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# THE INTRODUCTION OF THE EURO AND ECONOMIC GROWTH: SOME PANEL DATA EVIDENCE

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We use a difference in difference estimation framework to analyse the effects of the adoption of the euro on the level of per capita GDP for a sample of seventeen European countries (the EU15 plus Norway and Iceland) over the period 1990–2010. We find that the adoption of the euro may have raised the level of per capita GDP (and labour productivity) by about 4 percent. There is also some evidence that the impact of the euro has been smaller in the case of countries with a high debt-to-GDP ratio in 1999 when the euro was introduced. Results are robust to controlling for country fixed effects, time trends and to estimation strategies that control for cross-country parameter heterogeneity.

*JEL classification codes*: 043, 052
*Key words*: euro, economic growth, difference-in-difference

## I. Introduction

The economic troubles that have been characterizing the euro area since the burst of the sovereign debt crisis are well known and currently at the centre of the European economic policy debate. Many authors have discussed at length the major shortcomings of the euro project, such as the limited powers of the European Central Bank, the absence of a fiscal and financial union and the widening trade imbalances and gaps in productivity across countries (Shambaugh 2012). For some opinion makers the current institutional and economic arrangements of the European Monetary Union are so flawed and difficult to change that in some

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countries political pressures to leave the euro might soon enter into the mainstream political debate.

Notwithstanding the recent problems, the academic literature has been highlighting several possible channels through which the euro could positively affect income and productivity, namely lower exchange rates volatility and risk, increased trade, higher price transparency and stronger integration of financial markets and a full exploitation of the European Single Market, among others.

Surprisingly, in the academic literature the evidence on the macroeconomic effects of the euro on growth and productivity are scant at best, a notable exception being a recent paper by Bugamelli et al. (2010) which convincingly shows that the euro has led to stronger labour productivity growth in sectors that used to compete mostly in prices and in countries that tended to rely more on competitive devaluations.[1]

In this paper we aim to contribute to the debate on the economic effects of the euro by estimating the effect of the euro adoption on per capita GDP with yearly data for a set of seventeen European countries over the period 1990–2010 using a simple differences-in-differences framework. We find that, after controlling for country fixed effects and time trends, the euro had a positive impact on per capita GDP and labour productivity. In most regression specifications and estimation strategies we find that the euro had a positive effect, in the 3–4% range. These results are confirmed if we estimate the model using methodologies that take into account non-stationarity and panel cointegration issues; moreover, if we allow some dynamics into the model, the euro effect on per capita GDP could have been even slightly larger, although estimation strategies that deal with parameter heterogeneity suggest more conservative estimates of about 4%. Interestingly, we also find evidence of some heterogeneity across countries associated to macroeconomic imbalances that existed when the euro was introduced: in fact, some empirical estimates suggest that the effect of the euro falls with the level of the debt-to-GDP ratio in 1999. Although our approach could be considered a "crude" way to assess the impact of the euro on per capita GDP, nevertheless we believe it might provide a useful starting point for future research.

[1] In turn, there is a large literature on the positive effects of euro on trade (Bun and Klaassen 2007 and the references therein) and some empirical evidence on the effects of euro on disposable income inequality (Bertola 2010) and financial integration (Kalemni-Ozcan et al. 2009).

The remainder of the paper is organized as follows: in Section II we discuss the data and the methodological framework, while in Section III we present the main empirical results. Finally, Section IV concludes.

## II. Data and methodological framework

### A. Methodological framework

In order to evaluate the impact of the adoption of the euro on per capita GDP, we estimate different variants of the following equation:

$$lngdp_{it} = \beta_0 Euro_{it} + X'\delta + a_i + a_t + \gamma_i trend + u_{it} \ , \qquad (1)$$

where $lngdp_{it}$ is the log of per capita GDP, $Euro_{it}$ is a dummy variable equal to one after a country has adopted the euro and zero otherwise, $X$ is a vector of control variables, $a_i$ is a set of country fixed effects that control for the consequences of persistent factors (such as political and economic institutions, or social norms) that influence a country's per capita GDP but that might also have played a key role in the decision of adopting the euro, $a_t$ is a set of time dummies that captures common macroeconomic shocks, $\gamma_i trend$ is a set of country linear time trends that control for country differentials in the long run growth rates of GDP, and $u_{it}$ is an error term.

In particular, $X$ contains variables that economic theory suggests might influence GDP, such as the investment rate, the average years of schooling, the population growth rate, the degree of openness to trade, among others. In particular, if we control for the former three variables, equation (1) can be rationalised as resulting from the steady-state of a Solow growth model (Mankiw et al. 1992), where we allow the initial conditions as well as the exponential growth rate of technology to be country specific.[2]

[2] Czernich et al. (2011) have used a similar framework to analyze the macroeconomic impact of the introduction of broadband on GDP.

The econometric specification in equation (1) is a difference in difference (diff-in-diff) one, as we identify the impact of the introduction of the euro on per capita GDP using the within-country variation only, and therefore our results are robust to country specific unobserved heterogeneity. Moreover, we include, as a control group, a set of non-euro adopter countries, namely the UK, Sweden, Denmark and two non-EU (but EEA) countries such as Norway and Iceland. The choice of this group of countries is motivated by the necessity of having a group of control countries sufficiently homogenous with the early euro adopters in terms of institutions, economic policy and history.

The inclusion of the country time trends is important because it allows for the possibility that countries that have adopted the euro were on different growth paths: this is crucial because if, for example, non-euro countries had been on a relatively faster trend rate of growth than their euro counterparts, failing to control for this would lead us to underestimate the impact of the euro on per capita GDP.[3]

One point that deserves some discussion is the fact that in diff-in-diff models we might expect the existence of serial correlation within countries (Bertrand et al. 2004) but also correlation across countries in a given year (cross sectional correlation). For this reason, we use standard errors that are robust to arbitrary correlation in both the country and year dimensions (as well as robust to heterosckedasticity).

However, inference with two-way cluster-robust standard errors works well insofar as both dimensions are large and, in our case, N = 17 and T = 21 are on the lower bound of what is conventionally considered as a sufficient cluster size. Therefore, we report two-way cluster robust standard errors with the small sample correction described in Baum et al. (2010) and automated in the Xtivreg2 routine for Stata; we also report standard errors robust to heteroskedasticity and serial correlation using the Newey-West standard errors as in Azmat et al. (2012).

[3] For instance, results in Besley and Burgess (2004) show that diff-in-diff estimates can be highly sensitive to the inclusion of country specific time trends.

### B. Data

The empirical analysis is based on a balanced panel of seventeen European countries (the EU15 group plus two European Economic Area countries, namely Norway and Iceland) observed over the period 1990–2010. Adoption of the euro is proxied by a dummy variable equal to 1 after a country has adopted the euro (1999) and zero otherwise.[4] The data used in this study come from different sources. GDP, total population and total employment are taken from the Total Economy Database of the University of Groningen; in particular, GDP is measured in constant 1990 US$ converted at Geary Khamis PPP. Data on the working age population (proxied by population between 15 and 64 years) is from the AMECO database. In turn, information on investment rates (measured as the investment share of GDP) and the country level of openness are from the Penn World Tables, version 7.1. Finally, data on the average years of schooling in the population older than 25 years are taken from the Barro-Lee dataset: however, because data are available at a five years interval, missing data have been linearly interpolated.

## III. Empirical results

In Table 1, we report the empirical estimates of equation (1), where GDP is normalised by working age population. In Model 1, we start from a parsimonious specification, as we only control for country and year fixed effects.[5] Econometric estimates suggest that the adoption of the euro is positively correlated with the level of per capita GDP, although if we use clustered standard errors the effect is not statistically significant (the p value is 0.32). If we include country linear time trends (Model 2), the coefficient increases by about 50% and it is statistically significant at conventional levels of confidence: in particular, the adoption of the euro would be associated to an increase in per capita GDP of about 3.9%.

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[4] In the case of Greece the dummy takes the value of one since 2001 onwards.

[5] All regressions include dummy variables for EU membership and for episodes of "large" recessions (entailing a fall in per capita GDP larger than 4%) or "large" expansions (an increase in per capita GDP larger than 4%). No result however hinges upon the inclusion of these dummy variables.

We now probe the robustness of the euro effect with various checks. First, we consider the possibility that, notwithstanding the use of the country linear time trends, there might still be pre-trends in our data, possibly due to euro anticipatory effects, or to economic shocks that hit euro countries precisely when the euro was introduced. As suggested by Angrist and Pischke (2009), we have included two leads and one lag of the euro dummy in equation (1): if the effect of the euro is not due to omitted variables that make the so-called parallel trend assumption in diff-in-diff models invalid, one should find that the euro leads should be individually and jointly statistically insignificant (see Autor et al. 2007 for a similar approach); in turn, one lag of the euro dummy is included in order to allow the euro to affect GDP with a lag. Empirical results in column 3 reassuringly suggest that the leads are both individually and jointly largely statistically insignificant. In turn, the contemporaneous and lagged effects are individually either statistically significant at 10%, or barely insignificant, depending on the type of standard errors we consider, and always jointly significant at least at the 10% level. Interestingly, the total euro effect, which can be measured as the sum of the coefficients of the contemporaneous and lagged terms, is about 4.2%, only slightly larger than in the previous columns.[6,7]

In column 4 we add other regressors in equation (1), such as the log of the investment rate, the openess to trade and the growth rate of population. As we can see, the magnitude and the statistical significance of the euro coefficient is barely altered.[8] We have also added in the regression the log of schooling years in the population, the stock of R&D capital and the OECD index of regulation in the utilities sector (as a proxy for the economy-wide level of product market regulation): main results are not affected (see the online appendix).

So far we have not considered the issue of non-stationarity that might characterize some of the variables considered above. For this reason we test for non-stationarity of GDP, the saving rate, openness to trade and the population

[6] The standard error is 0.206 if we use cluster-robust standard errors and 0.156 if we use Newey-West heterosckedasticity and serial correlation robust standard errors.

[7] We have also considered the possibility that the euro not only had an effect on the level but also on the growth rate of GDP by interacting a linear time trend with the euro dummy: this interaction is positive but always largely statistically insignificant at conventional levels of confidence.

[8] We have also entered the various regressors one at a time: results are virtually unaffected.

growth rate using standard panel unit root tests as those proposed by Im, Pesaran, and Shin (2003) and Breitung (2000), and we can never reject the null of non-stationarity.[9] The same tests lead us to conclude that the above series are difference-stationary, i.e., I(1). We then test for the existence of a cointegrating relationship among the aforementioned variables (and the euro dummy) with the Westerlund (2007) panel cointegration tests, which consistently reject the null hypothesis of no cointegration (at the 5% significance level).[10]

We now re-estimate the model in column 4 with the Dynamic OLS Estimator (DOLS) for panel data of Mark and Sul (2001) which takes into account endogeneity of non-stationary regressors and serial correlation by adding past and future values of the first differences of the explanatory variables.[11] Estimation results displayed in column 5 suggest that the euro has a positive and statistically significant effect, with an order of magnitude of about 3.7%, broadly consistent with previous estimates.

In Model 6 we augment the regression in Model 4 with the lag of per capita GDP in order to allow for persistent/convergence effects. In particular, in Model 6 we simply use OLS and we find a short run impact of the euro of about 1.2%,

[9] In particular, in the case of the Im, Pesaran, and Shin test, we use two lags, country specific autoregressive parameters, a time trend, and demeaned data. We consider a similar structure for the Breitung test (and in this case we consider a version of the Lambda statistics which is robust to cross sectional correlation). We perform these tests with the Xtunitroot routine in STATA. These results are also confirmed by the T test for unit root in heterogenous panels with cross sectional dependence suggested by Pesaran (2003) and automated in the Pescadf routine for STATA. All results available from the author upon request.

[10] The basic idea of Westerlund (2007) is to test for the lack of a cointegrating relationship by determining whether there is an error correction mechanism at work for individual countries or for the panel as a whole. In practice, Westerlund (2007) proposes to estimate an error correction model and to test whether the coefficient of the error correction term is equal to zero, a rejection suggesting the existence of a cointegrating relationship. In particular, Westerlund (2007) suggests two statistics (Ga and Gt) for which the rejection of the null hypothesis can be taken as evidence for the existence of cointegration for at least one country; and two additional statistics (Pa and Pt) that pool the information over all countries and for which the rejection of the null hypothesis can be seen as evidence of cointegration for the panel as a whole. We have performed the various tests with bootstrapped standard errors in order to allow for cross sectional correlation using the Xtwest routine for STATA. Results are available from the author upon request

[11] We allow for country specific time trends and for two lags and two leads. The estimation was carried out with the Xtdolshm routine for STATA.

which implies a long run effect[12] of about 6.3%,[13] although the clustered standard errors suggest that the effect might be imprecisely estimated.[14]

In the regression reported as Model 7 we explore the existence of a possible weakness of previous estimates, i.e., the existence of cross-country heterogeneity in the effects of the euro (and of the other regressors) on GDP per person. In this case, assuming a common parameter across countries might in fact lead to biased estimates of a regressor's "average effect", especially in the case of dynamic specifications as that reported as Models 6 (Pesaran and Smith 1995). In order to deal with the heterogenous parameters issue we first re-estimate the static equation in Model 4 with the Mean Group estimator of Pesaran and Smith (1995), which allows for country specific parameter slopes (and error variance) by running one regression for each country and then averaging the coefficients. Empirical estimates (see the online appendix) confirm the previous results, although the magnitude is slightly smaller (0.029, s.e. 0.0078)). Moreover, we also estimate with the same Mean Group estimator a dynamic version of the previous equation by assuming that GDP follows a first order autoregressive process and re-parametrizing the equation as an Error Correction Model (see, for a recent application, Calderon et al. 2013):

$$\Delta lngdp_{it} = \varphi_i(lngdp_{it-1} - Z_{it-1}\delta_i) + \tau_i \Delta lngdp_{it-1} + \theta_i \Delta Z_{it} + u_i trend + e_i + v_{it}, \quad (2)$$

where $Z$ represents the vector of regressors, $\delta_i$ the country-specific vector of long run parameters, $\tau_i$ and $\theta_i$ the short term parameters, while $\varphi_i$ is the country specific speed of adjustment parameter in the Error Correction Model.[15] Parameter estimates reported as Model 7 suggest that, in this case, the long run impact of the

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[12] Obtained as $\beta_0/(1-\beta_y)$, where $\beta_y$ is the coefficient of lagged per capita GDP.

[13] It is however important to note that this long run effect is not significantly different from the short run effect identified in the various static specifications estimated above.

[14] However, the estimation of a fixed effects model with the lagged dependent variable might create endogeneity problems (Nickell bias). For this reason we have re-estimated the equation with the Bias-Corrected-Least-Squared-Dummy-Variable method proposed by Bruno (2005): in this case the short run effect is about 1%, with a long run effect of about 8%, statistically significant at conventional confidence levels.

[15] The regression is run with the Xtpmg routine for STATA.

euro on GDP is found to be about 0.037, statistically significant at the 10% level, suggesting that the previous 6% effect might be upwards biased.

In Models 8–9 we further explore the heterogeneity issue by interacting the dummy euro with the Debt-to-GDP ratio in 1999 (*Euro*D/Y_99*) in order to investigate whether countries with an high debt-to-GDP ratio have found it more difficult to fully exploit the economic benefits arising from euro membership. In fact, Dreger and Reimers (2013) find that unsustainably high debt-to-GDP ratios might have slowed down growth only in the case of euro member countries and justify their finding arguing that the lack of formal bailout mechanisms in the EMU might have generated an additional risk for the euro countries, therefore triggering higher interest rates and lower growth.[16] As shown in Table 1, the interaction term is negative, although statistically significant only in the static specification.

Interestingly, in both regressions the impact of the euro is no longer statistically significant in the case of countries with a debt-to-GDP ratio higher than 90% in 1999 (Greece, Italy and Belgium).[17] Although this result should be taken with caution, at a minimum it suggests that macroeconomic imbalances when the euro was introduced might have influenced its impact in some countries.

Finally, it is important to note that the paper's main results are confirmed if we consider labour productivity (GDP per person employed) as dependent variable; furthermore, results hold even if we drop the two non-EU countries, namely Norway and Iceland. Interestingly, if we drop the years 2009 and 2010, the euro effect slightly increases, a result consistent with the bad performance of the euro area in the current economic crisis.

[16] See also Baum et al. (2013) who provide some empirical evidence consistent with the possibility that, in the case of the euro countries, high debt-to-GDP ratios (exceeding 70%) might tend to put upwards pressure on the long term interest rates. Starting with Reinhart and Rogoff (2010), many studies have sought to empirically evaluate the existence of thresholds above which debt would slow down growth. See Baum et al. (2013) and Eberhardt and Presbitero (2014), among many others, for different conclusions on this issue.

[17] The 90% of debt-to-GDP threshold was derived by computing the marginal effect of the euro on log GDP, which is equal to the sum of the coefficient of the euro dummy plus the product of the coefficient of the interaction term and the debt-to-GDP ratio. Given the negative coefficient of the interaction term, the effect of the euro tends to fall as the value of debt-to-GDP ratio increases. If we consider a debt-to-GDP ratio of 90% (or more), the effect of the euro is no longer statistically significantly different from zero.

**Table 1. Empirical estimates: euro and per capita GDP in seventeen European countries over the 1990-2010 period**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| | OLS | OLS | OLS | OLS | DOLS | OLS | MG | OLS | LSDVC |
| Euro | 0.0291 | 0.0387 | 0.0182 | 0.0371 | 0.0374 | 0.0120 | 0.0367 | 0.067 | 0.016 |
| | (0.0142) | (0.0156) | (0.0077) | (0.0152) | (0.0128) | (0.0065) | (0.020) | (0.0221) | (0.0089) |
| | (0.0286) | (0.0200) | (0.0124) | (0.0185) | | (0.0098) | | (0.0252) | |
| lnsav_rate | | | | 0.1270 | 0.0137 | 0.0916 | 0.1492 | 0.1266 | 0.0916 |
| | | | | (0.0508) | (0.0242) | (0.0136) | (0.1007) | (0.0355) | (0.0115) |
| | | | | (0.0459) | | (0.0163) | | (0.0485) | |
| pop_gr_rate | | | | 0.0058 | 0.0348 | -0.0065 | 0.0308 | 0.0052 | -0.0075 |
| | | | | (0.0117) | (0.0060) | (0.0034) | (0.0676) | (0.0078) | (0.0029) |
| | | | | (0.0114) | | (0.0033) | | (0.0111) | |
| lnopen_to_trade | | | | -0.029 | -0.0083 | 0.088 | 0.3663 | -0.032 | 0.0905 |
| | | | | (0.0594) | (0.0432) | (0.028) | (0.2112) | (0.0645) | (0.0190) |
| | | | | (0.0994) | | (0.039) | | (0.0973) | |
| $lngdp_{t-1}$ | | | | | | 0.8027 | | | 0.8719 |
| | | | | | | (0.0483) | | | (0.0323) |
| | | | | | | (0.0755) | | | |
| Euro*D/Y_99 | | | | | | | | -0.0004 | -0.0001 |
| | | | | | | | | (0.0002) | (0.0001) |
| | | | | | | | | (0.0002) | |
| Euro_lag1 | | | 0.0245 | | | | | | |
| | | | (0.0156) | | | | | | |
| | | | (0.0134) | | | | | | |
| Euro_lead1 | | | 0.0086 | | | | | | |
| | | | (0.0100) | | | | | | |
| | | | (0.0124) | | | | | | |
| Euro_lead2 | | | 0.0009 | | | | | | |
| | | | (0.0009) | | | | | | |
| | | | (0.0013) | | | | | | |
| Country fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Time f.e. | Yes | Yes | Yes | Yes | No | Yes | No | Yes | Yes |
| Country trends | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 357 | 357 | 357 | 357 | 357 | 340 | 340 | 357 | 340 |

Note: country and year fixed effects in Model 1; country and year fixed effects and country trends in Models 2–4, 6, 8–9; country fixed effects and trend in Models 5 and 7. Models 1–4, 6 and 8 estimated by OLS with the Xtivreg2 routine in Stata; Model 7 with the MG estimator, Model 9 by the Bruno (2005) BCLSDV estimator. Model 5 estimated by DOLS. The first set of standard errors are HAC standard errors: Newey-West HAC standard errors are computed assuming a bandwidth of 3. Standard errors in Model 9 have been bootstrapped. The second set of standard errors in Models 1–4, 6 and 8 are robust to clustering in the country and year dimension with the Stata small sample correction. All regressions contain an EU membership dummy and a dummy equal to 1 for all country-year pairs characterized by large falls or increases in per capita GDP.

## IV. Conclusion

In this paper we have used a differences-in-differences framework to analyse the effects of the adoption of the euro on the level of per capita GDP for a sample of seventeen European countries over the period 1990–2010. Overall results suggest that the adoption of the euro might have had a positive effect on the level of per capita GDP, with an order of magnitude in the range 3-4%. Moreover, there is some evidence that, in countries with an high debt-to-GDP ratio when the euro was introduced, the impact of the latter might have been weaker: this result in turn suggests that an interesting avenue for future research is to shed further light on possible channels of country-level heterogeneity in the impact of the euro on economic growth.

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