HITTING AND HOPING: MEETING THE EXCHANGE RATE AND INFLATION CRITERIA DURING A PERIOD OF NOMINAL CONVERGENCE

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Abstract
This paper analyses the effect of price level convergence on the ability of Central and Eastern European Countries (CEECs) to meet both the inflation and the exchange rate criteria for Eurozone entry. The size of these convergence effects on the exchange rate (for inflation targeters) and for inflation differentials (under a fixed exchange rate) is estimated for a variety of different convergence scenarios. The key result, robust across all scenarios, is that countries with fixed exchange rates will find it much harder to simultaneously meet the criteria than inflation targeters. Convergence effects on inflation could keep countries with fixed exchange rates out of the Euro for a decade or more, whereas under inflation targeting, the 15% bands of ERM-II could provide sufficient room to accommodate convergence effects via the exchange rate.

JEL Codes: E52, E61, E31

Keywords: Central and Eastern Europe, Balassa Samuelson Effect, Convergence, Euro Adoption

1. Introduction

The eight Central and Eastern European countries (CEECs) who are EU members with a derogation from the single currency are all obliged to join the Euro at some point in the future. Admittance to the Eurozone is based on the fulfilment of the convergence Maastricht Criteria. In addition to nominal interest rate convergence and sound public finances,
candidate countries are also required to demonstrate both exchange rate stability—defined as two years membership in ERM-II—and low inflation—defined as inflation of no more than 1.5% above the average of the lowest three (positive) rates in all EU member states\(^2\). This paper examines how the inflation and exchange rate criteria can be simultaneously met during a period in which the price level in CEECs is rising towards the Eurozone level.

One way of measuring the rate of change in the relative price level is to consider the price of the consumer basket in a given CEEC, denominated in local currency and converted into euros at the prevailing market exchange rate. Over time, the euro denominated price of the basket in the CEEC will rise. Throughout this paper, this is referred to as the euro denominated inflation rate, denoted by \(\gamma\).

The core of the problem faced by CEECs can be summed up in the following equation. Defining \(s\) as the rate of change in the nominal exchange rate, and \(\pi_j\) as the (own currency) inflation rate in country \(j\), \(\gamma\) may be written as:

\[
\gamma_j \equiv \pi_j + \Delta s
\]

For countries which have a fixed exchange rate, \(s = 0\) all convergence takes place through an inflation differential, and hence \(\gamma\) is simply equal to the annual inflation rate \(\pi\). For countries whose monetary authorities target inflation (and have the same inflation target as the ECB), all convergence takes place through nominal exchange rate appreciation—this case \(\gamma\) is equal to the nominal exchange rate appreciation, \(\Delta s\) plus inflation. In either case, the higher inflation or the appreciation of the nominal exchange rate, may pose a threat to the simultaneous achievement of the exchange rate and inflation criteria.

Table 1 tabulates relative price levels, and makes clear that price level convergence in CEECs is still far from complete. All countries have some way to go before they even approach the lowest price levels in the original 12 Eurozone members.

\(^2\) Previous convergence reports have excluded countries with negative inflation from the reference group, although this qualification was not explicitly mentioned in the treaty of Maastricht.
Table 1: Relative Price Index 2005, EU15=100

<table>
<thead>
<tr>
<th>Country</th>
<th>GDP Deflator</th>
<th>Household Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2004 Intake:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Czech Republic</td>
<td>54</td>
<td>56.4</td>
</tr>
<tr>
<td>Estonia</td>
<td>55.8</td>
<td>62.7</td>
</tr>
<tr>
<td>Latvia</td>
<td>48.4</td>
<td>55.4</td>
</tr>
<tr>
<td>Lithuania</td>
<td>47.4</td>
<td>53.3</td>
</tr>
<tr>
<td>Hungary</td>
<td>58.6</td>
<td>62.1</td>
</tr>
<tr>
<td>Poland</td>
<td>52.4</td>
<td>58.2</td>
</tr>
<tr>
<td>Slovakia</td>
<td>52.6</td>
<td>56.2</td>
</tr>
<tr>
<td><strong>2007 Intake:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulgaria</td>
<td>35.3</td>
<td>42.2</td>
</tr>
<tr>
<td>Romania</td>
<td>43.2</td>
<td>51.8</td>
</tr>
<tr>
<td><strong>Lowest 3 Eurozone:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>80.1</td>
<td>82.2</td>
</tr>
<tr>
<td>Greece</td>
<td>81.5</td>
<td>84.7</td>
</tr>
<tr>
<td>Spain</td>
<td>86.5</td>
<td>86.8</td>
</tr>
</tbody>
</table>

Source: Eurostat

On the basis of the GDP deflator, it can be seen that CEECs typically have price levels of 45-60% of the EZ12, with lower figures for the 2007 intake. Consumer prices are slightly higher, but still only around 50-60% of the EZ12 level.

The difficulty of meeting the exchange rate and inflation criteria during a period of nominal convergence is well known and has led some to call for reforms of the existing criteria. However, what these studies lack is a direct evaluation of the likely size of convergence effects, a consideration of whether they are large enough to pose a serious problem with compliance, and for how long these convergence effects may pose a problem. Accordingly a key contribution of this paper is to quantify the size of these convergence effects, to examine whether they are big enough to pose a problem with meeting the criteria, and to consider for how long such effects may be present.

A related question is which entry strategy best copes with the problems posed by nominal convergence. De Grauwe and Schnabl (2005) consider the whether CEECs should opt for a tight peg or a gradual appreciation of their currency once inside ERM-II, but do not

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consider explicitly how large the convergence effects might be, or for how long they may be a
problem. On the other hand, Jonas and Mishkin (2004) examine whether the Czech Republic,
Poland and Hungary should persist with inflation targeting once inside ERM-II, but do not
consider explicitly the effects their choice of regime may have on achieving the exchange rate
criterion. Accordingly, the other contribution of this paper is to explicitly compare prospects
for meeting the criteria under inflation targeting and under a fixed exchange rate.

The paper is organised as follows: Section 2 describes the model used to generate
convergence paths. Section 3 analyses the ability of CEECs to meet the criteria under various
policy regimes. Section 4 estimates the probabilities of hitting the inflation criterion under a
fixed exchange rate using data from 1997-2006 for Eurozone members and countries fixed
tightly to the Euro. Final remarks are presented in section 5.

CEECS

The first step in the analysis is to formulate a stylised account of nominal
convergence. The approach used here is based on the Balassa Samuelson effect, which relates
convergence in price levels across countries to productivity convergence. The ultimate goal is
to derive various convergence scenarios which can be analysed for their policy implications.
This simple model serves to give a theoretical underpinning to those scenarios which is firmly
grounded in economic theory.

2.1 The Balassa Samuelson Effect and Price Differentials

The starting point is the standard textbook B-S model\(^5\). Suppose there are two
countries, \(j\) and the Eurozone. Two types of goods are produced, tradeables, \(Tr\), and non-
tradeables, \(NT\). Production is given by:

\[
Y_{Tr,j} = A_{Tr,j} K_{Tr,j}^\alpha L_{Tr,j}^{1-\alpha} \\
Y_{NT,j} = A_{NT,j} K_{NT,j}^\beta L_{NT,j}^{1-\beta}
\]

\[
Y_{Tr,ez} = A_{Tr,ez} K_{Tr,ez}^\alpha L_{Tr,ez}^{1-\alpha} \\
Y_{NT,ez} = A_{NT,ez} K_{NT,ez}^\beta L_{NT,ez}^{1-\beta}
\]

\(^5\) See Obstfeld and Rogoff (1998) for a full discussion of the model.
The nominal wage in each country is equalised across sectors, this implies

\[ P_{Tr,j} (1-\alpha) \Lambda_{Tr,j} k^{\alpha}_{Tr,j} = P_{NT,j} (1-\beta) \Lambda_{NT,j} k^{\beta}_{NT,j} \]  
\[ P_{Tr,ez} (1-\alpha) \Lambda_{Tr,ez} k^{\alpha}_{Tr,ez} = P_{NT,ez} (1-\beta) \Lambda_{NT,ez} k^{\beta}_{NT,ez} \]

where \( P \) denotes the price of the good in local currency, and \( k \) denotes \( K/L \). PPP holds for tradeable goods only:

\[ P_{Tr,j} = S P_{Tr,ez} \]

where \( S \) denotes the nominal exchange rate. Country price levels are defined by a common basket of tradeable and non-tradeable goods given by an average of prices in both sectors:

\[ P_j = P_{Tr,j}^i P_{NT,j} \]
\[ P_{ez} = P_{Tr,ez}^i P_{NT,ez} \]

The relative price of a basket of goods in country \( j \) relative to the Eurozone is thus given by:

\[ \frac{P_j}{S P_{ez}} \left( \frac{P_{NT,j}}{P_{NT,ez}} \right)^i \]

Thus the relative price level across countries is determined by the difference in the price of non-tradeable goods. The greater is, \( i \), the proportion of tradeables in the basket the more strongly a given non-tradeable price differential affects the relative price level.

From equations (4) and (5) it is possible to derive expressions for the relative price of non-tradeable goods as a function of the marginal products of labour:

\[ \frac{P_{NT,j}}{P_{Tr,j}} = \frac{(1-\alpha) \Lambda_{Tr,j} k^{\alpha}_{Tr,j}}{(1-\beta) \Lambda_{NT,j} k^{\beta}_{NT,j}} \]
\[ \frac{P_{NT,ez}}{P_{Tr,ez}} = \frac{(1-\alpha) \Lambda_{Tr,ez} k^{\alpha}_{Tr,ez}}{(1-\beta) \Lambda_{NT,ez} k^{\beta}_{NT,ez}} \]
Combining (10) and (11) with the PPP requirement in tradeable goods (5), the prices of non-tradeable goods in country j can be written as:

\[ P_{N,j} = S_{N,\varepsilon} \frac{A_{T,\varepsilon}}{A_{N,\varepsilon}} \]

and thus obtain the canonical Balassa Samuelson result. Following, De Grauwe and Schnabl (2005) the simplifying assumption productivity in the non-tradeable sector is constant across time and space is made. In such case, the ratio of the price levels is given by:

\[ \frac{P_j}{SP_{\varepsilon}} = \left( \frac{A_{T,\varepsilon}}{A_{T,\varepsilon}} \right)^\tau \]

Thus, the price ratio is equal to the ratio of tradeable sector productivities. This captures the stylised fact that CEECs with lower productivity, tend to have lower price levels than the Eurozone. Note that the nominal exchange rate \( e \) does not appear on the right hand side. This means that the relative price of the basket of goods in country \( j \) (compared to the Eurozone) depends only on the productivity differential in tradeable goods. If \( e \) is fixed (i.e. fixed exchange rate), then this relationship will hold via an adjustment in \( P_j \). If \( P_j \) is fixed by the authorities (i.e. a form of inflation targeting), then it will be the nominal exchange rate which does the adjusting.

### 2.2 The Balassa Samuelson Effect and Price Convergence

The next step is to introduce time, and analyse what happens as productivity and price ratios change. At time zero there is a disparity in prices (and productivity) and convergence takes \( \tau \) years. Price convergence takes place via faster tradeable sector productivity growth in country \( j \). This is often termed “catch-up” growth, because it is assumed that this differential in tradeable productivity growth rates exists only up to the point at which country \( j \) attains the same productivity level as the eurozone.\(^6\) This is captured by using a simple approach in the spirit of Hughes Hallett and Ma (2004)\(^7\), which assumes that productivity growth rates converge linearly to the EU average in \( \tau \) years, and that at the end of this process both levels

\(^6\) See Barro (1991) and Barro and Sala-i-Martin (1995) for pioneering paper on the empirics of GDP convergence

\(^7\) These authors examined the likely effect of productivity driven convergence between East and West Germany, albeit with a different assumptions about the path of the process.
and rates of tradeable productivity) are identical in both regions. Denoting time with subscript \( \tau \), and dropping the tradable subscript \( Tr \) in order to economise on notation the rate of tradeable productivity growth in year \( \tau \) is may be written as:

\[
g_{j,\tau} = g_{j,0} - \left(g_{j,0} - \bar{g}_{ee}\right) \frac{\tau}{T}
\]

where \( g \) is the growth rate in tradeable productivity. The level of tradable productivity in \( j \) is thus given by:

\[
A_{j,\tau} = A_{j0} e^{\int_{T_0}^{\tau} g_{j,0} - \left(g_{j,0} - \bar{g}_{ee}\right) \frac{L}{T} dt}
\]

(15)

Imposing the condition that convergence in levels and rates is completed in the same year \( T \) thus implies:

\[
\frac{A_{j,0}}{A_{ee,0}} e^{\int_{T_0}^{\tau} g_{j,0} - \left(g_{j,0} - \bar{g}_{ee}\right) \frac{L}{T} dt} e^{\int_{T_0}^{\tau} \bar{g}_{ee} dt} = e^{b}
\]

(16)

This convergence is shown diagrammatically below:

**Figure 1: Productivity Catchup in the Tradeable Sector**

![Diagram showing productivity catchup in the tradeable sector.](image-url)
Such a path of productivity growth, yields a similar pattern of convergence in terms of relative price levels. Re-writing (13) to yield an expression for the euro-cost of the consumer basket in country $j$ gives:

$$\frac{P_{i,\tau}}{S_{\tau}} = \left( \frac{A_{i,\tau}}{A_{e,\tau}} \right) P_{EZ,j}$$  \hspace{1cm} (13)*

Log differentiating this gives an expression for $\gamma$, the “euro-denominated inflation” in country $j$:

$$\gamma_{j,\tau} = \pi_{j,\tau} - s_{\tau} = i(g_{j,\tau} - \bar{g}_{e,\tau}) + \pi_{e,\tau}$$  \hspace{1cm} (17)

where $\pi$ denotes inflation, and (lower case) $s$ is the percentage change in the exchange rate. Substituting (14) in (17) shows that $\gamma$ is a linear function with respect to time:

$$\gamma_{j,\tau} = \pi_{j,\tau} - s_{\tau} = i(1 - \frac{\tau}{T})(g_{j,0} - \bar{g}_{e,\tau}) + \pi_{e,\tau}$$  \hspace{1cm} (18)

Which can be re-written as:

$$\gamma_{j,\tau} = \gamma_{j,0} - (\gamma_{j,0} - \pi_{e,\tau}) \frac{\tau}{T}$$  \hspace{1cm} (19)

The evolution of relative price levels is of the same functional form as the evolution of productivity levels.

The euro-denominated price level in country $j$ is given by:

$$\frac{P_{i,\tau}}{S_{\tau}} = \frac{P_{i,0} e^{\gamma_{j,0} - \pi_{e,\tau} \frac{\tau}{T} dt}}{S_{0}}$$  \hspace{1cm} (20)

and the evolution of the eurozone price level is given by:

$$P_{e,\tau} = P_{e,0} e^{\pi_{e,\tau}}$$  \hspace{1cm} (21)

The ratio of these two expressions gives the evolution of prices in country $j$ relative to the Eurozone:

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8 Proof: From (17)  $i(g_{j,0} - \bar{g}_{e,\tau}) = \gamma_{j,0} - \pi_{e,\tau}$. Substitute this into first term of the RHS of (18) and then rearrange.
This is shown diagrammatically below

**Figure 2: Price Level and γ Convergence**

This replicates the stylised fact that, γ tends to be higher during the initial phases of the convergence process, and then slows as price levels get closer. Moreover, it imposes an economically reasonable endpoint to the process—equalisation of price levels—, governed by productivity convergence.  

In reality inflation (and the exchange rate) will be subject to many other factors, but this approach provides a simple means, grounded firmly in economic theory, for identifying the underlying trend movement in real exchange rates over time, arising a result of convergence effects. Price convergence in this form was first developed by Kattai (2005) as a means of capturing convergence effects in a large macro model of a converging economy. Indeed this characterisation of underlying convergence dynamics is used by the Bank of Estonia’s own macromodel. What this paper adds is a formal derivation based on productivity convergence, to motivate this choice of functional form.

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9 This assumption is relaxed later on, where the case of persistent price differentials is analysed.

10 For a full discussion of how it can be incorporated in a model of a converging economy, see Kattai (2005, 2007)
2.3 Generating Convergence Scenarios

One approach would be to estimate empirically the size of convergence effects using data on productivity and real exchange rates. However, in the context of this model, this approach has a number of important drawbacks. Econometric work on the estimating size of the B-S effect tends to produce vastly different figures, depending on the methodology and data used (See Égert & Halpern, 2005; Égert, 2006). In part, this can be attributed to the fact that even if the theory were a perfect account of the underlying economic mechanisms, sufficiently disaggregated data is not available to quantify the size of the effect empirically. To correctly uncover the size of B-S effect, one first needs to decompose output (and prices) into tradable and non-tradable sectors. Output based measures exist only at a sectoral level, and an arbitrary decomposition must then be made. Moreover, goods typically contain both a tradable and non-tradable element, meaning that data on individual goods prices is not sufficient. In addition, data on productivity are incomplete and sparse, and so the majority of studies rely on labour rather than total factor productivity estimates.

An additional difficulty with empirical estimation concerns the dynamic properties of the BS effect. In particular, the model outlined generates the result that the BS effect is not constant over time. Empirical estimates which uncover a single point estimate of the effect and assume it to be constant over the sample period are thus inconsistent with the approach followed here.

Lastly, and perhaps most importantly, the ultimate goal of the analysis is to consider what would happen under a variety of plausible convergence scenarios. The goal is not to come up with a single prediction of the likely convergence scenario. Instead, the focus is on asking a “what if” question, to see how countries would fare under a variety of different convergence scenarios.

Eurostat’s relative price level data begins in 1995 and runs up to 2005. This is used to estimate the trend price level and $\gamma$ in the year 2000 ($\tau=0$). Given these values it is then possible to project the convergence scenarios forward from 2000 onwards. A simple diagrammatic representation of the case where a country converges to Eurozone inflation rates and price levels is shown in figure 3.
These diagrams also provide an intuition for the methodology used to calculate convergence speeds. The dotted lines can be thought of as the underlying “trend” price levels and inflation rates, tied down by price convergence considerations, around which the actual observed figure will fluctuate.

The data is taken from Eurostat on the relative price of the household consumption component of GDP. The HICP which is used for the assessment of the inflation criterion-yields comparable rates of inflation, but cannot be used for comparing price levels across countries. Eurostat does however publish a relative price index for various components of GDP and the index for household final consumption is used as the closest approximation to the relative HICP levels.

In what follows, four separate convergence scenarios are considered:

**Full Convergence:** CEECs converge to 100% of the EZ12 price level. $\pi_{EZ}$ is set at 0.02, implying the ECB (on average) delivers inflation of 2% per annum. Averaging the double log of the observed relative price level between 1995-2005 gives an estimate of the underlying trend relative price level in 2000. Similarly, averaging the observed values of $\gamma$ from 1995 to 2005 gives an estimate of the underlying trend $\gamma$ in 2000. This can then be used to estimate convergence speed using the following equation:
Given these values, and the constraint that price and inflation convergence happen simultaneously, equation (1) for can be solved for $T$, the date at which convergence is achieved, from which the convergence paths of the price level and $\gamma$ can then be derived. This was done numerically using the Mathematica software package.

**Partial Convergence:** CEEC prices only converge to the level seen in the periphery of the Eurozone. Greece and Portugal have price levels of just over 80\% of the Eurozone, so 0.8 is taken as a (conservative) benchmark figure. This implies that instead of (1) the following condition holds:

$$\frac{P_{j,0}}{P_{EZ,0}} e^{T \left( \frac{\gamma_{j,0} - \pi_{EZ}}{T} \right)_{t=0}^{T}} = e^{0}$$

(23)

$T$ can then be solved for in the same manner as above.

In the other two scenarios, the time, $T$, is fixed, and given the estimated value of relative prices in 2000, equation (23) is then solved for $\gamma_{j,2000}$. The figures of 25 and 50 years were chosen as corresponding roughly to upper and lower bounds of estimated convergence times in the literature (see table in Appendix for a full comparison)

**25 Year Convergence:** Convergence to 100\% of EZ12 price level, takes 25 years.

**50 Year Convergence:** Convergence to 100\% of EZ12 price level, takes 50 years.
Table 2: Implied Convergence Paths

<table>
<thead>
<tr>
<th>Country</th>
<th>EU15 (100%)</th>
<th>Periphery (80%)</th>
<th>25-year</th>
<th>50-year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>γ&lt;sub&gt;2005&lt;/sub&gt;</td>
<td>Conv</td>
<td>γ&lt;sub&gt;2005&lt;/sub&gt;</td>
<td>Conv</td>
</tr>
<tr>
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<td>5.59</td>
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<tr>
<td>EE</td>
<td>6.40</td>
<td>2027</td>
<td>6.40</td>
<td>2017</td>
</tr>
<tr>
<td>LV</td>
<td>6.20</td>
<td>2043</td>
<td>6.20</td>
<td>2032</td>
</tr>
<tr>
<td>LT</td>
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<td>8.12</td>
<td>2027</td>
</tr>
<tr>
<td>HU</td>
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<td>2040</td>
<td>5.94</td>
<td>2028</td>
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<td>4.69</td>
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</tr>
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<td>SK</td>
<td>2.16</td>
<td>2046</td>
<td>2.16</td>
<td>2035</td>
</tr>
<tr>
<td>BU</td>
<td>5.94</td>
<td>2072</td>
<td>5.94</td>
<td>2057</td>
</tr>
<tr>
<td>RO</td>
<td>5.02</td>
<td>2063</td>
<td>5.02</td>
<td>2049</td>
</tr>
</tbody>
</table>

Source: Eurostat, Authors own calculations, (figures rounded to nearest whole year)

CZ=Czech Republic; EE=Estonia; HU=Hungary; LV=Latvia; LT=Lithuania; PL=Poland; SK=Slovakia; BU=Bulgaria; RO=Romania

The white columns give the 2005 value of γ for each scenario, the grey columns give T, the estimated year in which convergence is achieved. Concerning convergence time to 100% of EZ12 price level (third column), the Baltics are the fastest to converge- taking a couple of decades, followed by the larger central European countries, with Bulgaria and Romania over 10 years behind. These numbers are comparable to other estimates in the literature derived from more sophisticated methods (see appendix for full details). If the endpoint of the convergence process is a price level of only 80% of the EZ12 (fifth column), then the convergence happens approximately 10 years sooner. This reflects the fact that in the case of 80% convergence, the price level has less far to go, than if the endpoint is 100% convergence. The 25 year and 50 year cases (7<sup>th</sup> and 9<sup>th</sup> columns) show convergence dates of 2025 and 2050 by construction.
3. The Effect of Nominal Convergence on Meeting the Maastricht Criteria

This section considers whether and under what circumstances these estimated convergence effects on inflation and the exchange rate may be large enough to constitute a problem for the fulfilment of the exchange rate and inflation criteria. The stylised interpretation of the criteria utilised is the following:

Following Brooke (2006), Égert & Kierzenkowski (2003) and the apparent logic of the ECB’s convergence report (2006), the exchange rate stability criterion is interpreted to mean a nominal appreciation of less than 15% from central parity\(^{11}\) during the stay in ERM-II.

In keeping with recent ECB convergence reports, inflation criterion is taken to mean 1.5% plus the average of the lowest 3 EU members, excluding all countries with negative inflation rates. Applying this formula to the EU25 from January 1998 to February 2006 and then averaging the difference between the reference value and actual Eurozone inflation yields the result that the reference value is on average 0.6% above Eurozone inflation.\(^{12}\) Combining this with the ECB’s inflation target yields the benchmark figure of 2.6%.\(^{13}\)

The next step is to consider how much inflation and exchange rate appreciation are allowed. Recall equation (1), which links euro denominated inflation rates, actual inflation rates, and the change in the nominal exchange rate: \(\gamma_j = \pi_j + s\)

\(^{11}\) In what follows the maximum tolerated depreciation need not be specified, because these calculations imply only an upward movement of the nominal exchange rate.

\(^{12}\) The exact figure is 0.564626, which is rounded to the nearest decimal place. See appendix for full details of the evolution of the reference value.

\(^{13}\) The results in this section are robust to alternative assumptions about the reference value. Assuming the reference value is 2.8% or even 3% makes little difference. See appendix for tabulations of results using these higher reference values.
If \( s = 0 \), then \( \gamma_j = \pi_j \). The maximum permissible inflation is \( \pi_j = 2.6\% \) which implies that \( \gamma_j = 2.6\% \). Thus the maximum euro denominated inflation rate that the Maastricht criteria permits an exchange fixer is 2.6\%.

Alternatively, this can be expressed in terms of the maximum permissible annual appreciation of the real exchange rate, where the latter is defined as:

\[
\Delta RER = s + (\pi_j - \pi_{ce})
\]

Given that \( s = 0 \) and \( \pi_{ce} = 2\% \), the maximum permitted inflation rate \( \pi_j = 2.6\% \) can be substituted in (4) to yield the maximum permitted real exchange rate appreciation, which comes out at 0.6\%.

The inflation targeter is allowed to appreciate upwards by 15\% over two years, which gives an annualised nominal appreciation of 7.2\% (rounding to one decimal place). Substituting the maximum permitted appreciation, \( s = -7.2\% \) and the actual inflation rate \( \pi_j = 2\% \) into the equation: \( \gamma_j \equiv \pi_j - s \), implies that \( \gamma_j = 9.2\% \). In other words, an inflation targeter is permitted over 3 times as much euro denominated inflation as an exchange rate fixer.

In terms of the real exchange rate, substituting \( s = -7.2\% \) and \( \pi_j = \pi_{ce} = 2\% \) into equation (15) implies a real appreciation of 7.2\%. Comparing this to the maximum permitted real appreciation allowed to an exchange rate fixer (0.6\%), it can be seen that an inflation targeter is permitted over 10 times as much real exchange rate appreciation.

One measure of the importance (and longevity) of convergence effects, is to calculate the time \( \tau^x \), beyond which convergence effects imply inflation of below 2.6\%. One interpretation of this date is as the point beyond which convergence effects are not strong enough on their own to imply failure of the inflation criterion. A second interpretation would be the date beyond which a country can “sustainably” meet the inflation criterion, in the sense
that before this point, they can only meet the criterion on a temporary basis by virtue of below trend inflation.

The relevant rate for assessing the inflation criterion is the 12 month average of the past 12 months year on year inflation rates. This sustainability requirement is shown diagrammatically in the left hand panel of figure 4.

The right panel depicts the situation faced by an inflation targeter. The line $s'$ shows the cumulative appreciation over the previous 2 years and the dotted line corresponds to the 15% upper bound. Compliance means the cumulative appreciation is lower than 15%.\(^{14}\)

**Figure 4: Simultaneous Compliance with Both Criteria**

These are shown in table 4 shows $\tau'$ under inflation targeting and fixed exchange rate regimes.

**Table 3: Sustainable Compliance with the Maastricht Criteria**

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Estimate time to convergence to</th>
<th>Fix time to convergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU15 (100%)</td>
<td>Periphery (80%)</td>
<td>25-year</td>
</tr>
<tr>
<td>$\pi$ targ</td>
<td>Fix e</td>
<td>$\pi$ targ</td>
</tr>
<tr>
<td>$\pi$ targ</td>
<td>Fix e</td>
<td>$\pi$ targ</td>
</tr>
</tbody>
</table>

\(^{14}\) This notion of compliance assumes first that the candidate country has in fact joined ERM-II at time $t-2$, and with a central parity equal to the prevailing market rate- as was the case with Slovakia.
<table>
<thead>
<tr>
<th>Country</th>
<th>Year 1</th>
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<th>Year 3</th>
<th>Year 4</th>
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<td>2040</td>
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</table>

Source: Authors own calculations, (figures rounded to nearest whole year)

CZ=Czech Republic; EE=Estonia; HU=Hungary; LV=Latvia; LT=Lithuania; PL=Poland; SK=Slovakia; BU=Bulgaria; RO=Romania

Under fixed exchange rates, it is evident that the current size of convergence effects on inflation is much larger than the maximum allowed by the Maastricht Treaty. All countries must wait many years before they can sustainably meet the inflation criterion. Under the first scenario (100% convergence, estimate T- third column), the first countries to meet the inflation criterion would be the Baltics in 15-20 years, with the central European nations following a decade later, and Bulgaria and Romania 10-20 years. Assuming that CEECs converge only to 80% of the Eurozone price level (5th column) brings these dates forward by about a decade. In the 25 year case, sustainable compliance occurs between 2021 and 2024, and under the 50 year case, between 2042 and 2045. The two striking things about these results are first that they are robust across all convergence scenarios, and second, they imply that the Baltic states- often viewed as being at the front of the queue to join- would in all likelihood be unable to sustainably meet the inflation criterion for almost 2 decades.\(^{15}\)

Under inflation targeting (table 4), the convergence effects alone are never big enough to imply an appreciation of more than 15% over the course of a 2 year stay in ERM-II, regardless of the convergence scenario used.

---

\(^{15}\) The Baltics would be able to sustainably meet the inflation criterion sooner if they only converged to 80% of the Eurozone price level. However, given their proximity to Scandinavian countries, it could be argued that 80% of the EZ12 price level is an unrealistically low endpoint for the convergence process when Sweden and Finland have relative price levels of 110% of the EZ12 level.
### Table 4: Forecast 2 year Appreciations within ERM-II Under Inflation Targetting  
(by date of joining)

<table>
<thead>
<tr>
<th></th>
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<th>80% Conv, Est T</th>
<th>100% Conv, 25yr</th>
<th>100% Conv, 50yr</th>
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<td>7.74</td>
<td>6.28</td>
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<td>10.36</td>
<td>7.63</td>
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<td>HU</td>
<td>7.18</td>
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<td>4.67</td>
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<td>PL</td>
<td>5.88</td>
<td>5.17</td>
<td>4.46</td>
<td>5.40</td>
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<tr>
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<td>7.57</td>
<td>6.48</td>
<td>5.40</td>
<td>7.04</td>
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<td>BU</td>
<td>7.11</td>
<td>6.51</td>
<td>5.92</td>
<td>6.89</td>
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<td>RO</td>
<td>6.66</td>
<td>5.93</td>
<td>5.20</td>
<td>6.33</td>
</tr>
</tbody>
</table>

Source: Authors own calculations

CZ=Czech Republic; EE=Estonia; HU=Hungary; LV=Latvia; LT=Lithuania, PL=Poland; SK=Slovakia; BU=Bulgaria; RO=Romania

This means that CEECs who target inflation have a reasonable amount of leeway on the exchange rate criterion to cope with either short term shocks to the exchange rate. Or, alternatively, this leeway could be used to stay in ERM-II for longer than 2 years without breaching the 15% upper bound.

These results imply a strong asymmetry between exchange rate regimes. Inflation targeters will find it much easier than fixed exchange countries to meet the criteria.

### 4. Meeting the Convergence Criteria Sustainably: An Empirical Analysis

For those countries who fix their exchange rate credibly, the key issue is the probability with which they can meet the inflation criterion. The analysis of the previous section concentrated on a theoretical model of trend inflation and/or nominal exchange rate appreciation based on a price convergence story. However, in reality inflation can, and does, depart substantially from the trend rates implied by nominal convergence. This section investigates empirically the role of price level differentials in determining the ability of a country to hit the inflation criterion. This is done using data from aspirant members who fix to the Euro, and from existing Eurozone members.

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16 It could be the case that upward revaluations in ERM-II do not imply failure of the exchange rate criterion. In such case a country could appreciate by more than 15% during their stay in ERM-II and still meet the criteria. This would further strengthen the asymmetry.
A direct empirical evaluation of the probability of hitting the exchange rate criterion under inflation targeting is not attempted in this section, because of the limited number of observations of aspiring members adopting inflation targets similar to that of the ECB.

To assess this the variable, $C_{j,k}$, is constructed which takes records the proportion of the past $k$ months in which country $j$ has met the inflation criterion. The model is estimated for $k = 1,3,6,12$.

Since, $C_k$ is a discrete variable, which can take $k+1$ different values, it is estimated as an ordered probit model\(^\text{17}\). Formally speaking, the latent regression estimated is:

$$
y_{j\tau} = \beta_{relp_{j,\tau-24-k}} + \varepsilon_{j\tau}
$$

and a series of cutoff points $Z_1, Z_2, \ldots, Z_k$ where $relp_{ji}$ is the relative price level between country $i$ and the Eurozone at time $\tau$.

The probability that $C_k$ takes a given value is thus:

$$
P \mid C = 0 = P(y < Z_1)
$$

$$
P \mid C = \frac{x}{j} = P(Z_{x-1} < y < Z_x), \quad \forall x < j
$$

$$
P \mid C = 1 = P(y > Z_k)
$$

The reference value is calculated, using the average of the lowest three positive inflation rates in the EU25. For relative prices, annual data on the relative price of household consumption was used, with linear interpolation to yield monthly figures.

The model is estimated using a sample consisting of four aspiring Eurozone members- Estonia, Latvia, Lithuania, and Slovenia plus the twelve current Eurozone members\(^\text{18}\). For the

\(^{17}\) As a robustness check, an ordered logit model was also estimated. The implied probabilities of $C=1$, were within $\pm 1\%$ of those obtained under the probit specification. A full set of results is available from the author on request.

\(^{18}\) The model is estimated using a sample consisting of four aspiring Eurozone members- Estonia, Latvia, Lithuania, and Slovenia plus the twelve current Eurozone members.
latter, the sample begins from January 1st 1999, for the former the time frame is restricted to cover the time frame in which their national currency was tightly fixed to the Euro. The results are summarised in table 6:

Table 5: Probability of Hitting the Inflation Criterion Under a Fixed Exchange Rate

<table>
<thead>
<tr>
<th></th>
<th>k=1</th>
<th>k=3</th>
<th>k=6</th>
<th>k=12</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$ (p-value)</td>
<td>0.0120 (0.000)</td>
<td>0.0355 (0.000)</td>
<td>0.0346 (0.000)</td>
<td>0.0339 (0.000)</td>
</tr>
<tr>
<td>$z_k$</td>
<td>0.7670</td>
<td>3.2927</td>
<td>3.3412</td>
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<tr>
<td>N</td>
<td>1113</td>
<td>1103</td>
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</tr>
<tr>
<td>Pseudo R-squared</td>
<td>0.0258</td>
<td>0.1415</td>
<td>0.1116</td>
<td>0.0861</td>
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</tbody>
</table>

The upper half of the table gives the results of the regressions for k=1,3,6,12. In each case the relative price co-efficient is highly significant.

The lower half of the table shows the probability implied by the estimated coefficients of hitting the criterion for a given price level.

Roughly speaking, the probability of hitting the criterion in any single month (k=1) improves by around 0.5% for every additional percentage point that $\text{RelP}$ increases by. As $k$ increases two things happen. First, the more consecutive months of compliance required, the lower the probability of success. Thus, a country with a low relative price level may be able to hit the criterion for one single month, but they find it much harder to hit it for longer

\[18\] During the sample period, Slovenia was in ERM-II.
periods of time. Second, the larger is \( k \), the more sensitive the probability is to the price level. For example when \( k=1 \) (first column), a country with a relative price level of 100% of the Eurozone is about one and a half times more likely to hit the criterion for a single month, than a country with a price level which is 50%. But if \( k=12 \) (last column), the probability of success for a country with a price level of 100% of the Eurozone is nearly fifteen times as great as the probability for the country with 50%

To see what the results might mean in terms of probabilities for CEECs, the estimated co-efficients from regression are matched up with the relative price levels implied by each of the convergence scenarios. For a given relative price level in a given year, it is possible to compute the probability of success. These probabilities are graphed below:

**Figure 5: Probability of C=1, k=12; 100% Convergence, Estimated T**

Figures 5 shows that the prospects for sustained compliance under a fixed exchange rate are relatively poor, at least for the next decade. The Baltics and Hungary have the highest probabilities (between 0.2 and 0.25) - on account of their having higher price levels than the other countries according to these stylised convergence scenarios. However, the probabilities
are significantly greater than zero, suggesting that if a CEEC is patient enough, sooner or later, a negative shock could come along which reduces inflation below the reference value for 12 consecutive months.

**Figure 6: Probability of C=1, k=12; 80% Convergence, Estimate T**

In the case of 80% convergence (figure 6), the ranking of the countries (Baltics and Hungary first, rest of central Europe next, followed by Bulgaria and Romania) in order of probability is broadly the same, and the overall prospects are similarly relatively low. Note that the upper bound of the probabilities is lower than the 100% convergence case (around 0.31 as opposed to 0.44). This is because the price level reached at the end of the convergence process is only 80%, and hence the probability of hitting the criterion associated with this is lower. However, this result should be interpreted with caution, because at the end of the convergence process, there will be no inflation differential vis a vis the Eurozone. In other words, there is an incompatibility between the econometric results (which postulate that at lower price levels the probability of hitting the criterion is lower- due to convergence effects) and this particular convergence scenario which assumes that the endpoint of the convergence process is a price level of 80% of the Eurozone.
Figures 7 and 8 show the probabilities under the 25 and 50 year convergence scenarios respectively. These latter figures also present a relatively pessimistic figure. First of all, in
the near future, the probabilities of hitting the inflation criteria for twelve consecutive months are relatively low- under even the most optimistic scenario, this figure does not reach above 25% until 2020. Second, giving up monetary policy, and hence the ability to “fine tune” inflation can be rather costly- in terms of failure to meet the reference value regularly- even when the convergence process has come to an end. Even in 2050 when all countries have converged (the extreme right of the diagram), the probability of hitting the inflation criterion for 12 consecutive months is still less than 0.5. This suggests that even after a country has completed the convergence process, and hence no structural inflation differential exists, they may still, on account of their inability to fine-tune the inflation rate, not comply with the inflation criterion in each and every month.

5. Concluding Remarks

In deciding between inflation targeting and fixed exchange rates, the authorities essentially choose by which channel- nominal exchange rate appreciation or an inflation differential- convergence in relative price levels will take place. In so doing, they also make an implicit choice about which convergence criterion they will use monetary policy to hit, and which criterion - insofar as they have no remaining monetary policy instrument- they will simply have to “hope” for.

This paper examines whether these convergence effects were strong enough to pose a problem for countries who wish to simultaneously hit the inflation and exchange rate criteria. However, what this paper demonstrates is that for any plausible convergence scenario these convergence effects imply, on average, persistent and sustained real exchange rate appreciations. It finds that countries with inflation targeting have much more scope to accommodate nominal convergence, and hence should find it much easier to satisfy the criteria simultaneously and sustainably. This re-enforces the conclusion of De Grauwe and Schnabl (2005), by explicitly quantifying the likely size of these convergence effects and finding that they will be large and relatively long lasting. These results are also highly robust to different convergence scenarios. That means that if convergence to Eurozone productivity levels takes anywhere between 25 and 50 years (and the literature on convergence suggests the convergence time will not lie outside these bounds), then the results hold. They also hold in the case that countries only converge as much as existing Eurozone periphery has.
A key goal of this paper was to analyse *under what circumstances* convergence effects are a problem, rather than to examine a single convergence scenario. A clear finding is that for any plausible convergence scenario, the results hold. To overturn the conclusions, one would need to assume that convergence is either extremely fast, extremely slow or that permanent price differentials will remain indefinitely, which are bigger than currently observed within EMU.

Another key result is that the oft repeated critique of the criteria- that they are incompatible with nominal convergence- is only true for fixed exchange rates, but not for inflation targeters. The recent experience of Slovakia demonstrates that inflation targeters can experience pressure revalue, but it is worth noting that the appreciations observed in the Slovak crown (around 10% annually) since it joined ERM-II are well above what could be implied by any plausible convergence scenario alone. On the other hand the inflation that prevents the Baltic states joining the Euro is generally less than what would be predicted by the convergence scenarios.

Matching these results up with the observed policy regimes currently in operation in CEECs, it is the Baltic states (with fixed exchange rates) who face greater difficulties from convergence than the larger central European nations who have tended to adopt inflation targeting. If there is a strong emphasis on meeting the criterion for a sustained period of time, and/or a forward looking element in the assessment of the inflation criterion, the Baltic states could be out of the euro for at least a decade, and possibly two implying that the states often held to be at the front of the queue could get leapfrogged not only by Slovakia, but other inflation targeters as well.

This paper provides some support for larger central European inflation targeters to remain so in the run up to EMU, as the convergence criteria are, *ceteris paribus*, easier to hit with this setup, than under a tightly fixed exchange rate. However, the question of whether the Baltic countries should switch from a currency board to an inflation targeting regime is not directly considered. Whilst this does allow for more leeway to accommodate nominal convergence, inflation targeting has its own difficulties in very small and open economies.
Inflation targeters could still run into difficulties, even if their exchange rate appreciates by less than 15%. Whilst it is unlikely that they would be excluded on the argument that eventually the exchange rate would breach 15%, they may run into trouble on the inflation criterion, if the ECB and European commission choose to examine sustainable compliance by means of a forward looking assessment of what inflation would be if the country were to join. In such case, these results concerning inflation under a fixed exchange rate suggest, all CEECs would struggle to meet the criteria- regardless of the entry strategy chosen- and hence further Eastern enlargement of the Eurozone would take decades rather than years.

One possible solution to the problem faced by exchange rate fixers is using other instruments to control inflation. For example, indirect taxes and/or administered prices could be manipulated to ensure that rate of inflation was temporarily brought down below the reference value. However, such an action would imply only generate a temporary fall in inflation and may fall foul of the sustainability requirement- especially since the fall could be traced to easily identifiable policy actions. Alternatively, fiscal policy could be deployed to reduce aggregate demand, provoke a recession or slowdown and hence reduce inflation. That would be sufficient to meet the reference value numerically, but could well be judged insufficient to meet the sustainability part of the criterion.

References


[36] WORLD BANK Progress Toward the Unification of Europe, 2000 World Bank, Washington DC.

Appendix A: Meeting the Inflation Criterion under Alternative Reference Values

Notes:

(1) In all tables, figures are rounded to the nearest whole year

(2) CZ=Czech Republic; EE=Estonia; HU=Hungary; LV=Latvia; LT=Lithuania, PL=Poland; SK=Slovakia; BU=Bulgaria; RO=Romania

Case 1: 100% Convergence, Estimate Time

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Case 2: 80% Convergence, Estimate Time

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Case 3: Convergence Takes 25 years

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Case 4: Convergence Takes 50 years

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Appendix B: The Reference Value (Jan 1998-February 2006)

Maastricht Inflation Criterion Reference Value, %

Reference value calculated as 1.5 percentage points plus the average of the lowest three (positive) inflation rates in all 25 countries. This doesn’t necessarily correspond to the actual figures used in convergence reports, because prior to 2004, some “non-members” are included in this measure.

Reference Value: Summary Statistics

Mean: 2.47
Median: 2.47
Standard Deviation: 0.33
Maximum: 3.3
Minimum: 1.83
Reference value minus Eurozone Inflation: Summary Statistics

Mean: 0.56
Median: 0.46
Standard Deviation: 0.35
Maximum: 1.3
Min: -0.17