS effects. Their estimations support the former model, whereas proofs for the latter are less compelling. They conduct panel estimations for 14 OECD countries using the pooled least square estimator, which is not appropriate for nonstationary data (most likely the case in their analysis). On the other hand, De Gregorio, Giovannini and Wolf (1994) use the standard HBS framework augmented by demand-side factors to analyse relative inflation (in terms of value-added deflators) in 14 OECD countries in 1970-1985. They find evidence that both the demand effect and faster relative productivity growth in the tradable sectors explain changes in relative inflation of non-tradables. The demand-side variables are proxied by real government expenditure (as a percentage of GDP) and real GDP *per capita*. Due to the application of a specific estimation method (SUR run on variables in first differences), they are able to capture only short-term effects. This contrasts with the long-term notion of the standard HBS model. Similarly, Canzoneri, Cumby and Diba (1996) provide evidence for productivity driven relative inflation in 13 OECD countries. They demonstrate the existence of cointegration in a relative inflation-productivity model.

In recent years empirical research into CEECs has also burgeoned. Numerous studies dealing with country-specific and panel estimations generally support the relationship between relative prices and relative labour productivity – the so-called Baumol-Bowen effect (for

[3] Germany, France, Italy, Spain, the Netherlands, Belgium, Austria, and Finland.

[4] Throughout the paper the terms "internal HBS effect" and "Baumol-Bowen effect" will be used interchangeably. For definitions of these effects see Section 3.

[5] Austria, Belgium, Denmark, Finland, France, Germany, Italy, Spain, Sweden, and UK.

[6] It should be mentioned that papers dealing with inflation differentials do not only deal with structural relative inflation – for other approaches see, for instance, Honohan and Lane (2003) and Cihak and Holub (2001).

instance De Broeck and Slok (2001), Dobrinsky (2001), Halpern and Wyplosz (2001), Egert *et al.* (2003), MacDonald and Wojcik (2003), and Rawdanowicz (2004)).[7] Among these papers, Egert *et al.* (2003) study not only estimate the HBS model but also conduct some back-of-an-envelope calculations of ensuing overall inflation. Given the low shares of non-tradables' prices in the consumer baskets in CEECs, it is concluded that the impact on overall inflation would be very limited. This stands in contrast to earlier estimates by Halpern and Wyplosz (2001), who evaluate the HBS effect at around 3.1-3.8 percentage points. However, the country and time coverage, as well as the econometric techniques of these studies, differ and the results cannot be directly compared. Egert *et al.* (2003) analyse both the internal and standard HBS effects on a panel of nine CEECs.[8] For this purpose panel unit-root and cointegration tests are employed. Evidence of these relations proves to be sensitive to the definition of tradable and non-tradable sectors and the relevant price indices, but the relationship between relative productivity and relative inflation (defined in terms of GDP deflators) turns out to be quite robust. On the other hand, Halpern and Wyplosz (2001) test the internal HBS effect on a panel of nine transition economies in Europe[9] using annual data between 1991 and 1999. In their model, explanatory variables comprise unconstrained sectoral productivity and demand effect (proxied by GDP *per capita*). The model is estimated using the GLS method. The demand effect proves to be significant and correctly signed. Evidence for a demand effect in the CEECs is also found by MacDonald and Wojcik (2003). Using the dynamic panel OLS estimation method for quarterly data for a balanced panel including Estonia, Hungary, the Slovak Republic and Slovenia, and covering the period 1Q1995-1Q2001, they demonstrate that both the relative productivity and demand effect (proxied by the share of consumption in GDP) are important in explaining relative inflation.

Summarising this short literature review, three facts should be highlighted. Firstly, empirical research both for developed countries and CEECs provides ample evidence in favour of the Baumol-Bowen effect (i.e. the relation between relative inflation and relative labour productivity), but less lucid proofs are found for the HBS model (relative-productivity driven real appreciation). Secondly, the demand-side effect is proven to have also a significant impact on structural inflation. Thirdly, the Baumol-Bowen mechanism is demonstrated to have inflationary consequences, though particular point estimates of this effect differ across studies and depend largely on the assumptions about tradables inflation. A broad consensus seems to emerge, however, that the structural relative price adjustments in the case of current and prospective euro area countries should contribute to inflation differentials not greater than 2-3 percentage points. Fourthly, the estimated coefficients are very sensitive to the model specification, definition of variables, as well as country and time coverage. This problem is particularly acute for CEECs, where data availability and quality are relatively poor. In addition, the econometric techniques vary quite substantially across presented studies, though panel methods are most common. Some of these methods are, however, not appropriate for estimations with nonstationary data. Against this background, the need for a standardised empirical investigation (primarily in terms of a model specification and definition of variables) becomes evident. In addition, a dichotomy in empirical investigations between advanced and transition economies stands out. Consequently, there is a lack of systematic tests of differences or similarities among them.

---

[7] See Egert (2003) for an extensive survey of empirical papers on the HBS effect and real exchange models in CEECs.

[8] Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, the Slovak Republic and Slovenia.

[9] The Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russia and Slovenia.

3. Theoretical model

Bergstrand (1991) devises a general equilibrium model of structural determination of relative inflation,[10] where equilibrium relative inflation and output depend both on demand and supply factors. The demand side of the model is derived from the maximisation of the non-homothetic, nested Cobb-Douglas-Stone-Geary utility function. The resulting formula for the demand equation expressed in terms of changes in relative variables is given by:[11]

$$\hat{X} = -\sigma_D \hat{p} + \alpha \hat{y} \tag{1}$$

where $\hat{X}$ is growth in relative demand (non-tradables vs. tradables), $\hat{p}$ – relative inflation (non-tradables vs. tradables), $\hat{y}$ – change in GDP *per capita* and σ_D – price elasticity of substitution in consumption between non-tradables and tradables. According to the model's properties, the last of these parameters is likely to be positive and close to one. On the other hand, the α parameter is ambiguously determined and depends on the relation between the weighted *per capita* minimum-consumption requirement for tradables and non-tradables. If this requirement is higher for tradables than for non-tradables, then α is positive. Bergstrand (1991) quotes selected statistics indicating that this should be the case, at least for poorer countries. In general, this hypothesis can be explicitly tested.

The supply side of the model is derived from the simple general equilibrium framework developed by Jones (1965) and is given by:

$$\hat{X} = \sigma_S \hat{p} - \beta \hat{k} - (1 + \sigma_S)\hat{\Pi} \tag{2}$$

where $\hat{k}$ is change in the capital-labour ratio, $\hat{\Pi}$ – change in relative productivity[12] (tradables vs. non-tradables) and σ_S – price elasticity of substitution between goods in production (along the transformation schedule), which is higher than zero. Coefficient β is dependent on the relative factor intensities in production. If non-tradables are more labour intensive in production, then β is negative (as written in equation 2) and an increase in the capital-labour ratio leads to lower relative supply of non-tradables.

Combining equations (1) and (2) yields the reduced-form equilibrium relations for relative inflation and output:

$$\hat{p} = \phi_1 \hat{\Pi} + \phi_2 \hat{k} + \phi_3 \hat{y} \tag{3}$$

$$\hat{X} = -\gamma_1 \hat{\Pi} - \gamma_2 \hat{k} + \gamma_3 \hat{y} \tag{4}$$

Equation (3) is of key importance given the goal of this paper. According to the model's properties, parameter Φ_1 is positive and γ_1 is negative as they are respectively positive and

---

[10] Relative inflation (or prices) refers to the distinction between non-tradables and tradables.

[11] The model equations in Bergstrand (1991) are actually expressed in relation to other countries (for instance, relative productivity refers to relative productivity [tradables vs. non-tradables] in relation to the same measure for another – reference – country). For the sake of simplicity and given the estimation-related considerations (explained in Section 5), the exposition of the Bergstrand model is presented without reference to a foreign country. "^" denotes the growth rate (dX/X).

[12] Relative productivity in the Bergstrand model is defined as a weighted average of the levels of productivity of each factor in a given sector.

negative functions of σ_D and σ_S. Parameter Φ_2 is positive and γ_2 negative under the assumption of relative labour-intensity of non-tradables. Similarly, under the assumption of a higher minimum-consumption requirement for tradables, Φ_3 and γ_3 are positive. The latter condition implies that income elasticity of demand for non-tradables is greater than one and for tradables less than one. Given this exposition, Bergstrand suggests that the sign of γ_3 should be tested empirically.

Summarising, equation (3) can be viewed as encompassing three theories of relative inflation: the Harrold-Balassa-Samuelson (HBS) effect, Heckscher-Ohlin (HO) relative-factor-endowment effect and the demand effect. The HBS model (Harrod, 1933; Balassa, 1964 and Samuelson, 1964) demonstrates how, under the assumption of economy-wide wage equalisation, international capital mobility and higher growth in relative labour productivity (tradables vs. non-tradables) can lead to higher relative inflation (non-tradables vs. tradables) and in turn, under the purchasing power parity (PPP) hypothesis for tradables, to a real appreciation of the currency in a country with higher growth in relative productivity. Given the adopted exposition of the Bergstrand model (see footnote 11), only the implication about relative inflation for one particular country is relevant here. Froot and Rogoff (1994) noted that in principle this mechanism refers to the Baumol-Bowen effect and not to the HBS model.[13] However, in many empirical papers no such a distinction is made and the term "internal HBS effect" is commonly used.

The HO hypothesis in the Bergstrand model links factor endowments and relative prices. Given the assumption that the production of tradables/non-tradables is more capital/labour intensive, the HO model implies relatively higher prices of non-tradables in countries that are relatively capital abundant (i.e., have comparative advantage in production of capital-intensive goods – under the assumption these are tradables). The demand effect refers to the Linder-type hypothesis (Linder, 1961), which relates the structure of consumption to GDP *per capita*. The higher the income, the higher relative consumption of non-tradables (services). Thus, according to this hypothesis, countries with faster economic growth (income) should experience higher growth in demand for non-tradables as compared to tradables and in turn relatively higher inflation in the non-tradable sector.

Finally, differences between demand and supply factors are discussed in broader perspective. Supply-side models are generally viewed as long-term models implying that in a small country consumer demand patterns do not affect relative prices of non-tradables (i.e. the supply is so elastic that demand shifts have no impact on relative prices) – Obstfeld and Rogoff (1996). In this case, demand matters only for quantity of produced/consumed goods. This paradigm requires that labour is perfectly mobile domestically and capital, in addition, internationally. Moreover, both tradables and non-tradables must be produced domestically. As Froot and Rogoff (1994) note, international mobility of capital is crucial as in the original HBS model it allows to tie down the interest rate. If this assumption does not hold (i.e. when a country is fully or partially shut off from world capital markets), the demand side of the model must be introduced. In addition, as the Bergstrand setup allows for endogenous supply responses (in contrast to the classical framework of HBS and HO models), the relative price

[13] To be more precise Baumol and Bowen (1966) analyse service-intensive goods rather than non-tradables (Obstfeld and Rogoff, 1996). However, one should expect a significant overlap between those two categories. The Baumol-Bowen effect (or the internal HBS) hinges primarily on the sectoral labour productivity differential and sectoral wage equalisation. On the other hand, the "overall" HBS requires in addition the PPP condition for tradables and international capital mobility. Consequently, the Baumol-Bowen effect is a necessary condition for the HBS effect, but not a sufficient one.

responses to their fundamentals are expected to be less elastic than under fully price-inelastic supply (Obstfeld and Rogoff, 1996).

4. Data definitions and sources

For estimations of two reduced-form equations of the Bergstrand model, four variables (relative productivity, relative output, income *per capita* and capital-labour ratio) are needed. The construction of a uniform and consistent database including these variables for all EU countries poses many problems which are briefly discussed below. The main sources of data are the OECD STAN database, Eurostat database and national statistical offices (for further details see Annex 2). The data are collected at an annual frequency.

Relative productivity is proxied by relative average labour productivity (tradables vs. non-tradables). This approach is suggested by Bergstrand (1991) in the empirical part of his paper.[14] For this purpose, the classification of tradables and non-tradables must be defined. Some controversy about this classification in the empirical literature exists and no standard methodology is proposed.[15] In this paper, a base classification defines tradables as manufactured goods, whereas non-tradables are construction, market and non-market services (see Annex 1). For the sensitivity check an alternative definition of non-tradables (which excludes non-market services) is pursued. Egert *et al.* (2003) find that different classifications of tradables and non-tradables have an impact on estimated elasticities. In addition, it is argued that due to problems with measuring non-market services value added (very often no direct output is observed), this sector should not be used for calculations of labour productivity (OECD, 2003). This reservation is especially relevant for an international comparison of productivity, which is, however, not pertinent to this paper (see Section 5). The neglect of agriculture, a feature of the work of Alberola and Tyrvainen (1998), is motivated by the fact that production of these goods is highly regulated and annual changes in output and prices are determined to a large extent by weather conditions and not technology advancements.

When discussing the computation of sectoral labour productivity, another relevant issue must be addressed. Average labour productivity in this paper is defined in terms of total employment (i.e. value added in constant prices per employed person – both employees and self-employed). However, it is generally acknowledged that productivity per hour worked is a better measure. Varying working hours and diverse treatment of self-employed and part-time workers may result in incorrect inferences about labour productivity in an international comparison. Unfortunately, due to data scarcity, hourly productivity measures cannot be employed. However, this is less of a problem for the Baumol-Bowen effect unlike the HBS effect (as an international comparison is not undertaken).

GDP *per capita* is constructed as GDP at constant prices (national currency) divided by the entire population.[16] Relative output is calculated based on the constant-price valued added in the relevant sectors. Given the above definition of labour productivity, relative prices are defined in terms of corresponding value-added deflators. This is the most consistent method and any potential bias due to the existence of regulated prices in consumer price indices is limited. The regulated prices are found to have a significant impact on estimates of relative

---

[14] Bergstrand pursues a cross-country OLS estimation for 21 countries in around 1975.

[15] For a further discussion on the tradables and non-tradables classification see, for instance, Rawdanowicz (2004).

[16] Refer to Annex 2 for detailed formulas of all variables.

price models for CEECs, as demonstrated among others by Egert *et al.* (2003) and MacDonald and Wojcik (2003).

Data for the variables described above are collected for 20 EU countries:[17] Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxemburg, the Netherlands, Poland, Portugal, the Slovak Republic, Spain, Sweden, and the UK. The length of times series among these countries differs significantly, with generally shorter series for the NMS (see Annex 3). Thus, estimations can be undertaken only for the unbalanced panel with the time dimension beginning for some countries as early as the 1970s and for others as late as the middle of the 1990s and ending between 2001 and 2003.

Finally, capital-labour ratios are calculated. This poses the biggest challenge due to the lack of meaningful data on capital stocks. For seven countries the ratios are computed using gross capital stocks in constant prices and total employment (Belgium, Denmark, Finland, France, Germany (post-1990), Italy, and the UK). However, this particular measure of capital input in production is very crude and imperfect. A better indicator is the net capital stock, which takes into account depreciation of capital and physical efficiency losses (OECD, 2003). Unfortunately, net capital stocks are available for even fewer countries. According to Schreyer (2003), the best proxy of capital stock as a production input is capital services. This term is based on the economic theory of production and refers to productive services from the cumulative stock of past investments for any given type of capital assets (Schreyer, 2003). Capital assets are not weighted by their value, but by their contribution to output and therefore better reflect productivity potential. Unfortunately, there are no time series of this indicator for the countries under investigation of sufficient length available. For the remaining countries the net capital stock is calculated using the perpetual inventory method.[18] This approach relates current capital stock to past capital stock, the rate of capital depreciation (consumption of capital), and the rate of new investment. Thus, given the data on fixed investment and the assumed capital depreciation rate, one can approximate capital stock. The problem with this method is that the depreciation rate depends substantially on the type of capital assets and is thus very unlikely to be constant across time and countries. However, using aggregated data leaves no choice other than to assume a constant depreciation rate. In this case, the perpetual inventory method may render only a very crude and possibly biased measure of capital stock.

5. Model estimations

The key objective of this paper is to test empirically the predictions of the Bergstrand model concerning determinants of relative inflation for the sample of EU countries and in turn investigate differences between the new and old EU member states. From this perspective, equation (3) is the key testable relation. It should be viewed as a long-term structural model of the relative inflation that encompasses the three alternative hypotheses. However, as Bergstrand (1991) suggests, in order to interpret the demand effect properly the income variable sign in equation (4) should also be investigated (see Section 3).

[17] Due to a break in times series for Germany in 1991 this country is treated as two separate countries – West Germany prior to 1991 and the united Germany starting from 1991. Thus, in fact there are 21 countries. No data are collected for Cyprus and Malta, and Slovenia as time series for employment of sufficient length are not available.

[18] Data based on this method are eventually not used in this paper – see footnote 21.

Pooling information both across time and countries is widely believed to bring more reliable parameter results and has recently been applied in empirical investigation of a variety of issues in international macroeconomics. Panels with a large time dimension should be better suited to handle adjustments dynamics, but they require addressing the issue of non-stationarity in the data. In recent years several methods of estimation and testing cointegration (unit roots) in dynamic panels have been developed (see Harris and Sollis, 2003). In this paper the panel group mean FMOLS estimator devised by Pedroni (2000) is employed.

This method draws on the time-series fully modified OLS estimator developed by Hansen and Phillips (1990). This is a semi-parametric approach which deals with endogeneity in single-equation models (in terms of contemporaniety and the failure of weak exogeneity – Patterson, 2000). This feature is especially important as, normally, estimations of reduced-form equations would lead to a simultaneous equation bias. Given a simple panel regression with *N* countries (*i=1,…, N*) and *T* periods (*t=1,…, T*):

$$y_{it} = \alpha_i + \beta_i x_{it} + u_{it} \tag{5}$$

the group mean FMOLS estimator is calculated as:

$$\hat{\beta}^*_{GMFM} = N^{-1}\sum_{i=1}^{N}\hat{\beta}^*_{FM,i} \tag{6}$$

which is a simple average of country-specific FMOLS estimators:

$$\hat{\beta}^*_{FM,i} = N^{-1}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}(x_{it}-\bar{x}_i)^2\right)^{-1}\left(\sum_{t=1}^{T}(x_{it}-\bar{x}_i)y^*_{it} - T\hat{y}_i\right) \tag{7}$$

where

$$y^*_{it} = (x_{it}-\bar{x}_i) - \frac{\hat{\Omega}_{21i}}{\hat{\Omega}_{22i}}\Delta x_{it} \tag{8}$$

$$\hat{y}^*_i = \hat{\Gamma}_{21i} + \hat{\Omega}^0_{21i} - \frac{\hat{\Omega}_{21i}}{\hat{\Omega}_{22i}}(\hat{\Gamma}_{22i} + \hat{\Omega}^0_{22i}) \tag{9}$$

and Ω and Γ are covariances and weighted sums of covariances obtained from long-term a covariance matrix of panel regression (5). Given the averaging of country specific estimates, this method is prone to outliers in country-specific estimates. A semi-parametric approach – such as FMOLS – does not, however, sacrifice many degrees of freedom and can be performed for an unbalanced panel. This method is best suited for assessing economic interpretation of a model as it focuses on testing significance and magnitudes of elasticities. It does not, however, formally test if the long-term relation (cointegration) stipulated by the economic model exists.[19]

Prior to a discussion of the results it should be noted that all estimations are undertaken for relative inflation (or quantities) from the perspective of a single particular country – i.e. without relating variables to some reference country in an analogy to the Baumol-Bowen

[19] For selected specifications of the Bergstrand model the existence of cointegrating vectors is formally tested by Pedroni (1999) panel cointegration tests (see Section 5.2 and Annex 4).

model. This approach has two advantages. Firstly, the problem of comparing different indices across countries is circumvented. Different weights and goods or services used in computation of the indices make international comparison difficult (see for instance Sarno and Taylor, 2002). This is especially relevant for comparison of price indices. Secondly, as noted by O'Connell (1998), estimations with variables normalised to one country may lead to cross-sectional dependence in time series panel data.

All the variables used in the estimations of the Bergstrand model are in logs and are treated as I(1) processes as inferred from Pedroni (1999) panel unit-root tests.[20]

5.1. The curtailed version of the Bergstrand model

Given only very few officially available time series for gross capital stock – which are anyhow a very crude and deficient measure of capital productive potential, the very short-time series for the NMS (which makes estimations with many observations questionable), and unsuccessful estimations with proxies of capital stock,[21] it has been decided to estimate the Bergstrand model without the capital-labour ratio – hence the curtailed version of the Bergstrand model. This does not mean that the capital-labour ratio is discarded as a potential explanatory variable, but that its meaningful econometric testing is virtually impossible. This also eliminates a potential problem of multicollinearity between income *per capita* and the capital-labour ratio. Countries with higher GDP *per capita* tend to have a higher capital-labour ratio.[22]

Table 1 shows the results of various forms of equations (3) and (4). The estimation of the curtailed version of the Bergstrand model renders generally significant and correctly signed panel elasticities. The alternative classification of non-tradables affects the significance of income *per capita* in the relative price equation. At the same time, estimations of the relative output equation of the curtailed version of the Bergstrand model prove a positive link between income *per capita* and relative output, confirming the expected mechanism behind the demand effect – see Section 3.

In order to gain more insights into productivity-driven relative inflation (the Baumol-Bowen effect), an unrestricted-productivity model is estimated. In this model productivity in tradables (PRO_T) and in non-tradables (PRO_N) enter the equation separately. This exercise aims at testing economic interpretation of this mechanism. In a standard model, labour productivity in tradables should enter with a positive sign, whereas productivity in non-tradables with a negative one. However, an alternative hypothesis of the non-tradables processing component (or distribution sector) is developed in which productivity in non-tradables can enter with a positive sign.[23] The empirical investigation in the literature provides some support to the distribution sector hypothesis (see MacDonald and Ricci (2001) and Lee

[20] Test results are available from the author upon request.

[21] Two sets of models were estimated. The first included seven countries for which the official data on gross capital stock were available. In the second set, the capital-labour ratio was derived using the perpetual inventory method (under the very crude assumption that depreciation rates are uniform across time and countries – making the capital stock dependent on investment growth only). In both approaches there were problems with the significance and signs of the capital-labour ratio. These estimation results are not reported here but are available from the author upon request.

[22] Though this problem seems to be more acute for cross sectional estimations (as in Bergstrand, 1991) rather than time series estimations.

[23] Depending on the assumption whether the distribution sector is more important for production of goods and services or for their final delivery to customers and how well it is proxied by the overall non-tradable sector.

and Tang (2003) for developed countries and Rawdanowicz (2004) for CEECs). The results in this paper corroborate the standard interpretation of the internal HBS effect. However, they should be treated with caution as the increase in the number of explanatory variables reduces the degrees of freedom and potentially introduces a correlation between productivity in the tradable sector and income *per capita*.

Table 1. The curtailed version of the Bergstrand model

Relative price equation – equation (3)							
	RP1		RP1		RP4		RP4
R_PRO1	0.46***	PRO_T	0.39***	R_PRO4	0.50***	PRO_T	0.45***
(t-stat.)	(12.9)		(10.7)		(15.2)		(13.1)
		PRO_N	-0.64***			PRO_N2	-0.42***
(t-stat.)			(-4.7)				(-8.9)
YPC	0.10***	YPC	0.31***	YPC	0.13	YPC	0.04***
(t-stat.)	(6.0)		(5.6)		(1.4)		(6.2)
Relative output equation – equation (4)							
	RC1		RC1		RC4		RC4
R_PRO1	-0.48***	PRO_T	-0.44***	R_PRO4	-0.48***	PRO_T	-0.48***
(t-stat.)	(-13.8)		(-17.4)		(-17.1)		(-24.0)
		PRO_N	0.91***			PRO_N2	0.71***
(t-stat.)			(16.8)				(21.4)
YPC	0.56***	YPC	0.22***	YPC	0.65***	YPC	0.40***
(t-stat.)	(20.9)		(7.6)		(30.3)		(20.3)

Source: Author's calculations.

Notes: *, **, *** – significant at 90%, 95%, and 99% level. For the description of variables see Annex 2. For all 4 models in the table the following 22 countries are used (number of time observations in brackets): CZE(9), EST(11), HUN(11), POL(8), SVK(10), AUT(27), BEL(33), DNK(33), FIN(33), FRA(24), DEU(12), GRC(7), ITA(33), LUX(18), NLD(16), PRT(23), ESP(22), SWE(23), GBR(31), DEW(22), LAT(8), LIT(7).

5.2. Country-block differences

Having estimated various specifications of the curtailed Bergstrand model for the EU countries as a group, differences between the new and old Member States can be investigated.[24] Table 2 contains estimates for the relative price and output equations for the two blocks of countries under investigation (only for the base definition of non-tradables). The first observation is that for the NMS relative productivity and for the OMS income *per capita* are insignificant (also for the unrestricted-productivity model). In addition, in the unrestricted-productivity model, labour productivity in tradables for the NMS is not significant. The lack of support for the relative productivity effect in the NMS contrasts with the findings in other studies (see Section 2). Relatively large differences in point estimates between two country blocks are also evident.

The significance of the demand effect in the NMS as opposed to the OMS may stem from the fact that many services were underdeveloped under the previous economic regime and during the initial stage of economic transformation in the 1990s there was rapid growth in service sectors accompanied by a strong shift in the consumption structure. International financial

[24] This division does not correspond perfectly to the euro area "in" and "out" countries but is a close proxy. It is reasonable to expect more differences in the Bergstrand model between old and new Member States rather than between strictly "in" and "out" countries.

integration as a factor may also provide some explanation for this outcome. As mentioned in Section 3, if the international capital mobility assumption is violated then the demand side must be introduced to the model. Limited international mobility of capital seems to be a common feature of CEECs in their early years of transition. An underdeveloped financial system and controls on capital flows contributed to this. If both explanations are plausible, then the demand mechanism should be expected to be less important for the NMS in the future and the determination of relative inflation should become more dependent on relative productivity, as is currently the case for the OMS.

Table 2. Country-block estimations of the Bergstrand model

	New Member States (NMS)			Old Member States (OMS)			
	Relative price equation – equation (3)						
	RP1		RP1		RP1		RP1
R_PRO1	0.23	PRO_T	0.08	R_PRO4	0.57^{***}	PRO_T	0.54^{***}
(t-stat.)	(1.5)		(1.1)		(14.6)		(12.2)
		PRO_N	-1.05^{***}			PRO_N	-0.45^{*}
			(-4.6)				(-2.6)
YPC	0.17^{***}	YPC	1.03^{***}	YPC	0.06	YPC	-0.02
(t-stat.)	(10.8)		(7.2)		(-0.1)		(1.9)
	Relative price equation – equation (4)						
	RC1		RC1		RC1		RC1
R_PRO1	-0.87^{***}	PRO_T	-0.73^{***}	R_PRO4	-0.30^{***}	PRO_T	-0.31^{***}
(t-stat.)	(-15.0)		(-18.8)		(-6.5)		(-8.3)
		PRO_N	0.88^{***}			PRO_N	0.92^{***}
			(9.8)				(13.7)
YPC	0.43^{***}	YPC	0.18^{***}	YPC	0.62^{***}	YPC	0.24^{***}
(t-stat.)	(12.8)		(4.7)		(16.6)		(5.6)

Source: Author's calculations.

Notes: *, **, *** – significant at 90%, 95%, and 99% level. For the description of variables see Annex 2. For the first two models in the table the following 7 countries are used (number of time observations in brackets): CZE(9), EST(11), HUN(11), POL(8), SVK(10), LAT(8), LIT(7); and for the last 2 models 15 countries: AUT(27), BEL(33), DNK(33), FIN(33), FRA(24), DEU(12), GRC(7), ITA(33), LUX(18), NLD(16), PRT(23), ESP(22), SWE(23), GBR(31), DEW(22).

Estimations of the relative-output model for both groups support the underlying assumption of a positive relation between income *per capita* and relative output of non-tradables (see Table 2). For this set of equations elasticities are broadly in line with each.

While interpreting country-block results it should be stressed that the time series for the NMS are very short and that this group contains a relatively small number of countries which experienced a number of country-specific shocks in the period under investigation. Consequently, the results for the NMS seem to be less reliable than for the OMS and should be treated with particular caution. These facts may also explain the difficulty in finding support for the supply-side determinants of relative inflation in the NMS.

Finally, it should be noted that in addition to panel group mean FMOLS estimations of the curtailed Bergstrand model's coefficients, formal tests are conducted to check whether the long-term relationships indicated by the model actually exist. For this purpose the Pedroni (1999) procedure is used. It calculates seven different panel cointegration statistics. The cointegration tests apply only to models with the base definition of tradables and non-tradables (see Annex 4). Although, not all cointegration test statistics render the same result, most of them indicate significant cointegration relations.

6. Policy implications

In Section 5, relative labour productivity and demand factors (as defined in the Bergstrand model) are demonstrated to be important determinants of relative inflation in EU countries. Hence, as long as there are differences in growth rates of relative productivity and income *per capita*, relative inflation in EU countries will differ accordingly. Under the assumption of similar inflation of tradables (which is more likely to hold for euro area countries than non-euro area countries as volatility of bilateral nominal exchange rate is eliminated), this implies that overall inflation differentials will persist. They are likely to be higher in the NMS, given their recent record of growth in income *per capita* and relative productivity, as well as their income gaps vis-à-vis the euro area average. In 2004, the gap varied between around 27% and 80% and this suggests still a large scope for catching-up. In this context, the key policy implications of the above-mentioned mechanisms are discussed with particular reference to the arguments articulated in the existing literature.

Should the inflation differential be a concern for monetary authorities in the euro area and does it require policy intervention? The ECB's view is that inflation differentials resulting from integration of markets or convergence in price levels should not pose problems to economic policy (ECB, 1999). Similar opinions are expressed by Honohan and Lane (2003) and De Grauwe (2003). They argue that inflation differentials or inflationary pressures stemming from the HBS effect or adjustments in the structures of consumer baskets should not trigger changes in monetary policy.

Although the ECB has neither the mandate nor the tools to address and control inflation developments at the country level, inflationary pressures stemming from structural factors are not entirely irrelevant to policy makers. As De Grauwe (2003) argues, inflation caused by the HBS mechanism has implications for the inflation target (see also Sinn and Reutter (2001) and Honohan and Lane (2003)). Any amendment in the price stability definition would require precise and robust estimates concerning the impact of the relative price adjustments on overall inflation. There are essentially three problems with such an analysis. Firstly, the conversion of relative inflation into overall inflation requires an identifying assumption. In an international comparison, it is usually assumed that tradables prices are identical. This working hypothesis is very strong and has important implications for the calculations of total inflation. In the real world, however, it may be far from true (see below). Secondly, precise estimates of relative inflation models are difficult to obtain. In the particular case of this paper, although the estimations proving the relation between relative prices and relative productivity and income *per capita* (as indicated by the Bergstrand model) hold empirically for the EU countries as a group, the estimated panel elasticities – both in terms of their magnitudes and significance – do not have to reflect precisely any given country-specific situation. Therefore, making calculations for a given country based on the obtained panel estimates is risky. Thirdly, monetary authorities deciding to change an inflation target are more interested in future than past developments. Consequently, in order to make inferences about future structural inflation due to changes in relative prices one should not only have precisely estimated elasticities deduced from a model, but also assume various predictions about the explanatory variables. This makes the task even less certain.

With the above caveats in mind, the panel elasticities applied to each analysed country indicate that on average in 1995-2001 the Bergstrand model (as captured by average changes in relative labour productivity and GDP *per capita* for a particular country) have caused relative inflation differentials of between 0 and 4.7 percentage points.[25] This implies that if the prices of tradables in all EU countries had grown at the same pace, the differences between the lowest and the highest inflation would have been around 3.6 percentage points.[26] However, tradables inflation has been quite diversified, with the spread amounting to 12.8 percentage points. Overall, in 1995-2000 tradables inflation in the analysed NMS reached 5.7% (annual average rate) and in the OMS 0.6%. This comparison does not take into account changes in nominal exchange rates within the block of the euro area countries and NMS (some changes in tradables prices could be an equilibrium phenomenon and reflect changes in nominal exchange rates in line with the PPP condition) nor changes in the exchange rate and tradable prices against the rest of the world.[27] It seems that upon fixing nominal exchange rates in the ERM II or the euro area, the differences in tradables inflation between the NMS and OMS should not be that pronounced.[28] Besides, to calculate the current or enlarged euro area average inflation one would have to apply the appropriate country weights. In this context, fears about higher inflation in the enlarged euro area due to stronger price increases in the NMS seem to be exaggerated as NMS have a low share in the euro area inflation aggregate.[29]

By analogy, in the context of euro area enlargement, structural inflation is invoked to question the appropriateness of the inflation criterion, which together with other Maastricht criteria, determines countries' readiness to join the monetary union. One line of reasoning suggests that structural inflation may lead to inflation so high that the Maastricht inflation criterion (i.e. HICP inflation not higher than 1.5 percentage points above average inflation for the three lowest-inflation countries in the EU) cannot be satisfied. In this situation, it is claimed that such countries would have to pursue restrictive monetary policy so as to bring inflation down to below the "equilibrium" level. This allegedly would lead to a trade-off between nominal and real convergence. Although, according to very rough estimates subject to a number of the above-mentioned caveats, it seems that for some countries relative price adjustments could in fact pose a problem in meeting the Maastricht inflation criterion, there are three reservations to this trade-off.

Firstly, the Bergstrand model refers to structural long-term inflation, but in the short-term inflation may be affected by a number of factors not related to relative price inflation.

---

[25] These numbers are calculated only for demonstrative purposes and are sensitive to the sample selection. The choice of the period 1995-2001 is determined by two considerations: limiting short-term shocks that could impact calculations, if based on one particular year, and the availability of data for all analysed countries in the most recent possible period.

[26] This figure depends on an assumption about the weights of tradables and non-tradables in the overall consumption basket. The presented calculations are based on the average weights for value added deflators (77% for non-tradables). If the overall inflation index for two countries (i=1,2) is given by $p_i = \alpha p_{N,i} + (1-\alpha)p_{T,i}$, where α is the weight of non-tradables prices, and if tradables inflation is identical, then the overall inflation differential amounts to $\alpha(p_{N,1} - p_{N,2})$. As these figures refer to value added deflators, they are not directly comparable with HICP inflation which is used for the Maastricht inflation criterion.

[27] While comparing relative/overall inflation among EU countries, it is implicitly assumed that the outside world does not have any effect on prices in the EU, which is a somewhat strong assumption to make.

[28] However, the impact of changes in exchange rates and tradables prices in the rest of the world will not be eliminated. In fact, Honohan and Lane (2003) argue that a differentiated geographic structure of foreign trade and ensuing sensitivity to euro exchange rate shifts in euro area countries is one of the important factors behind divergent trends in import and consumer inflation in 1999-2001.

[29] In 2004, the share of ten NMS in average HICP of the hypothetical enlarged euro area was around 10%.

Therefore, structural inflation may be of little importance in meeting the Maastricht inflation criterion and policy measures may not be needed to lower inflation below its long-term "equilibrium" level.[30] Although inflation stability should be achieved on a sustainable basis, once a country joins the euro area, the Maastricht inflation criterion is no longer binding. This does not mean that high inflation would be desirable, but there will be neither any lawful obligation to contain structural inflation nor tools to tackle it, so the trade-off will no longer exist. In 2004, seven out of twelve euro area countries exhibited inflation rates above those implied by the Maastricht inflation criterion.

Secondly, real convergence is a long-term process and even if fulfilment of the Maastricht inflation criterion required tighter monetary policy for two or three years (and consequently slower GDP growth), this would probably make little difference to real convergence as the NMS have a long way to go to achieve the euro area average level of development.[31] Very simple calculations indicate that for the NMS it would take roughly between 17 and 54 years to bridge half of the current gap in GDP *per capita* with the euro area average.[32]

Thirdly, it remains debatable whether on the eve of euro area enlargement monetary policy in the NMS aimed at forcing inflation below its long-term "equilibrium" level can be effective and whether in some countries it is feasible at all. Given the delayed effects of changes in interest rates and uncertainty about the inflation criteria, engineering the desired level of inflation could be very difficult in practice. In addition, many NMS pursue different forms of fixed pegs and consequently their monetary policy independence is significantly limited. Overall, disregarding the inflation criterion, it is in the interests of the NMS to pursue credible monetary policy aimed at sustainable price stability. This seems to be the best strategy for euro area entry. The above arguments do not, however, exclude the possibility that accession to the euro area for some countries could be delayed as a consequence of the fact that Maastricht inflation criterion is based on the three lowest-inflation countries. Such a criterion makes little economic logic if, for instance, the three benchmark countries experience deflationary shocks or/and are non-euro area members as it does not necessarily reflect price stability conditions across the entire monetary union (as was pretty much the case in 2004), nor the achievement of a low inflation environment in the candidate countries.

Finally, arguments related to the costs of inflation differentials should be mentioned. The first concerns international competitiveness and the second with differences in real interest rates. Inflation differentials in the context of fixed nominal exchange rates (which is the case of euro area countries and to some extent of countries that are in the ERM II) are often treated as indicators of international competitiveness. However, for international trade it is more important to look at prices of tradables (measured in one currency) and not necessarily at overall inflation. However, in theoretical models it is usually assumed the PPP hypothesis holds for tradables prices – especially in the HBS framework. Consequently, by definition, international competitiveness is not affected by differences in the overall inflation (or relative inflation). This implies that inferences about international competitiveness drawn from empirical estimations of relative inflation models (such as the Bergstrand model) should in addition look at developments of tradables inflation. The evidence in favour of the PPP even for tradables solely is not clear-cut, but there is a consensus that in the short term the PPP

[30] Maastricht inflation criterion is based on the average annual HICP inflation rates over the past 12 months prior to the examination.
[31] Such an argumentation ignores any hysteresis effects.
[32] These calculations reflect the half-lives based on average growth rates in GDP *per capita* relative to the euro area between 1996 and 2004.

does not hold and a mean reversion is quite lengthy. For instance, Rawdanowicz (2004) shows that in the NMS in the 1990s and the early 2000s the PPP does not hold even for tradables prices. If this is the case, international competitiveness may be affected and drawing conclusions on overall inflation differences from relative price models becomes more complicated.

Regarding differences in real interest rates, with common monetary policy and inflation differentials among monetary union members, differences in real interest rates may affect the degree of monetary policy restrictiveness in particular member states and cause wealth redistribution effects. Honohan and Lane (2003) note that sustained inflation differentials and the fear of weak adjustment mechanisms may lead to boom-bust cycles. They argue that countries with higher overall inflation (due to low real interest rates) are likely to experience overheating tendencies. On the other hand, Honohan and Lane note that the concomitant appreciation of real exchange rates (in terms of overall inflation) should act as a coolant factor (due to a deterioration in competitiveness). However, in the light of the previous paragraph, if overall inflation differentials stem from relative price differences and the PPP hypothesis holds for tradables, there will be no deterioration in competitiveness and the ensuing coolant effect will not be effective. Overall, the aspect of tradables prices equalisation is very crucial and deserves closer examination.

7. Conclusions

This paper aims at a standardised investigation of relative inflation for EU member states. The analysis is based on the theoretical model developed by Bergstrand (1991). This framework incorporates three alternative hypotheses of relative inflation – the sectoral productivity differential, demand effect and the relative capital-labour endowments effect. Various specifications of this model are estimated using the panel group mean FMOLS estimator developed by Pedroni (2000). It is suitable for dynamic panels where non-stationarity of variables is expected. Empirical estimations generally support the Bergstrand model, however due to problems with collecting reliable data on capital stocks, it is not possible to estimate the model including the capital-labour ratio. In the curtailed version of the model, labour productivity and the demand effect turn out to be generally significant and correctly signed. Also the key assumption behind the demand effect – on the positive relation between income and relative demand for non-tradables – is supported by the data. For the sake of a sensitivity and robustness check, various alternative specifications of the Bergstrand model are tested – in particular with regard to definitions of non-tradables and country-block grouping. The alternative classification of non-tradables generally does not result in a significant variation of estimated elasticities. The separate estimations for the NMS and OMS indicate differences in the mechanism of relative price determination. The demand effect turns out insignificant for the old Member States, whereas for the new Member States the relative productivity effect is insignificant. Although, the short data sample for the NMS undermines credibility of the empirical results for this group, the differences are consistent with theoretical considerations and the transition phenomenon (the shift in consumption towards non-tradables, development of market services, and limited access to international financial markets).

In general, the empirical investigation of this paper supports the findings of other studies especially as far as the significance of relative productivity and the demand effect in explaining movements of relative inflation are concerned. Given the many caveats in empirical estimations and problems with obtaining precise estimates of structural inflation, the results should be treated with caution and the ensuing policy implications should be carefully considered. In particular, relative inflation models are demonstrated to be a conceptually questionable framework for the analysis of overall inflation differentials – primarily due to a failure of the PPP hypothesis for tradables. Consequently, implications for the inflation target in the enlarged euro area, discussion on the Maastricht inflation criterion and international competitiveness are far from straightforward.

Bibliography

Alberola, E. and T. Tyrvainen (1998), 'Is There a Scope for Inflation Differentials in EMU? An Empirical Evaluation of the Balassa-Samuelson Model in EMU Countries', *Bank of Finland Discussion Paper*, No. 15/98, July

Asea, P.K. and E.G. Mendoza (1994), 'The Balassa-Samuelson Model: A General Equilibrium Appraisal', *UCLA Economics Working Paper*, No. 709, March

Balassa, B. (1964), 'The Purchasing Power Parity Doctrine: A Reappraisal', *Journal of Political Economy*, Vol. 72, pp. 584-596

Baumol, W.J. and W.G. Bowen (1966), *Performing arts: The economic dilemma*, New York: Twentieth Century Fund

Bergstrand, J.H. (1991), 'Structural Determinants of Real Exchange Rates and National Price Levels: Some Empirical Evidence', *American Economic Review*, Vol. 1, Issue 1, March, pp. 325-334

Canzoneri, M.B., R.E. Cumby, and B. Diba (1996), 'Relative Productivity and the Real Exchange Rate in the Long Run: Evidence for a Panel of OECD Countries', *CEPR Discussion Papers*, No. 1464

Canzoneri, M.B., R.E. Cumby, and B. Diba (2001), 'Productivity trends in Europe: Implications for Real Exchange Rates, Real Interest Rates and Inflation', *update of* Canzoneri, Cumby and Diba (1996)

Chinn, M. and L. Johnston (1996), 'Real Exchange Rate Level, Productivity and demand Shocks: Evidence from a Panel of 14 Countries', *NBER Discussion Paper*, No. 5709, August

Cihak, M. and T. Holub (2001), 'Convergence of Relative Prices and Inflation in Central and Eastern Europe, *IMF Working Paper*, No. WP/01/124, September

De Broeck, M. and T. Slok (2001), 'Interpreting real exchange rate movements in transition countries', *Bank of Finland Institute for Economies in Transition Discussion Papers*, No. 7

De Grauwe, P. (2003), *Economics of Monetary Union*, chapter 8, fifth edition, Oxford University Press, Oxford

De Gregorio, J., A. Giovannini, and H. Wolf (1994), 'International Evidence on Tradables and Nontradables Inflation', *European Economic Review*, Vol. 38, pp. 1225–1244

Dobrinsky, R. (2001), 'Convergence in Per Capita Income Levels, Productivity Dynamics and Real Exchange Rates in the Candidate Countries on the Way to EU Accession', *International Institute for Applied Systems Analysis Interim Report*, IR-01-038/September

ECB (1999), *Monthly Bulletin*, October

ECB (2003), 'Inflation Differentials in the Euro Area: Potential Causes and Policy Implications', *MPC report,* September

Egert, B. (2003), 'Assessing Equilibrium Exchange Rates in CEE Acceding Countries: Can We Have DEER with BEER without FEER? A Critical Survey of the Literature', *Focus on Transition*, Vol. 2, Oesterreichische Nationalbank, pp. 38-106

Egert, B., I. Drine, K. Lommatzsch, and C. Rault (2003), 'The Balassa-Samuelson effect in Central and Eastern Europe: Myth or reality? A panel study', *Journal of Comparative Economics*, Vol. 31, September, pp. 552–572

Egert, B., D. Ritzberger-Grunwald, and M.A. Silgoner (2003), 'Inflation Differentials in Europe: Past Experience and Future Prospects', *Focus on Transition*, Vol. 2, Oesterreichische Nationalbank, pp. 47-72

Froot, K.A. and K. Rogoff (1994), 'Perspectives on PPP and Long-Run Real Exchange Rates', *NBER Working Paper*, No. 4952, December

Halpern, L. and C. Wyplosz (2001), 'Economic Transformation and Real Exchange Rates in the 2000s: The Balassa-Samuelson Connection', *United Nations Economic Commission for Europe – Economic Survey of Europe*, No. 1, pp. 227-239

Hansen, B.E. and P.C.B. Phillips (1990), 'Estimation and Inference in Models of Cointegration', in T.B. Fomby and G.F. Rhodes, Jr (eds), *Advances in Econometrics*, Vol. 8, JAI Press, Connecticuat, pp. 225-248

Harris, R. and R. Sollis (2003), *Applied Time Series Modelling and Forecasting*, chapter 7, John Wiley & Sons Ltd, Chichester

Harrod, R.J. (1933), *International economics*, James Nisbet and Cambridge University Press, London

Honohan, P. and P.R. Lane (2003), 'Divergent inflation rates in EMU', *Economic Policy*, CEPR, CES, MSH, Vol. 18(37), pp. 357-394

Jones, R. W. (1965), 'The Structure of Simple General Equilibrium Models', *Journal of Political Economy*, Vol. 73, December, pp. 557-572

Lee, J. and M.K. Tang (2003), 'Does Productivity Growth Lead to Appreciation of the Real Exchange Rate?', *IMF Working Paper*, No. WP/03/154, July

Linder, S.B. (1961), *An Essay on Trade and Transformation*, Wiley, New York

MacDonald, R. and L. Ricci (2001), 'PPP and the Balassa Samuelson Effect: The Role of the Distribution Sector', *IMF Working Paper*, No. WP/01/38, March

MacDonald, R. and C. Wojcik (2003), 'Catching Up: The Role of Demand, Supply and Regulated Price Effects on the Real Exchange Rates of Four Accession Countries', *Strathclyde Discussion Papers in Economic*, No. 03-02

Obstfeld, M. and K. Rogoff (1996), *Foundations of International Macroeconomics*, chapter 4, MIT Press

O'Connell, P. (1998), 'The overvaluation of Purchasing Power Parity', *Journal of International Economics*, Vol. 44(1), pp. 1-19

OECD (2002), 'Inflation persistence in the euro area', *special chapter in OECD Economic Outlook*, No. 72, December

OECD (2003), STAN Database Documentation, October,
http://www.oecd.org/document/15/0,2340,en_2825_495649_1895503_1_1_1_1,00.html

Patterson, K.D. (2000), *An Introduction to Applied Econometrics: A Time Series Approach*, chapter 9, Palgrave Macmillan

Pedroni, P. (1999), 'Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors', *Oxford Bulletin of Economics and Statistics*, Vol. 61, pp. 653-670

Pedroni, P. (2000), 'Fully modified OLS for heterogeneous cointegrated panels', in B.H. Baltagi, T.B. Fomby and R.C. Hill (eds), *Nonstationary Panels, Panel Cointegration, and Dynamic Panels, Advances in Econometrics*, Vol. 15, Elsevier Science, Amsterdam

Rawdanowicz, L.W. (2004), 'Panel estimations of PPP and relative price models for CEECs: Lessons for real exchange rate modelling', *CASE Studies and Analyses*, No. 276, May

Samuelson, P. (1964), 'Theoretical Notes on Trade Problems', *Review of Economics and Statistics*, Vol. 46, pp. 145-154

Sarno, L. and M.P. Taylor (2002), *The economics of exchange rates*, chapter 3, Cambridge University Press, Cambridge

Schreyer, P. (2003), 'Capital Stocks, Capital Services and Multi-factor Productivity Measures', *OECD Draft Paper Economic Studies*, November

Sinn, H.W. and M. Reutter (2001), 'The minimum Inflation Rate for Euroland', *NBER Working Paper*, No. 8085, January

Annex 1. Classification of tradables and non-tradables

The grouping is based on the International Standard Industrial Classification, Revision 3. Tradables (**T**): Manufacturing (1537). For Latvia, Lithuania, and the Slovak Republic due to the limited data availability, a broader definition of tradables is adopted (**T**): Industry – Mining and quarrying; Manufacturing; and Electricity, gas and water supply (1014, 1537, and 4041). This is a second-best classification as electricity, gas and water supply seem to have the characteristics of non-tradables. Overall, manufacturing comprises the biggest share of total industry and the inclusion of mining and energy sectors should not make much difference.

Non-tradables. **N**: Construction; Wholesale and retail trade, restaurants, etc., Transport and storage, communication; Finance, insurance, real estate and business activities; Community, social and personal services (4500, 5055, 6064, 6574, and 7599); **N2**: Construction; Wholesale and retail trade, restaurants, etc., Transport and storage, communication; Finance, insurance, real estate and business activities (4500, 5055, 6064, and 6574).

Annex 2. Data definitions and sources

All formulas below refer to mathematical operations in logarithms. The following variables are calculated for every country.

Name	Definition	source
VA_T	Value added at current prices in tradables	STAN database; national sources for EST; Eurostat database for LAT, LIT, SLO
VA_N/N2	Value added at current prices in non-tradables	
VAK_T	Value added at constant prices in tradables	
VAK_N/N2	Value added at constant prices in non-tradables	
P_T	Prices of tradables P_T = VA_T – VAK_T	*derived*
P_N	Prices of tradables P_N = VA_N – VAK_N	*derived*
P_N2	Prices of tradables P_N2 = VA_N2 – VAK_N2	*derived*
RP1	Relative prices: RP1 = P_N – P_T	*derived*
RP4	Relative prices: RP4 = P_N2 – P_T	*derived*
EMPN	Total employment	STAN database; national sources for EST; Eurostat database for LAT, LIT, SLO
EMP_T	Employment in tradables	
EMP_N/N2	Employment in non-tradables	
PRO_T	Average labour productivity in tradables: PRO_T = VAK_T – EMP_T	*derived*
PRO_N	Average labour productivity in non-tradables: PRO_N = VAK_N – EMP_N	*derived*
PRO_N2	Average labour productivity in non-tradables: PRO_N2 = VAK_N2 – EMP_N2	*derived*
R_PRO1	Relative labour productivity: R_PRO1 = PRO_T – PRO_N	*derived*
R_PRO4	Relative labour productivity: R_PRO4 = PRO_T – PRO_N2	*derived*
RC1	Relative consumption/supply of non-tradables: R_PRO1 = VAK_N – VAK_T	*derived*
RC4	Relative consumption/supply of non-tradables: R_PRO4 = VAK_N2 – VAK_T	*derived*
POP	Population	Eurostat database
GDPV	GDP at constant prices	Eurostat database
YPC	GDP per capita: YPC = GDPV – POP	*derived*
CAPK	Gross capital stock at constant prices	STAN database and UK National Statistical Office for the UK
CLR	Capital-labour ratio: CLR = CAPK – EMPN	*derived*

Annex 3. Data sample

	Data sample			Data sample	
	start	end		start	end
Austria (AUT)	1976	2002	Italy (ITA)	1970	2002
Belgium (BEL)	1970	2002	Latvia (LAT)	1995	2002
Czech Rep. (CZE)	1993	2001	Lithuania (LIT)	1995	2001
Denmark (DNK)	1970	2002	Luxemburg (LUX)	1985	2002
Estonia (EST)	1993	2003	Netherlands (NLD)	1986	2001
Finland (FIN)	1970	2002	Poland (POL)	1995	2002
France (FRA)	1978	2001	Portugal (PRT)	1977	1999
Germany (DEU)	1991	2002	Slovak Rep. (SVK)	1994	2003
Germany (DEW)	1970	1991	Spain (ESP)	1980	2001
Greece (GRC)	1995	2001	Sweden (SWE)	1980	2002
Hungary (HUN)	1992	2002	United Kingdom (GBR)	1971	2001

Note: The samples indicated above may slightly differ across various models.

Annex 4. Panel cointegration tests

Cointegration equations:	YPC, R_PRO1, RP1	RP1, PRO_T, PRO_N, YPC	RP1, R_PRO1, YPC	RP1, PRO_T, PRO_N, YPC	RP1, R_PRO1, YPC	RP1, PRO_T, PRO_N, YPC
Without trend						
panel v-stat	1.5*	0.7	-0.1	-0.5	2.4***	1.5*
panel rho-stat	-1.3*	-0.1	0.1	0.5	-1.2	-0.2
panel pp-stat	-1.9**	-2.5***	-1.7**	-4.4***	-1.9**	-1.6*
panel adf-stat	-1.9**	-2.3***	-1.2	-3.3***	-2.2***	-1.8**
group rho-stat	1.6	2.6	1.7	2.1	0.8	1.7
group pp-stat	-1.5*	-3.5***	-0.7	-4.4***	-1.3*	-1.3
group adf-stat	-1.5*	-2.9***	-0.1	-2.7***	-1.8**	-1.7**
With trend						
panel v-stat	0.6	-0.2	-0.5	-1.2	1.2	1.0
panel rho-stat	0.5	1.6	1.1	1.8	0.3	1.1
panel pp-stat	-1.6*	-1.7**	-2.9***	-4.6***	-1.1	-0.7
panel adf-stat	-1.0	-0.4	-1.1	-0.9	-1.3*	-0.8
group rho-stat	3.1	4.3	2.4	3.3	2.1	3.0
group pp-stat	-3.5***	-5.9***	-5.0***	-9.6***	-0.8	-0.6
group adf-stat	-1.4*	-1.6**	-1.0	-1.8**	-1.1	-0.8
Countries included:	CZE(9), EST(11), HUN (11), POL(8), SVK(10), AUT(27), BEL(33), DNK (33), FIN(33), FRA(24), DEU(12), GRC(7), ITA (33), LUX(18), NLD(16), PRT(23), ESP(22), SWE (23), GBR(31), DEW (22), LAT(8), LIT(7).		CZE(9), EST(11), HUN (11), POL(8), SVK(10), LAT(8), LIT(7)		AUT(27), BEL(33), DNK (33), FIN(33), FRA(24), DEU(12), GRC(7), ITA (33), LUX(18), NLD(16), PRT(23), ESP(22), SWE (23), GBR(31), DEW(22)	

Source: Author's calculation.

Note: The panel cointegration tests are based on the procedure developed by Pedroni (1999). The null hypothesis is of non-cointegration. The first four panel tests refer to within-dimension estimators, whereas the last three to group-mean estimators. Therefore, the alternative hypothesis is different for these two groups. In the first case, the homogeneity of cointegration vectors is implied and in the second the vectors are allowed to vary. The test statistics are one-sided tests under the standard normal distribution. Under the alternative hypothesis, the panel v-statistics diverges to positive infinity, whereas other test statistics diverge to negative infinity.