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Inflation Differentials of Euro Countries and Their Determinants

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Abstract: The purpose of this paper is to examine the inflation differentials and their determinants in the first twelve euro countries that formed the eurozone. We focus on only these countries to capture the effects through the last 22 years from 1999 to 2020, without taking into consideration the changes in dynamics that were caused due to the integration of more countries since 2007. The dynamic panel data results, estimated with the system Generalised Method of Moments estimation method, show that it is mostly structural and cyclical factors that drive inflation differentials among these euro countries and that there are no significant indications that other convergence processes have taken place during this time span to explain increase in certain countries' inflation. We conclude by mentioning the potential role that inflation differentials could play in the European Central Bank's decision-making process.

Keywords: inflation differentials; inflation determinants; generalised method of moments; euro area

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1. Introduction

In 1993, the Economic and Monetary Union was launched. Its target was to create a common currency area in order to deepen the relations of the European countries and connect them through trade and monetary integration. The Maastricht treaty (Maastricht 1992) set the context in which this integration would take place. According to this treaty, one of the main targets for the member countries prior to the introduction of the euro should be the stabilisation of inflation so that it would not exceed the levels of the most productive countries of the euro area.

This was one of the 'Maastricht criteria' because inflation of these countries should be on the decided appropriate levels so that the introduction of the common currency along with the universal exchange rate and the single monetary policy would not find them far apart from the rest of the countries and create problems by their implementation.

There is an ongoing discussion on whether the European Central Bank (ECB) should focus only on the inflation of the euro area as a whole or if it should also pay attention to inflation levels of individual countries (Pirovano and Van Poeck 2011). We attempt to find the determinants of inflation differentials of euro countries and, based on them, contribute to the discussion of whether or not the ECB should be concerned with inflation differentials depending on whether their existence is explained as part of a process of convergence or it manifests structural differences between the members of the EMU.

The countries under study are the first 11 countries that joined the currency union in 1999 and Greece, which joined in 2001[1]. This is done in order to examine the possibility of convergence taking place between these countries since they had many years to develop deep economic relations. The countries that joined later had less time under common currency in order to integrate, which means less data available and possible changes in the

dynamics, which would not give a clear picture on the relations that developed between the first 12 countries.

The results of the study show no significant signs of convergence effects between the countries that would explain bigger inflation differentials during these years of the monetary union. On the contrary, it seems that the existing inflation differentials are generally explained by the persistence of inflation and the cyclical differences between the countries. It is also shown that inflation persistence has not yet diminished, which contradicts the expectations of researchers in the early years of the EMU. Consequently, the ECB has to keep these effects under consideration because, since the factors that drive inflation differentials are of this nature, it seems that a single monetary policy can have very different effects on each country, and pro-cyclical effects can drive the countries apart even more.

The rest of the paper is structured as follows. The next section contains a literature review of the research that has been done on the determinants of inflation differentials and the dangers they may pose. Section 3 presents some stylised facts about inflation differentials. Sections 4–6 contain the methodology chosen to model the inflation differentials, the data used and the results of the study, respectively. We conclude in Section 7.

2. Literature Review

Inflation is one of the most important measures of an economy's performance. It is the rate of change in prices of goods and services. All households are very interested in its movement because it directly affects their spending habits and forms their priorities. Consequently, it is of high importance that the fiscal and monetary authorities are able to measure it in a way that is accurate and comparable both to other economies and the same economy through the years.

Most countries and monetary authorities use a cost of living index to track inflation, namely the Consumer Price Index. Along with the creation of the Economic and Monetary Union (EMU) however, the Harmonised Index of Consumer Prices was introduced as a means to measure inflation in the monetary union. There are some conceptual differences between the two indexes. The HICP is not considered a cost of living index. It is supposed to emphasise the changes in prices as experienced by all households and not only the urban area households as the CPI does.

Every sector of products or services is weighted by a weight determined by the share of total spending that is devoted to that particular sector. It is these weights that make it possible for the HICP of the various countries in the EU to be compared with each other and for the European Central Bank eventually to be able to recognise the union-wide inflation levels and also the inflation differentials between the members of the currency union (Cecchetti et al. 2003).

The EMU was constructed as a vision of representing what is called an "Optimum Currency Area". This comes with a lot of individual country adjustments, new institutional features and, of course, guidelines and metrics for the assessment of its progress.

The term Optimum Currency Area (OCA) describes the geographical area that consists of multiple countries using a common currency instead of a national one, or using national currencies with linked exchange rates.

An OCA is characterised by the features that give the opportunity of the integration processes to be successful. The integration process starts from the labour market. If job opportunities in a country are considered as options from people of other countries, it means that the factors of production are mobile. Of course, the short-run mobility would be restricted because of the short-term costs, but the long-run effect is assumed to be significant. That is because an outcome of this labour mobility is the wage flexibility, which also affects prices within the OCA.

An OCA should also have integrated financial markets that regulate and keep the interest rates from diverging. It is important to mention, however, that this integration also needs a common central monetary policy and a generally aligned fiscal policy of the members of the currency area.

Last but not least, the inflation levels in an OCA should remain low, as well as the inflation differentials between its members. Of course, it is clear that some divergence is going to occur since a certain amount of time is necessary for the countries to eventually converge towards an inflation target, which is the prerequisite for the single monetary policy to be successful in its goals (Franks et al. 2018). However, Arestis et al. (2014) claim that inflation may move independently of target inflation policies, while Goncalves and Salles' (2008) research indicates that inflation targeting may be beneficial for developing countries.

Inflation, however, should also remain low so that the terms of trade, meaning the ratio of the index of export prices to the index of import prices, remain stable in favour of all the transactions that take place within the union.

An integration process is a gradual process with many difficulties along the way. In this paper, we focus mainly on the inflation differentials between the members of the euro area. It is important to mention that the European Central Bank's concern is the inflation of the euro area and not the inflation of specific countries, to the extent that they do not affect the euro area more than expected. Therefore, inflation differentials between the euro countries are something to be expected by the ECB and in some ways are also welcomed when they are a representation of the 'catching up' process of some countries during the integration phase, as described earlier. It is also the case that with only one common monetary policy, it is difficult to have more objectives other than price stability. More objectives would create the need for more specific country measures (Pirovano and Van Poeck 2011).

There have been many theories developed about what causes inflation differentials in a monetary union. In the following paragraphs, we present the ones that most researchers have focused on in the last two decades of research.

The most discussed possible cause of inflation differentials is the price level convergence of the member countries that occurs after the formation of the currency union (Hofmann and Remsperger 2005).

Currency unions in general attempt to smooth the labour and product trade inside the union. This trade is a factor that allows for wage and price convergence between the members, meaning that there are going to be inflationary pressures to the countries that are the furthest from the average of the union. This is commonly described as the Ballasa–Samuelson effect.

For years, the Ballasa–Samuelson effect (Samuelson 1964) was viewed as the main cause of inflation differentials considered by the researchers. The BS effect describes the inflation differentials between countries as a result of the Purchase Power Parity doctrine, which was studied a lot in the 1970s. Under the PPP, the ratio of the prices of the same products between two countries is the equilibrium exchange rate between the two currencies. Balassa stated that, assuming that there is relatively free trade, the currency of the country with higher productivity in the tradable sector would appear to be stronger relative to the other. This effect would explain the inflation in the countries with higher productivity since the tradable sector would grow faster than others. Of course, this inflation and wage increase in this sector would eventually transfer to the non-tradables as well, increasing the country's inflation overall.

Another cause of inflation differentials that has been examined by researchers and the ECB since the early years of the EMU is the so-called composition effect. This effect describes the inflation differences that can be portrayed due to the different consumer or household preferences of each country. Different preferences will indicate the use of different weights of certain consumption choices when it comes to estimating inflation and restrict the use of universal weights for all euro countries (Licheron 2007).

Inflation differentials can also be caused by the lasting effect of a shock. A shock can be the same for all the members of a currency union. The effect that it is going to have on them, however, can differ significantly. The reason is the underlying structural differences between the members' economies (Hofmann and Remsperger 2005).

A shock of this kind can be caused within the currency union or it can be imported (Lane and Honohan 2003). It can be a price shock (e.g., oil price fluctuations or energy

demand in general) letting the exposure of each country determine the consequences. For example, countries such as Germany with no hedging against an external energy demand shock in the trade market, such as the recent one, were not prepared and could not control effectively and immediately this kind of imported inflation. Additionally, we all know the effects that the recent pandemic of Covid-19 had on countries and the fiscal challenges that it created, once again to a different extent for each country.

Fiscal policy can also create inflationary pressures and increase inflation differentials in a monetary union. A government can enhance the cyclical divergence between the country members by implementing pro-cyclical policies, worsening the state of the economy.

Every potential cause of the inflation differentials that was mentioned above would need a different approach and policy implementation by the ECB. These different policies would most likely have different short- and long-term effects on each economy and the monetary union as a whole. Depending on the causes of the divergence of the inflation level of a country, an ECB policy that would target bringing it to the desired levels could worsen the situation unless the determinants of this inflation differentials were known. This is the reason why it is so important to gather all available information and to try to determine the causes in order to adjust the monetary mechanisms and implement policies accordingly. After all, as Pirovano and Van Poeck (2011) mention, some causes of inflation differentials such as structural rigidities are possibly a reason for concern for the fiscal and monetary authorities, and others that signal convergence between the economies are expected and desired.

When it comes to understanding inflation differentials, some researchers (Angeloni and Ehrmann 2021; Ivo and Clemens 2004; Beck et al. 2006; Rogers 2007) have turned to examine the US and their inflation differentials. This choice was made because the euro area is a relatively new common currency area compared to the US, which means less data availability and time for convergence between the regions, but also, in the case of the EMU, constant entrance of new members changes the balances and relationships among the countries, making it harder to come to a clear conclusion.

Although comparing the EMU to the US is insightful, there are substantial differences that require a different way of interpreting the data. When it comes to the EMU, the members are different countries with different speaking languages, wages, trades, fiscal policies and political views. As Lane and Honohan (2003) state, these factors make inflation differentials a much more complicated issue to handle compared to the US, where there is a central government, universal fiscal policy and wage setting mechanisms.

A harmless side of the inflation differentials is portrayed by the ones that are actually described by the BS effect. They are the ones observed as part of the expected and desired process of countries heading towards their new long-run equilibrium of price levels backed by faster wage growth and productivity (Lane and Honohan 2003). Other sources of inflation differentials, however, may pose a threat to the currency union.

The main source of concern stems from the fact that under a single monetary policy, the ECB issues the same interest rate for all member countries. Internal differences including those in the inflation rates in these countries may contribute to the creation of interest rate differentials within the countries, giving rise to persistent imbalances. Countries with higher than average inflation will have a lower real interest rate and vice versa (Hofmann and Remsperger 2005). This will lead to a further expansion of the already growing countries with higher inflation and a weakening of the countries with lower inflation.

A logical solution to this problem is the adjustment of the exchange rates. Unfortunately, under common currency, this is not a choice for the monetary authorities. Angeloni and Ehrmann (Angeloni and Ehrmann 2021) state that the rigidity of the exchange rate may be counteracted by the mobility of the real exchange rates of the countries. That means that if a country faces higher inflation, soon enough its real exchange rate is going to increase, causing a loss of competitiveness, which will force the price levels downwards, ultimately reducing inflation.

Additionally, we cannot rely on fiscal policy to solve these issues. Countries of the monetary union follow the same guidelines when it comes to fiscal priorities and fiscal policy in general (Zdarek and Aldasoro 2009).

Policy makers are in some ways restricted by the Commission guidelines.

Last but not least, one of the main dangers of inflation differentials is the threat they pose to the integrity of the monetary union itself. Inflation is something that every policy maker wants to avoid because of its unpopularity among the consumers-voters. At the same time, the appropriate measures to tackle it might bear the same unpopularity among the voters. Under these circumstances, people might blame the currency union. If the currency union proves to be (or just is believed to be) one of the main causes of inflation and, consequently, of the increase of the cost of living of the people when otherwise there would be enough flexibility by the government to tackle it effectively, the faith and the trust in monetary union would deteriorate (Hofmann and Remsperger 2005). In such a case, a scenario of destruction of the monetary union is plausible since the voters may start to reject and oppose the idea of the EMU.

3. Stylised Facts

The focus of this paper is on the first 12 countries that formed the EMU (11 in 1999 and Greece in 2001). It is an attempt to study the processes that took place in these 22 years of the common currency and the evolution of the inflation differentials between these countries without including the countries that joined later and had less time to converge.

In the previous section, it was described that the Economic Monetary Union started as an attempt to create a monetary union that would be described as an Optimum Currency Area. Does the EMU, however, fit into the description of an OCA? We can see if the basic criteria are fulfilled by now and examine whether or not the EMU operates as an OCA.

First off, when it comes to the 'one market' target that was set as a primary goal, necessary for the success of the monetary union, in their paper, Jappelli and Pagano (2008) mention that the European financial markets have been integrated, each to a different degree and a different time frame and pace. They mention that money markets integrated quickly, with yield differentials of government bonds relative to the 10 year German government bond declining near to zero almost immediately after the introduction of the euro.

However, other markets such as equities, corporate bonds and credit markets take more time to converge and still are not fully integrated. That is probably because of the few differences that exist between these countries, including tax rates, which can affect and shape the investment decisions of the households greatly, since the risk of exchange rate fluctuations has been eliminated by the introduction of the common currency.

Even though a lot of progress has been made in the financial markets integration after the creation of the EMU, Arpaia et al. (2016) cannot say the same about labour mobility in the euro area. One of the main characteristics that an OCA must have in order to be able to absorb shocks and smooth their effect between the unevenly exposed economies is the increased labour mobility between the geographical areas that form the OCA. In their paper, they argue that this mobility in the EMU is low. It is significantly lower than the mobility observed within these euro countries but also lower that the labour mobility observed in the US as a whole.

This, of course, is something that did not surprise the researchers since there are many difficulties faced by the EMU that are not relevant for the US, such as language barriers, large cultural differences, preferences, etc., that in some cases are very hard to overcome in order to achieve complete integration.

In their analysis, Jager and Hafner (2013) come to the conclusion that the EMU cannot, yet, be considered an OCA. They justify it by stating that the introduction of the euro at a time when there were structural differences between the first 11 countries led them to a production specialisation, which made them vulnerable to asymmetric shocks. The 2008 financial crisis was a shock of this kind. They emphasise that within the euro area, the integrated markets make transactions and capital mobility easy and effective, but the lack

of mechanisms such as increased labour mobility and wage level adaptation in order to react to shocks can result, and possibly has, in further divergence between the countries.

Consequently, since the EMU has not yet fully developed the optimal mechanisms to handle the economic shocks under the common currency, the fixed exchange rates and the uniform monetary policy, any imbalances will leave each member country with a different exposure, leading to enlarged structural differences including inflation, posing dangers to the sustainability of the monetary union itself. The extent of such imbalances can be shown in Neaime et al. (2018), where they highlight the effects that macroeconomic reforms in Germany can have on the inflation rates of Greece as part of the eurozone. This observation, however, does not satisfy the prediction that Frankel and Rose (1998) made almost 25 years ago, which stated that the prospects of integration in the EMU would be so beneficial for the countries that even if the EMU was not an OCA, it would soon become one as a result of the financial deepening and free trade. This was a reasonable assumption, but reality turned out to be different than expectations.

As Licheron (2007), Karanasos et al. (2016) and Weber and Beck (2005) mention, in the 1990s, years before the introduction of the euro, the inflation differentials of these countries were decreasing. However, from 1999 and on, there was an increase in inflation levels once again, which lasted up until the years of the financial crisis of 2008. Fritsche and Kuzin (2011) also discovered possible signs of convergence in the 1990s but state that their long-term study does not show significant evidence in favour of it.

Indeed, by looking at Figure 1, one can see that inflation levels are high in the years previous to the 2008 financial crisis but seem to decrease significantly in the years that followed it.

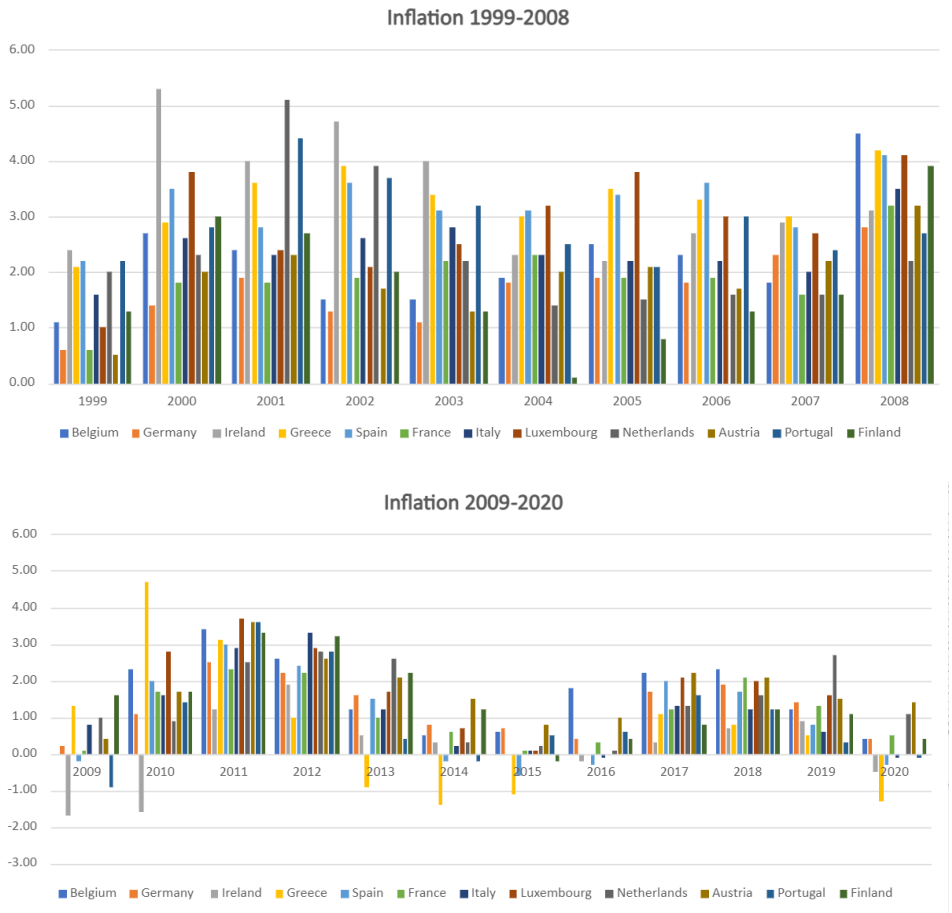

Figure 1. The above figure shows the inflation growth rate as a percentage change of the price levels of the previous year of the first 12 euro countries until the year 2008, and the figure below shows the rest of the years until 2020.

In the years running up to the financial crisis, we can notice higher inflation rates in contrast to the later years. In the early years of the EMU, the higher inflation was found in Greece, Ireland, Spain and Netherlands. After 2008, the inflation differentials were significantly reduced between the countries with only a few exceptions of outliers, mainly Greece and Ireland. As described by the relevant literature, we can look for the causes of inflation differentials by examining the fiscal stance of the countries, their productivity levels or their possible price convergence. We examine only the original 12 euro area countries in an attempt to observe the convergence process, or the lack of it, through the first 22 years since the start of the EMU while not including countries such as Slovakia, Slovenia, Estonia, etc., that entered the currency union later.

In the early 1980s, the first years of creation of the EMU, these kind of inflation differentials and their causes were examined under the scope of the Ballasa effect and the expected cyclical divergence of the member countries. Nowadays, researchers focus more on the structural differences between the euro countries in order to determine the causes of the inflation differentials. They examine possible determinants such as the fiscal policy that each country implements, which can affect the price levels within the country and their sensitivity to fluctuations of the euro/dollar exchange rate.

The analysis of Licheron (2007) also includes the fluctuations in oil price as a possible partial explanation of the persistent inflation differentials in the euro area. The reasoning behind this is that every country is exposed to oil prices to a different degree but those with the larger dependence tend to be the countries with the highest inflation because of their dependence on energy supply coming from abroad.

When it comes to price convergence, we can state that according to Figure 2, the data do not show signs of its existence. Greece, Portugal and Spain, which are the 3 countries with the lowest relative price level, remained at that place throughout the 22 year study period. The same is true for the three countries with the highest relative price levels, namely Finland, Belgium and eventually Ireland, which showed signs of divergence, and while it started around the average of the euro countries, its price level increased to be the highest among them.

Of course, when dealing with the price level convergence between the countries of a monetary union, even though this is reasonable and expected to be observed, we should always take into consideration the effect that the rest of the world has on the economies that we study. Even though these countries are part of the euro area and trade among them is not restricted, the fact that these countries trade with different non-euro area countries, and each of them with different volumes, should not be ignored, as it shapes the price levels of these countries.

Most of the relevant studies try to account for the effects that a cyclical position has on inflation and inflation differentials. A measure of the cyclical position of the countries is the output gap. A positive output gap means that the economy produces more than expected, which is indicative of increased demand and inflationary pressures. If the business cycles in a monetary union are not synchronised, then there is a threat posed by the single monetary policy. Since all the countries receive the same short-term interest rates, these rates will have a different effect between the countries and possibly enlarge the inflation differentials, leading to further external imbalances ECB (2023).

It is interesting to notice in Figure 3 that up to the point of the crisis of 2008, output gaps were mostly positive, implying highly productive economies with high demand, which could explain the inflationary pressures of the first decade of the 21st century, but since 2009, output gaps were negative, showing that the economies were operating below expectations, with Greece, Spain, Portugal and Ireland experiencing the consequences of the crisis to the highest degree, with Greece's output gap reaching −15%.

The fiscal measures taken by each government are a way of handling the shocks that the economy faces without the freedom of individual and country-adjusted monetary intervention. The reason that makes them possible driving factors of inflation differentials, however, is twofold. Appropriate fiscal measures are not always delivered for reasons

of political economy and their unpopularity among the consumers. Therefore, what can increase inflation differentials is the implementation of a possibly inappropriate fiscal policy or the willful ignorance of the appropriate unpopular one.

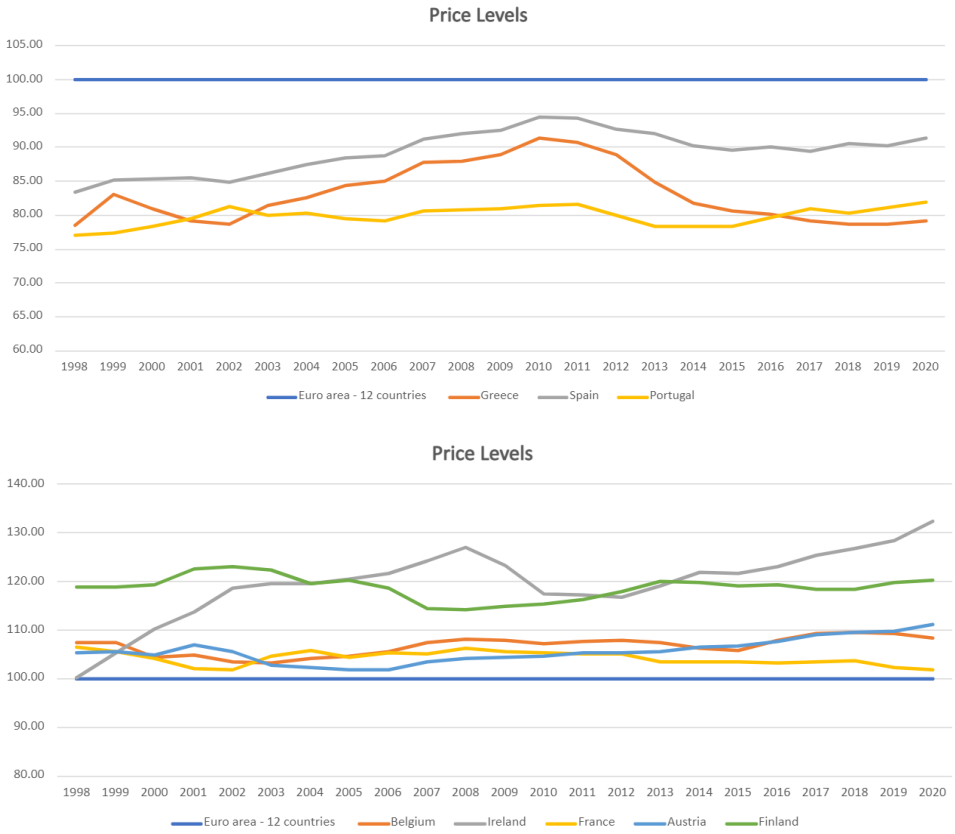

Figure 2. The above figure presents the price level of the three countries with the lowest price level compared to the 12 euro average. Namely Greece, Spain and Portugal. The figure below presents five countries with price levels above the average. Namely Belgium, Ireland, Austria, France and Finland.

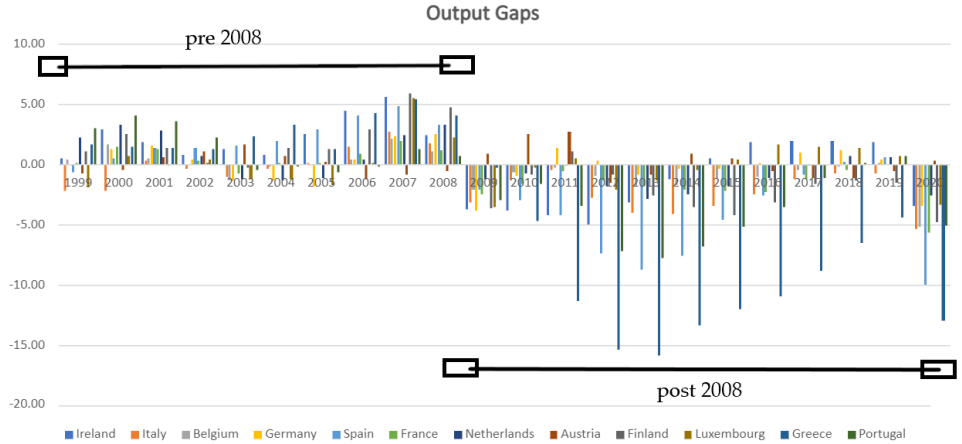

Figure 3. Output gaps of the 12 euro countries starting from the year 1999 until the year 2020.

The fiscal performance of the countries under study, as shown by the government deficits, shows that the only three countries that had government surpluses were Finland, Luxembourg and Ireland, but only in the years before 2008. In the following years, all countries showed deficits, with Germany and Luxembourg as the two exceptions for some of the years with slight surpluses, as it is shown in Figure 4.

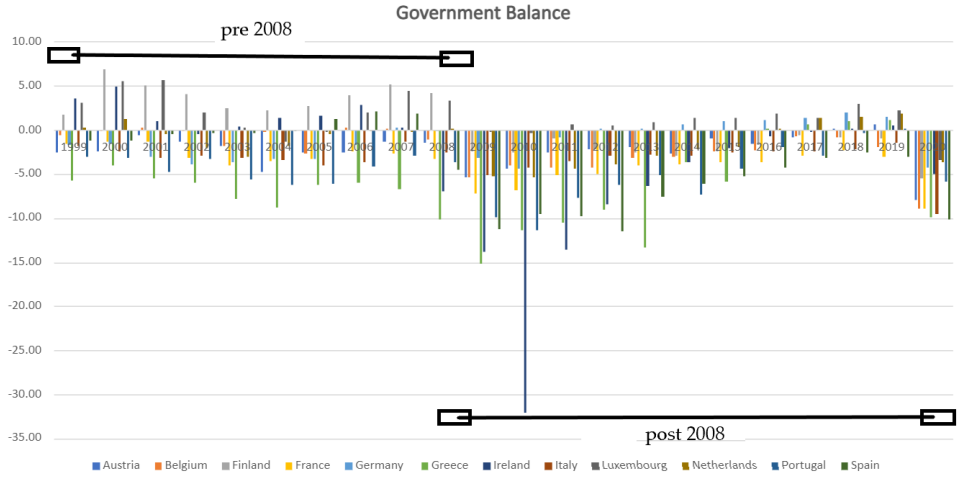

Figure 4. Government balances as percent of GDP of the 12 euro countries starting from the year 1999 until the year 2020.

A number of papers study the effect that real exchange rates have on inflation differentials in the euro area. In fact, Warmedinger (2004) claims that in the first two years of the monetary union, oil price movements and real exchange rate fluctuations played a major role in the inflation developments of the euro area. However, these facts are about the inflation of the euro area as a whole and do not contribute to the study of inflation differentials greatly. On top of that, the data of the IMF's International Financial Statistics on real effective exchange rates show that the real exchange rate differentials of the past 22 years are so close to zero that they are not even used in the model of the next section.

4. Methodology

To figure out the model that is going to be used, we looked at previous studies to obtain a grasp of what researchers have found about the properties of the data on the euro area inflation differentials. Studies such as Licheron's (2007) showed significant serial correlation of the residuals in a fixed effects least squares regression. In order to test if that serial correlation is also present in our data, we use the AR(1) Wooldridge (2002) test for serial correlation. Indeed, the test results in Table 1 show a significant serial correlation of our data.

Table 1. Wooldridge test for autocorrelation.

H_0: no first-order autocorrelation
F(1,11) = 13.910 Prob > F = 0.0033

To handle this autocorrelation problem, we add one lagged value of the dependent variable as an explanatory variable. Therefore, the model that we start with is:

$$\pi_{i,t} = \gamma_1 \pi_{i,t-1} + \boldsymbol{x}'_{i,t}\boldsymbol{\beta} + u_{i,t} \quad (1)$$

where $\pi_{i,t}$ is the inflation differential of a country i with the twelve euro area country average. $\pi_{i,t-1}$ is the lagged dependent variable and $\boldsymbol{x}_{i,t}$ is the vector of the independent variables, which are also constructed as the differentials of country i with the twelve euro area country average. $\boldsymbol{\beta}$ is the vector of coefficients that we want to estimate. Lastly, $u_{i,t}$ is the error term, which is usually represented as the sum of a country fixed effect α_i and an idiosyncratic shock $\epsilon_{i,t}$, giving $u_{i,t} = \alpha_i + \epsilon_{i,t}$.

As Baltagi (2005) mentions, it is known by construction that the model has an autocorrelation problem. This comes up because in this case, since $\pi_{i,t}$ is a function of $\epsilon_{i,t}$, it means that $\pi_{i,t-1}$ is also a function of the error term. Of course, this makes the Ordinary

Least Squares estimation method not appropriate because the assumption of the OLS for no serial correlation of the residuals is not satisfied.

Arellano and Bond (1991) have proposed an estimator that follows the Generalised Method of Moments estimation approach. Since they wanted to get rid of the correlation between the individual effects and the lagged dependent variable, which by construction exists in the model, a possible appropriate way to achieve this is by first differencing the model.

Now, the model becomes:

$$\begin{aligned} \Delta\pi_{i,t} &= \beta_1 \Delta\pi_{i,t-1} + \Delta \boldsymbol{x}'_{i,t}\boldsymbol{\beta} + \Delta u_{i,t} \\ \pi_{i,t} - \pi_{i,t-1} &= \beta_1(\pi_{i,t-1} - \pi_{i,t-2}) + \boldsymbol{\beta}(\boldsymbol{x}'_{i,t} - \boldsymbol{x}'_{i,t-1}) + (u_{i,t} - u_{i,t-1}) \end{aligned} \tag{2}$$

which now means that we are only left with the endogeneity problem. This can be tackled by using instrumental variables. What Arellano and Bond (1991) propose is that since it may not be the case that the researchers are in a position to have good quality instrumental variables, an alternative is to use lagged values of the existing variables.

These lagged values are considered as acceptable instrumental variables because we know that $\pi_{i,t-2}$ is strongly correlated with $\pi_{i,t-1}$. However, an assumption that they make is the one of no serial correlation between disturbances.

In order to decide on the lags of the variables that are going to be used as instrumental variables, they separate the variables into three categories. Strictly exogenous variables, predetermined variables and endogenous variables. If a regressor is strictly exogenous, then $E[u_{i,x}|x_{i,0}, x_{i,1}, \ldots, x_{i,T}] = 0$, which means that the regressor has no correlation with past, present or future disturbances. If the regressor is predetermined, then $E[u_{i,t}|x_{i,0}, x_{i,1}, \ldots, x_{i,t}] = 0$, which means that the current period error term is not correlated with current and past values of the regressor and therefore a one-period lagged value can be used as instrumental variable. Lastly, if the regressor is endogenous, then $E[u_{i,t}|x_{i,0}, x_{i,1}, \ldots, x_{i,t-1}] = 0$ and so values lagged two or more periods can be used as instrumental variables.

Therefore, the respective moment conditions that Arellano and Bond (1991) use are:

Lagged variable:	$E[\pi_{i,t-s}\Delta u_{i,t}] = 0$	s = 2,3,. . . ,t
Strictly exogenous:	$E[x_{i,t-s}\Delta u_{i,t}] = 0$	t-s = 0,1,. . . ,T
Predetermined:	$E[x_{i,t-s}\Delta u_{i,t}] = 0$	s = 1,2,. . . ,t
Endogenous:	$E[x_{i,t-s}\Delta u_{i,t}] = 0$	s = 2,3,. . . ,t

Arellano and Bover (1995) and Blundell and Bond (1998) showed, however, that a potential weakness in the Arellano and Bond estimation of Dynamic Panel Data models is that lagged levels can turn out to not be the most suited instruments for first-differenced variables. They propose an alternative approach, which includes lagged levels but also lagged differences as instruments. This approach is usually called the "system - GMM".

For this estimation, they add more moment conditions to the previous ones, and now we also have:

$$\begin{aligned} E[\Delta\pi_{i,t-1}(\alpha_i + \epsilon_{i,t})] &= 0 \\ E[\Delta x_{i,t-1}(\alpha_i + \epsilon_{i,t})] &= 0 \end{aligned} \tag{3}$$

To make sure that the model chosen is an appropriate model for the given data set, we can run some post-estimation tests. The first test is an overidentification test. Overidentification of a model is a problem that comes up when the number of instrumental variables is larger than the number of explanatory variables. This is not a rare case since the instrumental variables increase quickly with the number of periods in the data set. Roodman (2009) says that too many instruments relative to the cross-sectional sample size can cause biased coefficients and standard error estimates.

The second thing that should be checked about the model is the autocorrelation in the residuals. As was mentioned earlier, the main assumption for using the GMM method is that the disturbances $u_{i,t}$ are uncorrelated. If this holds, then $\Delta u_{i,t}$ will have negative first-order serial autocorrelation (by construction) but no higher-order autocorrelation. In fact, it is necessary to prove that there is no higher-order autocorrelation in order to be able to ensure the validity (meaning the exogeneity) of the lagged values of inflation differentials $\pi_{i,t-2}$ and $\pi_{i,t-3}$ as instruments.

The first post-estimation test is the Sargan (1958) test with the null that the instruments are valid. If the Chi-square test gives us a significant p-value, we reject the null hypothesis and conclude that the instruments are invalid. Otherwise, we do not reject the null hypothesis. The second test is the Arellano and Bond test for autocorrelation based on the residuals of the estimation. The null hypothesis is the absence of the second-order serial correlation in disturbances since the first-order autocorrelation is expected, as mentioned earlier.

5. Data

In our attempt to use the model described above in order to find what the actual determinants of the inflation differentials are in the 12 euro countries that first joined the eurozone, we use a set of variables that was decided according to the literature that was covered in Section 2. This data set consists of data for the span of 22 years from 1999 to 2020 in order to track the effects that these variables had on only this set of countries. Our data set does not include 2021 and 2022 data despite the recent pandemic and its effects on the economies. Identifying the COVID-19 crisis consequences on the subject studied is out of the scope of this paper because of unsatisfactory data availability in order to grasp its full extent. It is intended as an extension for future research.

First of all, data for inflation were gathered from the Eurostat database for the Harmonised Index of Consumer Prices (HICP). With these data, we calculated the average euro area inflation for the study period and also the inflation differentials for each country in order to use them as the dependent variable.

In order to test the theory, which suggests that in a monetary union the price levels tend to converge leading to higher inflation in these countries, we use the difference of the price level of a country from the average of the 12 countries under study. The data come from the Eurostat database and consist of the price indexes that show us how many currency units a given quantity of goods and services costs in different countries. We transformed the data in order to have the 12 euro country average as the base and used it to construct the price level differentials for each country. Since it is suggested that countries with negative price level differentials should have higher than average inflation, we expect a negative relationship between the variables.

To account for the cyclical divergence of the countries, we use the output gap differentials. The data come from the IMF's World Economic Outlook Database. A positive output gap differential means that the country is in a more expansionary phase relative to the euro average. According to the Phillips curve, this excess demand, possibly over full employment, increases wages, which, in the end, applies inflationary pressures in this country, which are going to be bigger compared to the rest of the countries.

Since the governments are constrained by the single monetary policy, the way that they can step in to try and adapt their economy to the current events is by taking fiscal measures. To account for them, we use the difference of the government's balance as a percent of GDP from the 12 euro country average. The data are drawn from the OECD database and later constructed as the government balance differentials between the countries. Countries that use a more conservative policy with low expenditures and taxes are expected to have a lower inflation compared to countries with expansionary policies and larger deficits, implying an expected negative coefficient.

The Ballasa–Samuelson effect states that countries with higher productivity in the tradables sector will experience higher prices and wages in this sector, which, consequently, will increase the wages of the non-tradables sector, which will translate as an overall

higher inflation for the whole country. To detect and measure this effect, we use Eurostat's labour productivity indicator. In fact, we will use the percentage change on the previous period compared to the euro average of the same period. In this case, we also expect a positive coefficient to show that higher productivity in the business sector leads to higher inflation overall.

Lastly, following the example of Licheron (2007), to account for the effect of exposure of each country to oil price fluctuations, we use the data on oil price growth in US dollars weighted by the Eurostat's percentage of merchandise imports that represents oil imports. If this relationship exists, it means that a higher oil price growth along with a high dependence on oil will lead to overall higher inflation in the country.

The descriptive statistics are presented in Table 2 and the data sources in Table 3.

Table 2. Descriptive statistics.

Variables	Mean	Std. Dev.	Min	Max	Observations
Inflation	0	0.796	−3.291	3.008	264
Output gap	0	2.496	−11.6	5.454	264
Price level	3.254	14.06	−22.632	39.76	264
Oil dependence	0	1.095	−6.662	5.144	264
Government balance	0	3.354	−24.063	7.738	264
Labour productivity	0	5.629	−15.116	58.658	264

Notes: All variables are expressed as differences from the 12 country average. The descriptive statistics include the no. of observations, the mean, the standard deviation and the maximum and minimum values observed among all the 12 countries through all the years under study.

Table 3. Data sources.

Variable	Source	Publicly Available at:
Inflation	Eurostat	https://ec.europa.eu accessed on 30 September 2023
Price levels	Eurostat	https://ec.europa.eu accessed on 30 September 2023
Output gap	World Economic Outlook IMF	https://www.imf.org/ accessed on 30 September 2023
Government balance	OECD	https://data.oecd.org accessed on 30 September 2023
Labour productivity	Eurostat	https://ec.europa.eu accessed on 30 September 2023
Oil price	ourworldindata.org	
Energy imports	Eurostat	https://ec.europa.eu accessed on 30 September 2023

6. Results

Our variable selection is such that we treat every variable as predetermined. That is because we cannot consider them as strictly exogenous. For every variable included, a case for causal relationships of the opposite direction between them can be made. For example, not only can government's balance affect the inflation rate, but also the inflation rate can be considered by the government and alter the fiscal policy. The same logic can also be applied to the rest of the variables.

The GMM results are presented in Table 4 along with the tests for overidentification and serial correlation in the residuals in Tables 5 and 6, respectively.

The results show significant effects on inflation differentials by their lagged value, the output gap differentials, the price level differentials and the government's balance differentials.

The effect of labour productivity and oil price fluctuations on inflation differentials seems to not be significant, and the estimator seems to find a coefficient with the opposite

sign to the one predicted. This means that we do not have sufficient evidence from the results to support the existence of a process described by the Balassa–Samuelson effect taking place.

On the other hand, we notice clearly the persistence effect of inflation differentials since the coefficient of the lagged levels is 0.477 and it is statistically significant at the 1% level.

Table 4. System Generalised Method of Moments estimation, dependent variable: inflation differentials.

Variables	Coefficient	St. Error
Lagged inf diff	0.477 ***	0.129
Output gap diff	0.077 ***	0.018
Price level diff	−0.011 ***	0.004
Energy price depend diff	−0.056	0.050
Government balance diff	0.052 **	0.023
Labour prod diff	−0.006	0.010
constant	0.049	0.037

Notes: Results of the system Generalised Method of Moments estimation. Significance level of the coefficients indicated by: ** = 5%, *** = 1%.

Table 5. Sargan test for overidentification.

H_0: valid instruments
Prob > chi2 = 0.538

Results obtained using Stata command xtabond2.

Table 6. Arellano–Bond test for autocorrelation.

H_0: no autocorrelation
test for AR(1) in first differences: Pr > z = 0.029
test for AR(2) in first differences: Pr > z = 0.612

Results obtained using Stata command xtabond2.

In addition, very significant seems to be the effect of the output gap differentials, which confirms the theory that an economy that is operating above expectations more than the average of the euro countries in question creates significant inflation pressure, which is responsible for 0.07% of every 1% increase of the inflation differentials.

The data seem to capture a phenomenon of price conversion, which, although statistically significant at the 1% level and with the expected negative sign coefficient, seems to be very small, explaining only 0.01% of every 1% change of inflation differentials.

Lastly, an effect statistically significant at the 5% level seems to be the one by the government's balance. The remarkable thing in this case is that the coefficient, which is admittedly small at 0.052, does not have the expected negative sign. This result is also common with the studies by Pirovano and Van Poeck (2011) and Licheron (2007).

All in all, the results show that the structural and cyclical factors explain most of the inflation differentials in these twelve euro area countries, while the equilibrating effects do not seem of statistical importance.

Finally, the post-estimation test of Sargan for overidentification has a *p*-value of 0.538, which means that we cannot reject the null hypothesis and that the ten instruments that are used are valid. In addition, the Arellano and Bond test for autocorrelation gives a *p*-value of 0.029, and therefore we reject the null of absence of first-order autocorrelation but cannot do the same for the second-order autocorrelation, as was expected and wanted. The results are shown in Tables 5 and 6.

7. Conclusions and Policy Implications

This paper examines the inflation differentials of euro countries and their determinants. This is important to add to the literature and contribute to the discussion on whether these differentials should affect the ECB's policy shaping process.

The results are based on a dynamic panel data estimation using the Blundell and Bond (1998) system GMM estimation method. They show that inflation differentials are mostly determined by the inflation persistence, which seems to be very strong, but part of them can also be attributed to the cyclical position of a country relative to the rest. On the other hand, there is no significant evidence to prove that the Balassa effect and the price convergence played a central role in the evolution of inflation differentials through the years.

These results are in agreement with the results of previous studies (Andersson and Masuch (2009); Altissimo et al. (2006)) that established that, especially in the early euro years, inflation differentials showed persistence and were caused by structural and cyclical factors. As Lane and Honohan (2003) also argue, it is more likely for inflation differentials to be more persistent inside a currency union because of the pro-cyclical effects that are generated due to the dynamics of real interest rates and national inflation levels.

Some of these studies (Hofmann and Remsperger (2005); Licheron (2007)) mentioned that because of the goal of low inflation and the single monetary policy, the strong persistence effects of inflation differentials would decrease and eventually vanish. Contrary to these expectations, our results, which are common with the results of Stylianou (2022), show that this persistence remains strong and statistically significant even after all these years despite the available time for convergence.

This reveals the complicated task of the ECB. Gregoriou et al. (2011) states that the degree of inflation persistence will either indicate the need for the economy's structural reforming or it will convince the policy makers that this persistence is a temporary phenomenon that will gradually fade over time. The fact that our results show persistent inflation differentials that are mostly affected by structural and cyclical factors suggests that additional country-specific policies and measures would probably turn out to be most suitable and efficient in achieving the goal of low inflation and inflation differentials in the eurozone. Eggertsson et al. (2014) show that even though one approach to closing any existing gaps in competitiveness among countries is to make structural reforms, the timing of these reforms is more important. That is because structural reforms can have undesired outcomes if implemented during a crisis. That is the reason a single monetary policy approach, without it being accompanied by country-specific measures, has the potential 'side effect' of slowing down a low productive economy even more or enhancing the production and inflationary pressures in an already inflationary country.

The above-mentioned conclusions can be drawn only for the studied euro area countries because we cannot assume that the same dynamics apply to other currency unions. However, they allow us to shape the opinion that in order for the European Central Bank to avoid pro-cyclical policies, it should take the inflation persistence and the cyclical position of the countries into consideration when applying monetary policy and it should also contribute to the decision making of the respective governments on country-specific policies.

In order to enrich our understanding on the topic of inflation differentials between euro countries and their implications on monetary policies, an interesting extension into future research would be the inclusion of more years into our data. The benefits of revisiting the topic in the future can be twofold. First, this extension of the time frame would allow us to include more euro countries since the time for convergence and its signs would have more time to manifest. At the same time, an intriguing addition that would be allowed this way is the inclusion of sufficient data for trustworthy valuation of the consequences of the COVID-19 crisis.

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Note

[1] Austria, Belgium, Finland, France, Greece, Germany, Ireland, Italy, Luxemburg, The Netherlands, Portugal, Spain.

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