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Aleš Bulíř, Jaromír Hurník

The Maastricht Inflation Criterion: "Saints" and "Sinners"

Aleš Bulíř and Jaromír Hurník *

Abstract

The Maastricht inflation criterion, designed in the early 1990s to bring "high-inflation" EU countries into line with "low-inflation" countries prior to the introduction of the euro, poses challenges for both new EU member countries and the European Central Bank. While the criterion has positively influenced the public stance toward low inflation, it has biased the choice of the disinflation strategy toward short-run, fiat measures—rather than adopting structural reforms with longer-term benefits—with unpleasant consequences for the efficiency of the eurozone transmission mechanism. The criterion is also unnecessarily tight for new member countries, as it mainly reflects cyclical developments.

JEL Codes: E31, E32, E42, F33.

Keywords: ERM2, Maastricht inflation criterion, new EU member countries.

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Nontechnical Summary

As part of the process toward monetary union, countries were required to fulfill three criteria, set out in the Treaty of Maastricht. One of them required countries to achieve one-year inflation of no more than 1½ percent above the average inflation rate of the three European Union (EU) member states with the most stable prices. The purpose of this criterion was to bring high-inflation EU countries in line with low-inflation countries before the euro was introduced. Although the criterion has achieved its aim of narrowing the inflation gap between EU countries, it has also encouraged countries to adopt short-run, fiat measures to reduce inflation rather than structural reforms with longer-term economic benefits. The study examines what implications this may have for the 10 new EU member countries, all of which are hoping to join monetary union in the near future.

From a purely numerical perspective, the Maastricht inflation criterion was a great success: the inflation differential between low- and high-inflation countries, which was in the double digits from the mid-1970s to the early 1980s, started to narrow in the early 1990s, declining to 2–3 percentage points by 1997. But from a policy perspective, it had some unintended consequences. To meet the criterion, EU member countries were faced with two choices to adopt credible monetary policy and market-oriented reforms that reduced inflation on a more permanent basis or opt for short-term measures, such as changes in regulated prices and indirect taxes and other measures that reduced demand, and forced wage moderation.

In the late 1990s, in their rush to adopt the euro, all EU members relied at least partly on short-term measures, leaving their goods and factor markets unreformed. Once the effect of these measures faded, however, inflation accelerated again in most countries. While the strategy of "low inflation now, reforms later" may have modest short-term costs, the long-term costs are high. The monetary policy transmission mechanism is likely to be less efficient and economic agents continue to base their decisions on expectations of higher inflation. This makes future disinflation more costly. In contrast, countries that implemented more long term structural reforms now benefit from flexible markets and expectations of low inflation going forward.

What does the experience of the old EU member countries imply for the new members (Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovenia, and Slovakia)? The simulation shows that countries with unreformed economies are likely to face much steeper costs when they try to bring down inflation in the future. This result holds for both the current euro zone members and new member countries. The latter would benefit from an inflation criterion that makes the choice of a short-term disinflation strategy less appealing. At present, the short, 12-month testing period of the Maastricht inflation criterion may encourage use of the fiat strategy. A longer testing period, perhaps covering the full business cycle, might be preferable. The tightness of the inflation criterion also provides a further incentive for one-off measures. These incentives could be alleviated by excluding countries with negative output gaps from the calculation of the criterion.

"And I shall sing about that second realm
where man's soul goes to purify itself
and become worthy to ascend to Heaven."
Dante; The Divine Comedy, Purgatorio, Canto I

1. Introduction

The Maastricht inflation criterion—inflation of no more than 1½ percent above the average inflation rate of the three European Union (EU) member states with the most stable prices—was designed in the early 1990s to bring such "high-inflation" countries as Italy and the United Kingdom into line with such "low-inflation" countries as Germany and the Netherlands prior to the introduction of the euro. While the inflation criterion motivated all-European inflation convergence in the late 1990s, it did not prevent an acceleration of inflation in several countries after their entry into the eurozone. What can the new EU member countries (NMCs) do to minimize the compliance cost of this criterion?[1]

Assessments of the Maastricht inflation criterion—by the European Union (European Commission, 2004), the IMF (Schadler, 2005), national central banks (Bárta, 2006), and this study—point to modest costs associated with the criterion, which are promised to be further ameliorated by the "flexibility" of the European Central Bank (ECB) in dealing with new member countries. The "temporal punishment" for past inflation sins, purgatory, seems low. Furthermore, history has shown that the criterion can be fulfilled with a healthy dose of administrative measures. There are, however, differences between the 1990s and 2000s.

Unlike the old EU member countries, which were mimicking the then "engine of Europe," Germany, and the most credible central bank, the NMCs are asked to match the performance of three countries that have in common only that they are in the downturn phase of their business cycles. A tight one-year inflation criterion may motivate the authorities to pursue fiat disinflation policies of short-term demand stabilization and government intervention at the expense of long-term structural reforms that would create a low-inflation environment (Ozkan, Sibert, and Sutherland, 2004). For example, a country may opt for a temporary wage freeze as opposed to liberalizing its labor market. The resulting monetary transmission distortions and inefficiencies are likely to increase the cost of future disinflations and complicate ECB policymaking for years to come.

The contribution of the paper is to link pre-euro disinflation strategies with the costs of future disinflations in nine calibrated country models. The results suggest that in countries that choose the fiat disinflation strategy of "low inflation now, reforms later" have modest short-term costs of disinflation, mostly attributable to "borrowed credibility" from the ECB. But their long-term costs are high, reflecting structural rigidities inherited from the past. In contrast, reformist countries benefit from flexible markets and forward looking agents, both of which push the disinflation cost

[1] The "old" member countries (EU-15) comprise Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. The new member countries consist of the Czech Republic, Estonia, Cyprus, Hungary, Latvia, Lithuania, Malta, Poland, Slovenia, and Slovakia.

down. Thus, the member countries would benefit from a criterion that makes to the choice of a fiat disinflation strategy less likely, either by calculating the criterion over the business cycle or by lengthening the evaluation period.

This paper is organized as follows. First, we link EU inflation developments with inflation drivers. Second, we discuss the nexus between structural reforms and the monetary transmission mechanism in the EU. Third, we formulate a simple model, calibrate it for nine EU countries, and compute hypothetical output losses from disinflation policies. Finally, we discuss the policy implications of the Maastricht criterion for the conduct of monetary policy in the NMCs and by the ECB.

2. Inflation in the European Union

The concept of the new European monetary order was simple. Once exchange rates were stabilized and inflation rates had converged, the former would be irrevocably fixed and the latter would be controlled by pan-European monetary policy executed by the ECB. This plan worked reasonably well in the 1980s and 1990s, and inflation remained close to the target "of close to but below 2 percent" during the early 2000s. The Maastricht criterion failed, however, to close the differential between high- and low-inflation countries.

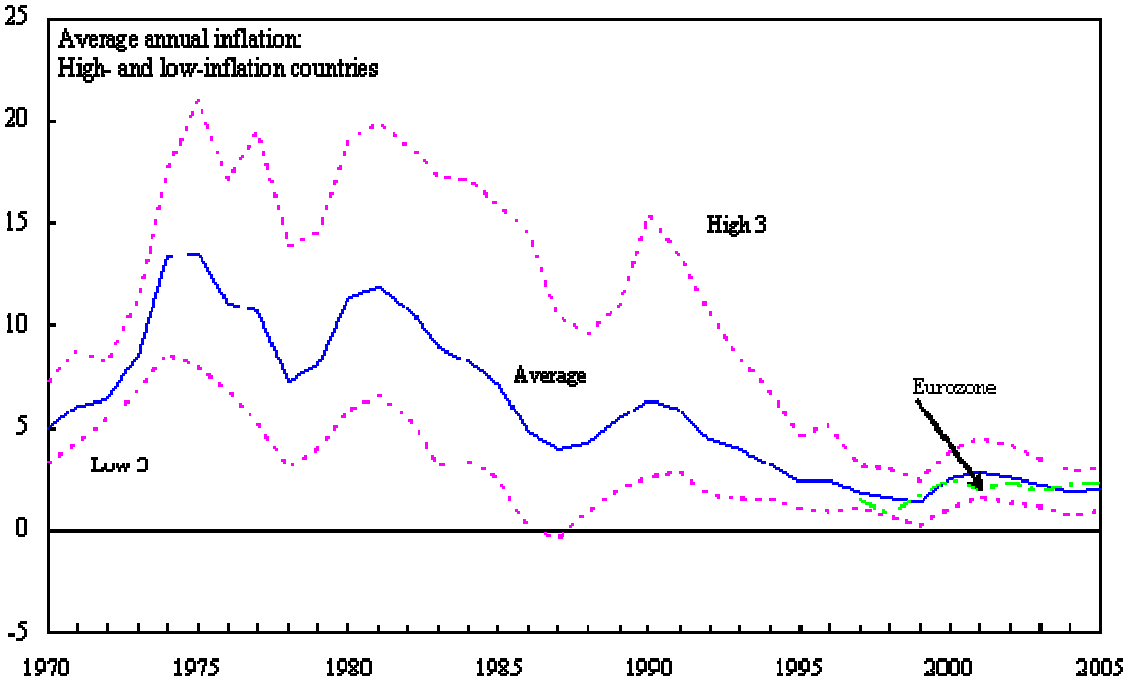
2.1 The Role of the Maastricht Inflation Criterion

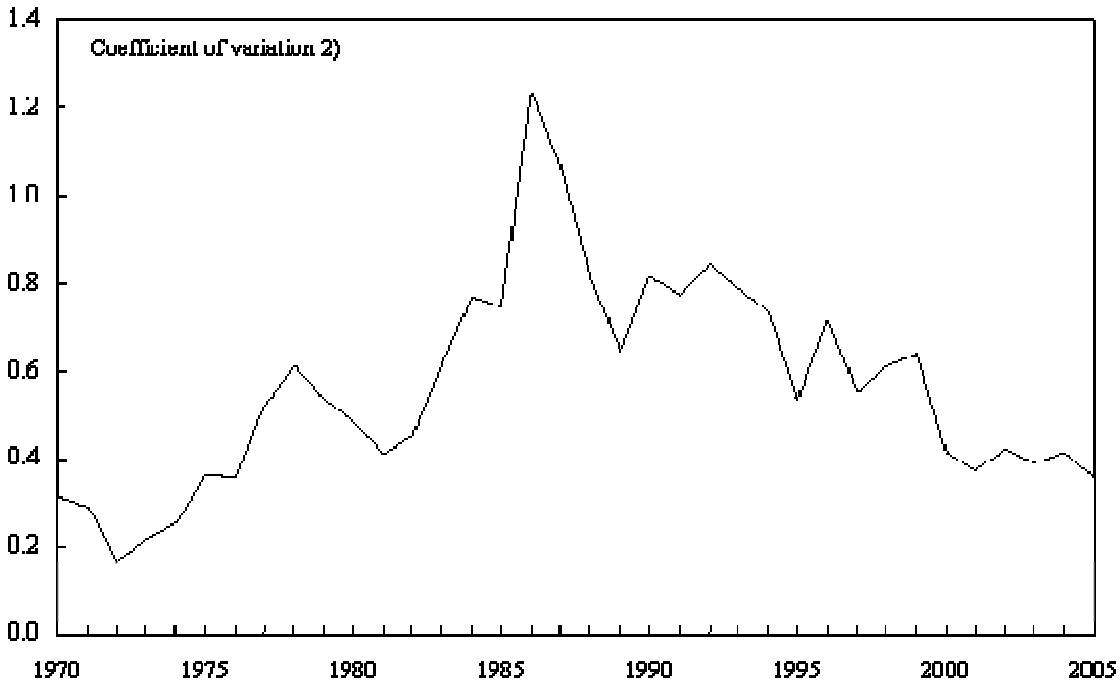
The European Monetary Union (EMU) was set up as an institutional arrangement to foster low inflation. Developments in the 1970s showed that time inconsistent policies fueled by distorted labor markets, tax systems prone to inflation bias, and other structural impediments made it difficult to ensure a low-inflation environment in Europe. Thus, the EU imposed various entry criteria for the EMU—such as the Maastricht inflation criterion—to encourage the EU countries to undertake fundamental economic reforms prior to joining the EMU (see Annex 1 for additional details). Indeed, the inflation differential between low-inflation and high-inflation countries, which was in double digits from the mid-1970s to the early 1980s, started to narrow in the early 1990s, declining to 2–3 percentage points by 1997 (Figure 1).

The Maastricht inflation criterion did motivate all-European inflation convergence, but the disinflation process was also facilitated by a secular decline in inflation. While the empirical literature is not entirely conclusive regarding the contribution of the criterion, it demonstrates that the criterion changed the preferences of the monetary authorities.[2] For example, it has been shown that the coefficient of policy aversion to inflation has increased (Cecchetti and Ehrmann, 1999; and Arestis and Mouratidis, 2004). The literature finds, however, a weak positive impact of structural reforms in the eurozone on the area's inflation, mainly because of slow and insufficient reforms (OECD, 2002; and Ahearne and Pisani-Ferry, 2006).

[2] Some useful, if incomplete, reviews of the inflation convergence literature are those of Bini Smaghi (1994), Kočenda and Papell (1997), and Camarero et al. (2000).

Figure 1: EU-15: Inflation Developments, 1970–2005 1)
(Annual inflation rate, in percent)





Source: World Economic Outlook, authors' calculations.

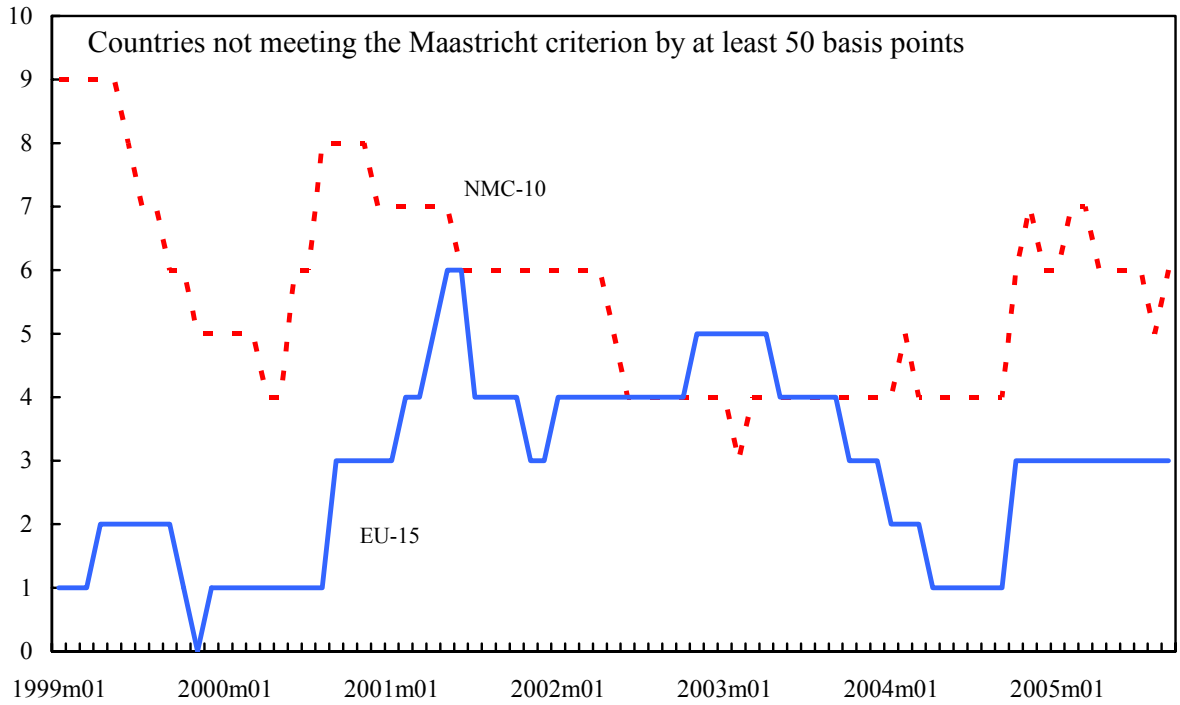
1) The EU-15 comprises Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. The eurozone excludes Denmark, Sweden, and the United Kingdom.

2) Sample standard deviation/sample mean.

2.2 The Maastricht Inflation Criterion: Sinners and Saints

The Maastricht inflation criterion is monitored and assessed only prior to the adoption of the euro, and each country is required to exhibit "saintly" inflation for at least one year. The obvious question is then whether the Maastricht inflation criterion (and the EMU in general) have succeeded in permanently lowering inflation. Have all the sins been purged?

Figure 2: Countries with Inflation above the Maastricht Inflation Criterion, 1999-2005 1/
(Harmonized indices of consumer prices)



Source: Eurostat, authors' calculations.
1/ EU-15 comprises Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, Sweeden, and United Kingdom. NMC-10 comprises the Czech Republic, Estonia, Cyprus, Hungary, Latvia, Lithuania, Malta, Poland, Slovenia, and Slovakia.

Following adoption of the euro, inflation in the three highest-inflation eurozone countries averaged 1 percentage point higher than what was required by the criterion specified for the member countries of the European exchange rate mechanism (ERM2) (Figure 2). On average, one in five EU-15 countries has recorded inflation at least 50 basis points above the Maastricht criterion. While this is far from the double-digit differentials seen in the 1970s and 1980s, under a fixed exchange rate regime such inflation still implies a long-term loss of price competitiveness unless it is compensated for by productivity growth. Inflation developments in the NMCs have varied and several countries have yet to converge to the level of the criterion (Latvia and Slovakia). The three highest-inflation NMCs have been missing the inflation criterion on average by 3.5 percentage points. Technically, of course, neither the eurozone countries nor the NMCs were bound by the criterion. It is the ECB that is responsible for inflation in the eurozone and none of the NMCs had to meet the criterion either, as they were not seeking to adopt the euro before 2006, although a few new member countries started to participate in the ERM2 immediately after their accession.

Which countries are the most frequent sinners, with inflation above the level implied by the Maastricht criterion? In the EU-15 group, Greece, Ireland, and Spain have had higher inflation, while among the NMCs the list includes Estonia, Hungary, Latvia, Slovakia, and Slovenia (Table 1). Six of the EU-15 countries had inflation above the Maastricht criterion at some point during 2001–2005, each of them for at least one quarter. In contrast, every NMC substantially exceeded the criterion, although Lithuania and Malta did so only briefly.

Table 1: EU Inflation Sinners 1/

(Number of quarters with inflation above the Maastricht inflation criterion) 2/

	1999-2005		2004-2005	
	Quarters (27)	Percent of total	Quarters (7)	Percent of total
EU-15				
Greece	20	75	7	100
Spain	11	41	4	57
Ireland	17	64	1	14
Luxembourg (Grand-Duché)	7	27	4	57
Netherlands	8	31	0	0
Portugal	14	51	0	0
NMC-10				
Czech Republic	11	40	0	0
Estonia	19	69	4	52
Cyprus	8	30	1	10
Latvia	9	32	7	95
Lithuania	2	6	0	0
Hungary	27	100	7	100
Malta	6	22	1	19
Poland	17	64	4	57
Slovenia	26	98	6	90
Slovakia	27	100	7	100

Source: Eurostat, authors' calculations.

1/ The following countries' inflation was not above the Maastricht criterion during these periods: Belgium, Denmark, Germany, France, Italy, Austria, Finland, Sweden, and United Kingdom.

2/ By at least 50 basis points in a month, the official "Maastricht" definition.

The saints—that is, the countries that have comprised the base for calculating the Maastricht criterion—are not particularly happy campers either, as these countries have experienced substantial negative output gaps (Table 2).[3] Low inflation has come at a cost of GDP below its potential as the economies move along a short-run Phillips curve. The only two saints in the EU-

[3] Potential output is estimated by European Commission staff from a Cobb-Douglas production function estimate with trend total factor productivity (the AMECO database).

15 group without a gap are France and the United Kingdom. The composition of the saints group changes—only five countries did not make it into the group for at least one quarter (Greece, Ireland, Italy, Spain, and Portugal). Four of the NMCs were temporarily a part of the reference group, typically also experiencing negative output gaps.

Table 2: EU Inflation Saints
(Number of Quarters with inflation equal or below the Low 3 reference inflation raye)

	1999-2005		2004-2005	
	Quarters (27)	Percent of total	Quarters (7)	Percent of total
EU-15				
Belgium	4	15	0	0
Denmark	5	20	5	76
Germany	18	67	1	19
France	8	30	0	0
Luxembourg (Grand-Duché)	2	7	0	0
Austria	7	25	1	19
Finland	8	30	7	100
Sweden	14	51	4	57
United Kingdom	14	51	0	5
NMC-10				
Czech Republic	6	22	2	29
Estonia	1	4	1	14
Lithuania	17	64	4	52
Poland	4	16	1	14

Source: Eurostat, authors' calculations.
1/ The following countries' inflation was not below the Low 3 reference inflation during these periods: Greece, Spain, Ireland, Italy, Netherlands, Portugal, Latvia, Hungary, Malta, Slovenia, and Slovakia.
2/ The official "Maastricht" definition.

2.3 Why Is Inflation in Some EU Countries Higher than in Others?

Against the background of a stable *average* inflation rate in the EU-15 countries, inflation accelerated in several, mostly high-growth, economies. The dispersion of European inflation drifted upward after the drive toward the euro pushed it downward sharply in the late 1990s and early 2000s. The differential between the three countries with the highest and lowest inflation rates fell from about 4 percent to less than 2 percent by 1997, only to stabilize between 2½ percent and 3 percent thereafter.

The dispersion of inflation rates across member countries has introduced noise into the ECB policymaking process to the extent that the EU-wide inflation rate reflects an average of national inflation rates and may not reflect cyclical conditions in any given country. It seems clear that a low level of average inflation in the eurozone over time would not necessarily translate into a low

level of volatility across countries.[4] It could be argued that regional price volatility is irrelevant for stabilization policy in an optimal currency area, but the eurozone is not an optimal currency zone and is unlikely to become one soon (Babetskii et al., 2004; and Schadler et al., 2005). Europe lacks the non-monetary equilibrating mechanisms, such as capital and labor mobility, that are found in optimal currency areas, and a greater reliance on relative price and wage changes among countries is needed. Countries with persistently high inflation are likely to lose price competitiveness unless higher prices are compensated by productivity growth. Developments in some eurozone countries—such as Italy or Portugal—seem to fit the pattern of competitiveness losses.[5]

Several explanations for the inflation differentials have been put forward, namely, price-level convergence, demand pressures, and "structural" distortions (Figure 3). In Annex 2 we review these in more detail and estimate the impact of these factors in a two-step generalized method of moments (GMM) panel regression. We find that EU-15 inflation during 1996–2005 was associated mostly with variability of the output gap and structural reform variables, while the price-level convergence variable was not statistically significant; however, its omission generates omitted-variable bias. Quantitatively, the output gap of 1 percent was associated with a reduction in annual inflation of about 0.3–0.4 percent. More regulation in product or labor markets by one sample standard deviation was associated with a rise in inflation, by 0.3–1.0 percent.

Empirical literature for the EU-15 countries has failed to find strong support for the Balassa-Samuelson effect.[6,7] Alberola-Ila and Tyrväinen (1998) found that tradable-to-nontradable productivity differentials are substantially smaller than those implied by the Balassa-Samuelson effect, as nontradables productivity growth has been much faster than thought earlier. As long as the productivity growth differentials remain small in the NMCs—as suggested by Égert et al. (2005) or Flek, Marková, and Podpiera (2003)—the Balassa-Samuelson effect is unlikely to explain fully either inflation or exchange rate appreciation. At the same time, however, a gradual change in the relative prices of nontradable goods has been observed in most NMCs. Thus, despite the fact that these relative-price changes cannot be linked directly to the productivity differentials, central bank forecasting models typically include trend variables to capture persistent real exchange rate appreciation.

The experience of the old member countries provides valuable lessons for new members. Apart from the relatively high sacrifice ratio, the impact of past reforms (or a lack thereof) drives inflation in the EU-15 countries. The lack of structural reforms may push inflation up in the future through two channels: first, through cost-push channels, as a result of either markup or wage-cost pressures; and, second, through its impact on the monetary transmission mechanism, by making inflation more persistent.

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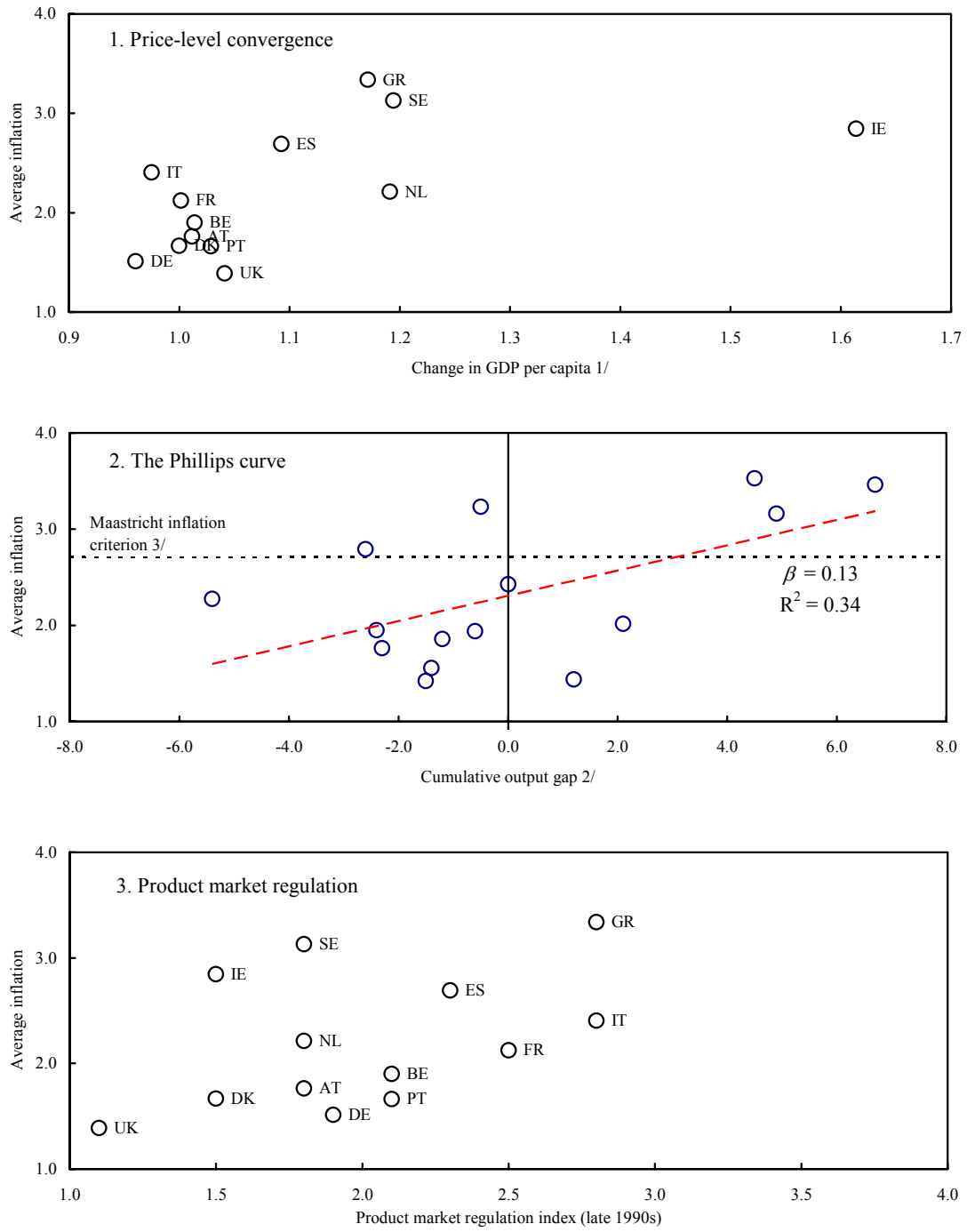
[4] See, for example, Angeloni and Ehrmann (2004) and Hofmann and Remsperger (2005).

[5] For a discussion of the ERM 2 regime for a few of the EU-15 countries, see, for example, Bulíř and Šmídková (2005).

[6] The Balassa-Samuelson effect is expected to work as follows. Productivity growth in the tradable good sector is assumed to exceed that in the nontradable good sector. Assuming further that wages equalize across sectors, faster tradables productivity growth pushes up wages in all sectors, thus leading to an increase in the relative prices of nontradables. With a fixed exchange rate, the relative-price increase in fast catching-up countries may result in an overall price level increase relative to slow-growing countries.

[7] For associated measurement problems see Čihák and Holub (2005).

Figure 3: EU-15: Three Factors of Inflation, 2001-05



Source: AMECO; World Development Indicators; World Economic Outlook; Conway et.al. (2005); authors' calculations.

1/ Change in GDP per capita in PPP terms, between 2005 and 1996, relative to Denmark.
2/ Output gap = actual GDP – potential GDP. Potential GDP is calculated from a Cobb-Douglas production function that includes labor, capital, and trend total factor productivity.
3/ Implied average value for 2001-05.

2.4 Taking Stock of the Authorities' Disinflation Choice: Minimizing Purgatory Pains

At the onset of disinflation, the national authorities assess the available disinflation tools, and their choice of which to use will matter for long-term inflation. The rate of inflation can be brought down either permanently by credible monetary policy and market-oriented reforms; temporarily by short-term, fiat measures; or by a combination of both. With regard to permanently reducing inflation, the authorities establish a low-inflation environment by consistently pursuing price stability and gradually embedding low-inflation expectations. As for temporarily reducing inflation, the authorities bring about ad hoc changes in regulated prices and indirect taxes, engineer sharp demand contractions to bring inflation down along a short-run Phillips curve, or forge a temporary consensus of price and wage moderation.

In the late 1990s, the authorities in eurozone member countries demonstrated the possibility of manipulating the consumer price index through changes in regulated prices and indirect taxation, and measures in factor markets. For example, the Irish government was advised to "reduce the headline rate of inflation by reducing indirect taxes" (Beggs, 2000). Virtually all EU-15 countries engaged in some sort of fiscal or accounting gimmickry in their rush to the euro (Koen and van den Noord, 2005; and Ahearne and Pisani-Ferry, 2006). The output costs of pre-euro demand contractions were justified by their temporary nature as compared to the permanent benefits of eurozone membership.

The optimal choice of disinflation tools depends of the cost of reforms and benefits of eurozone membership, conditional on meeting the inflation target. If the country puts enough weight on the benefits of membership, the authorities choose the fiat measures in order to enter as quickly as possible with maximum political support (Ozkan, Sibert, and Sutherland, 2004). In contrast, the disinflation strategy of long-term structural reforms can be protracted, possibly pushing the date of eurozone membership too far off. If, however, the country assigns less weight to the immediate benefits of the euro, then the authorities are likely to deliver low inflation by additional structural reform measures and fewer fiat measures. The country would then enter the eurozone at a later date, but with a healthier economy.

The choice of disinflation strategies also depends on whether the criterion is "tight" or "soft." A tight criterion will push the authorities toward fiat measures, as the chance of meeting such a target would be limited without aggressive steps. In contrast, a soft criterion should, other things being equal, push the authorities toward adopting reform measures, as the chance of meeting a soft target would be sufficiently high without fiat actions or gimmicks.

Post-euro developments suggest that the initial choice of the reform-or-fiat disinflation mix has had long-term consequences. Structural rigidities, solidified by the use of administrative measures in the run-up to the euro, translate into a flatter Phillips curve, making the monetary policy transmission mechanism less efficient and future disinflations more costly. While the fiat-measure strategy may appear optimal over the short term, the longer-term outcome may be quite different.

The failure to create a low-inflation environment is likely to push the rate of inflation up over time, calling for further rounds of fiat-measure disinflation.[8]

3. How Costly Can Disinflation Be And Why?

We now build on the above link between structural reforms and the monetary transmission mechanism to simulate the cost of disinflation policies. To this end, we build a simple country-specific model based on Walsh (2003), asking two questions:[9]

(1) "What output gap—resulting from a monetary policy action—would have been consistent with bringing inflation toward the Maastricht criterion?" This is a hypothetical question because (i) some of the countries in our sample are already eurozone members and the Maastricht criterion does not apply to them; (ii) the eurozone members do not have control over monetary policy; and (iii) the NMCs did not (or could not) enter the eurozone at the time point we selected for our simulations. The disinflation announcements in the eurozone countries can be thought of either as the ECB targeting same disinflation for all countries or as the country leaving the eurozone and regaining monetary independence.

(2) What is the magnitude of the sacrifice ratio for a uniform disinflation shock of 100 basis points? Although the exact numerical results of our simulations need not be taken literally, the identical model structure enables us to evaluate the long-term costs of disinflation across individual countries and link these costs to past disinflation strategies.

The estimates arguably correspond to an upper limit of plausible levels of the sacrifice ratio. The disinflation strategies are not vulnerable to the Lucas critique providing inflation expectations are modeled properly, i.e., model consistent (rational) expectations are used. However, if the disinflation strategy is supplemented by structural reforms, which may influence the market structural characteristics, the parameters that determine the output sacrifice ratio may change. These changes are likely to push the sacrifice ratio estimates down relative to our simulations. Nevertheless, we see our estimates as a natural benchmark against which disinflations can be compared.

3.1 The Model

The model consists of five equations that represent aggregate demand, aggregate supply, the uncovered interest rate parity condition, term structure, and the policy-reaction function (see Annex 2 for further details).The aggregate spending relationship corresponds to the open economy version of the traditional IS curve and takes the form:

$$y_t = a_1 y_{t-1} - a_2 r_{t-1} + a_3 q_{t-1} + u_t, \tag{1}$$

[8] For example, in March 2006 the European Trade Union Confederation recommended "a moratorium on indirect taxes and administrative prices" to keep inflation below 2 percent (European Trade Union Confederation, 2006).

[9] Walsh drew on a variety of models, both for the closed economy case (Fuhrer and Moore, 1995a and 1995b; Fuhrer, 1997; and Rotemberg and Woodford, 1997) and the open-economy case (Batini and Haldane, 1999; and Svensson, 2000).

where *y, r*, and *q* are the deviations of log output, the long-term real interest rate, and the real exchange rate from their steady state level, respectively; and u is an aggregate demand shock. While we do not know the underlying steady state levels, it is sufficient for our approach to assume that they are mutually consistent. Whereas the coefficient a_1 captures the persistence of output behavior, the coefficients a_2 and a_3 reflect the impact of the real interest and exchange rates, respectively, on economic activity.

The aggregate supply equation, the Phillips curve, is as follows:

$$\pi_t = b_1(b_2\pi_{t-1} + (1-b_2)E_t\pi_{t+1}) + (1-b_1)\pi_{t-1}^{imp} + \gamma y_{t-1} + \eta_t\,, \tag{2}$$

where π is the quarterly change of the price level, $E\pi$ denotes inflation expectations, π^{imp} is import price inflation (the sum of foreign inflation and the change of the nominal exchange rate), and η is an aggregate supply shock. Inflation is persistent and can decline either through the impact of expectations (b_2), a negative output gap (γ), or positive external shocks. The supply relationship encompasses multi-period, overlapping nominal contracts, extended beyond the direct impact of import prices. The latter is an important feature of small open economies that rely heavily on the exchange rate channel of monetary transmission (the exchange rate pass-through effect), with the coefficient $(1-b_1)$ approximating the weight of imported goods in the consumer basket.

Agents are not fully forward looking and base their inflation expectations both on history and currently available information:

$$E_t\pi_{t+1} = e_1\pi_{t+1}^e + (1-e_1)\pi_{t-1}\,, \tag{3}$$

where π_{t+1}^e represents model-consistent expectations. Expectations for all agents in the economy are "rational," but this does not prevent some of the agents from using the rule of thumb and looking at past inflation as well.

The relationship with the world is captured through the uncovered interest rate parity condition that relates the behavior of domestic and foreign interest rates and the nominal exchange rate, while exhibiting some persistence:

$$\Delta s_{t+1} = c_1\Delta s_t + (1-c_1)(ir_t - ir_t^* - prem_t) + \nu_t\,, \tag{4}$$

where Δs is the change in the nominal exchange rate; ir and $ir*$ are the domestic and foreign long-term nominal interest rates, respectively; $prem$ is the risk premium; and ν is an exchange rate shock. The coefficient c_1 determines the level of exchange rate persistence—higher values imply less sensitivity to interest rate changes. The long-term rate is approximated by the one-year nominal interest rate, while the short-term nominal interest rate is represented by the three-month nominal interest rate, which is directly linked to the policy reaction function. Looking forward, the long-term rate follows the term structure equation as a simple average of short-term interest rates.

The model is closed by a policy reaction function, the Taylor rule. The monetary authority responds to the level of expected inflation; the deviations of expected inflation from a target, π^T; and the output gap, while taking into account the previous-period policy stance, i_{t-1}:

$$i_t = d_1 i_{t-1} + (1-d_1)(\pi^e_{t+1} + d_2(\pi^e_{t+1} - \pi^T) + d_3 y_t) + \varepsilon_t, \quad (5)$$

where i is the domestic short-term nominal interest rate and ε is a policy shock. The monetary authority is fully forward looking and thus uses model-consistent inflation expectations, π^e_{t+1}, in its decisions.

The disinflation path is determined jointly by all elements of the model.[10] Other things being equal, disinflation requires an output gap and the inflation sensitivity to the output gap is determined by the slope of the Phillips curve, γ. However, disinflation is less painful if the agents are forward looking (a small b_2 coefficient), or the exchange rate is less persistent (a small c_1 coefficient), or both. To ensure comparability of individual countries, we assume that the weights of inflation and output stabilization—d_2 and d_3, respectively—in the policy reaction function are the same for all countries and equal to ½ (Taylor, 1993), while the policy persistence parameter, d_1, is country-specific.

3.2 Calibration

The choice of countries is based on their inflation history. We simulate disinflations in four EU-15 countries with historically high inflation rates: Greece, Ireland, Italy, and Spain; and in five NMCs: the Czech Republic, Hungary, Poland, Slovakia, and Slovenia.

The country-specific models are calibrated following the methodology outlined in Coats et al. (2003) and Berg et al. (2006). The parameters are based on: (i) economic principles; (ii) available econometric and anecdotal evidence; and (iii) the sensible behavior of the whole model. The calibration process is iterative: choosing reasonable parameter values, examining the properties of the model next, and changing the parameter values or the structure of the model, until the model behaves appropriately.

First, we replicate the structural-model Phillips curve estimates summarized in Rumler (2005) and other recent national central bank, ECB, and IMF publications, using the exact values of the estimated or calibrated coefficients.[11] Second, we set the remaining parameters to mimic the known features of the individual economies, drawing either on the impulse response functions from the published central bank models or structural VARs.[12] Both help us to assess the underlying dynamics in the countries under consideration. Although the estimates of impulse response functions in the NMCs should be taken with a grain of salt, they are useful for designing the dynamic properties of individual calibrations. They help us to replicate, for example, the strong exchange rate channel in Hungary, the stability of the real exchange rate in Slovenia, or the "two-peak" response of inflation to an interest rate shock reported in Poland.

Given the dual objective of replicating the economies' stylized facts obtained from the various VARs and doing it in comparable manner, the calibrated parameters of the rest of the model

[10] See Buiter and Grafe (2001) for a thorough discussion of the transmission mechanism.

[11] Coats et al. (2003), Gavura and Reľovský (2005), Łyziak (2002), Kłos et al. (2005), Jakáb and Kovács (2002), van Els et al. (2001), Berben et al. (2004), and Rumler (2005). If an exact estimation or calibration of the Phillips curve is missing, as in the case of Ireland, the model structure is calibrated to replicate the responses reported in Mojon and Peersman (2001) and Els et al. (2001).

[12] Arnoštová and Hurník (2005), Kuijs (2002), Wróbel and Pawlowska (2002), Vonnák (2005), Ganev et al. (2001), and Mojon and Peersman (2001).

equations do not necessarily coincide with any particular equation in the literature. Clearly, the same set of stylized facts can be captured through an alternative set of calibrations. For example, policy persistence can be captured either through the policy reaction function or through the other equations in the model. We have chosen the latter option, as this approach allows distribution of persistence into different channels, such as the exchange rate, inflation, and so on. Consequently, our Taylor rule persistence coefficient is on average only about ½ of that estimated by Clarida et al. (1998). As a result, the most variable coefficient in our calibrations is exchange rate persistence, capturing directly alternative approaches to exchange rate management by individual central banks. The higher the coefficient, the more the central bank was involved in exchange rate management.

The coefficients exemplify the impact of past policy choices. Reform laggards tend to have a flatter Phillips curve (Hungary, Italy), while countries with credible monetary policies benefit from the forward-looking behavior of economic agents (the Czech Republic, Ireland), and so on. We report the main country-specific coefficients in Table 3 and the economies' characteristics in more detail in Annex 3.

Table 3: The Main Coefficients Used in Country-Specific Models

	Output persistence (a_1)	Expectations formation (b_2)	The slope of the supply curve (γ)	Exchange rate persistence (c_1)	Taylor rule policy persistence (d_1)
	Old member countries				
Greece	0.60	0.40	0.20	0.90	0.40
Ireland	0.80	0.70	0.20	0.30	0.40
Italy	0.90	0.60	0.05	0.40	0.50
Spain	0.90	0.90	0.10	0.50	0.60
	New member countries				
Czech Republic	0.80	0.50	0.20	0.20	0.50
Hungary	0.90	0.50	0.05	0.50	0.90
Poland	0.90	0.80	0.30	0.50	0.40
Slovakia	0.90	0.50	0.10	0.90	0.50
Slovenia	0.90	0.70	0.20	0.90	0.50

Source: Various publications; authors' simulations.

3.3 Simulations

Basing calibrations on observed past behavior makes our results open to the Lucas critique, since we are asking what the optimal disinflation strategy is, *conditional on the past structure of the economy and historically observed agents' response to shocks*[13]. We find the past-structure scenario quite attractive, because it provides a benchmark against which scenarios of a changing policy environment can be compared. Of course, there is no a priori reason why the model coefficients should remain fixed during the whole disinflation period. We may overestimate the

[13] It is only the impact of structural reforms on the market structure, and thus on the structural parameters, that is open to the Lucas critique, as expectations are model-consistent.

sacrifice ratio if the country reforms during the disinflation period or if the agents become more forward looking.

In our first set of simulations—"what output gap would have been consistent with bringing inflation toward the Maastricht criterion?"—the monetary authority announces a lower (credible) inflation target equivalent to the Maastricht inflation criterion. The announcement specifies the target only, letting the authorities choose a disinflation path consistent with the lowest possible costs, given its reaction function. The magnitude of the disinflation announcement depends on inflation observed at the time of the announcement and the value of the Maastricht criterion at that time.[14]

The starting point of our simulations is the assumption of a typical transmission period: the disinflations in our simulations start six quarters before the particular country has had inflation at or below the criterion for the last time. In countries that have yet to meet the criterion—Hungary, Slovakia, and Slovenia—the disinflation starts six quarters before the end of our data sample; the same rule is applied for Greece, whose inflation did not satisfy the criterion during 2001–2005. The five-year disinflation trajectories and associated cumulative output gaps are thus fully model-dependent (Figure 4 and Annex 3).

While the disinflation costs in term of lost output are relatively low for the old member countries, given that their required disinflation was only 90 basis points on average, they are much larger for such high-inflation NMCs as Hungary or Slovakia. For example, Ireland's disinflation of 170 basis points would require sacrificing only about ½ percent of GDP during the next five years. In contrast, disinflations of 300 basis points and 600 basis points in Hungary and Slovakia would require sacrificing a whopping 7 percent and 12 percent of GDP, respectively. These results reflect a much less effective transmission mechanism in the two countries, but it is hard to imagine that the national central banks could justify such a disinflation strategy or that their policies would not become more credible in due course. In contrast, the three remaining NMCs show relatively small output losses: ¾ percent of GDP in the Czech Republic and Poland and 3 percent in Slovenia.

In our second set of simulations we normalize the disinflation shock to 100 basis points for all countries, thus avoiding the complication of different initial disinflation announcements. Following Cecchetti and Ehrmann (1999), we cumulate the associated output gap over both the three-year horizon and the full simulation horizon (Table 4). While our model does not allow calculation of confidence intervals, our simulation results are broadly similar to structural-model estimates of the sacrifice ratio for some countries from our sample. (Table A.3.3).

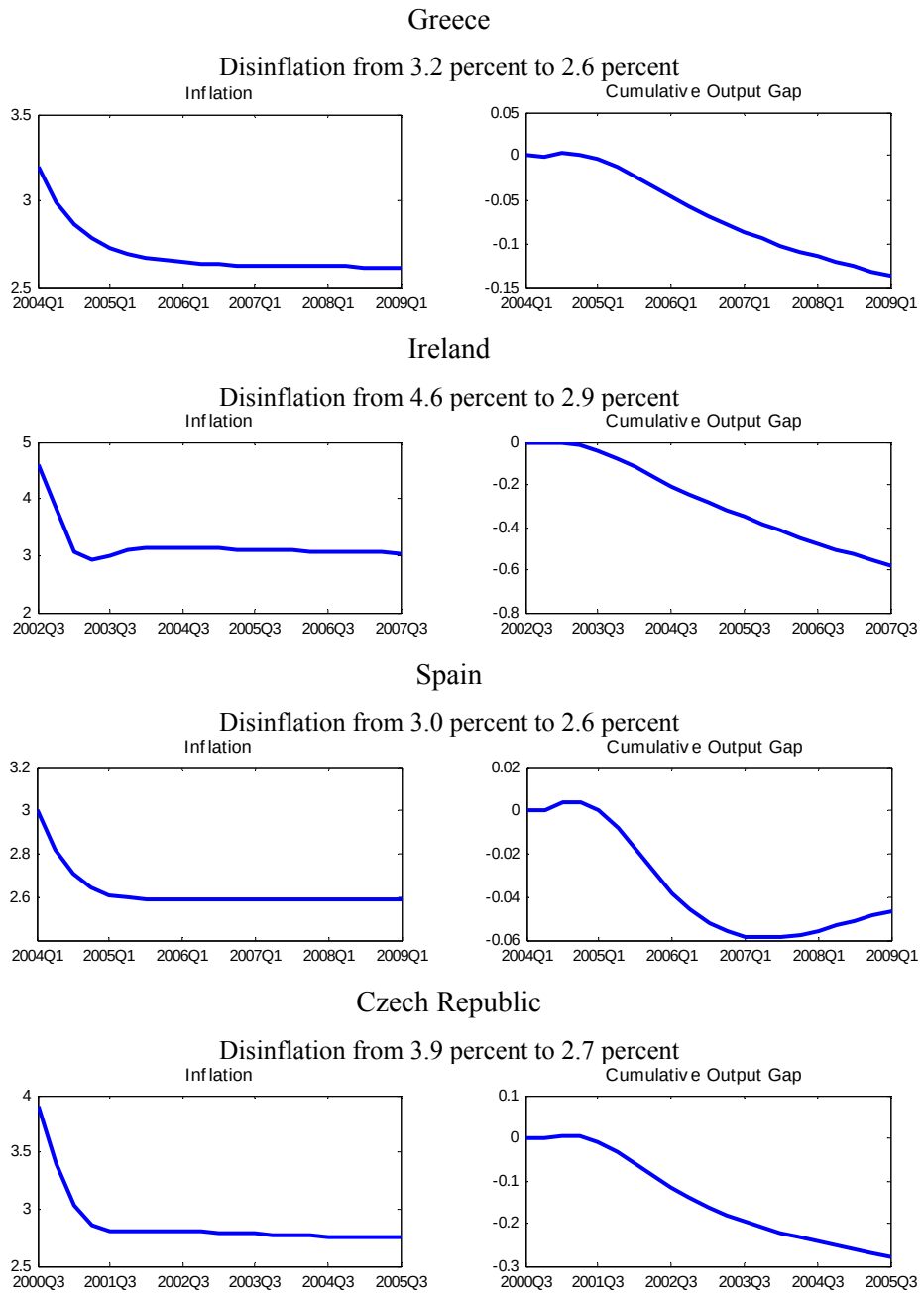
[14] We exclude Italy, which had inflation below the criterion during 1999–2005. It is worth noting that Italy's 2002–2005 cumulative output gap was equivalent to -2 percent of GDP.

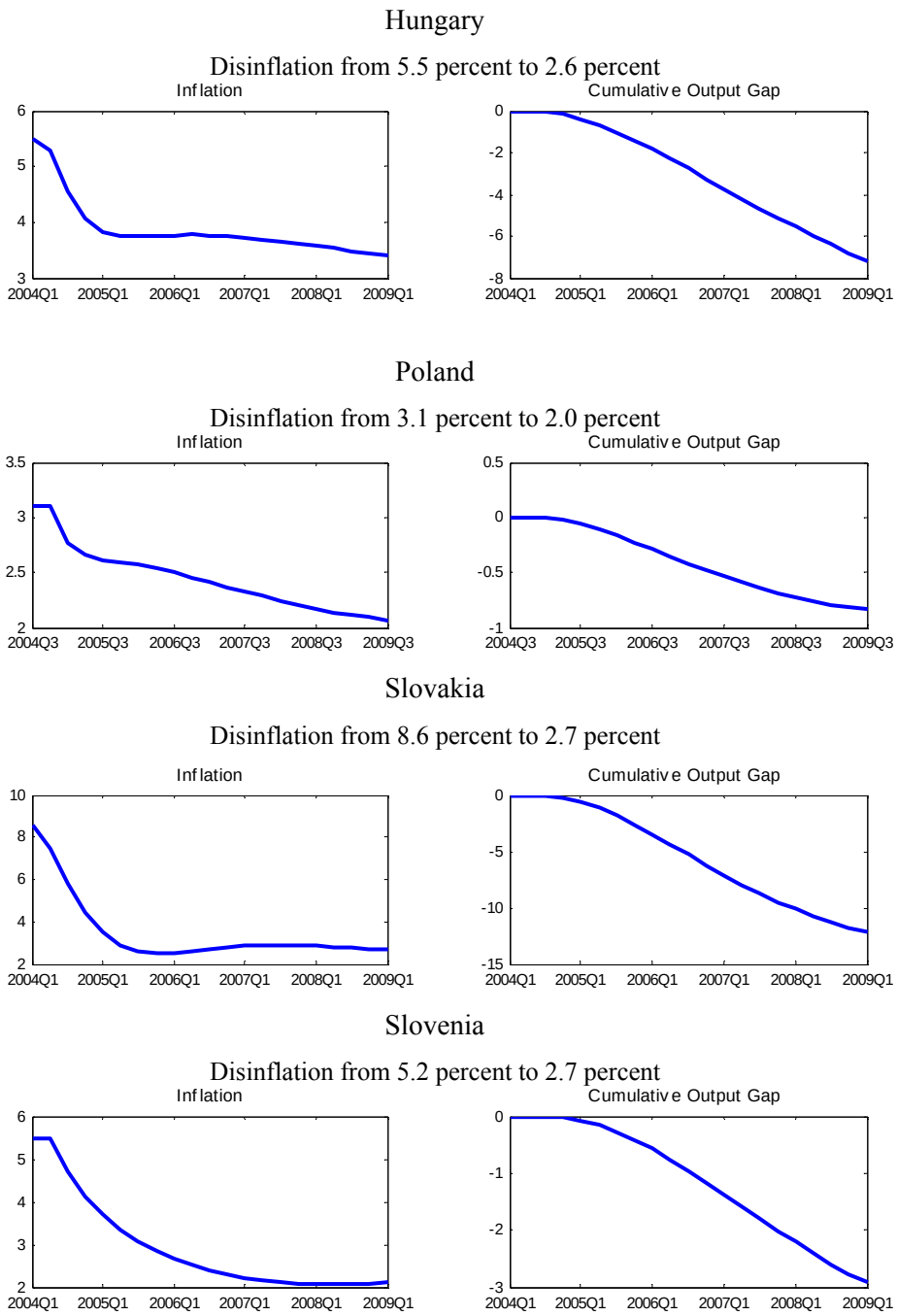
Table 4: The Sacrifice Ratios in a 100-Basis Point Disinflation *(In percent of GDP)*

	Old member countries				New member countries				
Cumulative output gap	Greece	Ireland	Italy	Spain	Czech Republic	Hungary	Poland	Slovakia	Slovenia
12-quarter	-1/10	-1/10	-½	-¼	-1/10	-¾	-½	-¾	-⅓
Full-horizon	-¾	-½	-3 ½	-1 ¾	-½	-4	-¾	-¾	-1 ⅓

Source: Authors' simulations.

Figure 4: The Disinflation Path and Cumulative Output Gap *(In percent)*





Source: Authors' calculations.

The output losses differ across countries and across simulation horizons, conditional on the stability of simulation coefficients. First, across countries, disinflation does not seem very costly in the Czech Republic, Ireland, and Poland, whereas the costs appear very high in Hungary and Italy and only marginally smaller in Slovenia and Spain. Second, across time horizons, while the three-year and full-horizon output losses are quite similar in the Czech Republic, Ireland, Poland, and Slovakia, the long-run losses are a multiple of the short-run losses in Greece, Hungary, Italy, Slovenia, and Spain. These differences can be attributed to the speed of the exchange rate pass-through as well as to the interest rate sensitivity of the exchange rate. In some countries, such as Hungary and Poland, the direct exchange rate channel helps initially to decrease inflation relatively quickly; however, further disinflation remains costly when this channel is exhausted

(see the detailed charts in Annex 3). Thus, the point about passing through purgatory on the way to the euro may have some validity after all (Buiter, 2004).

While the magnitude of the output losses is mostly persistency-related, this persistency cannot be solely attributed to the structural characteristics of the individual economies. The unemployment–inflation trade-off changes over time depending on monetary policy credibility (Laxton and N'Diaye, 2002). Thus, the large output losses in Hungary can be attributed to the limited credibility of national monetary policy, which has not been able to bring inflation systematically below 5 percent since 1990, and which disinflated from double-digits only in 2001, some five years later than in the Baltics and the Czech Republic. A similar argument can be made for Slovakia and Slovenia. In the eurozone countries, however, given the existence of a common monetary policy, the results should be attributable fully to the structural characteristics of the respective economies.

Our results for the selected EU-15 countries, most notably Italy and Spain, seem to be consistent with the policy choice of "low inflation now, reforms later." On the one hand, their short-term costs of disinflation are relatively modest, mainly because of "borrowed credibility" from the ECB. On the other hand, their long-term costs are high, reflecting structural rigidities inherited from the past. In their rush to the euro, these countries set aside reforms that would ultimately have left their economies more flexible and better prepared for future disinflations. In contrast, Ireland's economy seems more flexible and disinflations ought to be relatively painless over the long run.

4. Policy Implications

The policy relevance of the Maastricht inflation criterion has been unfairly downplayed. The criterion has had a profoundly positive impact on the public stance toward inflation and a less positive impact on the choice of instruments to achieve the desired inflation outcome in the run-up to the euro. EU member country authorities have known that inflation can be brought down either by short-term, fiat measures or by long-term, market-oriented reforms, or by a combination of both. While the former instruments are virtually costless in terms of domestic political capital, the latter can be costly, especially in economies with longstanding rigidities supported by influential political groups.

The choice between fiat and reform disinflation strategies is affected by the definition of the Maastricht inflation criterion. A tight definition of the criterion may tilt the NMCs toward the fiat-measure strategy, as the chance of meeting a tight target may seem limited without aggressive fiat measures. A softer criterion, in contrast, would make the long-run reform strategy more likely to succeed and, thus, more likely to be selected by the authorities. The fiat strategy may seem particularly attractive to countries that expect to benefit immediately from the euro, or that assign a high discount factor to the future because, for example, the leading political party faces reelection. Short-term benefits of the euro would come either from lower fiscal borrowing costs (Greece and Italy), reduced current account vulnerability (the Baltics), or from the ECB's low-inflation credibility (Italy, Hungary, and Slovakia). The benefits of lower interest rates, however, are not relevant for most NMCs—their public debt to GDP ratios are one-half or less compared with those of Greece and Italy in the 1990s. However, as the ratio of public debt to GDP continues to increase in some NMCs, they may find this benefit attractive after all.

The choice of whether to reform or not affects, however, both future inflation and the cost of future disinflations. On the one hand, regulated markets with high markups and labor costs generate inflationary impulses. On the other hand, economies with nominal rigidities tend to have inefficient monetary transmission mechanisms, and inflationary impulses need to be extinguished with larger output gaps. Although a country opting not to reform may succeed in lowering inflation temporarily, it will fail to address the underlying cost-push factors. Moreover, its sacrifice ratio would remain high, making future disinflations costly.[15] Having said that, some countries may still be better off by opting for fiat measures, especially if the ECB's credibility makes agents more forward looking.[16]

A rush toward low inflation would be costly both for the NMCs and for the ECB. It is not clear that all of the NMCs need (or would gain) monetary policy credibility. Moreover, even if such credibility gains were achieved in Hungary or Slovakia, would it be worth the output losses implied by our simulations? The long-term risks associated with a premature and fiat-driven entry into the eurozone are similar to those faced by some old member countries—stalled reforms, inflexible economies, and real exchange rate appreciation following euro adoption. The long-term impact on the ECB can be costly as well. The tighter the Maastricht inflation criterion, the more NMCs will choose the fiat measures, postponing structural reforms and worsening the eurozone transmission mechanism, with an adverse impact on ECB decision making.

Building on the above results, we draw two implications for the Maastricht inflation criterion. First, inclusion of economies with large negative output gaps in the three best performers has made the inflation criterion unnecessarily tight, providing incentives for fiat disinflation measures. It would seem preferable to exclude countries with negative gaps from the calculation, or to calculate the average inflation rate over the full length of the business cycle. This could be a relatively undemanding change—estimates of the output gap are published regularly by the EU (the AMECO database). Second, the short, 12-month testing period during the ERM2 period may further stimulate the NMCs to use the fiat strategy. A longer testing period, covering the full business cycle, would seem more appropriate.

5. Conclusions

The Maastricht inflation criterion has been an influential nominal rule for the past 15 years. It has helped reduce inflation dispersion among the EU countries to levels last seen in the 1960s, even though it could not prevent a gradual increase in inflation in some countries in the 2000s. While the criterion influences positively the public stance toward low inflation, it biases the choice of the disinflation strategy toward fiat measures in countries that have a lot to gain from the euro. These countries tend to opt for "low inflation now, reforms later," which yields low inflation instantly at the cost of postponing structural reforms and preserving comparatively high sacrifice ratios. While the purgatory of the ERM2 can be made relatively painless by fiat measures, such a

[15] It has been argued that "[...] measures, including reductions in indirect taxes and freezing administered prices, will not slow the momentum of underlying inflation and wage dynamics. Moreover, capping administered prices would entrench the current distorted price structure" (International Monetary Fund, 2005).

[16] Greece provides a good example of an improved transmission mechanism despite only modest reforms and mostly fiat-driven disinflation (Chionis and Leon, 2006).

strategy is likely to result in inefficient transmission mechanisms and costly disinflations, complicating ECB decision making.

The main contribution of the paper is finding empirical support for the link between the choice of disinflation strategies and disinflation costs. While disinflation does not seem very costly in countries that tend to be labeled as reformist, say, the Czech Republic or Ireland, the costs appear much higher in reform laggards, say, Hungary or Italy. To this end, we formulate a simple macroeconomic model, calibrate it using the available empirical results for the Czech Republic, Greece, Hungary, Ireland, Italy, Poland, Slovakia, Slovenia, and Spain, and simulate the output consequences of disinflation strategies. We find that—using past performance and assuming stability of our coefficients—the implied sacrifice ratios differ across countries and across the simulation horizons. These differences stem from the slope of national Phillips curves, expectations formation, and the level of output, inflation and exchange rate persistence.

Our results suggest two potential changes to the definition of the Maastricht inflation criterion. First, calculate it so as to avoid the influence of the business cycle, which periodically makes the criterion very tight. Second, lengthen the period for the criterion evaluation to avoid reliance on fiat disinflation strategies.

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Appendix 1

The Maastricht Inflation Criterion: A Short History Lesson

The Maastricht inflation criterion was designed as one of the instruments to stabilize the European currencies in preparation for the euro.[17] Following the oil shock of 1973, Europe experienced great nominal divergence, which thwarted further progress toward economic and political integration. When the nominal anchor of semi-fixed exchange rates failed, the European authorities decided to set simple and understandable targets that would constrain fiscal and monetary policies in the EU.

The European exchange rate mechanism (ERM) was introduced by the European Community in March 1979—as part of the European Monetary System (EMS)—to reduce exchange-rate variability and achieve monetary stability in Europe, in preparation for Economic and Monetary Union and the introduction of a single currency, the euro. While the new system set up various institutional instruments to prevent exchange rate movements outside a pre-specified level, macroeconomic conditions soon undermined it. The dispersion of inflation rates increased steadily, peaking in the mid-1980s, and the differential between low-inflation and high-inflation countries remained in double digits until 1991.

Diverging inflation rates and the associated volatility in real exchange rates made the quest for stable currencies elusive. Periodic adjustments raised the values of strong currencies—especially the Deutschmark—and lowered those of weaker ones. While during the late 1980s changes in national interest rates were used to keep the currencies within a narrow range (2.25 percent), the system eventually collapsed in the early 1990s owing to the differing economic policies and conditions of its members.

The collapse of the ERM spurred further coordination among EU member countries, which surrendered some of their monetary independence. The euro was established by the provisions in the 1992 Maastricht Treaty on European Union: in order to participate in the new currency, member states had to meet budget deficit, debt ratio, inflation, and interest rate criteria.[18] The inflation criterion was eventually defined as "an average rate of inflation, observed over a period of one year before the examination, that does not exceed by more than 1½ percentage points that of, at most, the three best performing Member States in terms of price stability"

[17] In this paper, when referring to the European Union prior to 2004, we have in mind the so-called EU-15, comprising Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. For the sake of simplicity we ignore some countries that participated in various associated arrangements but were not members of the EU.

[18] These macroeconomic conditions were specified in Article 109(j) of the Maastricht Treaty (http://www.eurotreaties.com/maastrichtec.pdf) and the inflation criterion read: "the achievement of a high degree of price stability; this will be apparent from a rate of inflation which is close to that of, at most, the three best performing Member States in terms of price stability."

(European Central Bank, 2004).[19,20] In 1999, ERM2 replaced the original ERM, while the original criteria were retained.

In May 2004, 10 new countries were admitted to the European Union (EU): the Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia. Seven of the NMCs—Cyprus, Estonia, Latvia, Lithuania, Malta, Slovakia, and Slovenia—entered the ERM2 in 2004 and 2005 and their inflation performance will be assessed accordingly.

[19] The ECB interprets the Treaty provisions as follows. First, the inflation rate is calculated using the increase in the 12-month average of the harmonized index of consumer prices (HICP) over the previous 12-month average. Second, the notion of "at most, the three best performing Member States in terms of price stability," is applied by taking the unweighted arithmetic average of the rate of inflation of the three EU countries with the lowest inflation and adding 1½ percentage points to that average. Third, negative rates of inflation, as in Lithuania in 2004, are excluded from the average.

[20] See Giavazzi and Pagano (1988) for an early justification of the inflation criterion.

Appendix 2

The Factors of Inflation in EU-15 Countries

Several explanations for the differentials have been put forward, namely, price-level convergence, demand pressures, and "structural" distortions. We review these in turn and reflect them subsequently in our simulations.

1. Inflation and the level of economic development

It has been observed that the average price level and the level of economic development are closely correlated—prices of nontradable goods and services tend to be substantially lower in countries with lower per capita GDP and *vice versa*. Thus, as the relatively poorer countries' income converges toward that of relatively richer countries, faster inflation in the initially poorer countries can be expected to bring the two price levels into line. Historically, the relationship has been close to unity: an increase in GDP per capita in purchasing power parity units relative to the EU average by 1 percent corresponds to an increase in the price level relative to the EU by 0.7–0.9 percent (Čihák and Holub, 2005). This adjustment can be effected either through higher domestic inflation (and a stable currency vis-à-vis the euro) or through nominal appreciation of the domestic currency (and a stable rate of inflation vis-à-vis the eurozone). Of course, the nominal appreciation channel is partly closed for countries in the ERM 2 regime and fully closed for eurozone countries—exchange rate fluctuations are limited during the ERM 2 and the currency is fixed thereafter.

The income level differentials seem to be a long-lasting source of future inflation—on current trends, the differentials are expected to close only in 10–25 years (Čihák and Holub, 2005). Arguably, this type of convergence-driven inflation is taken care of in the Maastricht criterion. The safety margin of the criterion—1½ percentage points above the rate of inflation in the three best-performing member states—should take care of most of this change in the price level. Indeed, most recent studies estimating the Balassa-Samuelson effect have not found its impact at above 1½ percentage points annually (see Mihaljek and Klau, 2006, for a review), although the longer-term impact of large capital inflows into the NMCs is difficult to estimate (Lipschitz, Lane, and Mourmouras, 2006).[21]

2. Inflation and aggregate demand

Aggregate demand fluctuations seem to explain a substantial part of the EU-15 inflation differential. Low inflation comes at a cost—disinflations tend to be associated with output below its potential as the economy moves along a short-run Phillips curve. During 2001–2005, a cumulative output gap of more than 1 percent of GDP relative to the average was associated with inflation lower than the EU-15 average by 0.1 percent. The gap–inflation nexus in the NMCs has been, predictably, much less tight than in the EU-15 countries, reflecting two factors. First, several of the NMCs went through periods of massive disinflations that necessitated substantial

[21] While capital inflows generate consumer booms and price pressures, exchange rate appreciation pushes inflation down through the import price channel. In some countries, e.g., the Czech Republic or Poland, the latter channel has offset the former channel.

demand contractions. Second, measurement problems continue to plague the national accounts in many NMCs.

The member states' cyclical stance is not taken into account in the calculation of the Maastricht criterion, making the criterion at times unnecessarily tight (Buiter, 2004; and Schadler et al., 2005). While the inflation rate in the three best-performing countries averaged about 1 percent during 1999–2005, in the early 2000s this rate hovered below 0.5 percent and in the mid-2000s below 0.8 percent. During these periods, the fast-growing ERM 2 countries would have had to engineer relatively strong demand contractions in order to meet the Maastricht criterion. Some of the new member central banks have resigned themselves to the need for tight demand policies in the run-up to the euro: for example, the Slovak National Bank (2005) in its inflation forecast for 2007–2008, announced that "monetary conditions should, however, throughout the period remain moderately restrictive so as to avoid the complete closing of the output gap."

3. Inflation and market regulation

The EU countries have differed substantially in their approach to market-oriented reforms and these differences affect both the generation of cost pressures and their transmission to consumer prices, creating potentially the most problematic of the three channels of inflation. Countries with more protected product and labor markets have had higher average inflation rates than those with less protected markets. Regarding product markets, protected economies tend to have both higher markups and a slower pass-through of external price shocks to consumer price inflation.[22] The countries that lagged behind the most in 1998 (France, Greece, and Italy) still did not bring their level of product market protection in 2003 to the median level (Conway et al., 2005). Regarding labor markets, trade unions in protected economies have exercised strong wage pressures, manifested in fast growth in unit labor costs (e.g., Italy). The progress toward less labor market protection has been even less pronounced, and labor markets have become actually less flexible in several EU-15 countries, offsetting EU policies of wage moderation (OECD, 2004; and Estevão, 2005).

Structural reforms—such as those that increase competition in domestic factor and product markets—tend to result in lower long-term inflation. This mechanism can operate either directly through smaller markups and more intensive price competition, which keep prices pressures in check, or indirectly through expectations formation, as agents in flexible economies tend to have more forward-looking expectations than agents in economies without such flexibility. As a result, economies with forward-looking agents tend to have less costly disinflations (Laxton, and N'Diaye, 2002).

4. Quantitative results

We find that EU-15 inflation during 1996–2005 was associated mostly with variability of the output gap and structural reform variables, while GDP per capita was not statistically significant. We estimated a panel regression of average inflation on relative PPP GDP per capita; a measure of the GDP gap; and various measures of structural reforms undertaken during this period in product market, administrative, and labor market regulation. To avoid potential simultaneity—for example, from inflation to the level of development and back to inflation—the panel is estimated

[22] See Angeloni and Ehrmann (2004), Bayoumi et al. (2004), and Honohan and Lane (2003).

as a two-step generalized method of moments (GMM) regression, with appropriate instruments (see Table A2.1).

Inflation in EU-15 countries is explained mostly by differences in individual countries' cyclical stance, although regulation in product and labor market matters as well. Quantitatively, the output gap of 1 percent has been associated with a reduction in annual inflation of about 0.3–0.4 percent. More regulation in product or labor markets by one sample standard deviation has been associated with a rise in inflation, by 0.3–1.0 percent. Although we could drop GDP per capita from the equation on statistical grounds—the coefficient is statistically insignificant—its omission generates omitted-variable bias. We note, moreover, that the coefficients are comparable with those in Čihák and Holub (2005).

The experience of the old member countries is instructive in several respects. Apart from the relatively high sacrifice ratio, the impact of past reforms (or a lack thereof) drives inflation in the EU-15 countries. The lack of structural reforms may push inflation up in the future through two channels: first, through cost-push channels, as a result of either markup or wage-cost pressures; and, second, through its impact on the monetary transmission mechanism, by making inflation more persistent.

Table A2.1. Determinants of European Inflation, 1996–2005

This table reports the results of panel regressions for EU-15 countries excluding Luxembourg. The dependent variable is the annual rate of inflation. GDP per capita is measured in PPP terms and is expressed as a ratio to Denmark's GDP (*World Development Indicators* database). The output gap is measured in percent of potential output (the production-function-based estimate in the *AMECO* database). Product market, administrative, and labor market regulation variables are based on data in Conway et al. (2005) and OECD (2004) respectively; observations are linearly interpolated. The index of regulation gives a weight of one-third to each variable. The estimation technique uses a two-step GMM, with one lag for instruments. Other instruments are the trend-based output gap and U.S. dollar GDP per capita relative to Denmark.

	A	B	C	D
GDP per capita	-1.835 (1.22)	-1.121 (0.91)	-1.126 (0.77)	-1.498 (0.92)
Output gap	0.429** (5.53)	0.409** (5.44)	0.337** (4.49)	0.374** (4.80)
Product market regulation	1.91** (3.81)			
Administrative regulation		0.237 (1.57)		
Labor market regulation			0.671* (2.09)	
Index of regulation				0.980* (2.41)
Country fixed effects	Yes	Yes	Yes	Yes
Years fixed effects	Yes	Yes	Yes	Yes
R^2	0.70	0.66	0.68	0.68
Observations	140	140	140	140

Note: *t* statistics in brackets.
* significant at 5 percent; ** significant at 1 percent.

Appendix 3
The Model

This annex details the model specifications and individual country calibrations. In addition, it presents extended graphs of simulated disinflation trajectories.

The model specification takes the form:[23]

$$y_t = a_1 y_{t-1} - a_2 r_{t-1} + a_3 q_{t-1} + u_t \tag{1}$$

$$\pi_t = b_1(b_2\pi_{t-1} + (1-b_2)E_t\pi_{t+1}) + (1-b_1)\pi_{t-1}^{imp} + \gamma y_{t-1} + \eta_t \tag{2}$$

$$\pi_t^{imp} = m_1\pi_{t-1}^{imp} + (1-m_1)(\pi_{t-1}^{*} + \Delta s_{t-1}) \tag{3}$$

$$E_t\pi_{t+1} = e_1\pi_{t+1}^{e} + (1-e_1)\pi_{t-1} \tag{4}$$

$$\Delta s_{t+1} = c_1\Delta s_t + (1-c_1)(ir_t - ir_t^{*} - prem_t) + \nu_t \tag{5}$$

$$i_t = d_1 i_{t-1} + (1-d_1)(\pi_{t+1}^{e} + d_2(\pi_{t+1}^{e} - \pi^{T}) + d_3 y_t) + \varepsilon_t \tag{6}$$

$$ir_t = f_1 ir_{t-1} + (1-f_1)[(i_t + i_{t+1} + i_{t+2} + i_{t+3})/4] \tag{7}$$

$$r_t = ir_t - E_t\pi_{t+1} \tag{8}$$

$$q_t = q_{t-1} + (\Delta s_t + \pi_t^{*} - \pi_t)/4 \tag{9}$$

where equations (1) to (9) represent aggregate demand, aggregate supply, import price formation, inflation expectations formation, uncovered interest rate parity, the policy reaction function, the interest rate term structure, the Fisher equation and real exchange rate formation, respectively. Tables A3.1 and A3.2 define the model variables and detail the country-specific calibrations. The values of the steady-state variables are normalized to zero and so are foreign inflation and interest rates. It follows that the steady-state level of the domestic nominal interest rate equals inflation (the steady-state level of the real interest rate is equal to zero) and the same holds for the steady-state level of the nominal exchange rate change. The latter simply equals the difference between domestic and foreign inflation.

The parameters are calibrated following the methodology outlined in Coats et al. (2003) and Berg et al. (2006). First, we replicate the Phillips curve estimates summarized in Rumler (2005). Second, we set the remaining parameters to mimic the known features of the individual economies. Below we summarize the salient features of the simulated economies that we reflected in our calibrations.

The old member states differ substantially in the observed persistence of their economies and in expectations formation. *Greece* is a low-persistency economy with respect to IS and Phillips curve persistency. The financial markets are, however, mostly backward looking, with persistent exchange rates. *Ireland's* monetary policy reacts quickly and forcefully, mostly through the exchange rate channel. Although output is not much affected by monetary policy shocks, the gap-to-inflation nexus is comparatively strong. *Italy* appears to have a highly persistent economy with a flat Phillips curve. This persistence is compensated only partly by reactive monetary policy

[23] The model was simulated in MATLAB, using the IRIS computing environment. Further details are available on request.

(low persistence in policy rates). *Spain* seems to be a highly persistent economy, but the Phillips curve is somewhat steeper than that of Italy.

The NMCs exhibit comparable persistence of their real economies and inflation, but they differ in the slope of their Phillips curves (i.e., monetary policy credibility), and in the forward-looking behavior of their financial markets (i.e., persistency in the exchange rate).

The Czech Republic is not particularly flexible, but the persistence is offset by a steep Phillips curve and largely forward-looking financial markets. *Hungary* has the least favorable monetary policy environment in our sample. A flat Phillips curve is accompanied by a mostly backward-looking element in exchange rate behavior. Moreover, the latter is buttressed by sluggish monetary policy reactions. *Poland* has a quick direct exchange rate channel, which is supplemented, with a lag, by the traditional output gap channel. This yields the specific "two-peak" response of inflation to a monetary policy shock reported in the literature. *Slovakia* exhibits mostly backward-looking behavior in the financial markets and monetary policy reactions are sluggish. Such persistency is only partially compensated by the Phillips curve, the steepness of which is below the sample average. *Slovenia* displays similar traits of backward-looking behavior in the financial markets, which calls for comparatively long-lasting policy effects. However, Slovenia's Phillips curve is steep, diminishing the cost of disinflation.

Table A3.1. Model Variables

y_t	the deviation of the log output from its steady state level
r_t	the deviation of the long-term real interest rate from its steady state level
q_t	the deviation of the real exchange rate from its steady state level
π_t	inflation, quarter-to-quarter change of the price level
$E_t\pi_{t+1}$	inflation expectations
π^e_{t+1}	model consistent inflation expectations
π^{imp}_t	the rate of growth of import prices
Δs_t	the change in the nominal exchange rate
i_t	the short-term (three-month) nominal interest rate is also the policy rate
ir_t	the long-term nominal interest rate
π^*_t	foreign inflation
ir^*_t	the foreign long-term nominal interest rate

Table A3.2. Parameter Calibrations

Parameters	Greece	Ireland	Italy	Spain	Czech Republic	Hungary	Poland	Slovakia	Slovenia
a_1	0.6	0.8	0.9	0.9	0.8	0.9	0.9	0.9	0.9
a_2	0.2	0.1	0.2	0.3	0.25	0.05	0.1	0.1	0.1
a_3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
b_1	0.9	0.6	0.9	0.9	0.8	0.8	0.8	0.8	0.7
b_2	0.4	0.7	0.6	0.9	0.5	0.5	0.8	0.5	0.7
γ	0.2	0.2	0.05	0.1	0.2	0.05	0.3	0.1	0.2
m_1	0.6	0.4	0.7	0.6	0.6	0.3	0.0	0.6	0.0
e_1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
c_1	0.9	0.3	0.4	0.5	0.2	0.5	0.5	0.7	0.9
d_1	0.4	0.4	0.5	0.6	0.5	0.9	0.4	0.9	0.5
d_2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
d_3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
f_1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

In Figure A3.1 we report in greater detail the graphs of the country-specific disinflation trajectories, adding the interest and exchange rates, and output gap to the information presented in Figure 3.

Table A3.3. Empirical Estimates of the Sacrifice Ratio 1)
(In percent of GDP)

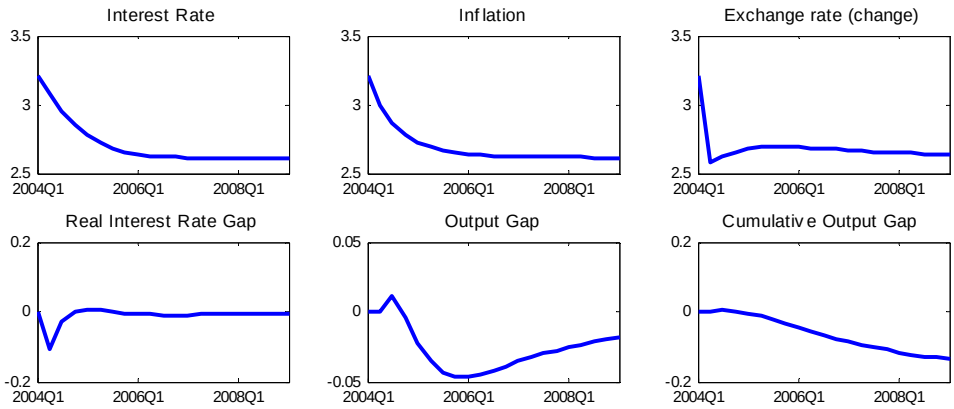
Author	Country or group of countries	Period of estimate	Sacrifice Ratio	Estimation technique
Ball (1994)	Ireland Italy Spain	1960-91	2.9 5.9 3.6	The ratio is estimated during identified disinflation period, conditional on assumptions regarding the output gap.
Cecchetti and Ehrmann (1999)	Ireland Italy Spain	1984-97	4.6 9.3 3.3	The ratio is estimated in a structural model.
Stasavage (2003)	Italy Spain The Czech Republic Slovakia	1990-99	1.7 1.8 1.8 -1.9	The ratio is estimated using Phillips curve regressions.
Cuñado and de Gracia (2003)	Ireland Spain	1960–2001	0.9 1.7	The ratio is estimated using Phillips curve regressions.
Diana and Sidiropoulos (2004)	Ireland	1960-90	Between 0.4 and 0.9	The ratio is estimated during identified disinflation period, conditional on assumptions regarding the output gap.
Bayoumi et al. (2004)	The eurozone	Simulation	Between 1.4 and 2.0	The ratio is estimated in the Global economy model (GEM).
Bárta (2006)	The Czech Republic	Simulation	1.0	The ratio is estimated in the Czech National Bank quarterly prediction model (QPM).
International Monetary Fund (2006)	The eurozone EU-15 NMCs	Simulation	2.1 1.4 1.6	The ratios are estimated in the Global economy model (GEM).

1) The sacrifice ratio is defined as the cumulative GDP loss associated with 100 basis point disinflation.

Figure A3.1. Disinflation Trajectories

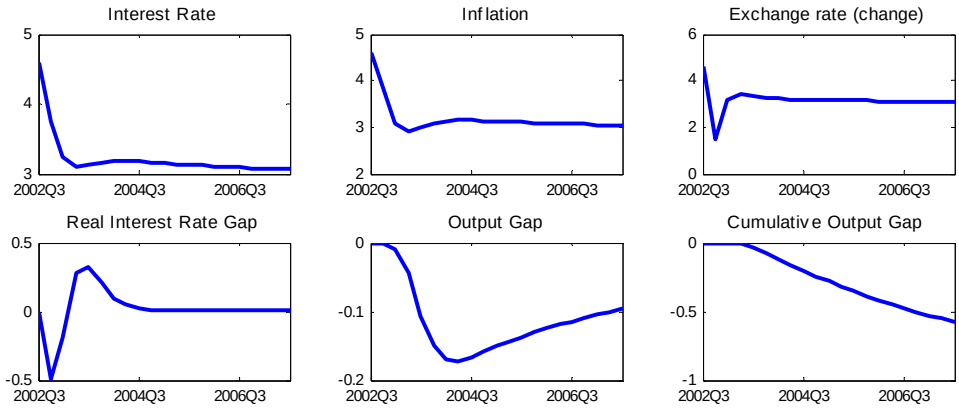
Greece

Disinflation from 3.2 percent to 2.6 percent



Ireland

Disinflation from 4.6 percent to 2.9 percent



Spain

Disinflation from 3.0 percent to 2.6 percent

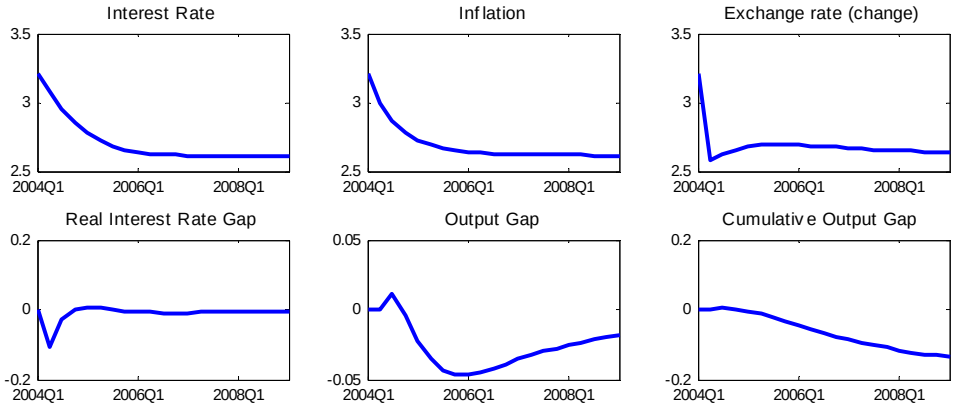
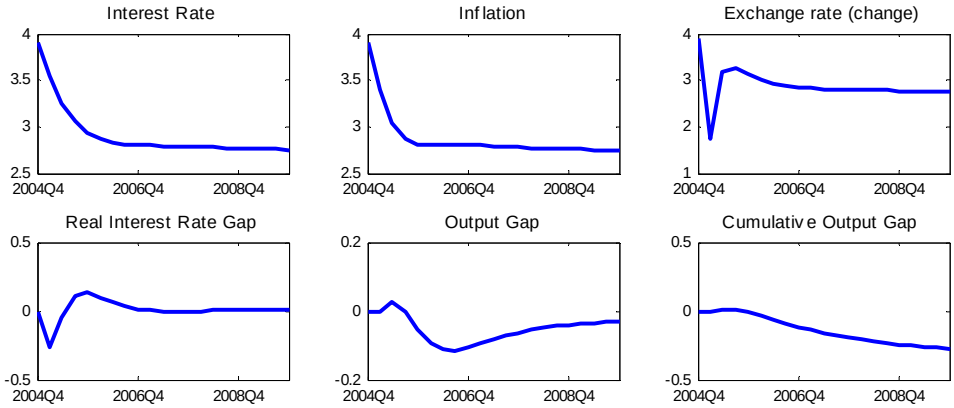


Figure A3.1. Disinflation Trajectories (Continued)

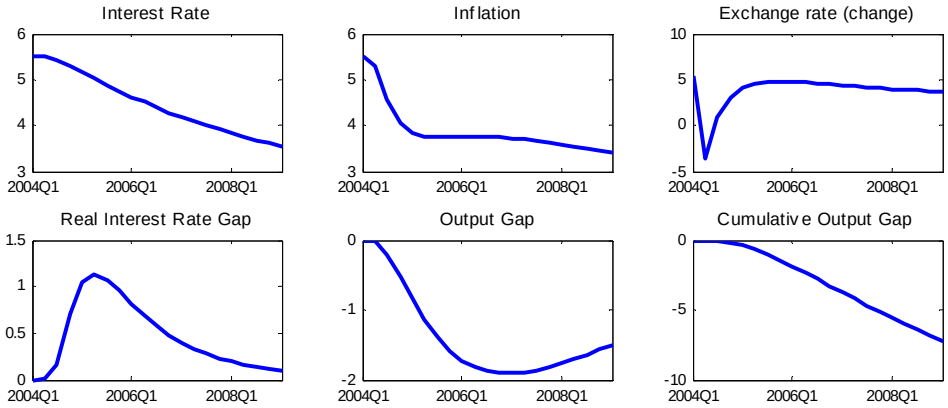
Czech Republic

Disinflation from 3.9 percent to 2.7 percent



Hungary

Disinflation from 5.5 percent to 2.6 percent



Poland

Disinflation from 3.1 percent to 2.0 percent

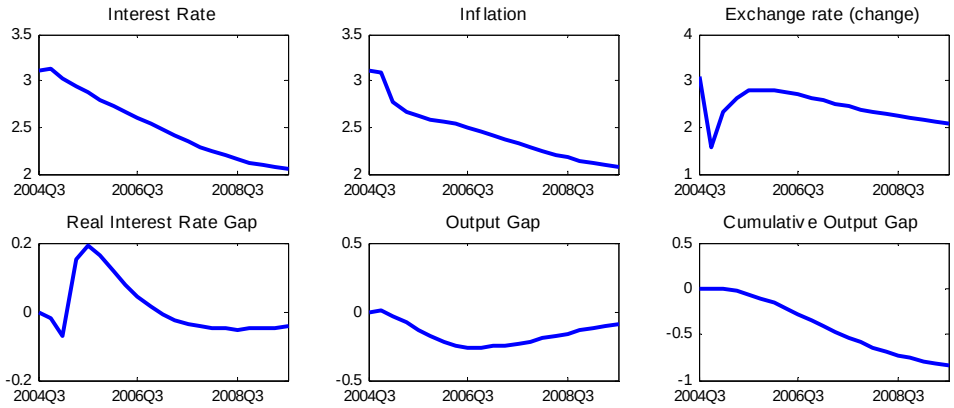
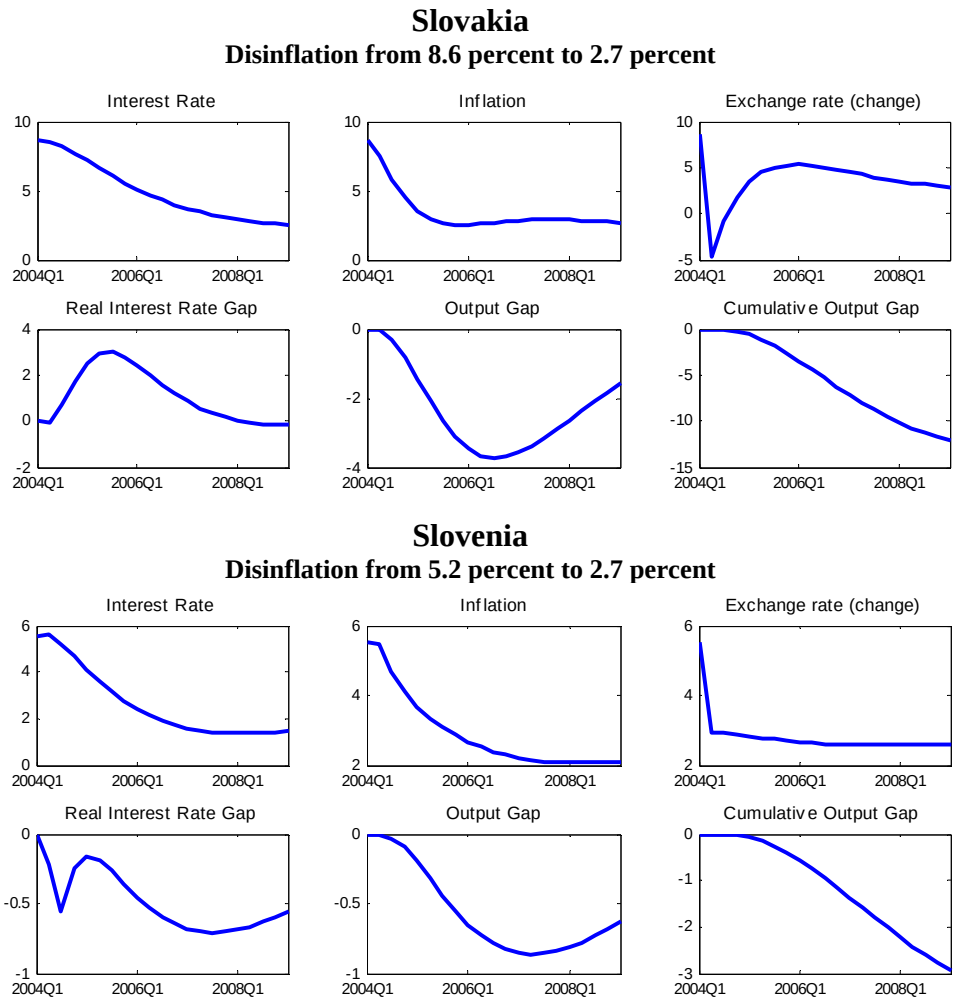


Figure A3.1. Disinflation Trajectories (Concluded)



Source: Authors' calculations.

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