The Output-Inflation Trade-Off In The EU: Convergence Or Divergence?

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Abstract

In this thesis the output-inflation trade-off is studied for the Euro-zone countries. The main question is whether the output-inflation tradeoff as remained stable as a consequence of the introduction of the European Central Bank (ECB). I find no definitive statistical evidence which indicates that the trade-off parameters have converged since the introduction of the ECB. However, I argue that this result could very well be misleading and I give possible explanations for the observed differences for the trade-off parameters.

Keywords: trade-off, inflation, output, Lucas hypothesis, ECB, convergence, monetary policy

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

In this thesis the emphasis will be on EU-countries and the changes observed in the output-inflation tradeoff. Currently the countries of the EU are in a recession and are also dealing with the so called debt-crisis. During this period there are a lot of discussions regarding (i) member states of the EU and the different types of economies in the EU zone and (ii) what type of policy should be pursued to get out of the recession. If an aggregate nominal demand policy is pursued then the effectiveness of this policy depends on the output-inflation trade-off. Because of this relationship between the effectiveness of the implemented policy and the output-inflation trade-off, it is important to study the determinants of the output-inflation trade-off and how this trade-off has changed over time. More specifically, it is important to study how the trade-off has changed as a consequence of past pursued policies and also as a consequence of political decisions that changed the way that policy is implemented. Knowledge of the behavior of the trade-off can lead to information about the quality of the pursued policy and the perceptions that economic agents have of the pursued policy. For example, if an expansionary aggregate demand policy is being pursued in an economy that also experiences high inflation, economic agents may be reluctant to adjust output to changes in aggregate demand and instead choose to adjust their prices instead. In this example the output-inflation trade-off is not favorable and the policy pursued is not very effective.

In this thesis the role of the European Central Bank (ECB) is important. We will study the output-inflation trade-off and how this trade-off has changed over time with the introduction of the ECB. The case of the ECB is interesting because it represents a big change in the way economic policy is pursued. One example is that individual member states have lost certain policy instruments such as the exchange rate. Another important aspect is that the ECB also has its own policy targets and that these targets are aimed at the whole EU. An interesting question that arises is whether the introduction of the ECB has affected the effectiveness of aggregate nominal demand policy. This question can be studied using output-inflation trade-off. In this thesis we will study the stability of the output- inflation tradeoff as a consequence of the institutional changes that accompanied the introduction of the ECB.

The research questions that will be explored are:

1. Does the trade-off parameter differ across countries and is there evidence in favor of the Lucas hypothesis ?
2. Do the trade-off parameters of different countries converge since the introduction of the ECB?

The organization of the thesis is as follows: in chapter 2 the relevant literature will be reviewed, in chapter 3 the model that will be used for the empirical analysis will be presented and in chapter 4 the data and the results of the empirical analysis will be presented. In chapter 5 the results of chapter 4 will be interpreted and finally chapter 6 will summarize and conclude.

Chapter 2: Literature Review

In this section the relevant literature will be reviewed. First the theoretical background surrounding the output-inflation trade-off will be discussed. I will discuss the two main models that have been constructed in order to explain the changes observed in the trade-off. I will also discuss two papers that link the theory and empirical findings of the trade-off to the theory of monetary policy games and policy preferences.

<u>Lucas [1973]</u>

In his classic paper Lucas reports the results of an empirical study of real output-inflation trade-offs, based on time-series data from 18 countries over the years 1951 – 1967. The data is examined under the hypothesis that average real output level are invariant under changes in the time pattern of the rate of inflation. More precisely, that there exists a 'natural rate' of real output. In order to test the relevant hypothesis Lucas constructs a model of the economy with the following features: (i) Nominal output is determined on the aggregate demand side of the economy, with the division into real output and the price level largely dependent on the behavior of suppliers of labor and goods. (ii) the rigidities which dominate short-run supply behavior result from suppliers' lack of information on some of the prices relevant for their decisions. (ii) The inferences that suppliers make on relevant, unobserved prices are made optimally ('rationally'). In his imperfect information model suppliers have to make a decision regarding the output and this decision should only depend on relative prices. But because of imperfect information, an agent cannot tell whether a change in price results from changes in the relative prices or from changes in the general price level. The supplier forms an optimal response, which in the Lucas model implies that part of the change in output comes from both sources. Since agents interpret any price change as partly relative, changes that in reality result from a nominal shock (which can lead to movements in the general price level) do have effects on the output (real effects).

The Lucas model gives an alternative explanation of the observed effects of aggregate demand policies. Aggregate demand policies tend to move inflation rates and output (relative to the trend) in the same direction, or alternatively, unemployment and inflation in opposite directions. These observations are captured by the Phillips curve and the standard explanation for these observations is that the terms of the trade-off arise from the relatively stable structural features of the economy and are thus invariant under different aggregate demand policies. In the Lucas model however, the trade-off arises because suppliers misinterpret general price movements for relative price movements. This reasoning also implies that a high variance in average prices will lead to a less favorable observed trade-off, because the probability increases that agents correctly judge the true source of price variation and choose not to adjust output. This last statement is the basis for the key insight provided by Lucas: the existence of a stable trade-off implies a relationship between variances of inflation rates and output rates. The implication is that if policies lead to wide variation in prices then they should (under the assumption of a stable trade-off as described by the short-run Phillips curve) also induce a comparable variation in real output. If these variances do not tend to move together we can only conclude that the trade-off tends to fade away the more frequently it is used. Lucas indeed finds evidence that in countries with low price volatility a change in nominal demand tend to have a large initial effect on real output and a small positive effect on the rate of inflation(a favorable trade-off parameter value). In countries with high price volatility the opposite appears to be the case. These observations are in line with the natural rate hypothesis and Lucas offers an explanation via his imperfect information model. The key contributions from Lucas are thus that he gives a test for the stability of the trade-off parameter and offers an explanation in terms of an economic model.

<u>Ball, Mankiw and Romer [1988]</u>

In their paper Ball et al (1988) develop a new Keynesian model that describes the relationship between the frequency of price adjustment, inflation and the slope of the Phillips Curve. In their model of price adjustment, the economy contains imperfectly competitive firms that change their prices at discrete intervals rather than continuously because price adjustment is costly. They also assume that price setting is staggered, with an equal proportion of changing prices at every instant, but that the length of time between prices changes (the rate at which the price level adjusts to shocks) is endogenous. In their model a firm's profit depends on three variables: aggregate spending in the economy, relative prices between individual firms and a firm-specific shock to either demand or costs. If price adjustment were costless firms would set their prices equal to the profit-maximizing level at every instant in time, but because adjustment is costly firms changes their prices only at intervals of a certain length (which is assumed to be constant). Maximizing profits is equivalent to minimizing profit losses from two sources in the model: adjustment costs and deviations of price from the profit-maximizing level. Ball et al (1988) solve the model and show how the (i) behavior of the price level (ii) behavior of real output and (iii) variance of output depend on the frequency of price changes. They find that the immediate effect of shocks on the price level is zero (because an infinitesimal proportion of firms change their prices right away); the effect of the shock grows over time; and asymptotically the shock is passed completely into prices. The central result concerns the relationship between the frequency of price changes and the effect of shocks: a longer interval between changes of individual prices leads to slower adjustment of the aggregate price level. The sizes of the real effects of nominal shocks are given by $1 - w(.)$, where $w(.)$ denotes the proportion of shocks that end up in the prices. They find that the variance of output depends on the variance of demand shocks and the size of the effects of shocks, $1 - w(.)$. Finally they solve for the equilibrium frequency of price changes. They find that this frequency is decreasing in the average rate of inflation, variance of demand shocks and variance of firm-specific shocks. High inflation causes a firm's profit-maximizing nominal price to change rapidly, which raises the benefits from more frequent adjustments. When the variance of a shock is large, the firm's future price is highly uncertain so that is does not want to fix its prices for too long.

The key predictions and implications for the output-inflation trade-off are that: (i) higher average inflation reduces the intervals between price changes, which in turn raises the proportion of a shock that is passed into prices, (ii) a larger variance of shocks also has the same effect. Implication (i) is in contrast with the predictions made by

Lucas (1973), because in Lucas' imperfect information model only the variances of random variables affect the uncertainty that agents face (and not the means). Ball et al proceed to test the predictions of their model empirically and find evidence in favor of the predictions. They find that, when used independently, both nominal output variability and mean inflation have explanatory power that is statistically significant in explaining variation in the trade-off parameter. However, when both variables are used as explanatory variables in the same regression, only mean inflation is statistically significant. The key argument made by Ball et al (1988) is that the mean inflation is an indication of the frequency at which agents adjust their prices and that frequent adjustments lead to a higher proportion of changes in nominal demand being transferred in the prices rather than leading to adjustments in output.

Swank [1997]

In his paper Swank presents the results of an empirical study of the relationship between macroeconomic performance and policy makers' preferences for real output growth and inflation. The 3 central questions that are addressed are: (i) what are the motives behind aggregate demand policy? (ii) do these motives affect macroeconomic performance and (iii) do these motives affect the real output-inflation tradeoff ? In terms of the output-inflation trade-off and the Lucas critique, question (iii) is clearly of central importance.

These questions are answered from a stabilization policy framework. The policy model used consists of two parts, one describing the preferences of the policy maker and the other describing the constraints that the policy maker faces due to the working of the economy. The preferences of the policy maker are given by a quadratic loss function and the constraints that the policy maker faces is given by the short-run Phillips Curve. Essentially the policy maker faces a constrained optimization problem with an objective function given by the quadratic loss function and the constraints given by the short-run Phillips Curve. From this optimization problem the resulting reaction function of the policy maker is derived. Note that because the policy maker is constrained by the Phillips curve, the trade-off parameter also appears in the reaction function of the policy maker. By first estimating the short-run Phillips curve and then substituting these estimates in the reaction function Swank derives estimates of the preference parameters in the loss function.

The connection with the work done by Lucas is that Swank also studies the relationship between the preference parameters and the trade-off parameter in the Phillips curve. In this sense Swank not only verifies the Lucas hypothesis but also offers an explanation for the observed relationship in terms of the preferences of policy makers. Swank finds a strong relationship between the trade-off parameter and the preferences of the policy maker. He finds that policy makers who attribute high priority to the output target relative to the inflation target tend to face a relatively steep Phillips curve. This result is in line with the result from Lucas (1973) which states that the trade-off between real output and inflation is favorable as long as it remains unused. Swank also finds that the higher is the real output growth target, the less a shock in nominal demand shows up in real output. Finally evidence is also found which confirm the results found by Ball et al that mean inflation is an important determinant of the output-inflation trade-off. The key insights form Swank are that the Lucas critique is relevant from a demand policy perspective in the sense that the trade-off between inflation and output is not invariant to the policy adopted by the policy maker. This in turn implies that institutional reforms that change the incentives that policy makers face could be welfare improving (reforms that emphasize inflation targeting instead of ambitious real output growth). This result is also in line with the results in the literature on monetary policy games, see for example Rogoff(1985), Barro and Gordon(1983).

Lippi [1998]

Lippi (1998) essentially combines the results and perspectives that have been discussed thus far. Lippi empirically investigates how policy motives affect the output-inflation trade-off. He uses the same stabilization policy framework that Swank (1997) has used where the policy maker is assumed to minimize a quadratic loss function subject to the constraints of the working of the economy. In fact he uses the same 2 step procedure to estimate the parameters in the loss function. The difference with the work done by Swank is that Lippi also estimates the relevant policy targets, i.e the desired growth rate of output and the 'inflation tolerance' parameter. Using these estimates a proxy for the desired output-gap is calculated. After estimating the short run Phillips Curve, Lippi proceeds to explain the output-inflation trade-off parameter in terms of the estimated (implicit) policy preferences and policy targets. Lippi essentially tests and compares the results obtained from Lucas (1973) and Ball et al (1988). Lucas states that the variation in nominal demand is relevant for explaining variation in the trade-off parameter, namely if policy makers engage in more frequent attempts to stimulate aggregate demand (leading to a high variance in of nominal output) the slope of the short-run Phillips curve (the trade-off parameter) decreases. On the other hand Ball et al provide evidence that the mean of inflation is relevant for explaining the variation in the trade-off parameter. Lippi explores both possibilities and he also tests whether the policy preferences and policy targets have additional explanatory power. This is similar to the work done by Swank, but Lippi also considers the explanatory power of the policy targets. Lippi finds evidence that essentially confirms the results from Ball et al that, when used independently, both nominal output variability and mean inflation have explanatory power that is statistically significant in explaining variation in the trade-off parameter. However, when considered together, mean inflation does not perform better than nominal demand variability in explaining the trade-off parameter. Nominal demand variability appears to be the only significant explanatory variable and this result is not in line with the results reported by Ball et al. Lippi goes one step further and also uses the policy targets as explanatory variables. The motivation for considering this relationship is that the policy parameters contain information that can be used by price setters in their decisions. He finds that the inflation aversion parameter is highly significant and has a positive effect on the trade-off parameter. When both the inflation aversion parameter and the output-gap are used the results remain the same; both variables are significant and have the expected signs. Finally Lippi also finds that when either inflation or nominal demand is used together with the policy targets in order to explain the trade-off parameter, neither are significant anymore. In general these results are in line with the Lucas critique in the sense that the type of policy pursued is not independent from the decisions that economic agents make regarding price setting and output.

Chapter 3: Model

In this section the model that will be used for empirical analysis is presented. I will discuss the model specification and the interpretation of the different parameters of the model.

Model for the Phillips Curve

The model for the Phillips Curve is given by:

$$y_t = \alpha_1 + \alpha_2 time + \alpha_3 y_{t-1} + \tau \Delta x_t + \varepsilon_t \ .$$

(i) t is the time index. Let T_{begin} and T_{end} denote the begin and end of the sample respectively.
We have that $t \in \{ T_{begin} \ , \ T_{begin} + 1, \ T_{begin} + 2 \ , \dots \ , \ T_{end} \}$.

This model has been slightly modified compared with the model that is used in Swank and Lippi. The variables in the model have the following interpretation:

(ii) y_t is the natural logarithm of the real GDP

(iii) x_t is the natural logarithm of the nominal GDP

(iv) $time$ is a variable that captures a lineair time trend. This variables takes on values that satisfies $time = t$.

(v) ε_t is a random variable that represents random disturbances. It is assumed that ε_t is white-noise.

(vi) Δ is the first difference operator, that is, $\Delta x_t = x_t - x_{t-1}$

Interpretation of parameters

There are also relationships between the various variables that are used in the model. If the above model specification is correct we can derive expressions for (i) the long-run growth rate implied by the model and (ii) the inflation rate implied by the model.

For the long-run growth rate the following expression in terms of the parameters of the model can be derived: $\Delta y^n = \alpha_2/(1-\alpha_3)$. In this expression Δy^n denotes the long-run or natural rate of output growth implied by the model.

For the rate of inflation [π_t] the following expression in terms of the parameters of the model can be derived: $\pi_t = \Delta x_t - \Delta y_t$. This expression is correct and follows immediately from the definition of inflation and from the definition of the variables in the model.

The parameter τ is the most important parameter in the model. This parameter is the so called trade-off parameter. The interpretation of this parameter is as follows: the parameter τ captures the fraction of the growth in nominal GDP that ends up in real GDP (the output). As a consequence it follows that $1-\tau$ captures the fraction of the growth in nominal GDP that ends up in the prices. Note that under the correct model specification it must hold that τ can only take on values between zero and one (because it represents a fraction) for the interpretation given above to make sense.

CHAPTER 4: EMPIRICAL ANALYSIS

In the first part of this section the data that is used will be discussed. In the second part of this section the empirical results will be discussed.

Data

In order to estimate the model that was discussed in the previous section data is needed for the real GDP and nominal GDP of the countries that are members of the euro-zone. The data was gathered from the World Bank database. Data was not available for all members of the Euro-zone; for 3 countries there was not sufficient data for the empirical analysis. Also the range of the available data also varies for groups of countries: (i) for 10 out of the 14 countries annual time-series data was available for the period 1960-2010. (ii) for 3 out of the 14 countries data was available for the period 1970-2010 , and (iii) for 1 out of the 14 countries data was available for the period 1975-2010.

Estimation of Model

I estimated the model for the Phillips Curve for different sample periods. (i) First I estimated the model for the full sample period in order to obtain descriptive statistics and the value of τ that holds for the full sample. (ii) Next I also estimated the model with a dummy variable for the period 1984-2010 and (iii) finally I also estimated the model with a dummy variable for the period 1999-2010.

The reason for including the first dummy variable in the model is that a lot of countries pegged their currency to the German (Deutsche) Mark around the year 1983 and this has effects on the way monetary policy is conducted. The reason for including the second dummy variable in the model is that we want to study the effects that the introduction of the ECB has had on the trade-off parameter, hence it is logical to use the year 1999 as a break-date.

The parameters in the model for the Phillips Curve are estimated using Least Squares. In order to correct for autocorrelation autoregressive (AR) terms of the dependent variable are included in the model. In order to judge when AR terms should be included in the model I used the Durbin-Watson (DW) test statistic and the following decision rule: add AR term if $1.6 < DW < 2.4$ does not hold.

Estimation Results using full sample

Using the full sample I estimated the model for the Phillips Curve discussed in the previous chapter and the results are given in the following table. Using these results we can get a general idea about how the estimates differ across countries and we can verify whether the results from Lucas (1973) continue to hold.

TABLE 1

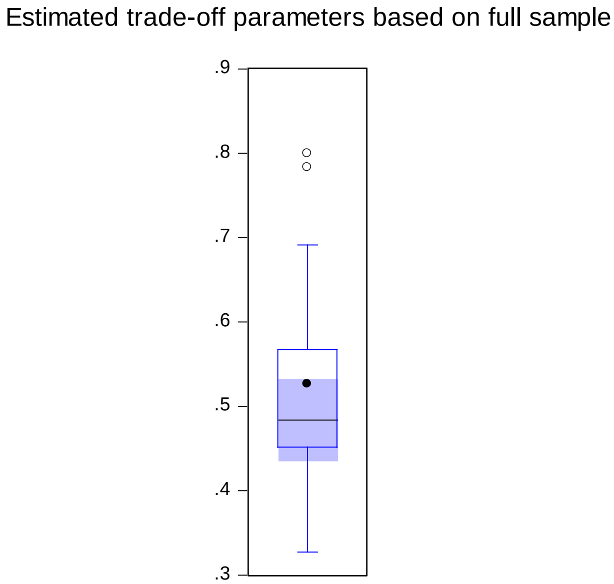
Regression over full sample 1960 – 2010

Land	τ- estimate	Max AR term	St. error	P-value
Austria	0.733930	1	0.057726	0.000
Belgium	0.650527	1	0.068310	0.000
France	0.587928	1	0.069003	0.000
Finland	0.575486	1	0.063606	0.000
Greece	0.567034	1	0.086017	0.000
Italy	0.485579	2	0.041990	0.000
Portugal	0.547790	1	0.101436	0.000
Spain	0.511516	1	0.071290	0.000
Luxembourg	0.417853	1	0.061992	0.000
Netherlands	0.529086	1	0.073372	0.000
Germany	0.812534	1	0.070215	0.000
Ireland	0.560499	1	0.076437	0.000
Malta	0.635945	1	0.062733	0.000
Cyprus	0.533489	1	0.052747	0.000

In the table ‘Max AR term’ denotes the maximum number of AR terms that have been included in the model in order to correct for serial correlation.

The estimated value for τ can be more easily compared using a diagram. For this purpose I have plotted the estimated values in the following box-plot. Here we can see that there are clearly differences in the estimated values for τ across countries.

Figure 1: Box-plot of estimated trade-off parameters



In order to verify whether the Lucas hypothesis holds we could consider a scatter-diagram of the variance of the growth rate of nominal GDP against the estimated values of the trade-off parameter. These results are given in the figures below. From these figures we can conclude that there is evidence in favor of the Lucas hypothesis in the sense that there is no clear relationship between the variance of inflation and the variance of the real GDP growth rate. We also find evidence that the output-inflation trade-off tends to fade away the more frequently it is used, because there appears to be a negative relationship between the trade-off parameter and the variance of the growth rate of nominal GDP. The correlation between the trade-off parameter and the variance of nominal GDP growth rate has a value of -0.551571 and appears to be significant if one uses a significance level of 5% (p-value of 0.0409).

Figure 2: Trade-off paramter vs variance nominal GDP growth rate

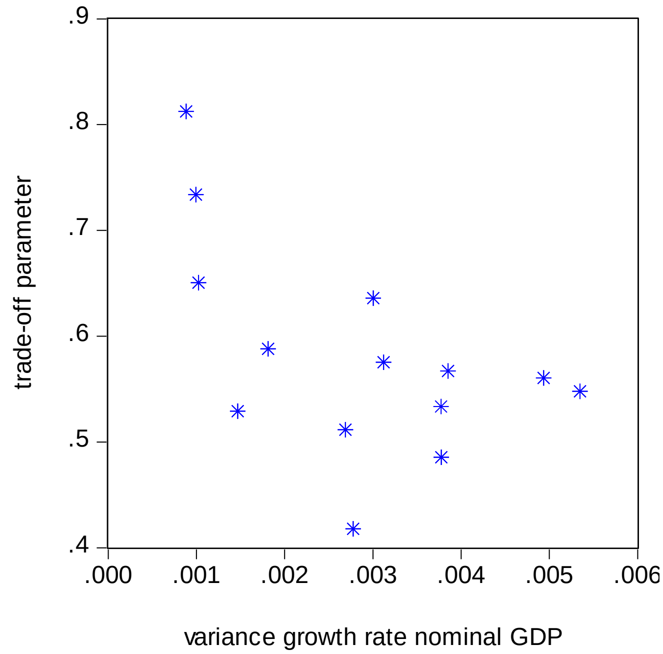
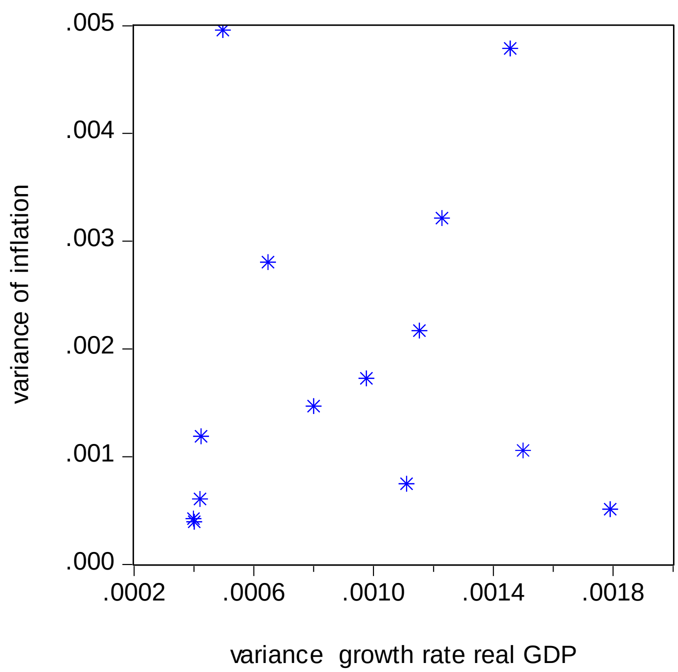


Figure 3: inflation vs variance of real GDP growth rate



Estimation results with dummy variable for 1984-2010

In order to analyze how the estimated values for τ vary over time I have estimated the model with a dummy variable for the period 1984-2010. The results are given in the following table. Using the estimated model we can compute the value of τ for the two sub-periods and compare their volatility.

TABLE 2

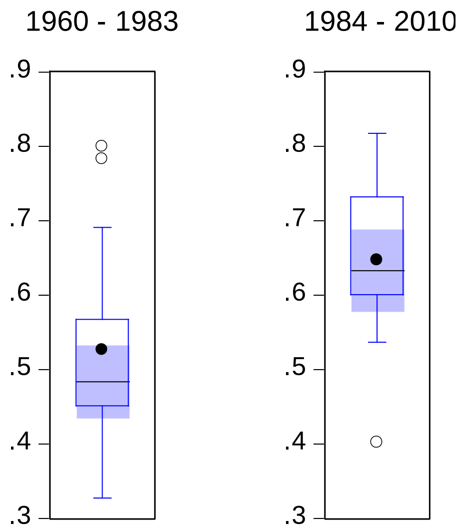
Regression with dummy variable 1 for 1984 – 2010

Dum1 = 1 if $time \geq 1984$, Dum1 = 0 otherwise

Country	τ-estimate	Dum1	Max AR term	St. error τ-estimate	St. error Dum1	P-value τ	P-value Dum1
Austria	0.783265	-0.133185	1	0.065256	0.083428	0.000	0.1177
Belgium	0.691406	-0.090330	1	0.081407	0.097790	0.000	0.3608
France	0.560922	0.079155	1	0.074432	0.079270	0.000	0.3236
Finland	0.451687	0.256952	0	0.058807	0.064015	0.000	0.0002
Greece	0.456049	0.146619	2	0.067974	0.199001	0.000	0.4655
Italy	0.470904	0.121661	2	0.040200	0.051491	0.000	0.0230
Portugal	0.567728	-0.165442	1	0.103452	0.096528	0.000	0.0937
Spain	0.498991	0.037763	1	0.078320	0.079879	0.000	0.6388
Luxembourg	0.327472	0.428418	0	0.060500	0.088369	0.000	0.000
Netherlands	0.456073	0.276380	0	0.069675	0.091489	0.000	0.0041
Germany	0.799890	0.017851	1	0.121510	0.125159	0.000	0.8875
Ireland	0.338815	0.290155	0	0.083767	0.075551	0.0003	0.0005
Malta	0.537705	0.236354	1	0.073826	0.092466	0.000	0.0154
Cyprus	0.428824	0.189335	1	0.103506	0.079904	0.0003	0.0249

In order to get an idea of how the parameter estimates change over time I have made a box-plot with the parameter estimates before and after the break date (see figure 2). From this figure we can conclude that the trade-off parameter has generally increased when the year 1984 is used as break-date. Furthermore it appears that the volatility of the trade-off parameter has also decreased over time. In the next subsection I will analyze the volatility in more detail in order to make more precise statements.

Figure 4: Boxplot of Trade-off parameter estimates (break-date 1984)



Estimation results with dummy variable for 1999-2010

In order to analyze how the estimated values for τ vary over time I have also estimated model with a dummy variable for the period 1999 -2010. The results are given in the following table. Using the estimated model we can again compute the value of τ for the two sub-periods and compare their volatility.

TABLE 3

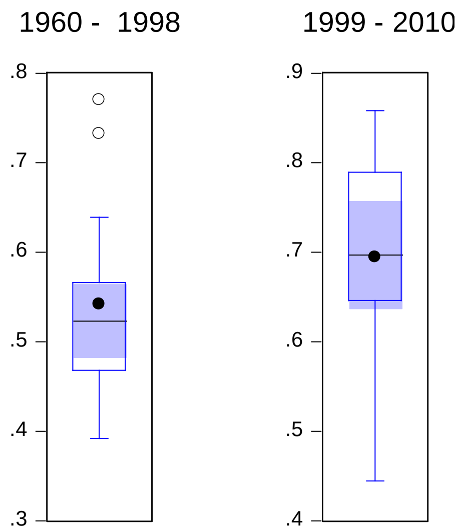
Regression with dummy variable 2 for 1999 -2010

Dum2 = 1 if $time \geq 1999$, Dum2 = 0 otherwise

Country	τ-estimate	Dum2	Max AR term	St. error τ-estimate	St. error Dum2	P-value τ	P-value Dum2
Austria	0.732384	0.004402	1	0.067374	0.097125	0.000	0.9641
Belgium	0.639199	0.041821	1	0.076877	0.125198	0.000	0.7400
France	0.545940	0.143364	1	0.077650	0.123520	0.000	0.2522
Finland	0.490084	0.321525	1	0.067661	0.121538	0.000	0.0113
Greece	0.548317	0.309937	1	0.086751	0.226529	0.000	0.1784
Italy	0.462006	0.290204	2	0.039788	0.106286	0.000	0.0093
Portugal	0.533977	0.172909	1	0.103916	0.228212	0.000	0.4528
Spain	0.468260	0.177883	1	0.075863	0.114843	0.000	0.1287
Luxembourg	0.391945	0.129785	1	0.067417	0.123115	0.000	0.2977
Netherlands	0.508996	0.053559	1	0.089526	0.123155	0.000	0.6658
Germany	0.770172	0.083441	1	0.095385	0.124555	0.000	0.5076
Ireland	0.415397	0.251893	1	0.092816	0.104310	0.0001	0.0214
Malta	0.514752	0.274654	1	0.067198	0.102893	0.000	0.0117
Cyprus	0.566121	-0.121514	1	0.056972	0.089044	0.000	0.1832

Again a box-plot can be made to illustrate the differences in the estimates for the trade-off parameter τ . These box-plots are given in the following figure. From these figures we can conclude that the trade-off parameter has generally increased over time when the year 1999 is used as break-date. However, it appears that the volatility has also increased over time. This is in contrast with what we found in the previous sub-section, where the volatility has decreased over time (if the year 1984 is used as break-date).

Figure 5: Boxplot of Trade-off parameter estimates (break-date 1999)



Test for Convergence

Using the results of the previous two sub-sections we can analyze the volatility of the estimated parameter more formally. Using the estimated model for the two break-dates we can calculate the estimated values for τ and compute their sample variances. By comparing these sample variances with each other we can then made a more precise statement about the convergence of the parameter estimates.

The sample variances for the estimates of τ are given in the following table.

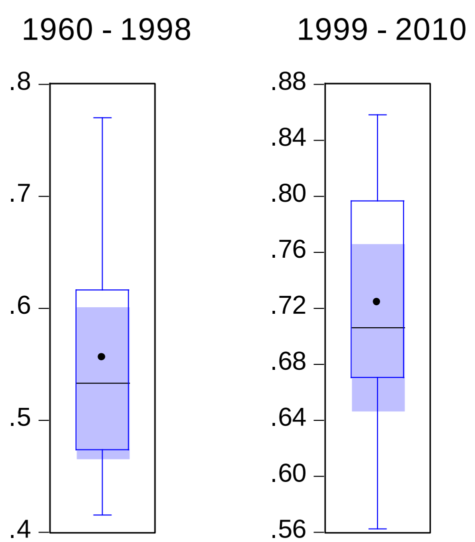
TABLE 4

sample variances for the estimates of τ

Sample period	Sample variance	
	All countries	Cyprus, Malta and Luxembourg excluded
1960 - 1983	0.021124674	0.021799833
1984 - 2010	0.011426553	0.011594138
1960 - 1998	0.011797401	0.012740481
1999 - 2010	0.014855287	0.008214424

Using these estimates we can see that there is indeed some type of convergence taking place. Note that the sample variance before 1984 is about 84% higher than in the period 1984-2010 and that this percentage stays about the same even if we exclude Cyprus, Malta and Luxembourg. Looking at the estimates corresponding with a break date for the year 1999 we find similar results. For example if you exclude Cyprus, Malta and Luxembourg from the sample we can see that the sample variance was about 55% higher before 1999 compared to the period 1999 – 2010 (see also figure 4). However, if we do not exclude these countries we find that the sample variance in the period 1999 - 2010 is 25 % higher than before 1999. A reason why it may be useful to exclude Cyprus, Malta and Luxembourg from the analysis is that their economies are generally not comparable to those of the other countries. Another reason for excluding them from the analysis is that Malta and Cyprus did not join the Euro-zone at the same time as the other countries, but much later around the end of the sample period.

Figure 6: Boxplot of Trade-off parameter estimates (Cyprus, Malta and Luxembourg excluded)



Using a formal F-test for the variances we can make more precise statements. When performing the F-test for the equality of variances we cannot reject the null hypothesis of equal variances at the conventional levels of significance. The results are given in the following table. In the next chapter I will interpret the results obtain here.

The test statistics in the table below were calculated by dividing the sample variance before the break-date by the sample variance after the break-date.

TABLE 5

F-test statistics for the test of equal variances for the two break-dates

Break-date	F test statistic		Critical value 5 % significance level
	All countries	Cyprus, Malta and Luxembourg excluded	
1984	1.8487	1.8802	2.98
1999	0.7942	1.5510	2.98

Chapter 5: Interpretation of Results

There are various ways in which the results of the previous chapter can be interpreted.

Statistical point of view

From a statistical point of view one could argue that the trade-off parameter is in fact not converging across countries. The motivation for this statement is quite simple: the null hypothesis of equal variances could not be rejected at conventional levels of significance. But if you look more closely there are also statistical reasons that indicate that this conclusion may not be correct. Note that the F-test was based on relatively few degrees of freedom such that it is in general hard to reject the null hypothesis of equal variances. There is no way around this constraint in the sense that the number of countries in the euro-zone is limited.

Economic point of view

The results could also be interpreted from an economic point of view. From an economic point of view a reduction in variation of about 50% could be interpreted as substantial. There is also an economic reason why it may be difficult to detect differences in volatility when the year 1999 is used as break-date. The reason for this is that countries that want to join the Euro-zone should meet certain criteria (the euro convergence criteria or Maastricht criteria[1]). Most of the criteria are based on the idea that the economies of countries that enter the euro-zone should not differ to much with respect to some macro-economic variables. For example, one criterion is that the inflation rate of an aspiring member should be no more than 1.5 percentage points higher than the average inflation rate of the three best performing member states of the EU. Essentially before a country can join the euro-zone (before the year 1999) its trade-off parameter should already be converging towards some (implicitly) agreed upon level, so that it is harder to detect differences as time goes by (after 1999). So from this

[1] The euro convergence criteria (also known as the Maastricht criteria) are the criteria for European member states to enter the third stage of European Economic and Monetary Union (EMU) and adopt the euro as their currency.

economic point of view the estimated variances do indicate that there is some type of convergence taking place. This convergence is stronger if 1984 is used as break-date because countries did not explicitly have the goal to join the euro-zone. If the year 1999 is used as break-date we observe that differences do become smaller but at a slower rate, here we find that the variances decrease with about 55% which could still be interpreted as substantial given the criteria that countries should meet if they want to join the euro-zone.

Interpretation with respect to the ECB

How can the previous results be interpreted from the perspective of the ECB? From the perspective of the ECB it is desirable that the trade-off parameters are converging, because they carry out policies that are directed at the whole EU and it would be desirable that the same policy does not affect different countries in very different ways. The ECB has as objective to maintain price stability throughout the whole EU. But the ECB also controls the money supply and the interest rate. Suppose that the ECB facilitates demand policies implemented by member countries and for example uses the interest rate as an instrument. If the trade-off parameters differ too much across countries the effects on price stability will also differ substantially across countries. However the ECB has a common goal with respect to price stability and trade-off parameters that differ to much could disrupt the achievement and feasibility of this common goal. This last argument is also consistent with the theory of the optimal currency area.

Thus for the policy purposes of the ECB the mean value and the variance of the trade-off parameters are of importance. A higher mean value of the trade-off parameter implies that a smaller fraction of changes in nominal demand end up in the prices and from a price stability perspective this is a desirable result. Secondly a low variance of the trade-off parameter implies that changes in nominal demand tend to have about the same effect on real GDP (and the price level) so that there are fewer obstacles to achieve the common goal of price stability and this is also a desirable result. From the estimation results above (see figure 6 and table 4) we can indeed conclude that the mean value of the trade-off parameter is higher since 1999 and also that the volatility of the trade-off parameter is lower.

Possible explanations

Until now I have considered arguments regarding the significance of the difference in volatility and the ability to detect differences in volatility, but now I shall also attempt to give some explanations for the observed differences in volatility. There are 2 central questions that I want to address here: (i) How can the difference in volatility for the time periods 1960 – 1998 and 1999 – 2010 be explained?, and (ii) How can the decline in the rate of convergence (when the year 1999 is used as break-date) be explained?

The first explanation for (i) is that the volatility for the period 1999 – 2010 was lower compared with 1960 – 1998 because of the euro convergence criteria: in order to join the Euro-zone differences between countries should not be too large. Hence a possible explanation could be that most of the convergence took place before 1999.

The second explanation for (i) is that the policy pursued by the ECB could be seen as an extension of the policy that the German Bundesbank had previously pursued. Note that the objective of the ECB is to maintain price stability and it could be argued that this strongly resembles the policy of the German Bundesbank (which was also targeted at keeping inflation low)[2]. Furthermore note that because of the relationship between the trade-off parameter and inflation, a policy that stabilizes inflation will also stabilize the trade-off parameter. If the inflation stabilization policy is correctly carried out, we would expect the trade-off parameters to converge.

A possible explanation for (ii) is related with the implementation of the so called Stability and Growth Pack. There have been reports that the member countries did not adhere to the Stability and Growth pack once they joined the Euro-zone so that it is possible that the convergence began to slow down[3].

[2] See for example Teulings et all (2011)
[3] See for example Teulings et all (2011)

Chapter 6: Conclusion and Discussion

In the first part of this chapter we will draw conclusions based on the results that were derived in chapter 4 and 5. In the second part we will discuss the limitations of this research and give some suggestions for future research.

Summary and Concluding remarks

In this thesis we have estimated the trade-off parameters for 14 different Euro-zone countries by using a model for the short-run Phillips Curve. After estimating these trade-off parameters I checked whether differences between countries were present and then I proceeded to check whether the hypothesized relationship between the variance of inflation and the trade-off parameter was plausible. Based on the graphical analysis that was carried out we conclude that the trade-off parameter indeed varies across countries and that the relationship hypothesized by Lucas does indeed seem plausible. Next I also studied how the trade-off parameter changes over time by using a regression analysis and controlling for 4 different time periods. I estimated the trade-off parameter for the periods (i) 1960-1983 , (ii) 1984-2010, (iii) 1960-1998 and (iv) 1999-2010 . Based on the results of the analysis I found that (i) the trade-off parameter has become less volatile over time and (ii) the differences in volatility are decreasing over time. The difference in volatility is however not statistically significant but I have argued that from an economic point of view these differences could be judged to be substantial. I also gave statistical arguments that make it hard to detect differences in volatility.

Discussion

The conclusions that were discussed are based on different aspects, namely (i) the model specification and (ii) the data and methodology that was used. The results were derived under the assumption that the specification that was given for the short-run Phillips Curve was indeed correct. This model was chosen because it was similar to those used by other authors who also did research on this subject and this makes it easy to compare these results with the results obtained from previous research. Also this thesis could be seen as an extension of the work done by other authors in the sense that the previous work discussion in the literature review did not study the convergence of the trade-off parameter.

The results are clearly sensitive to the data that was used. In this thesis data was used for 14 countries and for the period 1960 – 2010. As a result of the relatively few number of countries that were used in the analysis, the estimated parameters could not fully make use of asymptotic statistical properties. This is especially relevant for the F-test that was performed and also for the regressions that were performed. But this is off course a practical limitation because the number of countries that are part of the Euro-zone is limited.

Future research on the output-inflation trade-off could for instance be directed towards finding and testing for the correct specification of the Phillips Curve. From the graphical analysis that was carried out it appears that the relationship between the trade-off parameter and changes in nominal demand may be non-linear.

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