The European Journal of Comparative Economics
Vol. 20, no. 1, pp. 3-37
ISSN 1824-2979

On the relationship between income and control of corruption in the Eurozone

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Abstract

This study uses panel Granger causality and cointegration tests to examine the relationship between income per capita and control of corruption in the Eurozone. The analysis covers the entire Eurozone and subgroups of countries from 2002 to 2021. The results show that there is not a bidirectional predictive causal relationship between growth and the increase of control of corruption in the Eurozone. The Great Recession has had a significant impact on the relationship between control of corruption and income per capita, leading to a disconnection between the two variables after 2008, except for Eastern countries. A cointegrated relationship between these variables is found in Estonia, Latvia, Lithuania, Slovakia, and Slovenia. Policymakers need to tailor anti-corruption measures to the specific institutional contexts of each country in the Eurozone.

JEL classification: P00, F00, P16, P48

Keywords: Corruption, Eurozone, Income, Panel cointegration, Panel granger causality

1. Introduction

The connection between institutions and economic performance is well-established. North (1990) first demonstrated that the quality of institutions plays a significant role in economic growth, leading to a plethora of subsequent studies on this relationship. However, the concepts of institutions and institutional quality are broad, covering various aspects. As a result, some authors have chosen to focus specifically on certain elements, with corruption being one of the most widely studied.

Following this line of work, the aim of this study is to examine the relationship between income per capita and control of corruption in the Euro Area (EA) and determine if the pattern observed in previous studies holds true. Assuming a positive causal relationship between the two variables - where greater control of corruption leads to higher income per capita and vice versa - we use panel Granger causality tests to analyze if there is a predictive capacity between them.

There is a significant amount of research exploring this connection between corrupt behaviors and economic development. Mauro (1995) was one of the first to empirically demonstrate that corruption has a detrimental effect on growth. Since then, many authors have continued to investigate this relationship, utilizing advanced and

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http://dx.doi.org/10.25428/1824-2979/020
First published online: 18/05/2023

sophisticated techniques to examine whether the effect is consistent across all countries. However, these studies have yielded a range of results, making it challenging to assert that the relationship between economic performance and corruption is always straightforward and bidirectional.

Despite the variety of findings, the causality relationship between corruption and income per capita is clearly established and the positive causal relationship between per capita income and control of countries' corruption levels is evident. In regards to this two-way causality, some authors such as Chong and Calderon (2000), Littvay and Donica (2006), and Aidt, Dutta, and Sena (2008) suggest that it only occurs in certain groups of countries. They employ different estimation procedures to uncover cross-country evidence that the relationship between corruption and economic performance varies among different countries or groups of countries.

Law, Lim, and Ismail (2013) sought to validate the causality patterns between institutional quality and economic performance using panel Granger causality techniques. They analyzed 60 countries using two different datasets: the International Country Risk Guide (ICRG) database and the World Governance Indicators (WGI) from the World Bank. The authors applied the panel causality procedures developed by Hurlin and Venet (2001) and Hurlin (2004) to address heterogeneity and cross-section dependence. Their findings suggest that there is a bidirectional causality between income per capita and institutional quality for the full sample, however, this pattern is not consistent across all countries. In high-income countries, institutional quality is found to foster economic development, while in developing countries, higher levels of income are associated with better institutional quality. With regard to corruption, they found that while there is a bidirectional causality for the full sample, this pattern is not supported in richer economies, where the results do not indicate that corrupt behavior has a significant impact on real GDP per capita.

The study of institutional quality and corruption has also been developed for smaller areas, such as Europe. Several studies have analyzed, not the causal relationship, which they assume from the outset, but whether European countries have managed to converge in terms of institutions. Fernández-Villaverde, Garicano and Santos (2013), Papaioannou (2016), Schönfelder and Wagner (2019), Glawe and Wagner (2021), Beyaert, García-Solanes and Lopez-Gomez (2019, 2021) and Pérez-Moreno, Bárcena-

Martín and Ritzen (2020, 2021) have highlighted a lack of institutional convergence among European countries, with some specifically noting a gap in terms of corruption within the Eurozone. Blackburn, Bose and Haque (2006) theorize that this lack of institutional convergence hinders income convergence. This demonstrates that the relationship between corruption and per capita income is crucial to understand the economic development of countries.

Our focus is not to delve into the causal relationship itself, but rather the joint behavior of these variables in recent years and the possibility of a bidirectional relationship. Understanding this behavior helps us to determine if efforts to fight corruption are being maintained and what implications they have on income, as well as to comprehend why corruption divergences have been detected in the Economic and Monetary Union (EMU).

Detecting these behavioral patterns in an economically integrated region such as the Eurozone is critical for the implementation of public policies. Institutional asymmetries create significant structural macroeconomic imbalances that hinder the desired economic integration and income convergence, which were the primary objectives of the Delors Report (1988) and the Maastricht Treaty (1992). In the specific case of corruption, the absence of effective measures to monitor and deter corrupt practices can lead to misallocation of resources in corrupt countries. This, in turn, can negatively impact not only the well-being of the country in question, but also other EMU countries that may have discontinued providing aid to such nations.

This paper employs an advanced panel Granger causality test developed by Dumitrescu and Hurlin (2012), which is particularly suited for analyzing the Eurozone, as it accounts for both cross-section dependence and heterogeneity. We apply the test to the entire EMU, as well as different subgroups of euro countries that share similar economic, political, and historical features. With this, our objective is to identify the sources of any possible joint relationship between control of corruption and per capita income. To further explore the interaction between these variables, we also conduct the Pedroni (2004) panel cointegration test, which can detect long-term relationships between different variables.

Our findings show that increases in control of corruption do not predict increases in per capita income for the EMU as a whole or for its different subgroups. We observe a desynchronization between control of corruption and per capita income after the Great Recession, for both the core and peripheral countries. Furthermore, we find evidence of a long-term relationship between control of corruption and GDP per capita in Estonia, Latvia, Lithuania, Slovakia, and Slovenia.

These results have policy implications, particularly with regard to income per capita convergence among EA members, and also provide crucial insights for the development of anti-corruption policies by Euro Area authorities.

This paper is structured as follows: Section 2 provides a review of the literature on control of corruption and income. Section 3 describes the data and methodology used in the study. In Section 4, we present the results of the panel Granger causality and panel cointegration analysis. Section 5 presents a discussion of the results and economic policy derivations. Finally, Section 6 offers some concluding remarks.

2. Literature review

The literature on the relationship between income level and corruption has primarily focused on understanding the impact of corrupt behaviors on long-term economic performance. The findings from this literature are varied. Many studies suggest that there is a negative relationship between economic growth and corruption, while others propose that certain types of corruption may facilitate growth in countries or regions with poor institutional quality. These conflicting hypotheses suggest that the connection between economic development and corruption may be more complex and varied among different countries or groups of countries than previously thought.

In this context, Myrdal (1968) and Kurer (1993) argue that corruption always negatively impacts growth as it leads to the misallocation of resources. Mauro (1995) presents empirical evidence of the negative impact of corruption on growth through the use of an instrumental variable approach. For their part, Meòn and Sekkat (2005) investigate the interplay between institutional quality and levels of corruption, and through the use of multiplicative variables within a linear model, they find that corruption has a negative effect on growth regardless of the legal context. Similarly, Aidt (2011) identifies a strong negative correlation between GDP and levels of corruption.

Gründler and Potrafke (2019) argue that corruption negatively impacts growth by reducing foreign direct investment, particularly in autocratic countries. Sharma and

Mitra also conclude that control of corruption is associated with higher levels of growth and income. Conversely, Li, Xu, and Zou (2000) confirm the findings of Mauro (1995) but with a less severe impact. However, the hypothesis that corruption is bad is not supported by all the literature. Authors such as Leff (1964) or Huntington (1968) suggest that in situations where bureaucracy is prevalent, corruption may facilitate growth by streamlining bureaucratic processes.

Most of these studies, which use large samples, assume the existence of a bidirectional causality between corrupt behaviors and income. However, other papers that analyze specific countries or smaller groups of countries find limited evidence of this relationship. For example, Treisman (2000) and Paldam (2002) argue that corruption leads to poverty, but as countries develop, this relationship weakens, suggesting that as a country's GDP increases, the bidirectional relationship becomes less pronounced and the level of GDP primarily influences the magnitude of corruption. According to Beyaert, García-Solanes, and López-Gómez (2022), corruption has an indirect impact on economic growth by modifying the Solow model. Moreover, García-Solanes, Beyaert, and López-Gómez, (2023) suggest that the relationship between institutional factors and income is intertwined with potential GDP per capita in European countries.

Littvay and Donica (2006) detect the same link between these variables only in the case of Asian countries, while Aidt, Dutta, and Sena (2008) demonstrate a negative influence of corruption on economic growth, only in countries with good institutional quality. In the same vein but with some differences, other papers propose that this relationship may not be concurrent. For example, Lučić et al. (2016) argue that there is a two-way relationship but not a contemporaneous one, meaning that they influence each other, but with a delayed effect over time.

In addition to the aforementioned findings, there is also evidence of no relationship between corruption and income. For instance, Svensson (2005) concludes that control of corruption does not impact growth and thus, income levels. Similarly, Paiders (2008) finds no correlation between the Corruption Perception Index and GDP per capita among European countries. Aidt, Dutta, and Sena (2008) also observe no impact between them in countries with the worst institutional framework.

These findings have several implications. Firstly, the relationship between income and corrupt behaviors is complex and non-linear, and requires a nuanced understanding that takes into account the unique characteristics of each sample. Secondly, while a part of the literature supports a general bidirectional causal relationship between corruption and income, it is essential to explore the interrelation between these factors in specific areas, especially in economic integration areas, such as the EA.

These insights are of great importance, not only to develop accurate models of these linkages but also for informing EMU public policy. In such contexts, some shocks may prove challenging to address, especially if corruption is pervasive and impedes the effective use of resources. This can result in budgets being misallocated and failing to achieve their intended goals. Therefore, it is crucial to address corruption in a comprehensive and systematic manner in order to foster sustainable economic growth and development.

3. Methodology and data

After reviewing the existing literature on the effect of corruption on income, we detect that most studies use large samples of countries and obtain global patterns that may not apply to different economic areas.

In this paper, we analyze this relationship by applying advanced panel techniques. Specifically, we examine the predictive power of one variable over the other. Assuming that a causal relationship between the two is proved, if we do not detect that one predicts the other it means that something is happening in the Eurozone between these two variables and something has disconnected them.

To further explore this relationship, we study different subgroups of countries and see what happens within them between the control of their corrupt behaviors and their level of per capita income. In addition, we study the possibility that these variables have a long-term relationship that is conditioning the Granger causality results and outcome of policy implementation within the EMU.

3.1. Data

We conduct the analysis for the EA over the period between 2002-2021. The variables used are the control of corruption Indicator from the World Bank Governance

Indicators (WGI) and GDP per capita (constant 2015 US$), also derived from the World Bank. We examine the entire Eurozone and subgroups of euro countries that share similar historical, cultural and economic features.

The first subgroup analyzed is the Core group, which is formed by Austria, Belgium, Germany, Finland, France, Luxembourg, and the Netherlands. The second one is the Periphery, which is formed by Cyprus, Spain, Estonia, Greece, Ireland, Italy, Lithuania, Latvia, Malta, Portugal, Slovak Republic, and Slovenia. Papapioannou (2016) finds evidence of an institutional gap between the core and the periphery of the EMU. Examining these groups separately allows us to detect if this gap also exists in terms of predictive causality.

In addition, we study other subgroups: Southern and Eastern countries. Southern countries are Spain, Italy, Greece, and Portugal. After the Great Recession, corrupt scandals have been on the rise in these countries. In fact, Fernández-Villaverde et al. (2013) explain that, after the arrival of the Euro, these members received large inflows from core countries. These inflows fostered imbalances within the EMU by increasing their level of corruption.

The last examined group is called Eastern countries and is composed of Lithuania, Estonia, Latvia, Slovak Republic, and Slovenia. These countries shared a common political and economic past that differs from the rest of the euro members. Their former systems could condition the relationship between corruption and their levels of income.

Table 1 present descriptive statistics for control of corruption, both for the entire Eurozone over the period. The table provides information such as mean, standard deviation, minimum, and maximum values for each variable, providing an overall understanding of the data.

Table 1. Descriptive statistics: Control of Corruption of the Eurozone over the period 2002-2021.

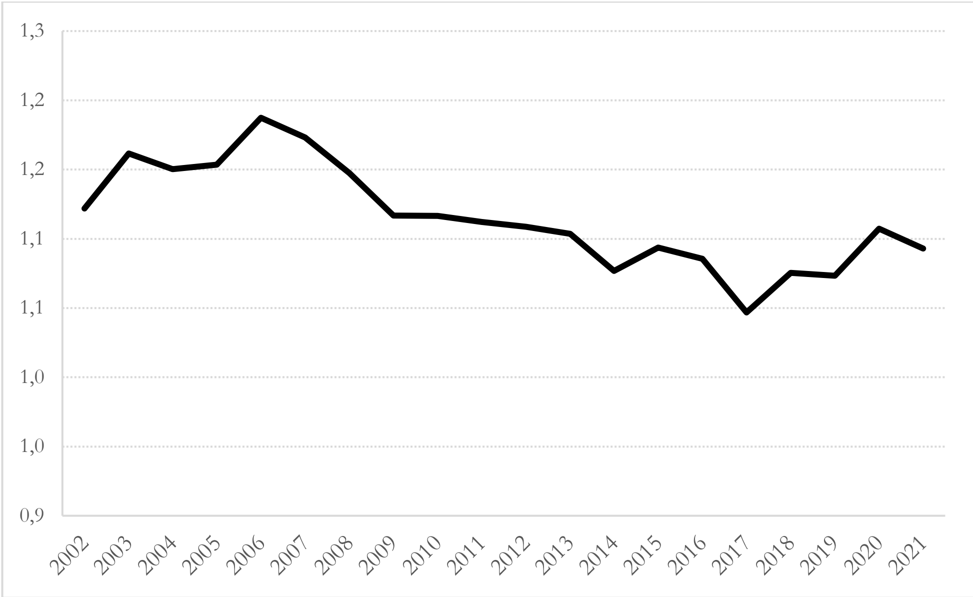
	Mean	Median	Standard deviation	Minimum	Maximum
2002	1.121	1.191	0.722	2.369	-0.050
2003	1.161	1.193	0.636	2.374	0.243
2004	1.150	1.125	0.653	2.374	0.153
2005	1.535	1.062	0.621	2.315	0.312
2006	1.187	1.085	0.657	2.454	0.156
2007	1.173	1.073	0.698	2.389	0.103
2008	1.147	1.178	0.698	2.321	0.112
2009	1.116	1.055	0.700	2.241	0.063
2010	1.116	1.063	0.688	2.152	-0.063
2011	1.112	1.081	0.695	2.192	-0.101
2012	1.108	1.170	0.721	2.227	-0.190
2013	1.103	1.181	0.715	2.200	-0.075
2014	1.077	1.071	0.703	2.159	-0.136
2015	1.093	1.004	0.694	2.256	-0.092
2016	1.085	0.892	0.697	2.228	-0.107
2017	1.046	0.854	0.666	2.203	-0.086
2018	1.075	0.866	0.702	2.207	-0.031
2019	1.073	0.918	0.689	2.150	0.039
2020	1.107	0.805	0.659	2.201	0.056
2021	1.093	0.851	0.649	2.270	0.207

Source: World Bank database

Table 1 and Figure 1 show how the control of dishonest behavior has been relaxed throughout the period analyzed. Especially after the Great Recession of 2008, after which the deterioration has been more evident. Despite this, in recent years, countries seem to have improved in terms of controlling their corruption levels, detecting an improvement since 2017, only disturbed by the COVID-19 pandemics.

It is also important to note that other descriptive statistics show that the variability among the countries that make up the EA is not very large. It is worth remembering that this is to be expected since we study an area of economic integration where economic and political characteristics should be similar. However, this is far from meaning that there is not enough variability among euro countries to allow econometric techniques to be applied to their analysis. To better understand this variability we show, in Figures A.1 and A.2, the standard deviation across countries for each year, as well as the standard deviation of each country for the whole period.

Figure 1. Control of Corruption: Eurozone average. Period: 2002-2021



Source: World Bank database

If we look at how the standard deviation of the euro countries (Figure A.1) has evolved over time, we discover that the years prior to Great Recession represent a turning point. In general, throughout the period, we detected an increase in volatility in terms of corruption, implying that differences in corruption across euro members increase.

Since 2018 this variability has been reduced. If we join the improvement in the mean of the indicator and the reduction of its variability between countries since 2017-2018, it becomes evident that corruption levels are not only reducing but that the differences between countries are also shortening. Nevertheless, the whole period is marked by asymmetries between the core, richer and with better institutions, and the peripheral countries, poorer and with higher levels of corruption, which are also exposed in figure A.2.

Figure A.2 exhibits the existing gap between the core and the periphery of the EMU in terms of the volatility of corruption control. It can be seen that countries such as Spain, Italy or Cyprus have experienced greater changes in their corruption control than the core countries. This is not surprising if we take into account that peripheral countries have higher levels of corruption and, therefore, have to fight more against these behaviors. In fact, this is good news that could predict a closing of core-periphery asymmetries.

In addition, it shows that the country that has experienced the greatest changes has been Spain while the most stable has been Germany. Two opposite extremes that illustrate well the institutional asymmetries that persist within the EMU and may be generating divergences in terms of per capita income, as well as creating inefficiencies in the implementation of public policies. Our Granger causality panel analysis is fully justified in order to shed light on this fact and allows us to infer some economic policy derivations.

3.2. Testing for panel Granger non-causality and cointegration

The analysis is focused, first, on Granger causality. The panel Granger Causality propose that an event x_{it} Granger causes other event y_{it}, when past information in x_{it} helps to predict y_{it}. The Dumitrescu and Hurlin (2012) test for panel Granger causality is a statistical test that is used to determine if one variable (the "cause") Granger-causes another variable (the "effect") in a panel data setting. The authors present a test for non-causality in heterogeneous panel data models using individual Wald statistics, which are then averaged across the cross-section units. This test has good performance in small samples, even when cross-sectional dependence is present, which makes it particularly appropriate for application to an area such as the Eurozone which is a small sample size where cross-section dependence is expected to exist.

Granger (1969) analyzes the relationship between two stationary series x_t and y_t with $t = 1, \ldots., T$. From a time-series perspective, the author develops a test that allows to know the predictive causal relationship between both variables. The used model is:

$$y_t = c + \sum_{k=1}^{K} \gamma_k y_{t-k} + \sum_{k=1}^{K} \beta_k x_{t-k} + \varepsilon_t \qquad (1)$$

The causal influence of variable x_t on variable y_t can be investigated by evaluating whether past values of x_t are significant predictors of the current value of y_t, even after controlling for past values of y_t. One common method to assess this is by using an F-test and testing the following null hypothesis:

$H_0 = \beta_1 = \cdots = \beta_K = 0$

If the null hypothesis is not supported, it can be inferred that a causal relationship from x_t to y_t exists. To investigate causality in the opposite direction, the x_t and y_t variables can be switched, and it is possible for both variables to have a mutual impact on each other, referred to as bidirectional or feedback causality.

Our focus has shifted towards working with panel data, thus this test, designed for time series analysis, needs to be adapted accordingly. To achieve this, we utilize the panel data test developed by Dumitrescu and Hurlin (2012). Their panel model is as follows:

$$y_{i,t} = c + \sum_{k=1}^{K} \gamma_{i,k} y_{i,t-k} + \sum_{k=1}^{K} \beta_{i,k} x_{i,t-k} + \varepsilon_{i,t} \tag{2}$$

where $x_{i,t}$ and $y_{i,t}$ are stationary variables for country $i = 1, \dots N$ in period $t = 1, \dots, T$. In this case, the model coefficients can differ among countries (i), but they remain unchanged across time (t). The lag order (*K*) is supposed to be consistent for all individuals. We have also to highlight that, to apply this test, we must work with a balanced panel dataset.

The null hypothesis of this test is:

$H_0 = \beta_{i,1} = \cdots = \beta_{i,K} = 0 \quad \forall i = 1, \dots, N$

The alternative hypothesis is:

$$\begin{array}{ll} H_A = \beta_{i,1} = \cdots = \beta_{i,K} & \forall i = 1, \dots, N_1 \\ \beta_{i,1} \neq 0 \; or \dots or \; \beta_{i,K} \neq 0 & \forall i = N_1 + 1, \dots, N \end{array}$$

where $N_1 \in [0, N-1]$ is unknown. If $N_1 = 0$, causality exists for all countries in the panel. However, if $N_1 \geq N$ causality is absent for all countries.

The authors suggest the following testing procedure:

1. Run N individual regressions as specified in equation (2).

2. Conduct F- tests on the K linear hypotheses, each testing for $\beta_{i,1} = \cdots = \beta_{i,K} = 0$, to obtain individual Wald statistics W_i.
3. Calculate the average Wald statistic $(\overline{W})$ by taking the mean of the W_i.

$$\overline{W} = \frac{1}{N}\sum_{i=1}^{N} W_i \tag{3}$$

Under the assumption that W_i are independently and identically distributed across individual, and for small N and T, Dumistrecu and Hurlin (2012) demonstrate that the appropriate statistic to use is $\tilde{Z}$:

$$\tilde{Z} = \sqrt{\frac{N}{2K} \times \frac{T-3K-5}{T-2K-3}} \times \left(\frac{T-3K-3}{T-3K-1}\right) \times \overline{W} - K \xrightarrow{d} N(0,1) \tag{4}$$

where the lag order (K) can be selected by using information criterion, in our case Akaike information criterion (AIC).

Finally, it is important to note that the purpose of the test is to identify causality across the entire panel and not just for individual observations. The rejection of the null hypothesis does not guarantee the absence of non-causality in some of the individual cases.

Once the Granger causality has been analyzed, and in the event of a bidirectional relationship being detected, our next step is to evaluate the existence of a cointegration relationship between these two variables, in cases where both are non-stationary. Cointegration is a statistical concept used in economics and econometrics to describe the long-run relationship between two or more time series variables. Cointegration is used to determine if two or more variables move together in the long run, meaning that they tend to return to their common mean over time, that means if two time series variables are cointegrated, it suggests that one variable can be used to predict the other in the long run, which has important implications for forecasting and analysis. The existence of cointegration between two or more variables can inform the design of policy and the implementation of strategies for economic growth and stability.

Thus, it is important to detect this relationship across the EA countries and, for this purpose, we apply Pedroni's cointegration test (Pedroni (2004)) which is widely used in empirical studies and proved to have good power properties.

This test involves regressing the residuals of the individual time series on lagged differences of the same series and a constant term, and then testing for the presence of a common stochastic trend across the individual time series. If the null hypothesis of no cointegration is rejected, it suggests that there is a long-run relationship among the time series in the panel.

Several statistics have been defined for this test, with up to seven options available. However, the author notes that the ADF group and panel perform better when T is less than 100. As a result, both ADF statistics are utilized in this analysis[1].

3.3. Estimation of panel cointegration model

Determining a cointegrated relationship between control of corruption and income in EA is a crucial question, especially when modeling this interrelation. If this relationship is found to be positive, practitioners and researchers must consider it when estimating a model that takes this into account and also must be taken into account in the implementation of policies affecting one of these two variables.

For panel data analysis, various estimation methods exist. However, Kao and Chiang (2001) have shown that the Dynamic Ordinary Least Squares (DOLS) method outperforms other methods such as Ordinary Least Squares (OLS), which can be biased in finite samples, and Fully Modified Least Squares (FMOLS), which does not improve these results. Therefore, we use the DOLS estimation method to accurately model the determinants of per capita income in the countries under analysis.

Dynamic Ordinary Least Squares (DOLS) is an extension of the traditional Ordinary Least Squares (OLS) method, which is used to estimate the parameters of a static regression model.

In a dynamic system, the relationship between variables may change over time, and DOLS is used to capture these changes by estimating the long-run relationship between the variables while controlling for short-run fluctuations. This is done by

[1] For greater details see Pedroni (2004).

including a lag of the dependent variable as an explanatory variable in the regression model.

The DOLS method estimates the parameters of the model by minimizing the sum of squared residuals, just like OLS. However, unlike OLS, the DOLS method takes into account the dynamic nature of the system by using information from both the current and past observations.

This approach, developed by Stock and Watson (1993) enhances the cointegrating regression by adding lags and leads of the explanatory variables to it, ensuring that the error term in the resulting cointegrating equation is not influenced by the complete history of fluctuations in the stochastic regressor. We apply Pedroni's extensions which is described as follows:

$$\tilde{y}_{it} = \alpha_i + \beta_i x_{it} + \sum_{j=-P}^{P} \gamma_{ij} \Delta X_{it-j} + \mu_{it}^* \tag{5}$$

where $i = 1, \dots, N$ are the countries in the panel, $t = 1, \dots, T$ the number of periods and $p = 1, \dots, P$ is the numbers of leads and lags including in the regression. x_{it} is the explanatory variable. $\tilde{y}_{it}$ and x_{it} are non-stationary variables which have been stripped of the individual deterministic trends. The β coefficients:

$$\hat{\beta}_{GM}^* = \left[\frac{1}{N}\sum_{i=1}^{N}\left(\sum_{t=1}^{T} z_{it} z_{it}'\right)^{-1}\left\{\sum_{t=1}^{T} z_{it}(\tilde{y}_{it} - \bar{y}_i)\right\}\right] \tag{6}$$

The t-statistics are designed to test $H_0 = \beta_i = \beta_0$ against $H_A = \beta_i \neq \beta_0$ and are computed:

$$\hat{t}_{\beta_i}^* = \left(\hat{\beta}_i^* - \beta_0\right)\left\{\hat{\sigma}_i^{-2} \sum_{t=1}^{T}(x_{it} - \bar{x}_i)^2\right\}^{\frac{1}{2}} \tag{7}$$

$$t_{\hat{\beta}_{GM}^*} = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} \hat{t}_{\hat{\beta}_i^*} \tag{8}$$

where z_{it} represents a $2(p + 1) \times 1$ vector of regressors that includes the lagged and leading values of the differenced explanatory variable. The long-run variance of the residuals, σ_i^2 is calculated using the Newey and West (1987) method, which accounts for both heteroskedasticity and autocorrelation.

4. Empirical results

In order to carry out the methodology accurately, it is important to follow a specific set of steps. Firstly, we must determine if the variables are stationary or not. If they are stationary, we can directly apply the Dumitrescu and Hurlin (2012) test. On the other hand, if they are not stationary, we must use the differenced series. It is crucial to note that if any of the variables is an integrated series of order greater than 1, the Dumitrescu and Hurlin test cannot be applied and cannot be analyzed[2].

Then, we conduct Granger causality and cointegration tests. The cointegration test is only relevant for non-stationary series. Finally, if appropriate, we conclude the process by estimating panel models with cointegration.

4.1. Panel unit root and cross-section dependence results

As explained above, the first step in our analysis is to determine the integration order of GDP per capita and control of corruption. To do this, we use the panel unit root test developed by Im, Pesaran, and Shin (2003), referred to as the IPS test in the following. The results of this test are presented in Table 2.

[2] Additionally, we assess whether the series exhibit cross-sectional dependence or not to determine if the methodology, which takes such dependence into account, is appropriate. Results are presented in Appendix 1.

Table 2. Panel Unit Root test (IPS). Period: 2002-2021

	IPS test p-values
Eurozone	
GDPpc	0.134
Control of Corruption	0.901
First differences of GDPpc	0.000**
First differences of Control of Corruption	0.007**
Core countries	
GDPpc	0.023**
Control of Corruption	0.501
First differences of GDPpc	0.000**
First differences of Control of Corruption	0.000**
Periphery	
GDPpc	0.698
Control of Corruption	0.971
First differences of GDPpc	0.039**
First differences of Control of Corruption	0.000**
Southern countries	
GDPpc	0.714
Control of Corruption	0.750
First differences of GDPpc	0.419
First differences of Control of Corruption	0.103
Eastern countries	
GDPpc	0.155
Control of Corruption	0.962
First differences of GDPpc	0.004**
First differences of Control of Corruption	0.001**

***Stationary variable*

The IPS test has been conducted on both the level and first differences of the data, with the results presented in Table 2. The results show that control of corruption is an integrated variable of order 1 at 5% for all groups of countries, with the exception of Southern countries. Meanwhile, Real GDP per capita is also found to be an integrated variable of order 1 in most groups, but a higher integration order is detected for GDPpc among Southern countries. Based on these results, causality and cointegration tests can be performed for all groups of countries except for Southern ones. Non-stationary variables have been differenced to carry out the panel Granger causality test.

This procedure involves evaluating the presence of cross-sectional dependence in the data. Our study focuses on the Eurozone, where there is a high level of economic integration, which may increase the likelihood of cross-sectional dependence. This phenomenon can impact the validity of the results of the tests performed, making it crucial to test for cross-sectional dependence prior to conducting the causality test. To achieve this, we employ the cross-sectional dependency test (CD) developed by Pesaran (2004).

According to the results presented in Table A1 (See Appendix 1), cross-sectional dependence is present at the 1% level of significance for all groups and for Real GDP per capita (GDPpc). However, no significant cross-sectional dependence was found for control of corruption for the entire EA and Periphery group, while it is present in the Core, Eastern, and Southern countries groups. The presence of cross-sectional dependence in a small group of countries fully justifies the use of the heterogeneous Dumitrescu and Hurlin (2012) test, which has been shown to have excellent properties in small samples with cross-sectional dependence.

4.2. Panel Granger non-causality analysis.

In this section, we present the results of conducting the panel Granger causality test on the EMU as a whole, as well as its constituent subgroups. To start, Table 4 displays the results for the Eurozone as a whole.

Table 3. Causality between GDP per capita and Control of Corruption. Dumistrescu and Hurlin test (2012). Countries: whole Eurozone. Period: 2002-2021

Null hypothesis	$\overline{W}$	$\widetilde{Z}$	P-values
Differentiated GDP per capita does not homogeneously cause differentiated Control of Corruption	2.129	-0.401	0.688
Differentiated Control of Corruption does not homogeneously cause differentiated GDP per capita	3.451	1.558	0.119

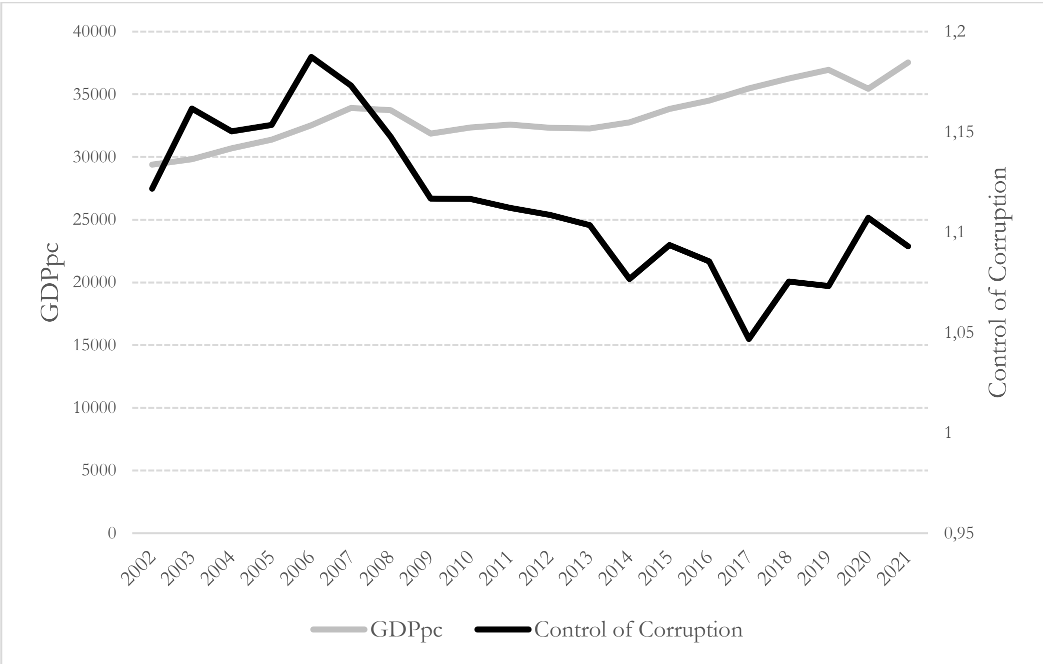
$N = 361$

**Rejection of the null hypothesis*

The results displayed in Table 3 suggest, robustly (See Appendix 2) that neither differentiated control of corruption nor differentiated real GDP per capita in the Eurozone cause the other. This implies that an increase in control of corruption in the EA cannot be used to predict the growth of income. These results are noteworthy as they highlight the lack of a relationship between the changes of income and control of corruption, and that the growth of these variables is not a good predictor of each other. This has several implications: first, it suggests that improvements in one or both variables may not necessarily lead to growth in the other. It also indicates a disconnect between lower levels of corruption and growth in terms of GDP per capita.

This lack of correlation could be attributed to factors that are affecting both variables for the entire EMU. Figure 2 shows the evolution of the average of these variables allowing to obtain more information.

Figure 2. Averaged Control of Corruption and GDPpc for the Eurozone. Period: 2002-2021



Source: World Bank database

This figure illustrates a distinct discrepancy between the Eurozone GDPpc and the control of corruption among its members. The data reveals that, on average, there has been an upward trend in the GDPpc, while the efforts to curb corrupt practices among euro states have decreased. This trend has become particularly evident since the Great Recession. Before 2008, there was a positive correlation between the two variables, which changed after the financial crisis.

Contrary to the prevailing literature, which suggests that a higher GDPpc is correlated with a stronger control of corruption in developed countries, the data from the EMU suggests a disconnect between these variables. These results are in line with Svensson (2005) and Aidt, Dutta, and Sena (2008), who also find no connection between corruption and income. Specifically, Svensson (2005) does not find, like we do, a connection between the growth of both variables, and we also obtain similar results to Paiders (2008), who specifically analyzes European countries and does not detect a relationship between them.

However, these results contrast with other more general findings that demonstrate a direct or indirect relationship between corruption and income [Law, Lim, and Ismail (2013), Gründler and Potrafke (2019), or Beyaert, García-Solanes, and Lopez-Gomez (2022)]. Our results highlight the importance of testing general patterns when considering smaller groups of countries. Failure to do so may model the relationship as a bidirectional one with the bias in the results that this implies. In addition to making erroneous inferences and failing to design effective policies.

It is widely accepted in the literature that there is a bidirectional causal relationship between the improvement of corruption and income growth. However, the Eurozone appears to be an exception after 2008. Figure 2 shows that the Great Recession had a profound effect on corruption in the EA, from which it has yet to recover. This is particularly concerning as this disconnection may be hindering the growth of per capita income.

Our methodology does not allow us to definitively claim that there is no causal relationship, but it does show that there is no correlation. This leads us to conclude that this situation is undesirable, as if the causal relationship does exist, as the literature suggests, then the Great Recession was so disruptive that it separated the path of these variables, causing harm to the growth of this area of economic integration.

The analysis of the Eurozone as a whole does not enable us to identify the source of this disconnection. For this reason, it is necessary to analyze different subgroups of European countries that share economic and institutional characteristics, in order to discover in which part or parts of the EMU this distortion is occurring.

Table 4. Causality between GDPpc and Control of Corruption. Dumistrescu and Hurlin's test (2012). Countries: Group of Countries. Period: 2002-2021 [3]

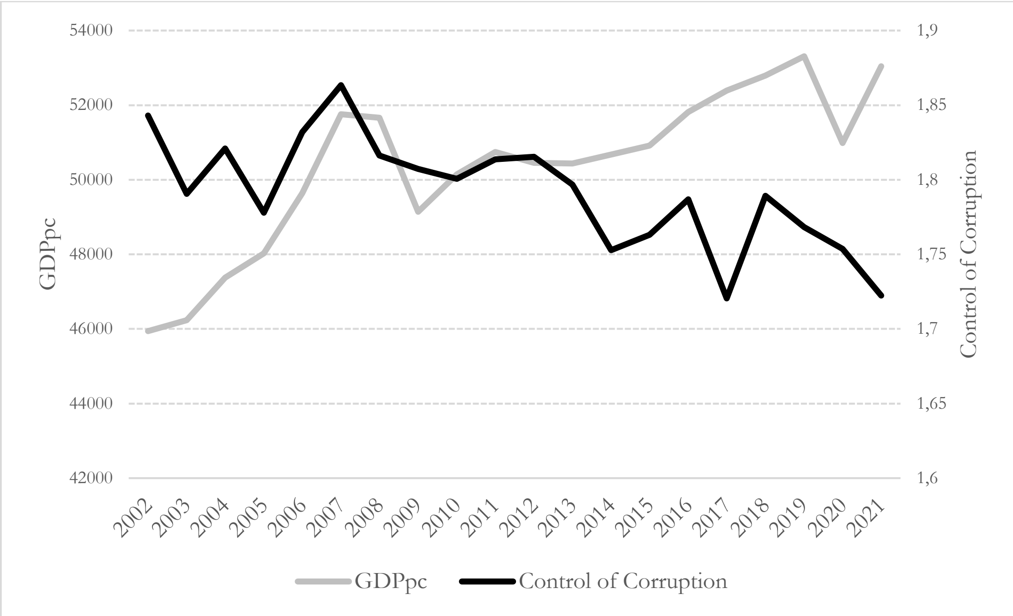
	Core countries ($N = 133$)		
Null hypothesis	$\overline{W}$	$\widetilde{Z}$	**P-values**
GDP per capita does not homogeneously cause Control of Corruption	1.604	-0.716	0.474
Differentiated Control of Corruption does not homogeneously cause GDP per capita	3.188	0.709	0.477
	Periphery ($N = 228$)		
Differentiated GDP per capita does not homogeneously cause Control of Corruption	2.562	0.191	0.848
Differentiated Control of Corruption does not homogeneously cause GDP per capita	3.502	1.299	0.193
	Eastern countries ($N = 95$)		
Differentiated GDP per capita does not homogeneously cause Control of Corruption	2.325	0.495	0.620
Differentiated Control of Corruption does not homogeneously cause GDP per capita	3.051	-0.056	0.955

**Rejection of the null hypothesis*

The results from Table 4 demonstrate that this disconnection stems from all of the subareas studied. Therefore, it is a general behavior that directly impacts the integration and governance of the Eurozone and makes the income level, although growing, potentially higher if these abusive behaviors were controlled. Let us now examine the average behavior of these subgroups.

[3] The core group of countries is made up of seven countries, the periphery of twelve and, finally, the eastern group of countries is made up of five.

Figure 3. Averaged GDP per capita and Control of Corruption. Core countries. Period: 2002-2021

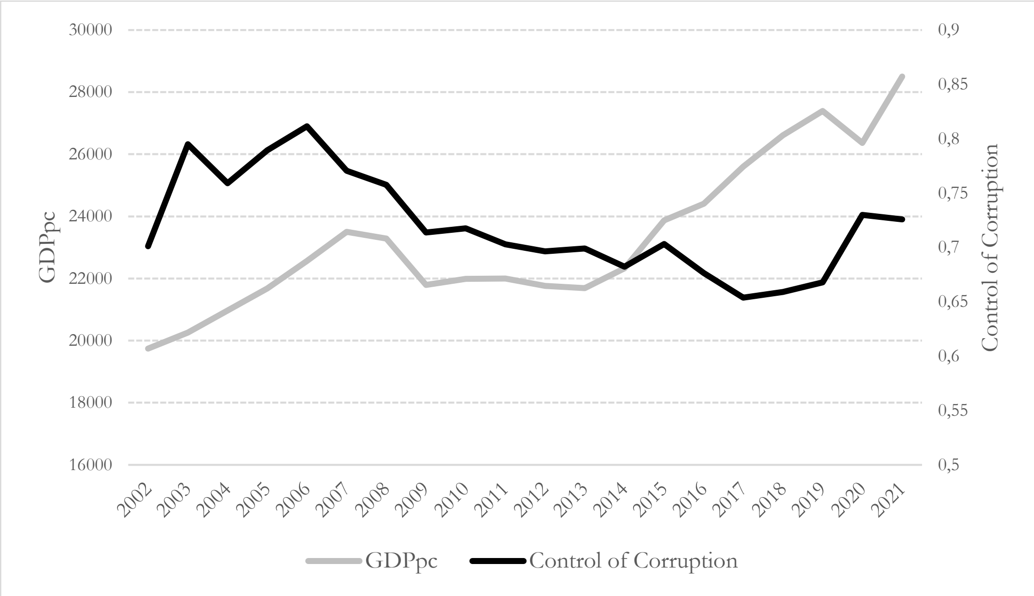


Source: World Bank database

For the case of the core countries, the relationship between corruption control and per capita income before the Great Recession is less evident than for the total of the EMU, although a very rapid growth of GDP per capita is shown, which is truncated in 2008. After that date, corruption control also begins to deteriorate, although it is not until after 2010 when a clear separation between the two variables becomes evident. This demonstrates two things: firstly, the richest countries in the EA also contributed to this distortion and their control of corruption has deteriorated in recent years. Furthermore, they were also affected by the Great Recession, but a few years later than the Eurozone as a whole.

The case of peripheral countries is similar to that of core countries, with greater variability in both income and corruption levels. However, the trend remains the same: greater control of corruption does not necessarily predict higher growth. Figure 4 further demonstrates this, as it reveals a divergence between real per capita GDP and control of corruption after the outbreak of the Great Recession.

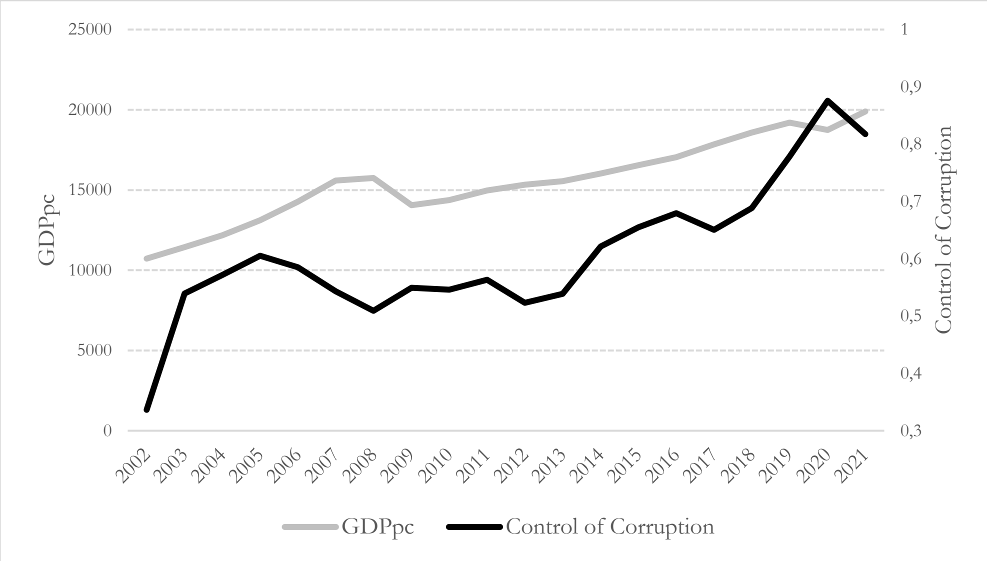
Figure 4. Averaged GDP per capita and Control of Corruption. Periphery. Period: 2002-2021



Source: World Bank database

This pattern is not seen in the case of countries that were part of the Soviet bloc. Despite the results of Granger's causality tests not indicating a predictive relationship between the two variables, there is a positive relationship in levels. In this group of countries, the increase in real per capita GDP follows the same trend as the control of corruption. Our observations suggest that the greater the control of corruption, the higher the income, which aligns with the existing literature and raises questions about the existence of a long-term relationship between these variables.

Figure 5. Averaged GDP per capita and Control of Corruption. Eastern countries. Period: 2002-2021



Source: World Bank database

To gain a deeper understanding of this relationship, we apply the cointegration test developed by Pedroni (2004) and find no evidence of a cointegrated relationship between control of corruption and real per capita GDP for the entire Eurozone. However, upon analyzing the three subgroups, a long-term relationship is detected in the case of Eastern countries, supporting the idea of different connections between these two variables among euro members. This is highlighted by the results of panel cointegration tests presented in Tables 5 and 6, which show the results for the entire Eurozone and for each subgroup.

Table 5. Panel Cointegration test by Pedroni (2004). Countries: complete Eurozone. Period: 2002-2021 [4]

	Null hypothesis: No cointegration
ADF-group	-0.233 (0.407)
ADF-panel	-0.868 (0.192)

**Rejection of the null hypothesis.*

p-values in parenthesis

[4] Lag length selection: Akaike Information Criterion

Table 6. Panel Cointegration test developed by Pedroni (2004). Countries: Group of Countries. Period: 2002-2021 [5]

Null hypothesis: No cointegration	Periphery	Eastern countries
ADF-group	-0.418 (0.337)	-1.960* (0.025)
ADF-panel	-0.551 (0.290)	-2.277* (0.025)

**Rejection of the null hypothesis*

p-values in parenthesis

Neither core nor peripheral countries show a cointegrated relationship between dishonesty and income, indicating that they do not share a common stochastic trend. However, in the case of former Soviet countries, the relationship between controlling corruption and real per capita GDP in the long-run is much closer, as shown in Figure 5.

Bayar et al. (2018) conducted a study on the cointegrated relationship between corruption and the shadow economy in the Central and Eastern European countries of the European Union. The authors found evidence of a negative long-run relationship between corruption and the size of the shadow economy, indicating that lower levels of corruption result in a smaller shadow economy. The study reveals that the average size of the shadow economy in Estonia, Latvia, Lithuania, Slovakia, and Slovenia is over 20%, which has a significant impact on income per capita. Therefore, reducing corrupt behaviors can encourage the emergence of income that is currently in the shadow economy, thereby increasing the levels of official GDP per capita. These findings are consistent with the results of the present paper, which also highlights the importance of controlling corruption in these countries to increase their wealth and facilitate their convergence with the richest euro countries. Such efforts would also contribute to achieving higher levels of integration and well-being across the EMU.

However, policymakers must be cautious when implementing policies related to controlling corruption or promoting income per capita, as these policies can have long-term impacts on the other variable. To assess the extent to which a particular policy affecting one variable can impact the other, it is necessary to estimate the long-run relationship using the following equation:

$$Log(GDPpc_{it}) = \alpha + \beta_1 \log(investment_{it}) + \beta_2 CC_{it} + \varepsilon_{it} \quad (9)$$

[5] We are not able to analyze Southern and core countries due to the results of the panel unit root tests.

where $log(GDPpc_{it})$ is the logarithm of GDP per capita of country i at time t derived from the World Bank. $\text{Log}(investment_{it})$ is the logarithm of Gross Fixed Capital Formation in percentage of GDP per capita of country i at time t which accounts for the level of investment in these countries. These data are also extracted from the World Bank. CC_{it} is the control of corruption indicator which takes part of the Worldwide Governance Indicators provided by the World Bank. Finally, ε_{it} is the error term. We estimate the cointegrated relationship with Panel Dynamic Ordinary Least Squares (DOLS) estimator explained in section 3. Results are presented in table 7.

Table 7. Estimation by Dynamic Ordinary Least Squares (DOLS). Countries: Eastern countries. Period: 2002-2021

Dependent variable: Log (GDPpc)	**Coefficient**	**P-values**
CC_{it}	0.657***	0.000
$\log(investment_{it})$	-0.452***	0.000
Adjusted-R^2	0.821	
Number of observations	86	
Leads and lags selected with AIC	1	
Long-run variance	0.0098	

**** significant at 1%, ** significant at 5% and * significant at 10%*

Table 7 provides evidence of a long-term cointegrated relationship between corruption control and real per capita GDP in Eastern eurozone countries. The estimated coefficients demonstrate that reducing corruption has a positive effect on long-term income per capita.

5. Discussion and policy implications

The level of GDP per capita does not seem to predict the level of control of corruption across the EMU, and also, controlling more corruption cannot predict a greater economic performance amongst euro members. This must be taken into account when using models with these two variables. If it neglects to analyze this relationship in-depth, there is a risk that the models used to evaluate and implement policies by European authorities will end up failing in diagnosis and, therefore, in finding solutions.

Additionally, our conclusions clash with the absence of institutional convergence within the common currency area, as highlighted by Beyaert, García-Solanes, and

Lopez-Gomez (2019), Pérez-Moreno, Barcéna-Martín, and Ritzen (2020, 2021), and Glawe and Wagner (2021), among others.

These authors provide evidence of an institutional gap among European countries, pointing out that there is a process of institutional divergence that creates severe imbalances within the EU and EMU. This process generates an institutional gap mainly between core and peripheral countries. Our findings are consistent with previous research regarding corruption, as we observe no predictive relationship between income and corruption, and a disconnection after 2008 that could exacerbate existing these divergences. The persistence of these differences poses a serious threat to income convergence and highlights the need for euro-area authorities to take action to address these issues and promote greater harmonization.

To promote greater convergence in anti-corruption efforts across all EA countries, Gugiu and Gugiu (2016) suggest that the EU should develop tailored anti-corruption policies that take into account the specific needs of each country, or even at the regional and local level. Similarly, Rodríguez-Pose and Ketterer (2020) emphasize that higher levels of institutional quality can enhance growth, but that one-size-fits-all policies for all lagging regions are not effective. Casagrande and Dallago (2021) also confirm that all countries can improve their institutions, but should follow their own models to do so. Furthermore, they note that countries in Southern and Eastern Europe, which tend to have weaker institutions, may need to make greater efforts than other members, but also have the potential to benefit more from these efforts.

Considering that most of the literature confirms a causal relationship between both variables, a predictive disconnection between them indicates that something is not being done correctly, and that greater efforts to fight corruption will bring greater levels of well-being than those currently existing. The possible measures taken to reduce corrupt behaviors should be different on each country or subgroup of countries due to the different relationship between control of corruption and income per capita throughout the euro members.

6. Conclusions

The relationship between control of corruption and income per capita has been extensively studied using various methodologies, yielding diverse results. The prevailing hypothesis in the literature is that there exists a causal relationship between these variables, with controlling corrupt behaviors having a positive impact on GDP per capita and vice versa. However, some studies have shown that this relationship is more complex and varies depending on the sample.

Numerous authors have highlighted the institutional asymmetries across EA countries, which have led to macroeconomic imbalances and asymmetric effects of economic and monetary policies, highlighting that the existence of this institutional gap jeopardize the economic well-being and the political and financial stability of the EMU.

In fact, our results suggest that the positive correlation between these variables is lost after the Great Recession. After the Great Recession, there is a disconnect between GDP per capita and control of corruption for the entire EA and its subgroups, except for the Eastern countries. Moreover, an absence of a bidirectional relationship is detected, which has implications for the modeling of the interrelationship between them.

In addition, the cointegration relationship detected in the case of Estonia, Latvia, Lithuania, Slovakia, and Slovenia demonstrates that the relationship between the fight against corruption and per capita income is heterogeneous across the EA. This further complicates the modeling of causal relationships and decision-making within the EMU.

The connection between the studied variables does not always hold and the Eurozone is a good example. Moreover, endogenous and exogenous shocks, such as the Great Recession, play an important role in this relationship potentially generating a disconnection between variables that were initially thought to be related.

Finally, our findings reveal the different interrelation between corrupt behaviors and income across the Eurozone, discouraging institutional convergence and hindering convergence in terms of GDP per capita. Although corruption control must be improved throughout the EMU to foster economic performance, the fight against corruption cannot be the same across all EMU members.

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Appendix 1. Additional results and descriptive statistics

Table A1. Cross-sectional dependency tests. Both variables. Period: 2002-2021

Null hypothesis: No cross-section dependence	CD Pesaran test p-values
Eurozone	
GDPpc	0.000***
Control of corruption	0.650
Core countries	
GDPpc	0.000***
Control of corruption	0.069*
Periphery	
GDPpc	0.000***
Control of Corruption	0.762
Southern countries	
GDPpc	0.000***
Control of Corruption	0.000***
Eastern countries	
GDPpc	0.000***
Control of Corruption	0.008**

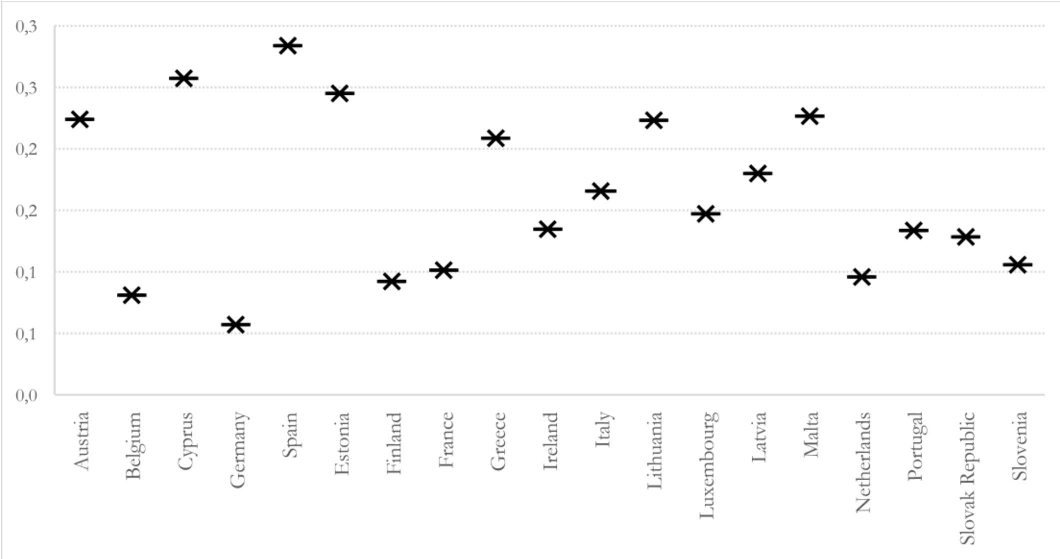
****Cross-section dependence at 1% ** Cross-section dependence at 5%*

** Cross-section dependence at 10%*

Figure A.1. Standard deviation across countries for each year. Period: 2002-2021

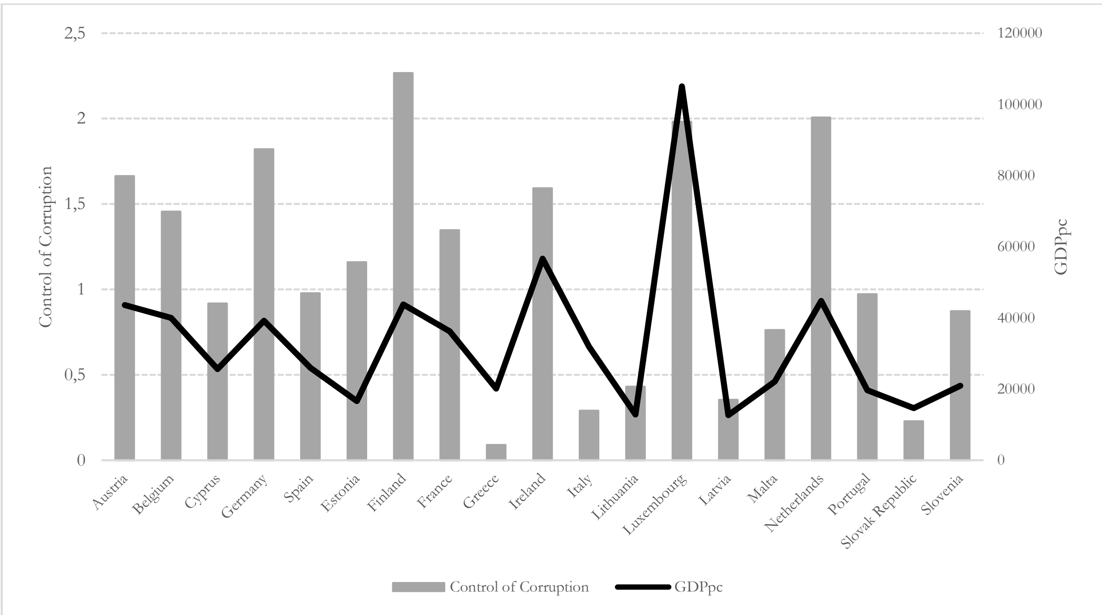
Source: World Bank database

Figure A.2. Standard deviation of each country's control of corruption over the period 2002-2021



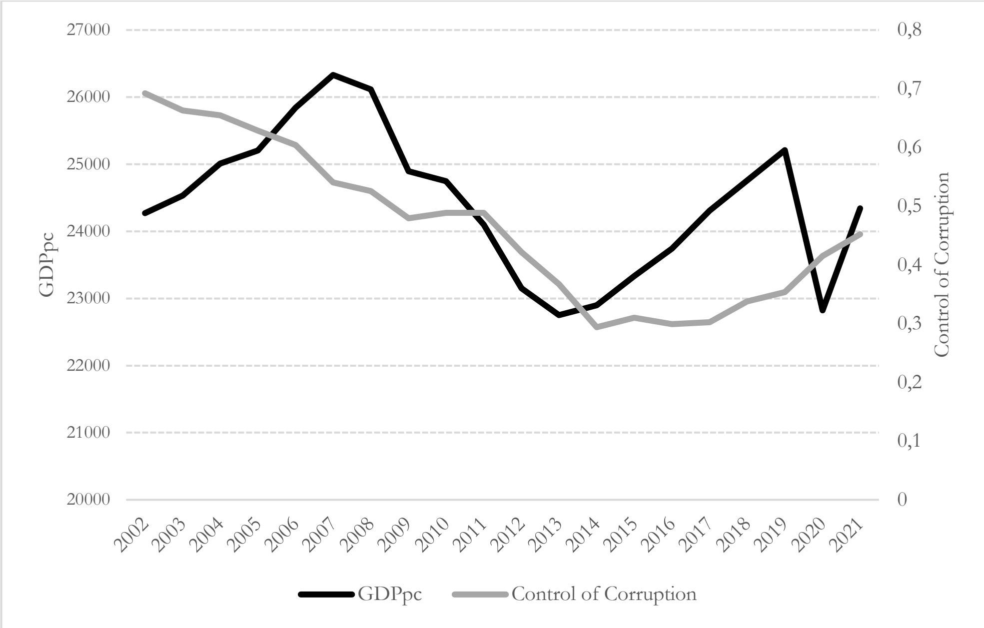
Source: World Bank database

Figure A.3. Averaged Control of Corruption and GDPpc for each euro member over the period. 2002-2021



Source: World Bank database

Figure A.4. Averaged GDP per capita and Control of Corruption. Southern countries. Period: 2002-2021



Source: World Bank database

Appendix 2. Robustness check

In order to give robustness to the results we have performed the same analysis with the Corruption Perception Index elaborated by Transparency International. The period that can be analyzed with time-series analysis is between 2012 and 2021. The difference in the sample period allows us to detect robust patterns. The obtained results are presented below.

Table A2.1. Panel Unit Root tests for CPI and GDPpc. Period: 2012-2021

	IPS test p-values
Eurozone	
GDPpc	0.134
CPI	0.701
First differences of GDPpc	0.000*
First differences of CPI	0.980
Core countries	
GDPpc	0.023*
CPI	0.020*
First differences of GDPpc	0.000*
First differences of CPI	0.061*
Periphery	
GDPpc	0.698
CPI	0.354
First differences of GDPpc	0.039*
First differences of CPI	0.003*
Southern countries	
GDPpc	0.714
CPI	0.511
First differences of GDPpc	0.419
First differences of CPI	0.002*
Eastern countries	
GDPpc	0.155
CPI	0.387
First differences of GDPpc	0.004*
First differences of CPI	0.480

**Stationary variable*

Table A2.2. Cross-sectional dependency tests for GDPpc and CPI. Period : 2012-2021

Null hypothesis: No cross-section dependence	CD Pesaran test p-values
Eurozone	
GDPpc	0.000***
CPI	0.000***
Core countries	
GDPpc	0.000***
CPI	0.145
Periphery	
GDPpc	0.000***
CPI	0.028***
Southern countries	
GDPpc	0.000***
CPI	0.539
Eastern countries	
GDPpc	0.000***
CPI	0.000**

****Cross-section dependence at 1% ** Cross-section dependence at 5%*

** Cross-section dependence at 10%*

According to the results of the stationarity analysis, we can only apply the Dumistrecu and Hurlin (2012) test to the Core and the Periphery.

Table A2.3. Causality between GDP per capita and CPI. Dumistrescu and Hurlin's test (2012). Countries: Core countries. Period: 2012-2021

	Core		
Null hypothesis	$\overline{W}$	$\widetilde{Z}$	**P-values**
GDP per capita does not homogeneously cause Corruption Perception Index	1.178	-0.253	0.800
Corruption Perception Index does not homogeneously cause GDP per capita	1.216	-0.223	0.823

Table A2.4. Causality between GDP per capita and CPI. Dumistrescu and Hurlin's test (2012). Countries: Periphery. Period: 2012-2021

	Periphery		
Null hypothesis	$\overline{W}$	$\widetilde{Z}$	**P-values**
Differentiated GDP per capita does not homogeneously cause differentiated Corruption Perception Index	7.497	4.285	0.010*
Differentiated Corruption Perception Index does not homogeneously cause differentiated GDP per capita	0.928	-0.542	0.587

**Rejection of the null hypothesis*

As for the study of cointegration or long-term relationship, we can only analyze the case of the countries that make up the periphery.

Table A2.5. Panel Cointegration test developed by Pedroni (2004) for GDPpc and CPI. Countries: Periphery. Period: 2012-2021

Null hypothesis: No cointegration	**Periphery**
ADF-group	-0.767 (0.221)
ADF-panel	-1.110 (0.133)

**Rejection of the null hypothesis*

P-values in parenthesis

The result of the stationarity analysis of the variables greatly limits the robustness analysis, however, we see that the results obtained do not generally contradict what we have obtained with the corruption control indicator developed by the World Bank.