European Monetary Union and the Cost of Disinflation

Sandeep Mazumder[1]

ABSTRACT

One of the unofficial goals of the formation of the European Monetary Union (EMU) was to enable member nations to keep inflation at a low and stable rate, while minimising the costs associated with trying to reduce the rate of inflation. This paper seeks to examine whether the formation of EMU has enabled the euro area countries to reduce the output losses that are associated with disinflations, which are captured by the sacrifice ratio. We find that the formation of EMU has not reduced the output costs of disinflation. Moreover, we find that the movement towards EMU following the Delors Report in 1989 coincides with greater output losses for eurozone countries that were undergoing disinflation. This suggests that EMU has not made it less costly for euro area countries to reduce their rates of inflation, and any achievement of price stability has only occurred at high cost.

1. INTRODUCTION

THE EUROPEAN MONETARY UNION (EMU) was established in Europe on January 1st 1999, and over a decade later the debates both for and against EMU rage on.[2] Has the formation of Europe's single currency, the euro, benefited the European Union (EU) and in particular the member states of the currency? A vast number of economists and commentators have written about this very question, and in this paper we concentrate upon the performance of EMU along one particular dimension: the stabilisation of inflation.

One of the goals of EMU before its creation was to produce low and stable rates of inflation among its member states (Meade, 1990). For instance, European Parliament (2011) claims that the 'primary goal' of EMU (via the European Central Bank, ECB) is to maintain price stability. Indeed, European Commision (2005) states that 'the EU Treaty sets maintaining stable prices as

a key objective of EMU', while others have described price stability in the EMU as 'one of the cornerstones of economic and monetary union, and, therefore, of the European Community as a whole' (Lenihan, 2008). The exact mechanism by which EMU could produce low and stable inflation rates is often thought to be through a central bank that is considered to be a credible inflation-fighter (van den Noord *et al.*, 2008). Specifically, Beetsma and Giuliodori (2010) argue that weak monetary authorities have an incentive to stimulate economic activity by expansionary monetary policy, and EMU provides a way in which monetary policy can be independent and therefore free from the 'inflation bias'.

A great majority of the research by the EMU's own institutions as well as external observers, have claimed that the ECB has successfully achieved price stability in the EMU. For example, European Commission (2005) states that 'the success of EMU and ECB in controlling price inflation is seen in the stable inflation rate'. Likewise, Gonzalez-Paramo (2005), Beetsma and Giuliodori (2010), and *Financial Times* (2011) argue that monetary policy has been extremely successful in EMU at achieving low and stable inflation.[3] Indeed Gonzalez-Paramo (2005) even goes so far as to say that 'the euro currency has been an unquestionable success — euro area price stability being the biggest exponent'. Former ECB President Jean-Claude Trichet also noted that 'price stability [in Europe]...is a remarkable result' (European Union, 2009). However, there is also some evidence that price stability in the EMU may not yet be fully achieved, although this camp appears to be in the minority in the literature.[4]

While many predicted that EMU would enable countries to lower their rates of inflation, whether by the ECB's credibility or by greater price competition among European firms — and indeed there is evidence suggesting that EMU has succeeded in controlling inflation — little attention has been paid to one crucial aspect of this debate. One of the goals of the formation of EMU was to achieve price stability in the eurozone: but has EMU enabled member countries to achieve low and stable inflation in a less costly manner than before they were a part of EMU? In other words, has EMU allowed member countries to disinflate in a manner that they were not able to prior to the formation of EMU? This paper tackles this very question.

We do this by using the sacrifice ratio, which measures the amount of output that is lost when trying to reduce trend inflation by one percentage point. Estimates of the sacrifice ratio for EU countries allow us to examine the different real costs that each country has had to pay in order to gain nominal convergence when joining EMU. Further, any differentials among EMU members' sacrifice ratios reveal difficulties when it comes to implementing a single monetary policy for the entire monetary union. For our estimates of EMU sacrifice ratios in this paper, we use Mazumder's (2014) data on sacrifice ratios to examine whether the EU countries who have adopted the euro have been able to reduce their rates of inflation in a less costly manner, compared to the time when they were not a part of the common European currency.

Our findings indicate that the formation of EMU has not enabled EU economies to reduce their sacrifice ratios. In fact, to the contrary, we find that the movement towards formation of the EMU following the Delors Report in 1989 is associated with a higher amount of output that was lost among euro area countries that were undergoing disinflation. This suggests that EMU has not made it less costly for euro area countries to reduce their rates of inflation. Therefore the debate as to whether EMU (and the ECB) have led to price stability in the eurozone is simply not enough: we must also examine the cost at which this price stability was achieved, and our results suggest that countries have paid a higher cost to achieve price stability than when they had the ability to conduct their own monetary policy.

The rest of the paper is organized as follows: section 2 provides some brief background on EMU, and examines the existing literature. Section 3 describes the measurement of EMU sacrifice ratios, section 4 presents our results, and section 5 concludes.

2. Background

2.1 EMU

One can trace the history of EMU all the way back to an initiative in 1969 by the European Commission, where the need for 'greater coordination of economic policies and monetary cooperation' was outlined, which various heads of states discussed in the Hague in 1969. The resulting Werner Report presented the first blueprint of an EMU, however the plan suffered following the collapse of Bretton Woods and rising oil prices in the early 1970s. Subsequently in 1979 the European Monetary System (EMS) was established to try to keep European exchange rates stabilised relative to each other, and the European Currency Unit (ECU) was introduced, serving as somewhat of a precursor to the euro. However, the foundations for the creation of EMU were firmly laid out in 1989 in the Delors report, which set out a specific plan to introduce monetary union in three stages. Essentially stage one of the Delors report allowed for the free movement of capital between member states, stage two saw the establishment of the European Monetary Institute (the precursor to the ECB) and the establishment of a new exchange rate mechanism (ERM II), and stage three saw the permanent fixing of exchange rates between national currencies, on 1 January 1999 (the euro was introduced subsequently as a physical currency, in 2002).[5] The eleven original members of EMU were Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain. One of the key features of the Delors report was the establishment of the European System of Central Banks (ESCB), while the Maastricht Treaty of 1992 laid out the specific macroeconomic objectives that member states must meet in order to join Europe's new monetary union.

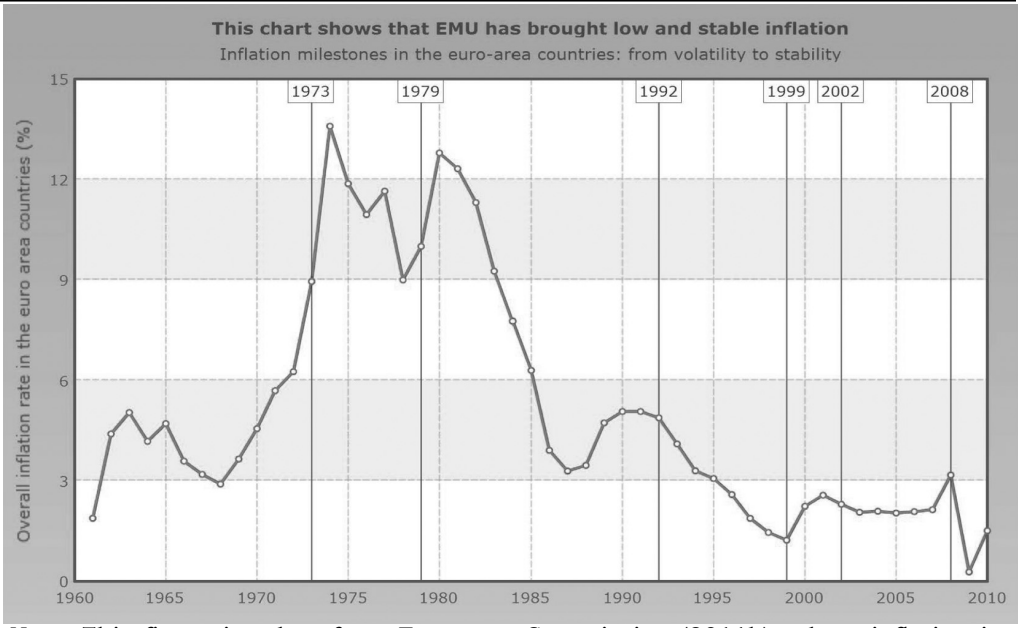
The existing body of research that examines the potential impact of EMU on inflation in the eurozone is divided between those who are in favour of the EMU achieving price stability (via the ECB) and those who argue against. In theory, monetary union can help to reduce inflation by reducing transaction costs associated with uncertainty on foreign exchange and money markets. Artis (1991) estimated that transaction costs prior to the formation of the EMU would be in the order of 0.3-0.4 per cent of EU GDP. However, the more common argument that is given in favour of EMU achieving price stability is the formation of a new credible central bank, the ECB. Some authors, such as de Quiros (1999) argue that the credibility of the ECB is inherited from the established inflation-fighting central bank of Germany, the Bundesbank. In particular, prior to the formation of monetary union, many central banks had weak records of fighting inflation, and instead acted on incentives to stimulate the economy by loosening monetary policy, thereby creating an 'inflation bias' as detailed in Beetsma and Giuliodori (2010). For example, Barro and Gordon (1983a, 1983b) argue that such inflation biases arise when nominal wage contracts are negotiated at certain intervals. In this case, the contracted nominal wage reflects inflation expectations for the duration of the contract, but once the contract has actually been signed, the central bank has an incentive to reduce interest rates. This incentive is even stronger when the central bank is not independent from the government. Therefore, assigning monetary policy-making abilities to a centralised institution such as the ECB which inherits credibility from the Bundesbank was seen as an excellent way of promoting low and stable inflation rates in the EMU. As Figure 1 shows, the inflation rate in the euro area appears to have been remarkably stable from 1999.

2.2 Sacrifice ratios

Given the success of EMU in achieving price stability, the next question that naturally arises is what costs have been paid as a result of reducing inflation? Put another way, what are the sizes of EMU sacrifice ratios? The definition of the sacrifice ratio is the amount of real GDP that is foregone in order to reduce trend inflation by one percentage point. Without question, the most prominent and widely-used method of measuring the sacrifice ratio is based on the seminal work of Ball (1994).

The first step taken in Ball (1994) is to identify episodes of disinflation. For sacrifice ratios expressed at the annual frequency, trend inflation is defined as a centred, eight-quarter moving average of quarterly inflation. Using this series for trend inflation, Ball then identifies inflation peaks and inflation troughs. An inflation peak in year t is defined as a year in which trend inflation is higher than in the years t-1 and t+1. Similarly, an inflation trough is where trend inflation in year t is lower than in years t-1 and t+1. Ball then classifies a disinflation episode as one that starts with an inflation peak and ends with an inflation trough, with the additional assumption that trend inflation has fallen by at least 1.5 per cent over the course of the disinflation.[6]

Figure 1: Euro Area Inflation, 1960-2010



Note: This figure is taken from European Commission (2011b), where inflation is computed from the HICP price index. The highlighted years represent: 1973-first oil crisis, 1979-second oil crisis, 1992-Maastricht Treaty, 1999-euro launched, 2002-introduction of euro banknotes and coins, and 2008-financial crisis.

The second step in calculating the sacrifice ratio is to then compute the losses in output that have occurred over the course of the disinflation episode. Ball does this by assuming output is at trend at the inflation peak, and then returns to trend one year after the end of the episode. In other words, there are frequently persistent effects of disinflation that cause output to return to trend only after a period of a year following the end of disinflation. Thereafter, Ball assumes that trend output grows log-linearly between the inflation peak and one year after the inflation trough, and we can then compute the output losses over the disinflation episode as the sum of the deviations between this log-linear fitted line for trend output and the log of actual real GDP. The third and final step is to compute the change in trend inflation over the course of the disinflation episode, and the sacrifice ratio is simply then the losses in output divided by the amount of disinflation.

Surprisingly, the measurement of EU sacrifice ratios has not received much attention in the literature, and furthermore the determinants of European sacrifice ratios is even less researched. Two notable papers that do attempt to quantify the output costs of EMU disinflations are Cunnado and de Gracia (2003) and Durand *et al.* (2008). In Cunnado and de Gracia (2003), the authors estimate the sacrifice ratio for each of the EMU countries for the period of 1960 to 2001, as well as computing a eurozone-wide common sacrifice

ratio. They obtain a range of sacrifice ratios from 0.55 to 1.96, with magnitudes in keeping with that of Ball (1994). In addition, they also reject the notion of a common eurozone-wide sacrifice ratio. The main problem, however, of Cunnado and de Gracia (2003)'s work is that they estimate the sacrifice ratio using the Phillips curve model. This is extremely limiting, because it constrains the inflation-output tradeoff to be the same during periods of disinflation as it is during periods of accelerating inflation. But if the sacrifice ratio is impacted by factors that only occur during disinflations, this constraint is quite severe. For this reason, the majority of papers now stay clear of using the Phillips curve to measure the sacrifice ratio.

Durand *et al.* (2008) also estimate EMU sacrifice ratios for the period of 1972 to 2003, where they find that the average sacrifice ratio in the EMU has risen.[7] They associate this rise with declining levels of average inflation, thereby finding a negative relationship between the initial level of inflation and the cost of disinflation. In addition, they investigate whether EMU sacrifice ratios have converged, by examining the standard deviation of their sacrifice ratio estimates across the subperiods of 1972-1993 and 1994-2003, where they find no evidence of convergence.[8] This means that the nominal convergence achieved by the Maastricht Treaty did not necessarily consist of genuine convergence of structural differences. This is problematic for EMU, because the different sacrifice ratios among EMU countries implies that a common monetary policy would produce asymmetric effects on member states' outputs. The main difficulty of Durand *et al.* (2008)'s sacrifice ratio estimates is that they are based on 10-year rolling windows on the 1972-2003 data. The problem here is that this can easily confuse periods where different forms of monetary policy were being used, possibly by completely different monetary policymakers. In other words, this method is quite vulnerable to the famous Lucas critique.[9] The way to get around this problem is to consider sacrifice ratios in an episodic manner, which is exactly what the Ball (1994) procedure is able to do. We therefore proceed with Ball's methodology when measuring EMU sacrifice ratios, as is done by the vast majority of researchers in the sacrifice ratio literature.

3 Data and measurement of EMU sacrifice ratios

Our estimates of sacrifice ratios are taken from Mazumder (2014), who estimates sacrifice ratios for every single country in the world from 1972-2007 using annual data. The one slight difference to the measurement of the sacrifice ratio in Mazumder (2014), as compared to Ball (1994), is the definition of trend inflation. Mazumder (2014) defines trend inflation as a centred, three-year moving average instead of a centred, eight-quarter moving average, given the availability of annual data rather than quarterly data. In practice, Mazumder reports that this slight modification of Ball's methodology yields sacrifice ratios that are near identical to those obtained by Ball.

Although we wish to examine the relationship between EMU and the sacrifice ratio, we require some countries in our sample who have not joined EMU in order to serve as a control group. This is easily accomplished by examining the sacrifice ratios from all members of the EU, since 'all member states of the European Union, except Denmark and the United Kingdom, are required to adopt the euro and join the euro area' (European Commission, 2011a). Therefore we select all EU members for our sample, excluding the United Kingdom and Denmark.[10] We find that EU countries have a mean value of the sacrifice ratio of 1.20 with a standard deviation of 1.95, which is slightly lower than for OECD countries as a whole (with a mean of 1.90 and standard deviation of 2.21).[11] The appendix to this paper lists all disinflation episodes and associated sacrifice ratios of EU countries (excluding the United Kingdom and Denmark) for 1972-2007.

The existing literature focuses heavily on the determinants of the sacrifice ratio, and therefore before we can examine the relationship between the formation of EMU and EU sacrifice ratios, we must also control for these other factors. Specifically, there are six determinants of the sacrifice ratio that we control for. First, Ball (1994) argues that the speed of disinflation is a significant determinant of OECD sacrifice ratios, where faster disinflations are less painful. In other words, there is evidence that the 'cold-turkey' approach to disinflation results in less damage to the economy than a gradual approach to reducing trend inflation. We capture the speed of disinflation in our regressions by defining $\Delta\pi$ and *Length* , where the former is the amount of disinflation over the episode and the latter is the length in years of the episode. Second, we also control for the initial value of inflation at the onset of the disinflation episode, π_0, which is found by many authors, such as Zhang (2005) and Goncalves and Carvalho (2009), to be a significant determinant of the sacrifice ratio. Third, we also control for nominal rigidities by using the idea of 'inflation history' as detailed in Hofstetter (2008). Specifically we define π_H as the average of inflation in the five years prior to the start of the disinflation episode. Fourth, we examine the impact of trade openness, *Openness*, on the sacrifice ratio, where openness is measured as the ratio of imports to real GDP, using data from the International Monetary Fund's (IMF) *International Financial Statistics*. Previous research (such as Temple, 2002) builds upon Romer's (1993) argument that greater openness leads to more competition, which puts downward pressure on prices. Therefore we might expect to see a negative relationship between openness and inflation, and therefore a negative relationship between openness and the sacrifice ratio. Fifth, a great deal of the literature also examines the role played by central bank independence, *CBI*, on sacrifice ratios, which we also consider using central bank independence data from Polillo and Guillen (2005).[12] Finally, we also consider the Daniels *et al.* (2005) argument that openness and central bank independence must be considered together in a sacrifice ratio (*SR*) regression, as well as the interaction of these two factors. Thus an example of a sacrifice ratio regression is

something like the following equation, with error term ε:

$$SR = Constant + \beta_1 \Delta\pi + \beta_2 Length + \beta_3 \pi_0 + \beta_4 \pi_H + \beta_5 Openness + \beta_6 CBI + \beta_7 Openness \times CBI + \varepsilon \quad (1)$$

Given these determinants of the sacrifice ratio that are commonly tested in the literature, we also define three new dummy variables that are designed to ascertain the connection between the formation of EMU and sacrifice ratios of member states. First we define a dummy variable, *Euro*, which is equal to 1 for all EU countries that are currently members of the single European currency, and 0 otherwise. This provides somewhat of a crude way in which to test the connection between the adoption of the euro and the sacrifice ratio. Second, we then refine this dummy variable to account for the timing of euro adoption, where $\widehat{Euro}$ is a dummy variable equal to 1 for countries that had adopted the euro prior to the onset of a disinflation episode (0 otherwise).[13] And third, we define *Delors* as a dummy variable equal to 1 for original members of the single European currency, where disinflation occurs after the Delors report of 1989, and 0 otherwise.[14] In other words, we argued in section 2.1 that the Delors Report is where the plans for EMU were firmly laid, therefore the original members of the common European currency would have started to make plans to join the euro at that stage. Therefore *Delors* captures the movement of the original euro members towards monetary union, which was subsequently confirmed in the Maastricht convergence criteria.

4 Results

Table 1 displays our results using the *Euro* dummy variable, where all regressions are conducted using ordinary least squares (OLS) with heteroskedasticity and autocorrelation consistent (HAC) standard errors.[15] In column (1) we regress EU sacrifice ratios on the $\Delta\pi$, *Length*, and *Euro*. We find that *Length* has a highly positive and significant coefficient, indicating that longer disinflations are much more costly to EU countries in terms of higher output losses. In other words, our findings agree with the notion of cold-turkey disinflations, where a goal of reducing trend inflation is best achieved if done in a speedy manner. Surprisingly we find no significance for $\Delta\pi$ which is highly negative and significant when considering advanced economies from the entire world (see Ball, 1994, and Mazumder, 2014). This suggests that the cost of disinflation in EU economies does not depend on the size of disinflation. In other words this implies that either large or small reductions in trend inflation carry similar output losses. Arguably one could take this as weak evidence of 'costless' disinflation that rational expectations predicts may happen if a credible central bank attempts to lower trend inflation.

Lastly, in regression (1), we find a positive coefficient for *Euro*, indicating that members of the euro currency have higher sacrifice ratios than non-euro EU countries. However this is not a statistically significant result. In col-

Table 1: The Sacrifice Ratio and Disinflations for Current EMU Members, 1972-2007

Dependent variable: SR	*(1)*	*(2)*	*(3)*	*(4)*
Constant	-1.6036	-1.6851	-2.0780	-1.2551
	(0.6173)**	(0.8096)**	(0.9292)**	(0.9553)
$\Delta\pi$	-0.0066	-0.0179	-0.0225	-0.0156
	(0.0046)	(0.0154)	(0.0138)	(0.0156)
Length	0.4223	0.4434	0.4273	0.4117
	(0.1004)***	(0.1162)***	(0.1081)***	(0.1164)***
π_0		0.0126	0.0175	0.0105
		(0.0121)	(0.0113)	(0.0125)
π_H		-0.0056	-0.0053	-0.0055
		(0.0080)	(0.0066)	(0.0079)
Openness			2.0799	
			(2.1719)	
CBI				-0.4996
				(1.2782)
Euro	0.6556	0.5828	0.5417	0.6166
	(0.4987)	(0.5581)	(0.5505)	(0.5611)
$\bar{R}^2$	0.2622	0.2997	0.2049	0.1978
N	65	61	58	58
	(5)	*(6)*	*(7)*	*(8)*
Constant	-1.3176	-1.6524	-1.2961	-1.4244
	(1.4034)	(0.7247)**	(0.7694)*	(1.2670)
$\Delta\pi$	-0.0211	-0.0061	-0.0065	-0.0059
	(0.0146)	(0.0039)	(0.0046)	(0.0040)
Length	0.3988	0.3875	0.3985	0.3650
	(0.1146)***	(0.0929)***	(0.0991)***	(0.0944)***
π_0	0.0160			
	(0.0118)			
π_H	-0.0055			
	(0.0068)			
Openness	0.7524	1.1992		1.4088
	(7.6208)	(1.8990)		(7.2378)
CBI	-1.3376		-0.3814	-0.2002
	(2.0851)		(1.2352)	(2.1022)
Openness x CBI	3.1437			-0.5434
	(11.8710)			(11.6372)
Euro	0.5743	0.5936	0.6995	0.6420
	(0.5798)	(0.4798)	(0.5052)	(0.5071)
$\bar{R}^2$	0.1406	0.2261	0.2293	0.1691
N	55	62	62	59

Notes:
SR is the sacrifice ratio, $\Delta\pi$ is the amount of disinflation (trend inflation at peak minus trend inflation at trough) over the disinflation episode, *Length* is the number of years of the disinflation episode, π_0 is trend inflation at peak, π_H is the average of inflation in the previous 5 years, *Openness* is the ratio of imports to real GDP, *CBI* is central bank independence, and *Euro* is a dummy variable equal to 1 for EU countries that are currently members of the single European currency (0 otherwise). OLS estimation is implemented with HAC standard errors. ***, **, and * denote significance at the 1, 5, and 10 per cent levels respectively.

umn (2) we also control for the initial level of trend inflation during an episode (π_0), and nominal rigidities (with π_H), but neither are statistically nor economically significant. In (3) we also control for openness, and in (4) we control for central bank independence. Finally in (5) we test both *Openness* and *CBI* simultaneously, as well as the interaction between the two. The negative coefficients we obtain for *CBI* indicate that there may be some credibility bonus of having an independent central bank, while the positive coefficient for the interaction term suggests that central bank independence is enhanced by greater trade openness. However, none of these coefficients are statistically significant.

Also note that while the $\bar{R}^2$ may seem low in Table 1 (in the range of 0.2 to 0.3), this is in keeping with what the literature finds (for instance Ball, 1994, and Temple, 2002, find R^2 to be in the region of 0.1-0.3). One possible cause for the lack of statistical significance in Table 1 is collinearity between independent variables. To examine this issue, consider the correlation matrix between the independent variables in Table 2. Taking a rule-of-thumb magnitude of 0.6 or higher to denote a high level of correlation, this shows that both π_0 and π_H are potentially collinear with several of our other regressors. Therefore in regressions (6), (7), and (8) we replicate the regressions of (3), (4), and (5) but without the initial level of inflation and inflation history. However the inferences from our results remain exactly the same even when dropping π_0 and π_H. Thus the most notable result in Table 1 concerns the coefficient for *Euro*, which is positive in all regressions from (1) to (8), although all of these coefficients are statistically indistinguishable from zero. In other words, although the current literature argues that EMU has successfully achieved price stability, our results indicate that for current members, inflation stability has not happened at a lower cost since joining EMU. In other words, becoming a euro currency member has not significantly reduced the output losses incurred during disinflations.

We then refine our definition of the EMU dummy variable to the case where the euro is adopted before the onset of disinflation, as defined by $\widehat{Euro}$. The results for these regressions can be found in Table 3, where we see very similar inferences to those in Table 1. In particular the inferences for *Length*, π_0, π_H, *Openness*, *CBI*, and the interaction term all remain the same in these regressions, where we see that the duration of disinflation appears to be the main determinant of EU sacrifice ratios. Specifically, longer disinflations are more costly. While the coefficient on $\Delta\pi$ is not significant in regressions (2)-(5), when we drop π_0 and π_H in (6)-(8) we do see statistical significance for the amount of disinflation. Therefore there is some weak evidence that the amount of trend inflation that is being reduced may have some importance in determining the loss of GDP over the disinflation episode in question. In all regressions from (1) to (8) we obtain a positive coefficient for $\widehat{Euro}$, which is again not statistically significant. This therefore means that accession to EMU has not reduced output losses that are associated with disinflating. If anything, the positive coefficients indicate that adopting the euro has made the process of reducing inflation more painful for EMU members.

Table 2: Correlation Matrix Between Independent Variables

	$\Delta\pi$	*Length*	π_0	π_H	*Openness*	*CBI*	*Euro*	$\widehat{Euro}$	*Delors*
$\Delta\pi$	1.0000								
Length	0.2845	1.0000							
π_0	0.9862	0.2155	1.0000						
π_H	0.6971	0.1855	0.7040	1.0000					
Openness	-0.0432	-0.2233	-0.0752	-0.0191	1.0000				
CBI	-0.1418	-0.2680	-0.1400	-0.1004	0.3952	1.0000			
Euro	-0.5149	-0.1242	-0.5410	-0.5860	0.0523	0.1228	1.0000		
$\widehat{Euro}$	-0.0894	-0.1549	-0.1032	-0.1318	0.1443	0.4500	0.1404	1.0000	
Delors	-0.1854	0.0737	-0.2143	-0.2567	0.0903	0.1888	0.3087	0.4547	1.0000

Note: $\widehat{Euro}$ is a dummy variable equal to 1 for countries that were members of the single European currency before the onset of a disinflation episode, and *Delors* is a dummy variable equal to 1 that were original members of the single European currency and where disinflation occurred following the Delors Report.

Table 3: The Sacrifice Ratio and Disinflations Following Adoption of the Euro, 1972-2007

Dependent variable: SR	*(1)*	*(2)*	*(3)*	*(4)*
Constant	-1.1228 (0.5220)**	-1.2325 (0.7071)*	-1.6202 (0.8553)*	-0.5564 (0.9871)
$\Delta\pi$	-0.0086 (0.0045)*	-0.0169 (0.0162)	-0.0212 (0.0149)	-0.0148 (0.0169)
Length	0.4313 (0.1051)***	0.4511 (0.1226)***	0.4316 (0.1152)***	0.4140 (0.1242)***
π_0		0.0108 (0.0123)	0.0154 (0.0118)	0.0087 (0.0129)
π_H		-0.0080 (0.0078)	-0.0075 (0.0064)	-0.0077 (0.0077)
Openness			1.9651 (2.1518)	
CBI				-0.9572 (1.2773)
$\widehat{Euro}$	0.7045 (0.9939)	0.7259 (1.0337)	0.6466 (1.0474)	1.0075 (1.1150)
$\bar{R}^2$	0.2536	0.2326	0.2007	0.1970
N	65	61	58	58
	(5)	*(6)*	*(7)*	*(8)*
Constant	-0.8273 (1.3370)	-1.1925 (0.6376)*	-0.5925 (0.8039)	-0.9736 (1.2272)
$\Delta\pi$	-0.0202 (0.0157)	-0.0079 (0.0039)**	-0.0086 (0.0046)*	-0.0078 (0.0040)*
Length	0.4012 (0.1213)***	0.3938 (0.0975)***	0.4026 (0.1043)***	0.3689 (0.0988)***
π_0	0.0143 (0.0122)			
π_H	-0.0075 (0.0064)			
Openness	1.6487 (7.5280)	1.0961 (1.8896)		2.4560 (7.2234)
CBI	-1.4273 (2.0614)		-0.7563 (1.2582)	-0.1187 (2.1020)
Openness x *CBI*	1.3974 (11.2114)			-2.7261 (11.3333)
$\widehat{Euro}$	0.9341 (1.0940)	0.6324 (1.0123)	0.9262 (1.0735)	0.8799 (1.0716)
$\bar{R}^2$	0.1387	0.2175	0.2209	0.1602
N	55	62	62	59

OLS estimation is implemented with HAC standard errors. ***, **, and * denote significance at the 1, 5, and 10 per cent levels respectively.

Table 4: The Sacrifice Ratio and Disinflations Following the Delors Report, 1972-2007

Dependent variable: SR	*(1)*	*(2)*	*(3)*	*(4)*
Constant	-1.1382 (0.4649)**	-1.4709 (0.6256)**	-1.7997 (0.7550)**	-0.5463 (0.8964)
$\Delta\pi$	-0.0061 (0.0034)*	-0.0225 (0.0138)	-0.0259 (0.0136)*	-0.0195 (0.0139)
Length	0.3593 (0.0832)***	0.3955 (0.1001)***	0.3918 (0.0986)***	0.3375 (0.1025)***
π_0		0.0170 (0.0103)	0.0205 (0.0108)*	0.0142 (0.0104)
π_H		-0.0035 (0.0053)	-0.0036 (0.0046)	-0.0027 (0.0050)
Openness			1.6283 (1.9143)	
CBI				-1.3406 (1.2302)
Delors	2.0169 (0.7094)***	2.0994 (0.7162)***	1.8432 (0.7396)**	2.2368 (0.7300)***
$\bar{R}^2$	0.4187	0.4140	0.3583	0.4011
N	65	61	58	58
	(5)	*(6)*	*(7)*	*(8)*
Constant	-0.3955 (1.2508)	-1.1264 (0.5821)*	-0.3946 (0.7614)	-0.4440 (1.1932)
$\Delta\pi$	-0.0255 (0.0144)*	-0.0058 (0.0031)*	-0.0059 (0.0035)*	-0.0058 (0.0033)*
Length	0.3481 (0.1052)***	0.3379 (0.0812)***	0.3133 (0.0843)***	0.2989 (0.0840)***
π_0	0.0199 (0.0112)*			
π_H	-0.0035 (0.0046)			
Openness	-1.0962 (6.1080)	0.5452 (1.7146)		0.1613 (5.8888)
CBI	-2.8009 (2.5301)		-1.0763 (1.1865)	-1.0047 (2.3754)
Openness x *CBI*	6.6733 (10.7947)			0.8214 (10.5162)
Delors	2.0050 (0.7674)**	1.7686 (0.7397)***	2.1210 (0.7198)***	1.8563 (0.7702)**
$\bar{R}^2$	0.3284	0.3586	0.4040	0.3198
N	55	62	62	55

OLS estimation is implemented with HAC standard errors. ***, **, and * denote significance at the 1, 5, and 10 per cent levels respectively.

We find significant results, however, when we consider the *Delors* dummy variable in Table 4. In all regressions from (1) to (8) we find a highly positive and significant coefficient for *Delors*, which is also highly economically relevant with coefficient magnitudes in the range of 2. In other words, the Delors report of 1989 which laid down the plans for the formation of EMU, made it very costly for the original euro members to disinflate. Moreover, for these economies the Delors report is associated with an increase in their sacrifice ratios by about 2, which is a very large amount given the mean value for all EU sacrifice ratios from 1972 to 2007 is 1.2. Many will argue that such output losses were to be expected given the Maastricht convergence criteria, but the evidence clearly shows that countries were able to disinflate in a less painful manner before the Delors report was concluded. In other words, the evidence suggests that we should not be too quick to declare price stability in EMU a success without paying attention to the cost that was paid to obtain it. And the results in Table 4 show that the Delors report entailed very severe costs for the original members of the euro when they chose to join the third and final stage of EMU. We also see in these results that the length of disinflation continues to be a positive and significant determinant of EU sacrifice ratios, while there is some evidence that the amount of disinflation does matter ($\Delta\pi$ is significant at the 10 per cent level in all regressions except (2) and (4)) when also accounting for the Delors report. Openness and central bank independence, however, continue to be insignificant in our sacrifice ratio regressions.

5 Conclusions

EMU was created in 1999. Over a decade later, many researchers and commentators have concluded that EMU has accomplished one of its primary tasks, that is to produce a low and stable rate of inflation across the eurozone, engineered by the ECB's monetary policy. However, little-to-no attention has been devoted in the literature to the costs that have been paid to accomplish this price stability. In other words, what are the EU sacrifice ratios and did the formation of EMU impact the behaviour of sacrifice ratios?

We investigate this question by using Mazumder's (2014) data set on EU sacrifice ratios. Thereafter we create three different dummy variables to capture the formation of EMU, while also controlling for the speed of disinflation, the initial level of inflation, nominal rigidities, trade openness, and central bank independence. Overwhelmingly we find that longer disinflations are more costly, giving weight to the 'cold-turkey' approach to reducing inflation. Moreover, our results indicate that the adoption of the euro has not had a statistically significant effect on EU sacrifice ratios. If anything, the output costs of disinflation have increased, because we consistently obtain positive coefficients for our euro dummy variables. This inference is confirmed when we control for the Delors report — which was the first time we saw plans for EMU firmly written down — where we find that the Delors report has a highly pos-

itive, statistically, and economically significant effect on EU sacrifice ratios. In other words, the formation of EMU seems to be associated with an increase in EU sacrifice ratios for euro members, meaning that these countries have lowered their rates of trend inflation while simultaneously incurring very high output losses. This therefore means that these output losses were significantly lower before plans to establish the EMU were made. Thus even if we consider EMU's achievement of price stability a 'success', it appears to have been achieved at a high price.

Accepted for publication: 3rd April 2014

Appendix: EU Sacrifice Ratio Estimates from Mazumder (2012)

This appendix displays each of the disinflation episodes for EU member states (excluding the United Kingdom and Denmark) for the period of 1972 to 2007, using annual data. This table displays the onset of each disinflation episode, the length of the episode, the rate of trend inflation at the peak, the amount of disinflation, and the associated sacrifice ratio.

Country	*Start of Episode*	*Length (years)*	*Initial Trend Inflation (%)*	*Change in Trend Inflation (%)*	*Sacrifice Ratio*
Austria	1974	5	8.50	4.24	1.53
	1981	7	6.19	4.51	0.77
	1992	7	3.66	2.73	3.51
Belgium	1975	5	11.54	6.34	-0.09
	1982	6	8.01	6.67	1.58
	1990	9	3.26	2.02	7.08
Cyprus	1976	2	8.44	2.24	-1.71
	1980	8	11.24	8.76	2.08
	1992	7	5.47	2.98	2.06
Czech Republic	1997	7	9.32	7.74	2.34
Estonia	2001	3	4.45	1.79	0.29
Finland	1975	5	16.27	7.32	2.24
	1981	7	11.06	7.03	0.93
	1989	7	5.85	4.96	8.07
	2001	4	2.50	1.86	1.18
France	1975	3	11.65	2.20	-0.39
	1981	7	12.95	10.11	0.84
	1990	9	3.37	2.58	7.78
Germany	1974	5	6.62	3.13	2.74
	1981	7	5.67	5.26	2.14
	1993	7	4.07	3.09	0.91
Greece	1974	4	18.59	5.90	-0.11
	1991	10	18.57	15.51	2.85

Hungary	1979	4	7.65	1.67	0.94
Ireland	1975	4	18.89	6.37	0.31
	1980	8	14.44	10.28	1.09
	1990	5	7.71	5.22	3.32
	2001	4	5.03	2.33	-0.65
Italy	1975	4	17.60	2.52	-0.31
	1981	7	19.06	13.84	0.93
	1990	4	6.33	1.77	0.22
	1994	5	4.57	2.68	-0.61
Luxembourg	1975	5	11.54	6.33	-0.41
	1982	6	8.00	6.65	2.12
	1990	9	3.25	2.02	5.75
Malta	1974	2	7.91	2.38	-0.45
	1980	5	11.47	11.99	-0.23
	1994	4	4.23	1.72	-2.00
Netherlands	1975	4	9.63	4.71	-0.89
	1981	7	6.39	6.35	1.60
	2001	5	3.26	1.91	3.77
Portugal	1990	9	12.31	9.91	2.31
Slovakia	1994	4	10.64	4.44	-0.69
	2000	3	9.98	3.58	0.18
	2003	4	6.46	3.50	2.27
Slovenia	2001	5	8.26	5.41	1.09
Spain	1990	9	6.48	4.44	6.46
Sweden	1981	7	11.47	6.71	0.82
	1990	4	8.75	5.71	1.34
	1994	5	3.13	2.85	-1.01

ENDNOTES

1. Department of Economics, Wake Forest University, Box 7505, Winston Salem, NC 27109. Email Addresses: mazumds@wfu.edu. I would like to thank the submissions editors Simeon Coleman and Piers Thompson, as well as the anonymous referees for their helpful comments on this paper.

2. We refer to EMU as the European Monetary Union, but it is also known as Europe's Economic and Monetary Union.

3. Moreover, Hartmann and Herwatz (2009) argue that EMU has also helped reduce inflation uncertainty within the currency union.

4. For example, Ciobanu (2008) and European Commission (2012) note that persistent inflation differences exist among euro area countries, while Caporale and Kontonikas (2009) counter the Hartmann and Herwatz (2009) claims by arguing that inflation uncertainty has actually risen in EMU. Interestingly, Busetti *et al.* (2007) make the

argument that there has not been complete inflation convergence in EMU, but rather there are two separate 'clubs' of inflation countries. Becker and Hall (2009) also find convergence clubs form when considering inflation rates of EMU countries together with new EU members from Eastern Europe, while also finding little evidence of convergence of EMU inflation rates in the years following inception (specifically from 2003 to 2007).

5. See Sebea (2007) for further details on the stages of EMU as well as further description of the Maastricht convergence criteria.

6. Also, Ball only considers cases where trend inflation at peak is less than twenty per cent. For disinflation episodes where inflation is higher than twenty per cent see Mazumder (2013).

7. Durand *et al*'s (2008) estimates of EMU sacrifice ratios range from 0.35 to 0.63.

8. Also known as a test of σ-convergence. Durand *et al* (2008) also check whether there is convergence in the spread of sacrifice ratios (the difference between the highest and lowest EMU sacrifice ratio for each period) and also find no convergence in this measure.

9. Smith (2009) estimates a VAR for EMU countries with domestic variables (real output, inflation, the real exchange rate, real equity prices, and short- and long-term interest rates) and foreign variables (output, inflation, equity prices, short- and long-term interest rates, and oil prices), to investigate whether the Lucas critique applies in practice to EMU. Smith finds the Lucas critique not to be important from an empirical perspective, although there is evidence of structural changes in the interest rate-setting behaviour in EMU following the creation of the ECB.

10. The UK and Denmark are excluded from the data set since these countries are the only ones in the EU to have 'opt-out' status from the single European currency. In other words all EU countries are required to join EMU in the future with the exception of the UK and Denmark.

11. Note that our sacrifice ratio range is from -2.00 to 8.07, which is a wider range than found in Cunnado and de Gracia (2003) and Durand *et al* (2008). However this is to be expected given that the former uses a Phillips curve to estimate the sacrifice ratio and the latter employs 10-year rolling windows. In other words these other estimates are averaging over multiple disinflation episodes, which is precisely what Ball (1994)'s seminal method seeks to avoid.

12. Since the CBI data only cover the period of 1989 to 2000, we also make the additional assumption that the level of central bank independence that existed in 1989 also existed for the period of 1972-1988, and the level of central bank independence that held in 2000 also continued for 2001-2007.

13. We also created a dummy variable that captured the creation of the ECB, but this produces virtually identical results to $\widehat{Euro}$, therefore we do not report the results in the paper.

14. We also try a dummy variable for disinflations occurring only after the Maastricht Treaty was signed (for original euro members), but this produces far less interesting results than we obtain with *Delors*, thus we do not report those results here. In any

case, the Delors report is what we want to focus on, since this is what really laid the foundations for EMU.

15. Where least squares is used throughout the literature. Ball (1994) does investigate potential endogeneity from the amount of disinflation being used to calculate the sacrifice ratio (*SR*) as well as being a regressor ($\Delta\pi$), but finds that using instrumental variables makes little-to-no difference to the results obtained and hence uses OLS.

References

Artis M (1991) 'One market, one money: An evaluation of the potential benefits and costs of forming an economic and monetary union', *Open Economies Review*, 2(3), 315-321.

Ball L (1994) 'What determines the sacrifice ratio?' in Mankiw N G (ed) *Monetary Policy*, Chicago IL: University of Chicago Press.

Barro R J and Gordon D B (1983a) 'A positive theory of monetary policy in a natural rate model', *Journal of Political Economy*, 91(4), 589-610.

Barro R J and Gordon D B (1983b) 'Rules, discretion and reputation in a model of monetary policy', *Journal of Monetary Economics*, 12(1), 101-121.

Becker B and Hall S G (2009) 'How far from the Euro area? measuring convergence of inflation rates in Eastern Europe', *Economic Modelling*, 26(4), 788-798.

Beetsma R and Giuliodori M (2010) 'The macroeconomic costs and benefits of the EMU and other monetary unions: An overview of recent research', *Journal of Economic Literature*, 48(3), 603-641.

Busetti F, Forni L, Harvey A and Venditti F (2007) 'Inflation convergence and divergence within the European monetary union', *International Journal of Central Banking*, 3(2), 95-121.

Caporale G M and Kontonikas A (2009) 'The Euro and inflation uncertainty in the European monetary union', *Journal of International Money and Finance*, 28(6), 954-971.

Ciobanu A M (2008) 'Macroeconomic performances of European monetary union members', *International Conferences on Applied Economics Proceedings*, 207-211.

Cunnado J and de Gracia F P (2003) 'Sacrifice ratios: Some lessons from EMU countries, 1960-2001', *International Review of Applied Economics*, 17(3), 327-337.

Daniels J P, Nourzad F, and VanHoose D D (2005) 'Openness, central bank independence, and the sacrifice ratio', *Journal of Money, Credit and Banking*, 37(2), 371-379.

de Quiros L B (1999) 'The European monetary union: A political time bomb', *Cato Journal*, 19(1), 143-160.

Durand J J, Huchet-Bourdon M and Licheron J (2008) 'Sacrifice ratio dispersion within the Euro zone: what can be learned about implementing a single monetary policy?',

International Review of Applied Economics, 22(5), 601-621.

European Commission (2005) *Did the Euro cause prices to rise? perceptions and reality*, Brussels: European Commission.

European Commission (2011a) *Adopting the Euro-who can join and when*, Brussels: European Commission.

European Commission (2011b) *Inflation and the EU*, Brussels: European Commission.

European Commission (2012) *Inflation and the EU*, Brussels: European Commission.

European Parliament (2011) European monetary policy-ftu 5.3. European Parliament.

European Union (2009) *EU economic and monetary union: a framework for stability. European Union*, Delegation of the European Commission to the USA.

Financial Times (2011) ECB must favour no nation. London: The Financial Times.

Goncalves C E S and Carvalho A (2009) 'Inflation targeting matters: evidence from OECD economies' sacrifice ratios', *Journal of Money, Credit and Banking*, 41(1), 233-243.
Gonzalez-Paramo J M (2005) 'European monetary union. where do we stand?' Speech At the Euro Conference, Kuala Lumpur, Malaysia.

Hartmann M and Herwartz H (2009) 'Did the introduction of the Euro impact on inflation uncertainty? - an empirical assessment'. *European Economy Economic Papers* 396, Directorate General Economic and Monetary Affairs, European Commission.

Hofstetter M (2008) 'Disinflations in Latin America and the Caribbean: A free lunch?', *Journal of Macroeconomics,* 30(1), 327-345.

Lenihan N (2008) 'The price stability mandate of the European system of central banks: a legal perspective in Current Developments in Monetary and Financial Law', ed. IMF, *International Monetary Fund*, 17-42.

Mazumder, S (2014) Determinants of the sacrifice ratio: evidence from OECD and non-OECD countries. *Economic Modelling* 40(C), 117-135.

Mazumder S (2013) 'High inflation and the sacrifice ratio', *European Economic Letters*, 2(2), 71-76.

Meade J (1990) 'The EMU and the control of inflation', *Oxford Review of Economic Policy*, 6(4), 100-107.

Polillo S and Guillen M F (2005) 'Globalization pressures and the state: The global spread of central bank independence', *American Journal of Sociology*, 110(6), 1764-1802.

Romer D (1993) 'Openness and inflation: Theory and evidence', *The Quarterly Journal of Economics*, 108(4), 869-903.

Sebea M (2007) 'EMU enlargement: will Great Britain join?', *Romanian Economic Business Review*, 2(1), 25-34.

Smith R (2009) 'EMU and the lucas critique', *Economic Modelling*, 26(4), 744-750.
Temple J (2002) 'Openness, inflation, and the phillips curve: A puzzle', *Journal of*

Money, Credit and Banking, 34(2), 450-468.

van den Noord P, Dohring B, Langedijk S, Martins J, Pench L, Temprano-Arroyo H and Thiel M (2008) 'The evolution of economic governance in EMU'. *European Economy Economic Papers* 328, Directorate General Economic and Monetary Affairs, European Commission.

Zhang L H (2005) 'Sacrifice ratios with long-lived effects', *International Finance*, 8(2), 231-262.