Uncovering the (Possible) Relationship between Central Bank Independence and Economic Growth*

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Abstract

This work estimates the relationship between Central Bank independence (CBI) and economic growth using dynamic panel models. We use two measures of CBI: the Legal CBI index and the irregular turnover rate. When an irregular turnover of the Central Bank governor occurs it harms growth. On the contrary, the Legal CBI index is a positive factor for growth, although only when restricting to countries belonging to monetary unions. Additionally, we perform several counterfactual exercises for the use of different Legal CBI indexes. Results show that Euro Area countries are better off inside the monetary union than outside and also than they would be if using the levels of the Bank of England, the former Deustche Bundesbank, the Federal Reserve, or the Bank of Japan. Finally, we analyze sub-samples taking into account the level of income, the number of crises, the existence of Quantitative Easing policies, and different time-windows. Interestingly, 1990-2013 was a period hurtful for growth for the entire sample but benign for countries that belong to monetary unions.

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Keywords: Central bank independence; Economic growth; Monetary Unions; Dynamic panel models; Counterfactual analysis.

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1 Introduction

Can a country's economic growth benefit from Central Bank independence (CBI)? We assess if CBI has a positive influence on economic growth aside from the existing benefits that it has on targeting a low inflation. The clear separation between the Government and the Central bank is particularly important, in order to prevent negative spillover effects between fiscal and monetary policy. The credibility, transparency, and independence of the central bank creates a pro-growth environment, for example, by increasing the confidence of investors in the monetary and financial system, hence, increasing investment, and economic growth. We want to assess this hypothesis using two indicators of Central Bank independence, the Legal CBI inde and the Irregular turnover rate. Additionally, we also study the relationship between CBI and economic growth in the specific context of monetary unions, where this topic also has special relevance not only because of the interaction between monetary and fiscal policy, but also because of spillover effects between member countries.

Central Bank independence has been the most consensual solution for the dynamic inconsistency problem, which can persist when a non-independent monetary authority is frequently buying Government securities to finance Government expenditures. The increase in money supply needed to buy Government securities leads to inflation, even if this was not the original goal of the monetary authority – this inter-temporal inconsistency fosters uncertainty among private agents. An increasing degree of Central Bank independence (CBI) suggests that there will be a higher commitment to a previously defined policy, which should be maintained independently of the needs of Governments. The seminal works of Buchanan and Wagner (1977), Kydland and Prescott (1977), Sargent and Wallace (1981), Barro and Gordon (1983), Backus and Driffill (1985), Alesina (1989), Walsh (1994), and Ferguson (2006) support the previous arguments.[1]

Economic growth might also be affected by Central Bank independence. In the literature we find theoretical arguments that CBI is harmful for economic growth. Alesina and Summers (1993) and Walsh (1994) state that a more independent Central Bank can be less worried about the volatility of the economy when their main goal is price stability, and that these Central Banks therefore might not care about stabilizing the business cycle. Rogoff (1985) and Alesina and Summers (1993) claim that low inflation due to contractionary monetary policy may lead to higher real interest rates, which are detrimental for investment, and hence, economic growth. However, the literature also considers theoretical arguments that find benefits for economic growth with the existence of an independent Central Bank. Nordhaus (1975), Lindbeck (1976),

[1] Empirical examples of this literature include Bade and Parkin (1988), Alesina (1988), Grilli *et al.* (1991), Cukierman (1992), Cukierman *et al.* (1992, 1993), De Haan and Sturm (1992), Alesina and Summers (1993), Eijffinger and Schaling (1993, 1995), Eijffinger *et al.* (1996, 1998), De Haan and Kooi (2000), De Haan and Sturm (2001), Daunfeldt and De Luna (2002), Obben (2006), Klomp and De Haan, J. (2010), and Garriga (2016).

Hibbs (1977), and Alesina and Summers (1993) claim that an independent Central Bank cannot help the Government performing stop-and-go policies, and in this way promotes output stabilization. Grimes (1991), Stockman (1991), Cukierman *et al.* (1992), De Haan and Sturm (1992), Alesina and Summers (1993), Fischer (1993), De Gregorio (1993, 1996), and Jones and Manuelli (1993) state that price/inflation stability reduces uncertainty, which improves the capacity of the private sector for planning, possibly increasing the level of economic activity, leading to a more efficient resource allocation, more investment, and hence economic growth.

From the previous paragraph we can conclude that the theoretical literature on the relationship between Central Bank Independence and economic growth presents mixed results. Hence, this theoretical debate must be extended to the empirical literature, to check if this debate can be settled. The empirical literature on this subject is still very scarce, contrary to what happens in the study of the relationship between CBI and inflation.

De Haan and Sturm (1992) found a non-significant relationship between CBI – given by the Grilli *et al.* (1991) index, the Alesina (1989) measure, or the Eijffinger and Schaling (1995) measure – and output (measured by the GNP growth rate). However, for 18 OECD countries, the final measure of independence of Grilli *et al.* (1991) is the only one showing a negative relationship with output variability, measured by the standard deviation of GNP growth rate, during the period 1970-1978. Cukierman *et al.* (1993) found, for the period 1960-1989 through a pooled cross-section time series for 55 countries, that the turnover rate of Central Bank governor (a proxy for actual independence) has a negative relationship with the *per capita* economic growth rate. The same happens when using a simple cross-section analysis for 51 or 52 countries, a standard panel regression for 47 low developed countries subsample, and an IV estimation method (panel) for 52 countries. Regarding just 30 developing countries, either with or without three outliers, from 1970 to 1990 (although there were four countries for which data were available only for the 1980s), turnover rate (TOR) appears to have a negative relationship with private investment as a share of GDP. TOR does not show any significance in industrial countries and Legal CBI is not significant in the previous scenarios. Using a fixed effects panel method, Garriga (2016) also regressed the GDP growth rate in terms of, among others, Central Bank independence (measured by the Legal CBI). The measure is significant only when dividing the entire sample into two different income subsamples, having a negative coefficient on high-income countries and a positive one for low and middle-income countries.

Eijffinger *et al.* (1996), using a panel data estimation technique (Hsiao, 1986), estimated monetary policy reaction functions, also considering the current account surplus and economic growth, with respect to an actual level of central bank independence measure, from 1977 (third quarter), to 1999 (fourth quarter),

considering 10 developed countries. The authors conclude that the relationship between CBI with average output growth (and its variance) is not significant. Using the OLS estimation method for the period 1972-1992 (20 developed countries), and two subperiods 1972-1982 (11 EMS countries), and 1983-1992 (9 non-EMS countries), Eijffinger *et al.* (1998) considered the Grilli *et al.* (1991), Alesina (1988, 1989), Eijffinger and Schaling (1993, 1995), and Cukierman (1992) independence indexes and the only significant relationship found was one using the first index during the second subperiod (with a positive sign). Concerning economic growth variability, none of the Central Bank independence variables show significance. Akhand (1998) studied 56 countries for the period 1960-1989, with the Legal CBI and the TOR from Cukierman *et al.* (1992), and two measures of political and non-political turnover from Cukierman and Webb (1995), and concluded that none of the variables is robustly significant when accounting for growth. Akinci *et al.* (2015) used an ARDL model to study the effect of contemporaneous CBI – constructed by the Heritage Foundation – on economic growth considering European Union member countries from 1995 to 2011 and found a positive relationship between the two variables. Aklin and Kern (2020) find that an increase in CBI leads to a decrease in financial regulations, since governments try to find an escape in order to generate political benefits in the short-term. The increase in the relevance of the financial sector can increase investment, hence economic growth.

The literature about the relationship between central bank independence and economic growth in the context of monetary unions is even rarer. Strong (2021) studies central bank independence in developing countries, comparing the relationship between CBI (with the turnover rate) and inflation, between the African Financial Community (CFA) currency zone and African countries outside this currency zone. Even though the focus is on inflation, and not on the economic growth, the author finds that the effect of central bank independence depends on a country being a member of a currency union. A former article by Bagheri and Habibi (1998) studies the relationship between CBI and political institutions. Monetary unions are political institutions and although the authors do not specifically study monetary unions, they do study the effect of political freedom and political stability, which are indirectly related with monetary unions. They find evidence of a positive relationship between political institutions' proxies and CBI (using the legal CBI), for both Western and developing countries' democracies. The turnover index of CBI presented no connection with these institutional variables. Bodea and Hicks (2015) find that democracies show lower money supply growth, hence lower inflation, via a more disciplined Central Bank, reflecting in this way a higher degree of CBI. Garriga and Rodriguez (2020) find that legal CBI is important to curb inflation and is also conditional on the strength of political institutions. Kern *et al.* (2019) and Reinsberg *et al.* (2021) study the effect of the International Monetary Fund (IMF) on CBI, for 124 countries in the period 1980-2012, and find that

targeted lending conditions increase CBI. So, at least in the short-run, due to the increasing credibility of the monetary and financial systems, investment can increase as well as economic growth.

Our contribution to the literature is threefold. First, and the most important one, we use a panel database that comprises, at most, 173 countries, between 1970 and 2017, allowing for a World-wide perspective on this issue. With this goal, we estimate dynamic panel models using the Arellano-Bover (1995)/Blundell-Bond (1998) method with Windmeijer (2005) standard errors correction and the Hausman-Taylor (1981) procedure, and we seek to overcome an omitted variables problem that exists in the previous literature, i.e., most studies used only the economic growth rate and a CBI measure in their estimations, thus neglecting the possible effect of the determinants of economic growth identified in the literature. Second, we use two measures of independence: one that was developed by Cukierman *et al.* (1992) and updated by Garriga (2016), consisting of a legal measure of Central Bank independence (Legal CBI), available for 173 countries, from 1970 until 2012; and another based on De Haan and Sturm (2001), updated by Dreher *et al.* (2008) and De Haan *et al.* (2010), measuring the actual level of independence of a Central Bank (given by an irregular turnover dummy of its Governor), available for 157 countries, between 1970 until 2017. Finally, since the legal CBI index is the most used in this literature, we present several counterfactual exercises in the context of monetary unions. This is because the robustness exercises in monetary unions return a positive significant coefficient, the only significant result for the Legal CBI in our work. We analyse what the gains/losses would be that a country could observe in its GDP *per capita* growth rates in the scenario of having a Central Bank acting the way a different Central Bank does (or did) measured by its Legal CBI of reference.

Results show that the Irregular turnover rate of the Central Bank Governor can be accountable for growth, in an harmful way, in the entire sample, and especially so for countries outside monetary unions. On the contrary, the legal central bank independence (Legal CBI) index is a positive determinant for growth, but only when countries belong to a monetary union. Out of the four components of the Legal CBI index, the Limitations on Lending to the Government is the most important one, having a positive impact on economic growth in monetary unions. The Chief Executive Officer (CEO) and the Objectives components appear to be harmful for economic growth, related to a Central Bank, and its governor, more disattached from Government interests. The Policy formulation component has no impact on economic growth. Moreover, we do counterfactual exercises in the context of monetary unions where we simulate how growth would have been had the Legal CBI and Limitations on Lending to the Government indexes registered different values than observed. Euro Area countries are better off now than if they still had the levels of Central Bank independence before joining this monetary union, and also than if they have the levels of the Bank of

England, the former Deustche Bundesbank, the Federal Reserve, or the Bank of Japan.

Finally, we do sub-sample analysis by the level of income, the number of crises, the existence of Quantitative Easing (QE) policies, and different time-windows, both for the full sample as well as for monetary unions countries only, for the Legal CBI and for the Limitations on Lending to the Government component. Low and Middle-income countries inside monetary unions jeopardized growth. Using QE policies does not bring gains to the economic growth in the full sample, whereas the results for the existence of crises are apparently mixed. Considering the time windows, 1990-2013 was a period where having higher Legal CBI and Limitations on Lending to the Government components was hurtful for growth for the entire sample. For countries that belong to monetary unions, both 1980-2006 and 1990-2013 periods present a positive relationship between Legal CBI and Limitation on Lending to the Government and economic growth. In sum, results seem to point to the conclusion that Legal CBI in a monetary union has special relevance, since a common or a harmonized monetary policy increases credibility, transparency, and enhancing investors' confidence, thus potentially increasing economic growth.

Our work is structured in the following way. In section 2 we define our empirical methodology, presenting the database and the econometric approach. In Section 3 we discuss our results for the full sample and also for monetary unions for the two indexes of central bank independence, and in Section 4 we perform several counterfactual analyses for the use of different Legal CBI indexes, in the context of monetary unions. Section 5 considers the analysis by several sub-samples, such as income levels, the existence of crisis, quantitative easing, and time-windows. Section 6 concludes.

2 Empirical Methodology

In this section we describe the data and the econometric methods. The period of analysis ranges, at most, between 1970 and 2017 for 173 countries[2]. We do not have the same time-period for all the variables and for all countries, and as a result we have an unbalanced panel.

For our benchmark model we present results for the full sample and also a partition between countries inside a monetary union and countries that are not. A monetary union is the final level of monetary integration. This specific level involves coordination of monetary policies between member countries, i.e., the establishment of common monetary goals, and this has a direct impact on central bank independence, hence, on economic growth. In this analysis we use Garriga's (2016) dummy concerning monetary unions: it is equal to 1 if a country belongs to a monetary union and equal to 0 otherwise – the first type of countries are

[2] Please note that Hong Kong and Macao, although they are Chinese regions, are treated as countries in our sample, as it happens in most of the databases we use.

designated as monetary union countries, otherwise are non-monetary union countries. Garriga (2016) defines this dummy variable as: "...whether the country's monetary policy is in the hands of a regional monetary union...". The monetary unions included are the West African Economic and Monetary Union (WAEMU), which includes Benin, Burkina Faso, Cote d'Ivoire, Guinea-Bissau, Mali, Mauritania, Niger, Senegal, and Togo; the Economic and Monetary Community of Central Africa (EMCCA), which includes Cameroon, Central African Republic (not included in our database), Chad, Republic of the Congo, Equatorial Guinea, and Gabon; the Organization of Eastern Caribbean States (OECS), which includes Antigua and Barbuda, Dominica, Grenada, Montserrat (not included in our database), St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines; and the Euro Area, which in our database, due to constraints (mostly due to the accession year) only includes Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovak Republic, Slovenia, and Spain. These monetary unions comprise 35 countries in total.

2.1 Data

In this sub-section we present the dependent and independent variables.

2.1.1 Dependent Variables

The variable that we aim to explain is economic growth. We use the growth rate of real GDP *per capita* to define the economic growth rate.

- **Real GDP *per capita* Growth Rate** – for the calculation of this variable we used real gross domestic product (GDP) at constant 2010 USD, using the official 2010 exchange rates applied to each country's local currency. Data for real GDP are from the World Bank database, which is a compilation of the World Bank National Accounts data and the Organization for Economic Cooperation and Development (OECD) National Accounts data. We divide real GDP by the population to obtain real GDP *per capita*. Population data reflect midyear estimates and comprehend the *de facto* population of each country, including all the residents, despite their legal status or if they are citizens or not. Data were taken from the World Bank database. We compute the growth rate of the Real GDP *per capita*, taking the first differences of ln(GDP *per capita*). We also used the growth rate of real GDP as the dependent variable but found similar results. We present the findings for the real GDP *per capita* growth rate because population growth is significantly different across countries in the World and therefore in *per capita* terms economic growth is not over/under evaluated.

2.1.2 Independent Variables

The independent variables are divided in two groups: the Central Bank independence measures and economic growth determinants. We are going to use, interchangeably two Central Bank independence measures - the Legal Central Bank Independence Index (Legal CBI) and the Irregular Turnover.

Central Bank Independence Measures

- **Legal Central Bank Independence Index**

The Legal Central Bank Independence Index (Legal CBI) reflects the legislation defining the relationship between fiscal and monetary institutions. Cukierman *et al.* (1992) provided an index, which contained 16 variables, aggregated into four composite variables: Central Bank Chief Executive Officer (CEO), Policy Formulation, Objectives, and Limitations on Lending to the Government. The index is between 0 (lowest independence) and 1 (highest independence). A more detailed description, as well as the weights applied on each parameter of the index, can be consulted in Table 1. Garriga (2016) updated the data for the four aggregate variables, so we use the database constructed by this author, which runs from 1970 until 2012, for 173 countries. [3]

[3] Please see the detailed definitions of the composite variables in the Appendix. The countries that don't have information for this variable are: Afghanistan, Angola, Aruba, Bermuda, Brunei Darussalam, Eswatini, French Polynesia, Hong Kong (China), Iraq, Kiribati, Macao, China, Mozambique, and Netherlands Antilles.

Table 1. Legal Central Bank Independence Index

Variables	Weight
1. Chief Executive Officer (CEO):	0.20
a. Term of office	
b. Who appoints CEO?	
c. Dismissal	
d. May CEO hold other offices in Government?	
2. Objectives	0.15
3. Policy Formulation:	0.15
a. Who formulates monetary policy?	
b. Who has final word in resolution of conflict?	
c. Role in the Government's budgetary process	
4. Limitations on Lending to the Government:	0.50
a. Advances (limitation on nonsecuritized lending)	0.15
b. Securitized lending	0.10
c. Terms of lending (maturity, interest, amount)	0.10
d. Potential borrowers from the bank	0.05
e. Limits on Central Bank lending	0.025
f. Maturity of loans	0.025
g. Interest rates on loans	0.025
h. Central Bank prohibited from buying or selling Government securities in the primary market?	0.025

Adapted from Cukierman *et al.* (1992)

- **Turnover of the Central Bank Governor**

Regarding this variable, we use the database constructed by De Haan and Sturm (2001), later updated by Dreher *et al.* (2008) and De Haan *et al.* (2010). These studies have found that the Irregular Turnover presents a significant relationship with the inflation rate in the case of developing countries, whereas with the Legal CBI it does not. Hence, although our analysis is focused on the relationship between the growth rate and central bank independence, we are considering also the Irregular Turnover because our database includes developing countries and also because the previous studies did not consider this relationship. The argument developed by De Haan and co-authors in their work, state that legal indicators may be less informative than they should be, because, one thing is what the law says and the other is what in reality is made.[4]

- **Irregular Turnover** – dummy variable that is equal to 1 if at time t the turnover happens before the legally defined mandate, meaning that the Central Bank is not independent, and 0 otherwise. The turnover

[4] Countries for which there is no information include: Antigua and Barbuda, Azerbaijan, Benin, Burkina Faso, Cambodia, Cameroon, Comoros, Cote d'Ivoire, Dominica, Grenada, Liberia, Mali, Mauritania, Moldova, Niger, San Marino, Senegal, Sierra Leone, Somalia, St, Kitts and Nevis, St, Lucia, St, Vincent and the Grenadines, Tajikistan, Timor-Leste, Togo, Tonga, Turkmenistan, United Arab Emirates, Uzbekistan.

rate computed by Cukierman (1992), Cukierman *et al.* (1992), and Eijffinger and Schaling (1995) includes both regular and irregular turnover of the Governor of the Central Bank, which is not a precise measure of actual independence and could result in misleading results. Irregular turnover is considered a measure of actual independence. The data are from 1970 until 2017, for 157 countries.

We plot below the relationship between real GDP *per capita* growth rate and the two measures of Central Bank independence described above - Irregular Turnover and Legal CBI. The value each variable takes corresponds to its yearly average across countries. In both Figures 1 and 2, the pairwise correlation between the variables calculated is -0.0248 and -0.0770, respectively. The negative correlation between the actual independence of a Central Bank (Irregular Turnover) and economic growth was expected: if the irregular turnover is high, meaning CBI is low, economic growth should decrease. The negative correlation between the Legal CBI and economic growth was not expected. Further analysis must be developed in order to understand this relationship. In Figures 3 and 4 we plot the same relationships, but only for the case of monetary unions. The correlations are again negative: -0.0843 for Irregular Turnover and -0.0786 for the Legal CBI.

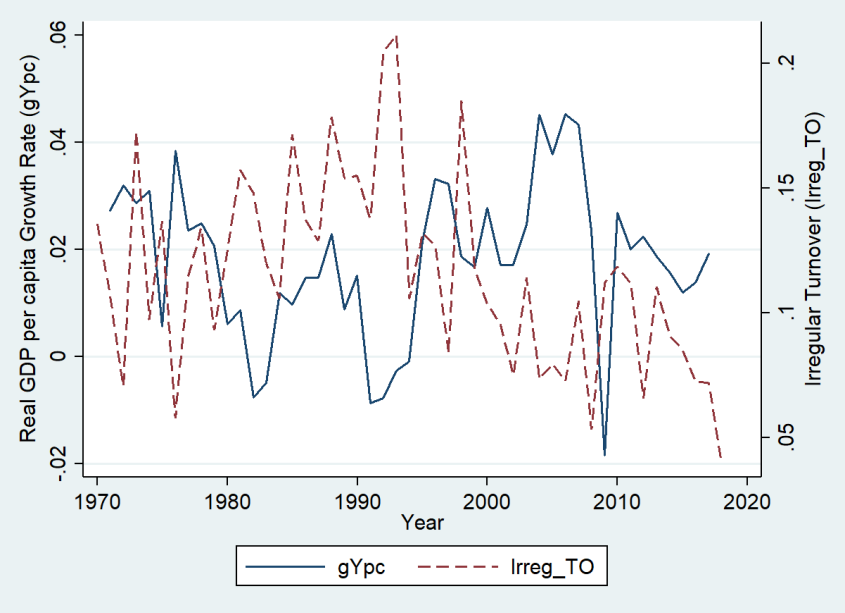

Figure 1. Real GDP per capita Growth Rate and Irregular Turnover

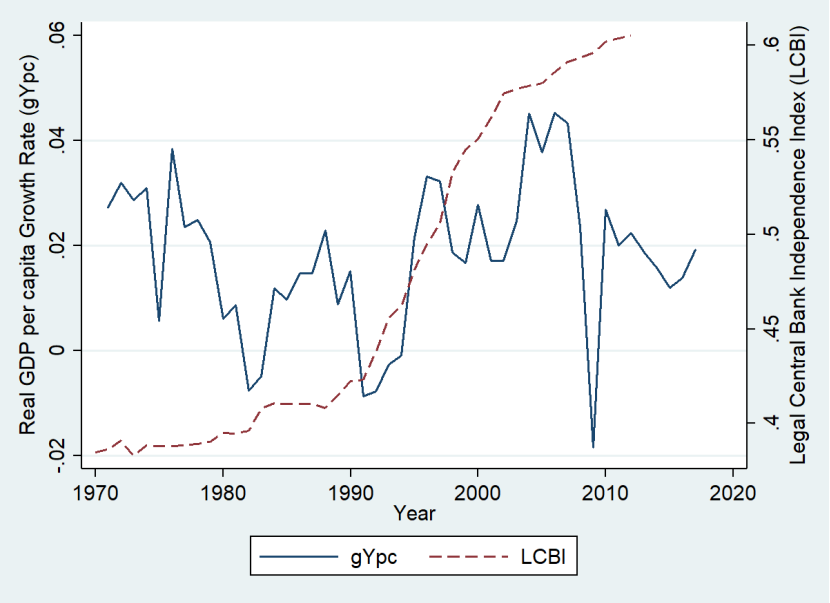

Figure 2. Real GDP per capita Growth Rate and LCBI Index

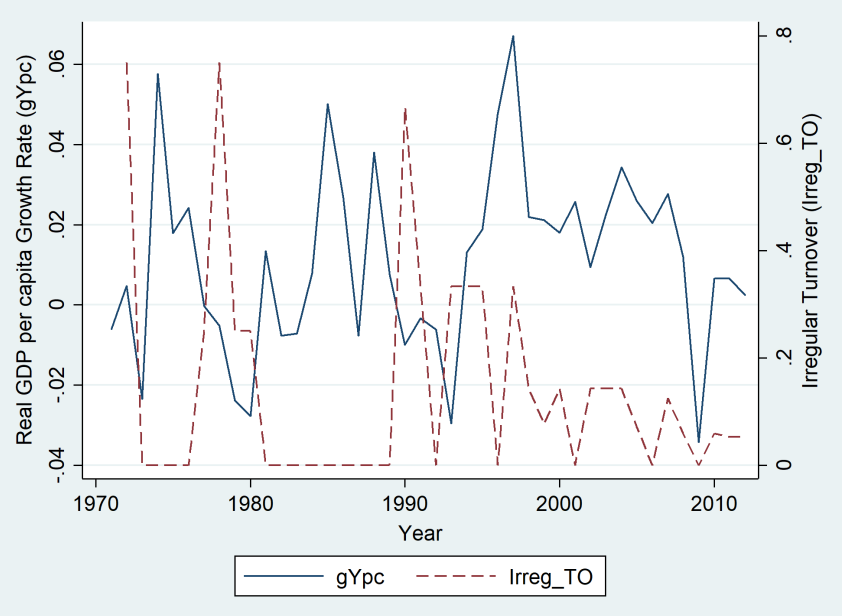

Figure 3. Real GDP per capita Growth Rate and Irregular Turnover in Monetary Unions

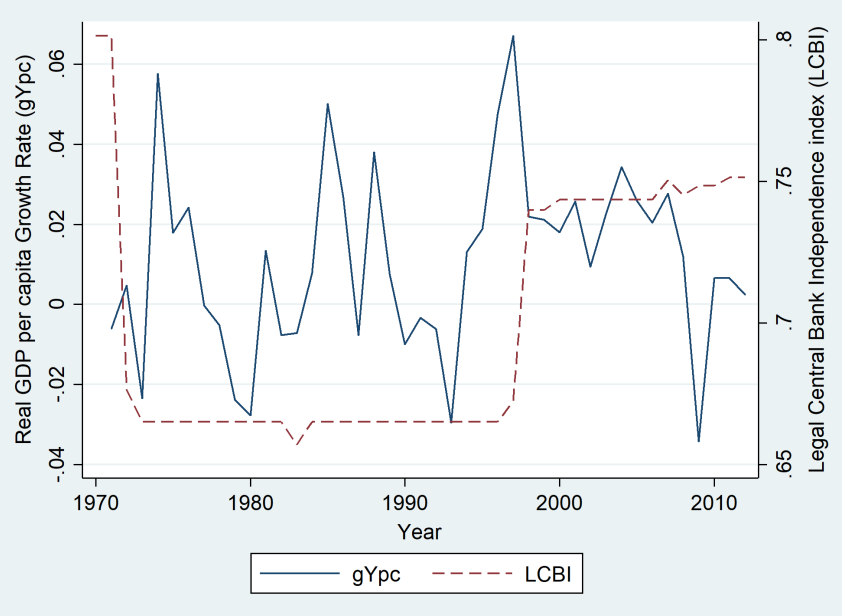

Figure 4. Real GDP per capita Growth Rate and LCBI Index in Monetary Unions

Additionally, in the Apendix (Tables A1 and A2) we have summary statistics for these two variables, for the full sample and for subsamples, in which we divide countries by monetary/non-monetary union countries,

levels of income, and intersection between these last two.[5] Regarding Legal CBI, we can see that there is a substantial difference between countries that belong to monetary unions (0.71) and countries that don't (0.45). This difference is further observed when we analyze monetary unions/non-monetary unions vis-à-vis income level, since high income countries (0.83) and low-medium income countries (0.66), which belong in monetary unions, present higher mean values for Legal CBI that countries that don't belong in monetary unions (0.51 for low-medium income countries and 0.45 for high income countries). Income levels alone are similar.

In terms of Irregular Turnover, the most striking difference is between high income countries (0.07) and low-medium income countries (0.13), with the last ones presenting a higher mean for irregular turnover (lower central bank independence). This difference can also be seen when analyzing income levels with monetary unions/non-monetary, i.e., low-medium income countries have always an higher irregular turnover, regardless of belonging (or not) to a monetary union.

Economic Growth Determinants We also detail the variables that we use as proxies for economic growth determinants, recurring to the economic growth literature.

- **Investment (% GDP)**

Investment comprehends the gross capital formation, which includes the sum of the inventories' level net changes and the money in an economy spent on additions to fixed assets (in % of GDP). Data from 1970 to 2017, were taken from the World Bank database, which compiled information from the World Bank national accounts database and the OECD National Accounts database. We expect a positive relationship of this variable with GDP since investment in physical capital increases output *per* effective labour unit.

- **Government Expenditures (% GDP)**

General government final consumption expenditure (in % of GDP) comprehends all the expenditures on goods and services of the government. Data from 1970 to 2017, were taken from the World Bank database which compiled information from the World Bank national accounts database and the OECD National Accounts database. We expect a negative relationship between economic growth and government consumption as a share of GDP, since a higher allocation of resources to the Government takes away resources from the private sector (crowding-out effect).

[5] There are countries in our database that do not have data for income level, such as: Cape Verde, Cote d'Ivoire, Eswatini, Hong Kong (China), Macao (China), Netherlands Antilles, Sao Tome and Principe, Serbia. Additionally, the countries that do not have data for belonging (or not) to monetary unions are: Aruba, Bermuda, Brunei Darussalam, French Polynesia, Hong Kong (China), Kiribati, Macao (China), Netherlands Antilles.

- **Debt-to-GDP ratio**

The debt-to-GDP ratio corresponds to the total gross Government debt of a country (in % of GDP). Information about this variable, which comprehends the period 1970-2015, was taken from the International Monetary Fund (IMF). According to Reinhart and Rogoff (2010) the relationship between the debt-to-GDP ratio and economic growth is non-linear and it depends on the level of the public debt, being positive for low levels and negative for high levels of the debt-to-GDP ratio.

- **Government Balance (% GDP)**

The general Government net lending/borrowing (in % of GDP) will be equal to the difference between Government revenues and Government expenditures and net investment in non-financial assets. This variable was taken from the World Bank database, with information compiled from the Government Finance Statistics Yearbook and data files of the IMF, ranging between 1972 and 2017. Ball and Mankiw (1995) argue that the initial effect of the deficit on the economy starts on national savings, which are reduced, although less than the amount of public savings reduction once private saving is increased. Furthermore, from the fundamental equation of macroeconomics, it follows that a deficit also makes a country an importer of goods and services and an exporter of assets, in net terms. A decrease in national savings will make the supply of loans (from savers) to be lower for private agents, which will increase interest rates and reduce investment. The increase of interest rates will increase the attractiveness of a country's domestic assets, bringing a higher return, and therefore foreign investors want to acquire domestic currency, leading to a higher currency demand and a subsequent appreciation. Domestic goods, now more expensive relative to foreign goods, will make exports decrease and imports increase, generating a deficit in the trade balance. Also according to the fundamental equation of macroeconomics, the country's output will be lower and economic growth will decrease. Considering the case of a surplus, the opposite process takes place and we expect its impact to be positive concerning economic growth.

- **Inflation Rate**

The inflation rate is the growth rate of the consumer price index, in annual terms, between 1970 and 2017. This variable was taken from the World Bank database that uses the International Financial Statistics and data files of the IMF. In theory, there is the possibility for inflation to have either a positive or a negative effect on economic growth and economic research also found that the relationship between growth and inflation can be non-linear, namely following a quadratic specification. Although it appears to be possible to have one or the other type of relationship, we expected it to be negative in linear terms, as it is in most cases of previous empirical work.

- **Life Expectancy and Human Capital Index**

Life expectancy considers the expected number of years a just born child might live if mortality patterns are considered to be the same during his/her life as at the moment of birth. This variable was also taken from the World Bank database, for the period 1970-2017. A higher life expectancy is reflected in a higher accumulation of human capital, and it should therefore have a positive effect on economic growth (Lucas, 1988; Rebelo, 1991; Caballé and Santos, 1993).

The human capital (HK) index is calculated through the average years of schooling and returns to education. It was computed for a number of countries by Barro and Lee (2013) and for the remaining countries from the update of Cohen and Leker (2014) of the work of Cohen and Soto (2007). This variable was compiled by Feenstra *et al.* (2015) from the Penn World Tables, version 9.1, with data running from 1970 until 2014. Barro (1998) found that the initial level of human capital has an ambiguous relationship with economic growth, since this variable in his work is composed of three different variables – the secondary and higher schooling average years of attainment for males 25 years old and older; the interaction between the previous and the initial level of GDP; and life expectancy at birth – the expected relationship is positive with the first and third variables and negative for the second.

- **Rule of Law**

The variable reflecting the rule of law captures the individuals' perception of the extent to which they accept rules, as well as the confidence they have in these rules. This variable is given by an aggregate indicator, characterized by a standard normal distribution, with values between -2.5 and 2.5. A lower value means that the country has a weak governance and a higher value the opposite. This variable was taken from the World Governance Indicators and it was developed by Kaufmann *et al.* (2010), at the World Bank. Data are for the period 1997-2017. In the work of Barro (1998), the relationship of the rule of law index with economic growth is positive, since trust in institutions and private property induces investment and hence economic growth.

- **Democracy Index**

We use the Polity2 index, from the Center for Systemic Peace, developed by Marshall *et al.* (2017), for the period 1970-2017, which values range between -10 (strongly autocratic) and 10 (strongly democratic), as our democracy index. The role of democracy on economic growth is theoretically inconclusive. Barro (1998) states that a democracy usually expands political rights which, in turn, promote economic rights and, as a consequence, economies grow. A democratic system should also promote limited but balanced

powers to institutions, avoiding situations that are more characteristic of autocracies in which a dictator is free to use his power to make non-productive investments or steal a country's wealth. But he also mentions that a democracy, characterized by a majority voting decision-based system, tends to transfer income from rich to poor, which can retard economic growth. Additionally, there can be autocracies in which, if the dictator is not involved in central planning, he/she might not have any motivation not to have economic freedom and, by doing so, it promotes economic growth. In Barro's work he found that the democracy index (measuring the right to have truthful participation in politics) has a positive effect on growth if included in the regression along with its square (which has a negative effect), defining an inverted U-shape, i.e., a non-linear relationship.

- **Terms of Trade**

The terms of trade index corresponds to the ratio between the export unit value indexes and the import unit value indexes. The index is measured relative to the base year 2000. The data source for this variable is the United Nations Conference on Trade and Development (UNCTAD), comprehending the period 1980-2017. Barro (1998) found that the GDP *per capita* growth rate was positively influenced by the terms of trade. Changes in the terms of trade, such as changes in relative prices (domestic and foreign), can change real income and consumption domestically, but real GDP will only be affected when changes in terms of trade promote a change in employment and output, since governments can promote opposite policies.

- **Research and Development (R&D) Expenditures (% GDP)**

The gross domestic expenditures on research and development – basic research, applied research, and also experimental development – in % of GDP, comprehends capital and current expenditures in R&D by private firms, government, higher education, and private non-profit institutions. This variable was taken from the World Bank database with information provided by the UNESCO Institute for Statistics for the years 1996 until 2016. In endogenous growth models characterized by incorporating R&D in their frameworks (e.g., Romer, 1986), growth should be positively influenced by R&D, since there is the propensity to benefit from *ex post* monopoly powers that are more prone to do R&D activities and reap their benefits.

A summary of the descriptive statistics for the variables described in this sub-section is presented in Table 2, containing statistics both for the full sample and also for monetary unions.

2.2 Econometric Approach

After defining the variables we use on this work, we check whether or not each of them is stationary. The number of countries is 173 and periods are fewer than 50, which means that we rely on large N (cross-

Table 2. Summary of Descriptive Statistics

Full Sample

Variable	Obs	Max	Min	P50	Mean	Std.
GDP *per capita* growth rate	7274	0.877	-1.049	0.021	0.018	0.001
Legal CBI	5699	0.979	0.016	0.479	0.492	0.203
Irregular Turnover	7045	1.000	0.000	0.000	0.114	0.318
Investment (% GDP)	6643	89.381	-5.739	22.846	23.623	8.699
Government Expenditures (% GDP)	6441	135.794	0.000	15.497	16.096	6.831
Debt to GDP ratio	6518	2092.920	0.003	45.348	58.384	60.931
Government Balance (% GDP)	3523	129.183	-203.719	-1.910	-1.723	7.001
Inflation Rate	6587	23773.130	-18.108	5.804	28.171	371.788
Life Expectancy	8682	85.417	18.907	68.412	65.524	10.563
Human Capital Index	5891	3.734	1.007	2.085	2.144	0.715
Rule of Law	3439	2.100	-2.606	-0.215	-0.056	0.986
Democracy Index	6779	10.000	-10.000	4.000	1.681	7.271
Terms of Trade	4866	721.052	21.396	100.962	112.754	39.160
R&D Expenditures (% GDP)	1780	4.428	0.005	0.564	0.923	0.927

Monetary Unions

Variable	Obs	Max	Min	P50	Mean	Std.
GDP *per capita* growth rate	876	0.878	-0.347	0.014	0.013	0.067
Legal CBI	892	0.857	0.501	0.802	0.711	0.136
Irregular Turnover	323	1.000	0.000	0.000	0.105	0.307
Investment (% GDP)	684	73.495	0.000	20.890	20.738	7.762
Government Expenditures (% GDP)	683	34.514	0.000	15.712	15.513	4.851
Debt to GDP ratio	843	434.907	0.474	59.962	67.582	50.198
Government Balance (% GDP)	375	27.260	-32.014	-2.204	-2.301	4.480
Inflation Rate	759	23773.130	-17.640	2.785	50.883	882.252
Life Expectancy	840	82.476	35.884	55.869	60.723	13.458
Human Capital Index	614	3.663	1.007	1.490	1.886	0.851
Rule of Law	413	1.999	-2.130	0.641	0.330	1.135
Democracy Index	706	10.000	-9.000	-1.000	0.603	7.255
Terms of Trade	660	357.576	21.397	100.000	111.335	40.395
R&D Expenditures (% GDP)	224	3.749	0.043	1.483	1.490	0.881

sections) for the asymptotics of the model's estimation and testing procedures. With this purpose, the Fisher-type test (Choi, 2001) and the Im-Pesaran-Shin (2003) test are performed for all the variables. These two methods are specific for unbalanced panel data and assume a null hypothesis in which all panels contain a unit root against an alternative that at least one of the panels is stationary (see also Levin *et al.,* 2002). Almost all variables are stationary with the exceptions of life expectancy and the human capital index, for which we apply first differences. R&D Expenditures in % of GDP is the only one inconclusive, since it does not have enough observations to perform the two stationarity tests for unbalanced panel data.

Due to persistence, economic growth typically depends on its past values so we use a linear dynamic panel data model in this work. Our model has the following general form:

$$y_{i,t} = \beta_0 + \sum_{j=1}^{J} \alpha_j y_{i,t-j} + \sum_{k=1}^{K} \beta_k EGD_{k,i,t} + \beta_{K+1} CBIM_{i,t} + v_i + \epsilon_{i,t} \tag{1}$$

where, for cross sections (countries) $i = 1, ..., N$ and periods $t = 1, ..., T$, $y_{i,t}$ is the dependent variable (growth), the α's are the coefficients associated with the lagged dependent variable (J lags at most), the β's are the model's coefficients related to K economic growth determinants, $EGD_{k,i,t}$, including as well as the Central Bank independence measure, $CBIM_{i,t}$ (Legal CBI or Irregular Turnover, interchangeably), and v_i are the N individual fixed country effects and $\epsilon_{i,t}$ the *i.i.d.* shock with variance σ_ϵ^2. The number of countries N and years T depend on whether we are using the full sample or a particular subsample, such as the case of the countries that belong to a monetary union. We consider Legal CBI and Irregular Turnover interchangeably because both measure independence but through different approaches, namely the legal framework and the actual perspective of independence, respectively.[6,7]

The issue of reverse causality, in the sense that CBI possibly depends on inflation, has been discussed in the literature (see, for example, Cukierman *et al.*, 1992, De Haan and Van't Hag, 1995, De Haan and Kooi, 2000, Cukierman, 2008, Dreher *et al.*, 2008, and Dreher *et al.*, 2008). On the contrary, and to the best of our knowledge, reverse causality from growth to CBI has not been an issue identified by the existing literature. In a very recent paper, Romelli (2022), using a new dataset, studies the potential drivers of reforms in central bank institutional design and one of them is a measure of economic growth. He provides weak evidence that GDP growth (proxied by a dummy variable that takes the value of one if GDP growth

[6] We tried several different models to see how results were robust to alternative specifications. First, we added nonlinearities in the model through Legal CBI, either by introducing quadratic terms or having a log/exponential/reciprocal relationship. Second, having both Legal CBI and Irregular Turnover in the model or adding an interaction between Legal CBI and Irregular Turnover or Legal CBI and inflation. Third, because maybe higher values of Legal CBI are a result of countries that grow more, we looked at subsamples for which the Legal CBI is below a particular threshold. Fourth, instead of a single year Irregular Turnover, by taking the number of irregular turnovers for the last 5 or 10 years.

[7] Government expenditures and government balance are in theory related, but in our sample there are not highly correlated (value of around -0.3 for the full sample and for countries in monetary unions).

in the last two years has exceeded the average over the last 10 years) helps explain the constructed index of CBI.

The estimation and inference method is the Arellano-Bover (1995)/Blundell-Bond (1998) approach, considering that it is designed for samples with a large number of countries and a small time period. It relies on the IV/GMM approach and assumes no autocorrelation in the idiosyncratic errors and that the panel effects in level terms cannot be correlated with the first difference of the dependent variable's first observation. Using the Stata software, the list of instruments are: for the differenced equation, the lags of the dependent variable and the first differences of the explanatory exogenous variables; for the level equation, the first lag of the first difference of the dependent variable and the intercept. The Sargan test is (very) sensitive to the number of lags of the dependent variable. As noted by Roodman (2009, page 128), "instrument proliferation can overfit endogenous variables and fail to expunge their endogenous components". Moreover, tests of overidentifying restrictions, such as the Sargan test, are little informative on the validity of instruments (Parente and Silva, 2012). In light of this, to avoid pvalues of the Sargan test of one, thus being more unlikely to have point estimates that are inconsistent and making results and conclusions more valid, we restrict the number of instruments used in the estimation approach.

The estimation can be performed either using a one-step or a two-step approach. The difference resides in how identification is achieved: the one-step takes all coefficients simultaneously, while the two-step does it sequentially. Both can be performed with robust standard errors under heteroscedasticity. We estimated the models using the one and two-step approach and with and without the robust standard errors. We present the results for the two-step estimation with robust standard errors. In fact, the specification tests failed for the case of the one-step contrary to what happened to the two-step. Hwang and Sun (2018) claim that the two-step usually improves efficiency when compared to the one-step and that it has associated test statistics with greater power. For the two-step approach, Arellano and Bond (1991) argue that the usual standard errors have a tendency to be downward biased, thereby affecting the point estimates. For this reason, we correct the standard errors using the robust ones by Windmeijer (2005). Furthermore, we test if the idiosyncratic errors are (not) serially correlated and if the moment overidentifying restrictions are valid.[8]

3 Empirical Results for the Benchmark Model

In this section we present the main results for the benchmark model where we compare the importance that each measure of central bank independence (Legal CBI and Irregular Turnover) has to explain economic

[8] In Stata, the first test (abond) can only be performed under robust standard errors and the second test (Sargan) under non-robust standard errors. Both can only be applied to the same model for the two-step estimation with standard errors that are not robust.

growth, using the full sample or splitting it by the level of monetary integration (monetary union countries or non-monetary union countries, those who are or not in a monetary union).

3.1 Full Sample and by Level of Monetary Integration

Table 3 presents the estimation results for the GDP *per capita* growth rate model using the Legal CBI measure and Table 4 with the Irregular Turnover variable. For a matter of completeness, we compare the results using the full sample with the subsamples of monetary union countries and non-monetary union countries. To guarantee some coherence in the analysis, the list of covariates that stay in all models includes the determinants that are found to be statistically significant for at least one specification. Following the discussion in the previous section, we consider one lag of the dependent variable that can be used as instruments for the Arellano-Bover (1995)/Blundell-Bond (1998) two-step estimation with the Windmeijer (2005) standard errors correction. Because of the large number of countries this was the estimation approach for the full and non-monetary union countries samples. Here, according to the Arellano and Bond test, we do not reject the hypothesis of no autocorrelation of the error term, and based on the Sargan test these models are probably far from being misspecified.[9]

For the monetary union countries sample we do not have results with one lag of instruments. The robust standard errors fail to be obtained for up to 3 lags of instruments for the Legal CBI model and 2 for the Irregular Turnover (the "variance matrix is nonsymmetric or highly singular"). Thus, we present for the monetary union countries two different estimation approaches. One is the standard Arellano-Bover (1995)/Blundell-Bond (1998) with 4 (3) lags of instruments for the Legal CBI (Irregular Turnover), where the Sargan's pvalues take the value of one. As an alternative, we consider the Hausman-Taylor (1981) approach for the Legal CBI and the well-known fixed effects estimator for the Irregular Turnover, both using robust standard errors. The reason why we use the fixed effects estimator is because the number of monetary union countries is now about the same as the number of periods and, therefore, the bias of this estimator is surely not as severe as in the full and non-monetary union countries samples where N is "large". Finally, we need to use the Hausman-Taylor (1981) instead of the fixed effects estimator when the central bank independence variable is Legal CBI because in the data this variable is time-invariant, thus omitted from the model due to perfect collinearity.

Remarkably, Legal CBI is statistically significant and has the expected sign, promoting economic growth, only when considering monetary union countries. On the other hand, Irregular Turnover influences growth

[9] We also tried two lags (maxldep(2)) but the main results are essentially the same. For the full sample, Legal CBI's pvalue is 0.460 and the pvalue of the Sargan statistic is 0.860; the Irregular Turnover's coefficient is -0.005 (significant at a 5% level) and the pvalue of the Sargan test equals 0.984. The Sargan pvalues are too close to one and therefore we decided to report the results for one lag.

Table 3. Results for GDP *per capita* growth rate with Legal CBI

	Full Sample	Monetary Union Countries (UC)		Non-Monetary UC
	A&B/B&B(maxldep=1)	A&B/B&B(maxldep=4)	H&T	A&B/B&B(maxldep=1)
GDP pc growth rate_L1	0.103 (0.067)	-0.237^{**} (0.098)	-0.033 (0.104)	0.139^{**} (0.067)
GDP pc growth rate_L2	-0.213^{***} (0.044)	-0.282^{***} (0.094)	-0.156^{*} (0.082)	-0.190^{***} (0.042)
Investment (% GDP)	0.002^{**} (0.001)	0.004^{***} (0.001)	0.004^{***} (0.0009)	0.002^{**} (0.001)
Gov. Expend. (% GDP)	-0.004^{***} (0.001)	-0.009^{***} (0.002)	-0.006^{***} (0.001)	-0.003^{***} (0.001)
Gov. Balance (% GDP)	0.002^{***} (0.001)	0.001 (0.001)	0.0005 (0.0006)	0.002^{***} (0.001)
Inflation Rate	-0.00002^{***} ($6.29e{-}06$)	-0.0002^{***} (0.00003)	-0.0002^{***} (0.00002)	-0.00005^{***} (0.00001)
Inflation Rate (square)	$8.68e-10^{***}$ ($2.51e{-}10$)	$1.15e-08^{***}$ ($1.47e{-}09$)	$1.01e-08^{***}$ ($1.16e{-}09$)	$7.00e-09^{***}$ ($1.85e{-}09$)
var. HK Index	-0.253^{*} (0.150)	-0.344 (1.062)	-0.156 (0.354)	-0.210 (0.150)
var. Life Expectancy	-0.009^{***} (0.003)	0.005 (0.005)	0.005 (0.006)	-0.015^{***} (0.005)
Legal CBI	-0.005 (0.023)	0.298^{*} (0.174)	0.102^{**} (0.042)	-0.009 (0.022)
Intercept	0.041 (0.029)	-0.142^{***} (0.111)	-0.039^{*} (0.020)	0.045 (0.033)
Arellano and Bond test	0.771	0.673	–	0.783
Sargan test	0.196	1.000	–	0.311
Observations(N,Ta,Tm)	$2140(106, 20, 40)$	$245(23, 11, 17)$	$245(23, 11, 17)$	$1856(99, 19, 40)$

NOTES: Standard errors in parentheses; estat abond and estat sargan are the pvalues;

*,**,*** stands for statistically significant at 10%, 5%, 1% levels, respectively;

Ta (Tm) is average (maximum) number of years for the N countries;

A&B/B&B: Arellano-Bover (1995)/Blundell-Bond (1998); H&T: Hausman-Taylor (1981);

maxldep: maximum number of lags of the dependent variable that can be used as instruments.

Table 4. Results for GDP *per capita* growth rate with Irregular Turnover

	Full Sample	Monetary Union Countries (UC)		Non-Monetary UC
	A&B/B&B(maxldep=1)	A&B/B&B(maxldep=3)	FE	A&B/B&B(maxldep=1)
GDP pc growth rate_L1	0.100^{*}	-0.105	-0.004	0.124^{**}
	(0.055)	(0.193)	(0.139)	(0.058)
GDP pc growth rate_L2	-0.230^{***}	-0.299^{**}	-0.274^{***}	-0.211^{***}
	(0.038)	(0.134)	(0.052)	(0.040)
Investment (% GDP)	0.002^{**}	0.004^{*}	0.004^{***}	0.002^{**}
	(0.001)	(0.002)	(0.0009)	(0.001)
Gov. Expend. (% GDP)	-0.003^{***}	-0.004	-0.011^{***}	-0.003^{***}
	(0.001)	(0.004)	(0.003)	(0.001)
Gov. Balance (% GDP)	0.002^{***}	0.003	0.0001	0.002^{**}
	(0.001)	(0.003)	(0.001)	(0.001)
Inflation Rate	-0.00002^{***}	-0.0003^{**}	-0.0003^{***}	-0.00006^{***}
	($7.50e{-}06$)	(0.0001)	(0.00004)	(0.00001)
Inflation Rate (square)	$9.00e-10^{***}$	$1.26e-08^{**}$	$1.31e-08^{***}$	$7.35e-09^{***}$
	($2.94e{-}10$)	($5.23e{-}09$)	($1.76e{-}09$)	($1.98e{-}09$)
var. HK Index	-0.110	0.033	-0.245	-0.144
	(0.160)	(0.863)	(0.506)	(0.160)
var. Life Expectancy	-0.010^{***}	0.0008	0.001	-0.015^{***}
	(0.003)	(0.009)	(0.006)	(0.004)
Irregular Turnover	-0.004^{*}	0.010	0.012^{*}	-0.006^{**}
	(0.002)	(0.009)	(0.005)	(0.002)
Intercept	0.034	0.007	0.145^{**}	0.032
	(0.033)	(0.073)	(0.068)	(0.038)
Arellano and Bond test	0.783	0.571	–	0.985
Sargan test	0.298	1.000	–	0.360
Observations(N,Ta,Tm)	$2298(103, 22, 42)$	$173(17, 10, 17)$	$173(17, 10, 17)$	$1898(97, 20, 40)$

NOTES: Standard errors in parentheses; estat abond and estat sargan are the pvalues;

*,**,*** stands for statistically significant at 10%, 5%, 1% levels, respectively;

Ta (Tm) is average (maximum) number of years for the N countries;

A&B/B&B: Arellano-Bover (1995)/Blundell-Bond (1998); FE: Fixed Effects;

maxldep: maximum number of lags of the dependent variable that can be used as instruments.

negatively only when considering countries that are not part of a monetary union. The full sample wouldn't allow us to reach this empirical evidence. By putting all countries in the same pool, we find that Legal CBI is not statistically significant whereas Irregular Turnover is but only at a 10% level. This means that according to this index composition, a CEO with a longer mandate or a country where a Government has low authority to appoint or dismiss this CEO, and a Central Bank with high authority concerning policy formulation, the main goal of which is price stability with high limitations on lending to the Government, will not contribute positively (as it was expected) or negatively for a country's economic growth. Irregular Turnover is (barely) significant and has a negative effect on GDP *per capita* growth rate, as expected. This implies that when a Central Bank Governor or CEO initiates her or his mandate out of the legally defined period, this will harm economic growth when compared to the situation in which turnover is regular or there is no turnover at all. In particular, it punishes growth by about 0.4 p.p. in the year it happens. An irregular turnover can occur whenever a country's Government decides, thus reflecting a low independence degree: the new governor or CEO is better aligned with the wishes of the Government, and this convergence can produce benefits for both parts. Recalling some theoretical arguments presented in the Literature Review section and which link Central Bank independence and economic growth directly, one of the benefits can be related to the electoral cycle: if a Government wants the monetary authority to take actions to create pre-electoral booms in the economy, in order to earn more votes and thereafter creates a recession, economic growth will suffer from this lack of independence. This manipulation of policies is accompanied by a lack of care for price stability, actions' predictability, and credibility.[10,11]

In monetary union countries an increase of 0.01 (one percentage point of index) for Legal CBI will make GDP *per capita* growth rate increase by approximately 0.003 (for the Hausman-Taylor estimator it is of 0.001). This might occur since a country that is considered to be part of a monetary union (with fixed exchange rates or, at most, with a single currency) is subject to a high level of regulatory, supervisory, and legal enforcement (direct or indirect) procedures, having less freedom than it would if it did not belong to a monetary union, since its actions can impact in a negative way, both its own fiscal policy and also other members' economies. When a country begins a monetary union membership, at least one of the components of Legal CBI in Table 1 is positively reinforced and the arguments presented in the literature review about the impact of Legal CBI on economic growth should be considered, like for instance the increasing credibility

[10] We also look at the contemporaneous effect as well as the lagged effects of irregular turnovers on economic growth. In particular, we measure the effects on cumulative economic growth between t and $t+h$. For $h = 1, ..., 5$, the coefficient on Irregular Turnover has a negative point estimate but is clearly not statistically significant.

[11] We may question whether central bank independence matters within a union given that the individual central banks have no power in terms of monetary policy. Therefore, we reestimated the models using the subsample that ends in 1998, the year prior to the eurozone came into existence with the official launch of the euro (alongside national currencies). The main conclusions stay the same: Legal CBI is not statistically significant whereas Irregular Turnover clearly is.

of the monetary and financial system, that can potentially increase investment, and hence economic growth. In fact, Legal CBI appears to be much higher on average (approximately 0.71) in the monetary union countries' subsample than amongst the non-monetary union countries (around 0.45). Strong (2021) finds that the (positive) effect of central bank independence depends on a developing country being a member of a currency union, even though the author focus is on inflation, not on economic growth. Previous literature that found a positive relationship between Legal CBI and economic growth include Akinci *et al.* (2015) and Aklin and Kern (2020).

Irregular Turnover, by the same line of reasoning, should be higher in countries that are not in a monetary union having a higher probability to be susceptible to Government pressures. Indeed, the irregular turnover is, on average, higher in countries that do not belong to monetary unions (approximately 0.13) when compared to the opposite situation (around 0.11) and this indicator has a negative effect on economic growth. Our results for the Irregular turnover are supported by previous literature like Cukierman *et al.* (1993).

Those remaining significant determinants of economic growth have the expected signs. First, growth persistence is smaller for monetary union countries (the two autogressive coefficients are more negative than the ones for non-monetary union countries). Second, the impact of Investment (in % of GDP) on GDP *per capita* growth rate for monetary union countries, considering that an increase in physical capital promotes a country's productivity, is twice as big as for those countries that do not belong to a monetary union (an increase of 1 p.p. in this variable for monetary union countries will make growth increase by 0.4 p.p.). Third, Government Expenditures (in % of GDP) shows a negative relationship with growth since, as mentioned, there might exist a crowding-out effect, according to which an increase in the Government Expenditures might lead to a reduction in the resources' allocation to the private sector: for monetary union countries, an increase in Government Expenditures (in % of GDP) by 1 p.p. makes GDP *per capita* growth rate decrease by approximately 0.6-1.1 p.p. (the impact for non-monetary union countries is smaller). Fourth, recalling some arguments previously presented, an increase in Government Balance (in % of GDP) can be a reflection of a deficit reduction, which might increase national savings, increasing either the supply of loans to private agents as well as investment by a decrease in interest rates; this decrease in interest rates decreases a country's assets return – demand for domestic currency from foreign investors might diminish and a deficit in the trade balance is reduced. The same will happen if there is a surplus increase. In particular, Government Balance (in % of GDP) is also accountable for growth but considering only non-monetary union countries. Fifth, inflation's overall relationship with growth is negative until its values are extremely high. This confirms some arguments previously presented, namely considering the facts that when inflation shows

variability it will promote uncertainty, it can be considered a tax on investment, it can create distortions and rent-related activities and, finally, that it can even increase the probability of shocks in the financial system. The significance of the squared inflation term confirms only that this variable has a non-linear relationship with growth, defining a convex (U-shaped) function.[12] Sixth, both variation of the Human Capital Index and variation of Life Expectancy are not statistically significant to explain growth in countries that belong to a monetary union.

3.2 Decomposition of the Legal CBI

For a more in-depth analysis of the impact of each component of the Legal CBI (cf. Table 1) on growth, Table 5 shows the results for all possible combinations of the Legal CBI components. The model is the same as in Table 3 for countries belonging to Monetary Unions, but with Legal CBI replaced by a particular combination of the 4 components: Chief Executive Officer (CEO), Objectives, Policy Formulation, and Limitations on Lending to the Government. For the whole set of 10 models, we only present the estimate of the main coefficient because the other estimated parameters are similar to Table 3.

There is evidence that the four components of the Legal CBI contribute differently in explaining the growth rates. The Limitations on Lending to the Government is the most important component in the sense that, whenever it is present, the parameter is statistically significant and with the magnitudes closest to the ones presented in Table 3. The weight of this component, as we can see in Table 1, is 50% of Legal CBI index. A higher value for this component means that the Central Bank is prohibited from lending to the Government, which potentially prevents inflation from increasing. On the contrary, Policy Formulation does not seem to be important to determine growth. Whenever this component is present, the coefficient becomes statistically insignificant. With respect to the components CEO and Objectives, both are barely significant and when each comes alone in the model it has a negative point estimate, meaning that both do not potentiate growth. When we look at the definitions of CEO and Objectives, we can see that the higher the values for these components of Legal CBI (i.e., higher independence), the lower will be their potential to increase growth. A higher value for the CEO component means that the Government has low authority

[12] As in Vuletin and Zhu (2011), to account for outliers, we also considered the transformation of inflation using $D \equiv 100\frac{inflation}{1+inflation}$, and, maintaining the original variable, remove existing outliers. The transformed inflation rate is found to be not statistically significant, thus leading to a worse benchmark estimated model. With respect to outliers, we follow Vuletin and Zhu (2011) and exclude the observations with the highest 10% of inflation rates. For the Legal CBI, the results do not change: it remains significant only for monetary unions (with a slightly larger estimated coefficient). On the contrary, the Irregular Turnover is now never found to be statistically significant (not even for no-monetary union countries). The reason being that in our sample most of the countries with hyperinflation do not belong to Monetary Union's (6% observations dropped from the monetary union countries subsample and 14% from non-monetary union countries). The median inflation for the full sample is 5.8%, in Monetary Union's is 2.8%, and outside Monetary Union's is 7.3%. Bolivia has an inflation rate of 11750% in 1985, Peru of about 7482% in 1990, the Democratic Republic of Congo of approximately 4129% in 1992 and 23773% in 1994, Ukraine of around 4735% in 1993, and Angola of approximately 4145% in 1996.

Table 5. Results for GDP *per capita* growth rate with Legal CBI decompositions

	A&B/B&B(maxldep=4)	H&T
CEO	−0.322	−0.425*
	(0.458)	(0.250)
Objectives	−0.703	−0.899*
	(0.634)	(0.462)
Policy Formulation	1.005	0.287
	(1.294)	(0.191)
Limitations on Lending to the Government	0.247**	0.122**
	(0.116)	(0.056)
CEO & Objectives	−0.227	−0.294*
	(0.269)	(0.163)
CEO & Policy Formulation	0.073	−0.146
	(0.577)	(0.179)
CEO & Limitations on Lending to the Government	0.302*	0.133**
	(0.163)	(0.056)
Objectives & Policy Formulation	0.120	−0.131
	(1.434)	(0.268)
Objectives & Limitations on Lending to the Government	0.296*	0.136**
	(0.162)	(0.061)
Policy Formulation & Limitations on Lending to the Government	0.225*	0.103**
	(0.127)	(0.044)
Objectives & Policy Formulation & Limitations on Lending to the Government	0.248*	0.109**
	(0.134)	(0.046)
CEO & Policy Formulation & Limitations on Lending to the Government	0.244*	0.103**
	(0.135)	(0.042)
CEO & Objectives & Limitations on Lending to the Government	0.318*	0.137**
	(0.174)	(0.057)
CEO & Objectives & Policy Formulation	0.007	−0.172
	(0.274)	(0.136)

NOTES: Standard errors in parentheses;
*,**,*** stands for statistically significant at 10%, 5%, 1% levels, respectively;
A&B/B&B: Arellano-Bover (1995)/Blundell-Bond (1998); H&T: Hausman-Taylor (1981);
maxldep: maximum number of lags of the dependent variable that can be used as instruments.

in legal terms, to appoint or dismiss the Governor and his/her mandate is longer, hence the Government loses the power to choose someone that could be potentially more pro-growth. A higher value for Objectives means that the first, and only, objective of the Central Banks is price stability, disregarding other objectives, like for example economic growth.

4 Central Bank Independence in Monetary Unions

Earlier we concluded that Central Bank independence measured by the Legal Central Bank Independence Index (Legal CBI) is important to promote growth in those countries that are subject to a monetary union. This result is robust whether we use the Legal CBI index as a whole or if we take particular decompositions of its main four components.

In this section we undertake the following prediction exercise. What gains/losses would a country observe in its *per capita* GDP growth rates in the scenario of having a central bank acting the way a different central bank does (or did) measured by its Legal CBI of reference? In this sort of counterfactual analysis we assume that the country's (or monetary union's) central bank of interest could indeed set its monetary policy as it is

(or was) in any other central bank in the World and that this would not affect the remaining determinants of the growth model. We focus our attention on hypothetical states of the whole Euro Area and of its countries, and at the end we construct beliefs considering all countries in the world that belong to a monetary union.

To quantify our hypothesis, let the values of the central bank independence measure (CBIM) of the country of interest and the country of reference be $CBIM_0$ and $CBIM_R$, respectively. From the estimated models in Tables 3 (monetary union countries) and 5, we consider the CBIMs of Legal CBI and Limitations on Lending to the Government, respectively. Because we estimated dynamic models, the response of growth to a change in CBIM is permanent and therefore we obtain the long-term multipliers, with variables at their equilibrium levels:

$$(1-\widehat{\alpha}_1-\widehat{\alpha}_2)\,GDPper\ \widehat{capitagrowthrate}^* = EstimatedControls^* + \widehat{\beta}CBIM^*. \tag{2}$$

Defining $GDPper\ \widehat{capitagrowthrate}_0^*$ and $GDPper\ \widehat{capitagrowthrate}_R^*$ as the estimated equilibrium growth rates evaluated at the CBIM of the country (or area) of interest and the country (or area) of reference, respectively, for the same value of controls, the counterfactual gain/loss in growth is

$$GDPper\ \widehat{capitagrowthrate}_0^* - GDPper\ \widehat{capitagrowthrate}_R^* = \frac{\widehat{\beta}}{(1-\widehat{\alpha}_1-\widehat{\alpha}_2)}\left(CBIM_0^* - CBIM_R^*\right), \tag{3}$$

the difference of the observed CBI measures weighted by the long-term multiplier. We refer to it in the text and Figure and Table as mean or mean difference.

Quite often the prediction exercise ignores the uncertainty behind the estimation and model selection processes. Related to this fact, we consider the quantification of a minimum impact (gain or loss) in growth to be very important in this type of counterfactual approach. To that extent we also compute $GDPper\ \widehat{capitagrowthrate}_0^* - GDPper\ \widehat{capitagrowthrate}_R^*$ but taking $\widehat{\beta}$ equal to the value of its estimated lower bound from the corresponding 90% confidence interval. We denote it by LB and refer to it in the text and Figure and Table as lower bound or LB difference.

4.1 Countries From the Euro Area in the Year Prior to Joining It

The countries that belong to the Euro Area entered this monetary union in different years: Austria after 1997, Belgium 1997, Finland 1997, France 1997, Germany 1997, Greece 1999, Ireland 1997, Italy 1997, Luxembourg 1997, Malta 2006, Netherlands 1997, Portugal 1997, Slovak Republic 2008, Slovenia 2006, and Spain 1997. We do not have results for Latvia and Lithuania because both countries joined the Euro Area after 2012, the last year of our dataset. Cyprus and Estonia are also not included in this analysis because,

although part of the Euro Area, they have values of the CBIM different from the aforementioned 15 countries (for those 15, the Legal CBI equals 0.8565).

In this section we compare, for each country in the Euro Area, the estimated growth rates based on the observed CBIM in 2012 to the one if the level of CBIM was exactly equal to the observed just before entering the Euro Area. That is, the hypothetical gains/loss in each Euro Area country's economic growth is if it still had the CBIM at the moment it joined this monetary union. For example, $CBIM_R^*$ is Spain's LCBI in 1997 and $CBIM_0^*$ is Spain's LCBI in 2012. The inferred gain/loss is therefore $\frac{\widehat{\beta}}{(1-\widehat{\alpha}_1-\widehat{\alpha}_2)}\left(CBIM_0^* - CBIM_R^*\right)$. The results are in Figures 5 (mean) and 6 (lower bound), obtained for both Legal CBI and Limitations on Lending to the Government.

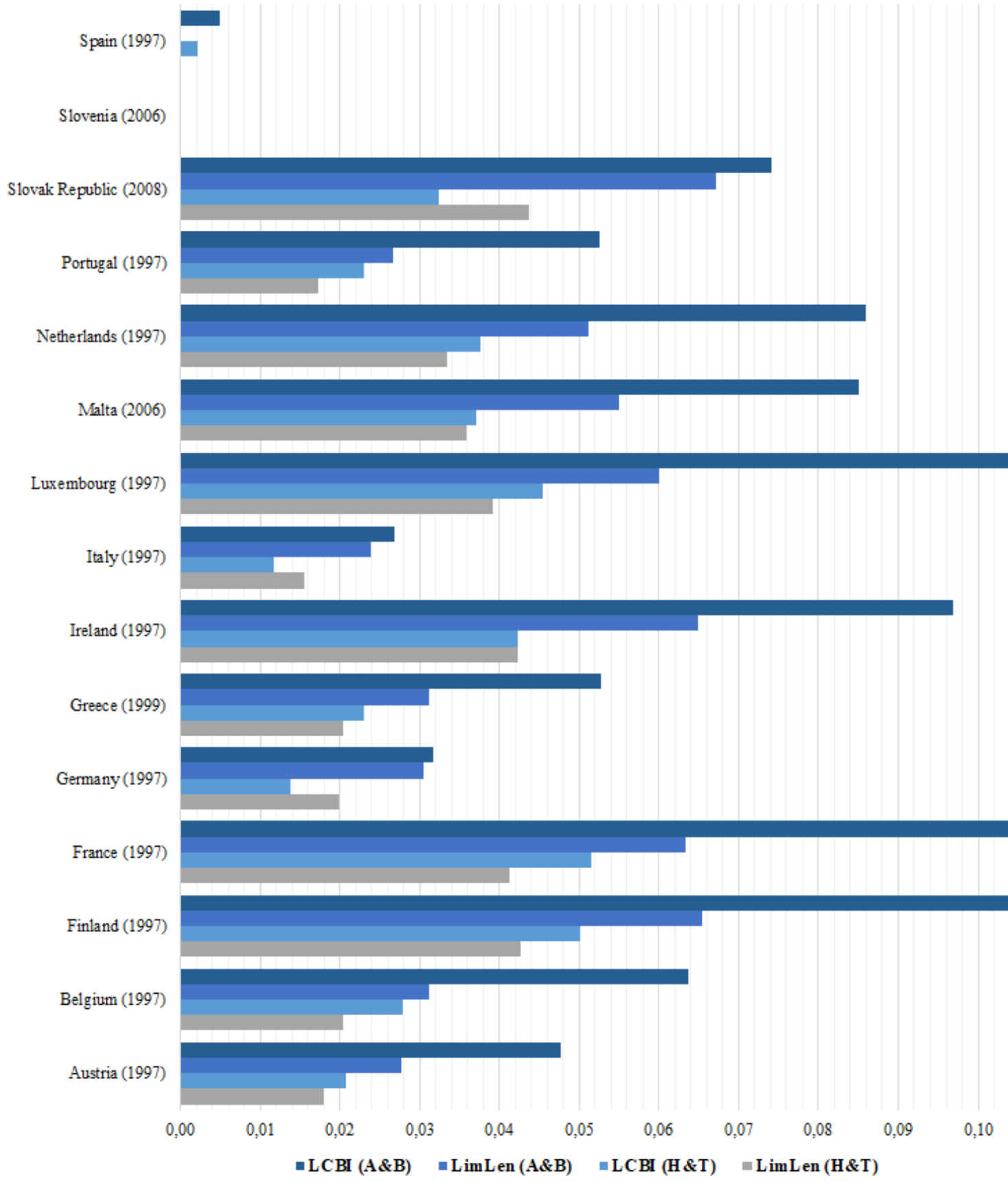

Figure 5 Counterfactual with the Scenario Before Joining the Euro Area Main (mean)

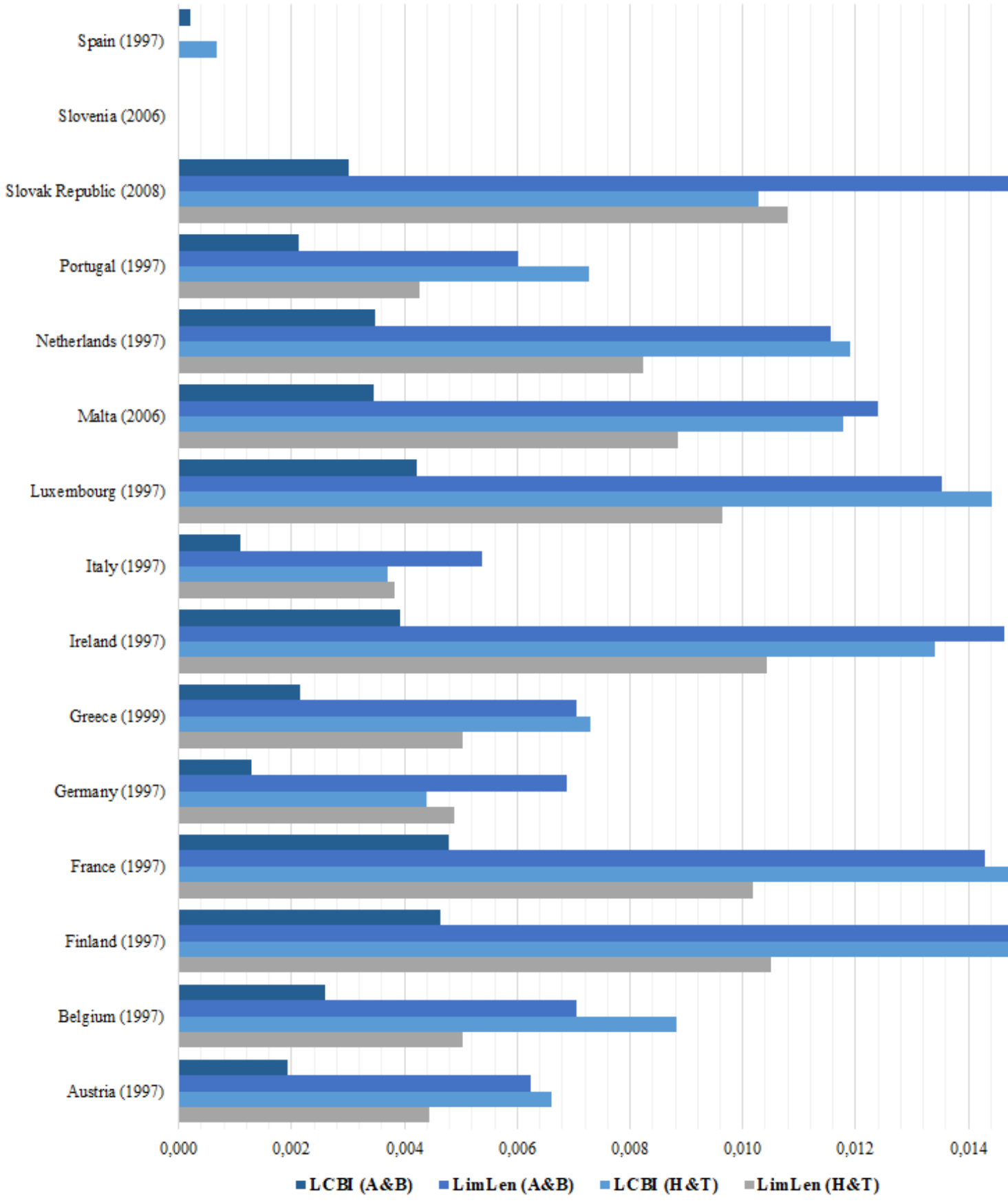

Figure 6 Counterfactual with the Scenario Before Joining the Euro Area Main (Lower Bound)

With the exception of Slovenia, all countries in the Euro Area would have smaller expected growth rates if their central banks had independence levels equal to those observed before entering the monetary union. Drawing the conclusion that the decision of joining the Euro Area was beneficial to growth in these countries is a long shot, and we do not attempt to claim it, but it seems that some gains in growth were obtained after the monetary policy started to be set by an entity more independent of local governments.

The countries with the smallest differences are Spain, Italy, and Germany and with the greatest are France, Finland, and Luxembourg. The growth differences with the Legal CBI are greater than the Limitations on Lending to the Government for the mean but smaller for the LB. In particular, for the former, the minimum losses range from 0.02% in Spain to 0.48% in France (0.02% and 1.63%, respectively, using the Hausman-Taylor (1981) estimator), and for the latter from zero in Spain to 1.43% in France (zero and 1.02%, respectively, using the Hausman-Taylor (1981) estimator). So, apparently, Spain's growth was not affected by the change of its LCBI after joining the Euro Area in 1997 (in 1997 the LCBI was equal to 0.831 and from 1998 to 2012 was 0.856). But Spain (and Slovenia) were the exception in this monetary union. For the 15 countries, the average minimum loss is 0.26% and 0.9%, respectively (0.89% and 0.64%, respectively, using the Hausman-Taylor (1981) estimator). In sum, despite some more extreme values, it seems that countries joining the Euro Area may increase equilibrium GDP *per capita* growth rates by about 1% per year.

4.2 Main Central Banks in the World

In the previous section we observed that Cyprus and Estonia do not have the same CBIM as the other 15 countries. So a natural counterfactual exercise to perform is evaluating the hypothetical gains/losses in their economic growth if adopting the actual ECB (Euro Area) measure of Legal CBI. The results are in Table 6. Interestingly enough, the impact on Cyprus is different than the one for Estonia. There could exist gains for Cyprus in joining the ECB rules by at least a minimum of 0.2% per year (0.4% with the Hausman-Taylor (1981) estimator) whereas for Estonia there is no impact at all. The Cyprus' LCBI is equal to 0.575, much smaller than the Euro Area's (0.856), whereas for Estonia there is no such difference. The values for Cyprus in Table 6 are negative because $CBIM_0^*$ refers to Cyprus and $CBIM_R^*$ to the Euro Area. Hence, just as in the previous section, it seems that being part of the "Euro" group is not harmful for long term growth.

In this section we also perform a second type of counterfactual analysis. We ask the question of what could happen to growth in Euro Area countries in the event of the ECB acting in the same way as other important central banks in the World, measured by the corresponding values of their Legal CBIs. We compare to the former Deutsche Bundesbank (DB, until 1997), the Bank of England (BoE), the US Federal

Table 6. Counterfactual with the Main Central Banks in the World

		Mean difference				
	"0"\"R"	ECB	DB	BoE	US Fed Res	BoJ
Legal CBI	Cyprus	−0.055 −0.024	–	–	–	–
	Estonia	0 0	–	–	–	–
	Euro Area	–	0.031 0.014	0.030 0.013	0.073 0.032	0.082 0.036
Limitations on Lending to the Government	Cyprus	−0.027 −0.017	–	–	–	–
	Estonia	0 0	–	–	–	–
	Euro Area	–	0.030 0.020	0.007 0.005	0.029 0.019	0.062 0.041
		LB difference				
Legal CBI	Cyprus	−0.002 −0.007	–	–	–	–
	Estonia	0 0	–	–	–	–
	Euro Area	–	0.001 0.004	0.001 0.004	0.003 0.010	0.003 0.011
Limitations on Lending to the Government	Cyprus	−0.006 −0.004	–	–	–	–
	Estonia	0 0	–	–	–	–
	Euro Area	–	0.006 0.005	0.001 0.001	0.006 0.005	0.014 0.010

NOTES: A&B/B&B(maxldep=4) is the top value; H&T is the bottom value

Reserve System (US Fed Res), and the Bank of Japan (BoJ). The results are in the last four columns of Table 6.

The Legal CBI measures of the Euro Area are greater than those from the other Central Banks and for that reason, and because the Legal CBI has a positive estimated impact on growth, the ECB's countries could incur losses if they had started adopting the legal measures of the other Central Banks. Growth could eventually drop by at least 0.1% per year in the Euro Area if the ECB behaved like the Bank of England, 0.1% like the former Deutsche Bundesbank, 0.3% like the US Fed, and 0.3% like the Bank of Japan (with the Hausman-Taylor (1981) estimator these values are 0.1%, 0.4%, 0.5%, and 1%, respectively). As mentioned earlier, this is not an absolutely binding conclusion, but it is fair enough to say that the legal system of the ECB is friendly to economic growth in the Euro Area. The Legal CBI for the Bank of Japan is 0.436, for the Federal Reserve is 0.480, for the Deutsche Bundesbank is 0.695, and for the Bank of England is 0.701. Differences in the Legal CBI rely mostly on the Limits on Lending to the Government component, which additionally weights 50% in the index. The losses that the Euro Area member countries would incur if they adopted the legal measures of the other Central Banks are negatively correlated with the value of the Legal CBI for each Central Bank, i.e., the lower the Legal CBI of a Central Bank, compared with the one of the ECB, the greater the losses.

4.3 Country with the Greatest Legal CBI in Sample

The Legal Central Bank Independence Index aggregated into its four composite variables is observed for a total of 173 countries, not all belonging to a monetary union. The most recent value of the Legal CBI in 15 countries of the Euro Area is one of the greatest (0.8565) but is not the maximum observed in the dataset which is of 0.979 by Bosnia and Herzegovina, a country in Europe that does not belong to any monetary union.[13] In our last counterfactual exercise, we quantify growth differences by how much over the years the 37 countries subject to monetary unions might have gained if they had the level of Legal CBI of Bosnia and Herzegovina (0.979). We obtain results for the differences evaluated at the estimated coefficient and at the estimated coefficient's lower bound, and in each we compare the cases of the Legal CBI's model and the Limitations on Lending to the Government model.

We conclude that for most of the monetary unions, gains in yearly growth could have been considerable. The smallest gains correspond to the countries in the Euro Area. For the Limitations on Lending to the Government there are no differences and using the Legal CBI the hypothetical estimated smallest (average) gain is of 0.1% (3.6%) per year. Using the Hausman-Taylor (1981) estimator these are 0.4% and 1.2%, respectively.

Important gains would occur in the West African Economic and Monetary Union. The minimum gain is 0.2% for the Legal CBI and 0.75% using the Limitations on Lending to the Government (around 0.5% by the Hausman-Taylor (1981) estimator). At the estimated coefficient, the gain is 5.3% (3.3%) for the Legal CBI (Limitations on Lending to the Government). For the alternative estimator it is almost 2%.

The countries with the greatest hypothetical increase in growth belong to the Economic and Monetary Community of Central Africa, followed by those in the Organization of Eastern Caribbean States. At the estimated coefficients, the potential increase in growth can reach values of two digits. In particular, for the Legal CBI models, these countries in Central Africa would gain 14% and those in the Caribbean 10%. Once we study the lower bounds, we find that the minimum gains are 0.6 (2%) for the Legal CBI (Limitations on Lending to the Government) in Central Africa and 0.4 (1%) for the Legal CBI (Limitations on Lending to the Government) in the Caribbean. Using the Hausman-Taylor (1981) estimator we expect minimum gains of around 1% per year.

The gains of the two African monetary unions are higher than the gains for the Euro Area, since the original values for the Legal CBI and for the Limitations on Lending to the Government are lower for the two African monetary unions than for the Euro Area, hence the distances from the high values for Boznia and Herzegovina for the two indexes are much higher, implying much higher gains for the African monetary

[13] Bosnia and Herzegovina's LCBI is 0.979 decomposed as CEO=0.895 and the other three equal to 1 (Policy Formulation, Objectives, and Limitations on Lending to the Government).

unions.

From the experiments in these three sub-sections we could confirm our main result: the higher the Legal CBI and also Limitations on Lending to the Government, the higher the gain in belonging to a monetary union, in what concerns economic growth. A monetary union increases the independence of the Central Bank, hence, its credibility, as well as increasing the transparency of the monetary and financial system, increasing the confidence of investors, leading to higher economic growth rates.

5 Further Sub-Sample Analysis: Income Level, Crisis, Quantitative Easing, and Time Windows

In this section we perform a variety of extensions that work as robustness exercises for our benchmark results (Tables 3 and 5): we divide our entire and monetary union countries samples by income levels, banking, currency and sovereign debt crisis (Crisis), quantitative easing (QE) performed, and not-performed by countries, and time windows, estimating new regressions to see how results compare for distinct groups.[14] Table 7 presents the results for all these analysis, namely the coefficient of interest Legal CBI or Limitation on Lending to the Government using the appropriate estimation methods. The monetary union countries' QE and high-income countries are the same and for that reason the results coincide. The "NA"s are a consequence from having a small sample of countries or years which creates a problem of collinearity in the corresponding models.[15]

5.1 Income Levels

According to the Solow (1956) model, economic growth is different between countries that exhibit different levels of development (income). With this exercise we want to assess if different income levels, and by the Solow model, different economic growth rates, have an impact in its relationship with CBI. To divide the sample by income levels, we use the World Bank classification, which includes four different levels of income based on the estimates of gross national income (GNI) *per capita* in $US, considering the period 1987-2017: low-income, lower middle-income, upper middle-income, and high-income. Because of the sample size, we merged three of these groups – low-income, lower middle-income and upper middle-income – into a single one, the Low & Middle-income. This classification criteria changes through time, being calculated every

[14] Another robustness exercise was to divide the sample by continents: America, Africa, Asia, Europe, and Oceania. The process of matching each country to its continent was based on data from the Central Intelligence Agency (CIA). We do not present the results because only a few variables are significant, namely lagged growth and Investment (in % GDP). The CBI measures are not statistically significant.

[15] Descriptive statistics for Legal CBI and Limitations on Lending to the Government by these disaggregations can be found on Tables A1 and A3 in the Appendix.

Table 7. Results for GDP *per capita* growth rate by Income Level, Crisis, and Quantitative Easing

	Observations (N,Tavg,Tmax)	Legal CBI		Limitations on Lending to the Gov.	
		Full Sample			
		A&B/B&B(maxldep=1)		A&B/B&B(maxldep=1)	
Low & Middle-income	934 (75,12,24)	−0.017 (0.025)		−0.026 (0.029)	
High-income	622 (39,16,24)	−0.026 (0.018)		−0.043* (0.024)	
Crisis	1335 (72,19,40)	0.027 (0.020)		0.029 (0.027)	
No Crisis	751 (30,25,40)	−0.042*** (0.012)		−0.072*** (0.015)	
Using QE	721 (24,30,40)	−0.036*** (0.012)		−0.068*** (0.021)	
Not Using QE	1419 (82,17,40)	0.012 (0.025)		0.012 (0.036)	
1990–2013	1484 (105,14,21)	−0.044*** (0.016)		−0.061*** (0.019)	
1980–2006	1298 (93,14,25)	0.006 (0.019)		0.002 (0.023)	
		Monetary Union Countries			
		A&B/B&B(maxldep=4)	H&T	A&B/B&B(maxldep=4)	H&T
Low & Middle-income	68 (6,11,17)	NA	−0.032** (0.012)	NA	−0.043** (0.017)
High-income	167 (16,10,13)	0.368 (0.541)	0.098 (0.073)	0.598 (0.880)	0.157 (0.117)
Crisis	148 (14,11,17)	0.577 (0.957)	0.032 (0.025)	NA	0.034 (0.049)
No Crisis	93 (8,12,13)	NA	NA	NA	NA
1990–2013	245 (23,11,17)	0.298* (0.174)	0.102** (0.042)	0.247** (0.116)	0.122** (0.056)
1980–2006	123 (19,6,13)	NA	−0.0001 (0.042)	0.213** (0.108)	0.013 (0.053)

NOTES: Standard errors in parentheses; NA: Results not available;

*,**,*** stands for statistically significant at 10%, 5%, 1% levels, respectively;

Tavg (Tmax) is average (maximum) number of years for the N countries;

A&B/B&B: Arellano-Bover (1995)/Blundell-Bond (1998); H&T: Hausman-Taylor (1981);

maxldep: maximum number of lags of the dependent variable that can be used as instruments.

year in July using the World Bank Atlas method.

The results confirm the non significance for the full sample (at a 5% level) but contradicts those for the monetary union countries: apparently, by the Hausman-Taylor (1981) estimator, Legal CBI and Limitations on Lending to the Government penalize growth in Low & Middle-income countries. For the monetary union countries with high income there is no impact on growth, regardless of the estimation approach. This is somehow contrary to what occurred in Garriga (2016), where this measure of independence had a negative coefficient on high-income countries and a positive one for low and middle-income ones.

5.2 Crises

We wanted to assess if the relationship between CBI and economic growth reacts differently to negative periods of the business cycle, i.e., we wanted to test if the cycle (short-run movement) has some influence on the trend of GDP (long turn, economic growth) and on its relationship with CBI. In order to perform an analysis of the impact of different crises, we used a dataset of Laeven and Valencia (2008, 2013), updated by the authors in 2018, which contains information on crises (banking, currency, and sovereign debt crises) around the world, for the period 1970-2017. We divide the sample in two: countries that had at least two crises during that period (Crisis) and countries that had none or just one (No Crisis). It is also important to highlight that we do not consider what type of crisis occurred in a specific country, merely if a crisis occurred.

First, consider the countries that faced two or more crises. For the full sample or for monetary union countries, Legal CBI and Limitations on Lending to the Government are not statistically significant when accounting for economic growth. Things are different for countries that had at most one crisis. There are no results for monetary union countries, but for the full sample, Legal CBI and Limitations on Lending to the Government are highly significant with a negative impact on growth.

From a total of 158 countries, there are 9 that did not experienced any type of crise during the period under analysis. The majority had one crisis (42 countries), 30 had two crises, and 33 had three crises. Argentina had the largest number of crises (12 of them). The average number of crises is 2.86. We can make the criterion more restrictive for a country to be in a "Crisis" situation. Instead of two, suppose that it needs at least three crises (around the sample's average). The results do not change (cf Table 7): countries facing crises, for the full sample or monetary union countries by the Hausman-Taylor (1981) estimator, Legal CBI and Limitations on Lending to the Government are not statistically significant, and countries with at most 2 crises, the full sample confirm the negative impact of Legal CBI and Limitations on Lending to the Government on growth. Finally, countries with at most 2 crises that belong to a monetary union do not

present statistical significance for Legal CBI and Limitations on Lending to the Government, except for the case of the Legal CBI using Hausman-Taylor (1981) estimator (estimated impact of 0.136 for a significance level of 10% only).

By making the "Crisis" criterion less restrictive (i.e., dividing the sample in countries that had at least one crisis versus those that had none), we do not have enough observations to estimate the models for the second group of countries. For countries that experienced at least one crisis, for the full sample, Legal CBI is not statistically significant when accounting for economic growth, whereas for monetary union countries it has the expected positive effect, but only for the Hausman-Taylor (1981) estimator. These confirm the benchmark results. The reason behind this can also be the fact that only few countries had no type of crisis, considering the countries and the time period for which data are available. The countries that did not experienced any crisis are Australia, Barbados, Bhutan, Brunei, Canada, Hong Kong, Mauritius, Singapore, and St. Kitts and Nevis.

5.3 Quantitative Easing

Quantitative easing works as an increase in the supply of money by buying government bonds and other securities from banks, lowering the cost of money. A lower cost of money means interest rates are lower and banks can lend with easier terms. These means more money at a lower cost, so investment and consumption could increase, and hence economic growth. Hence, we wanted to see if QE as an instrument of monetary policy has some influence on the relationship between CBI and economic growth. We divided our entire sample into countries that performed measures of unconventional monetary policy (i.e., quantitative easing) and countries that never used it as a way to conduct monetary policy, based on public information from central banks. The QE countries are: all the countries in the Euro Area, Japan, Switzerland, Sweden, the United Kingdom, and the United States of America.

Using the full sample, Legal CBI and Limitations on Lending to the Government are not significant for countries not using QE but, contrary to the benchmark model, they push growth down in countries that use QE policies. QE policies imply a stronger intervention of the Central Bank in the economy and Legal Central Bank Independence prevents a stronger intervention.[16]

[16] We couldn't perform the estimations regarding Legal CBI and Limitations on Lending to the Government for Monetary Unions and QE policies, since data for the Legal CBI and its component only is available until 2012, and QE policies in the Euro Area begins afterwards.

5.4 Time Windows

In our final sub-sample exercise, we restrict the period under analysis. In particular, we follow Garriga and Rodriguez (2020) and consider two shorter periods: from 1990 until 2013, in which we exclude the decades of 1970s and 1980s, and from 1980 to 2006 so that we do not include the world's financial crisis in the sample.

Contrary to Garriga and Rodriguez (2020), we find differences for distinct time windows. First, we consider the full sample (monetary union countries and non-monetary union countries) and compare each one of the two sub-periods to the whole period as in the original benchmark model (Cf Tables 3 and 5). The main conclusion is that we confirm the non-statistical significance of Legal CBI and Limitations on Lending to the Government for 1980–2006 but now obtain a clear significant negative impact of these CBI measures on economic growth for the period 1990-2013. So, apparently, during the most recent decades, which included the global financial crisis, more independent central banks harmed the economies. Second, we look at those countries that belong to a monetary union (monetary union countries). Now, it is the period 1990–2013 that confirms the significant positive impact of Legal CBI and Limitations on Lending to the Government on the economic growth, which we obtained using the whole time period in our sample. Interestingly, these measures are no longer significant to explain growth during the period 1980–2006, except for the Limitations on Lending to the Government using the GMM estimation. That is, maybe the global financial crisis reinforced the importance of having more central bank independence to promote growth in countries inside monetary unions.

6 Conclusion

This work investigates how the independence of a country's Central Bank can influence its economic growth, by controlling for other variables that are, theoretically and empirically, considered as determinants of economic growth, such as Investment (% of GDP), Government Expenditures (% of GDP), Debt-to-GDP ratio, Government Balance (% of GDP), the inflation rate, the life expectancy, the human capital index, the rule-of-law, the democracy index, the terms of trade, and the R&D Expenditures (% GDP). With this purpose, we analyse a total of, at most, 173 countries for a 48-year period (1970-2017). We also do an analysis of this topic in the specific context of monetary unions. In order to measure Central Bank independence, we use a legal index of Central Bank independence, and another measure of *de facto* independence, corresponding to a dummy of the irregular turnover of the Governor or CEO. We use as measure of economic growth, the growth rate of real GDP *per capita*.

Results show that the Irregular turnover rate of the Central Bank Governor penalizes economic growth

by 0.4 p.p. for the entire sample (0.6 p.p. for countries outside monetary unions). A higher Legal CBI index is positive for growth, but only when restricting to countries belonging to monetary unions. We do a further decomposition of the Legal CBI in its four components and study their impacts in a monetary union context. We conclude that the Limitations on Lending to the Government component is the most important component, having a positive impact on economic growth. That is, there are gains from having a Central Bank with a higher degree of limitations on lending to the public sector (e.g., advances, securities, and maturities). Other components like the Chief Executive Officer (CEO) and the Objectives are harmful for economic growth, since they imply a Central Bank, and its governor, more disattached from Government interests. Finally, the Policy formulation component is not statistically significant to explain economic growth.

We also present several counterfactual exercises for the use of different Legal CBI and Limitations on Lending to the Government indexes in the context of monetary unions. The most striking conclusion is that Euro Area countries are hypothetically better off with its level of Central Bank legal independence, and its component, than they would be if having the level of the Bank of England, the former Deustche Bundesbank, the Federal Reserve, or the Bank of Japan. For last, we do sub-sample analysis by the level of income, the number of crises, the existence of Quantitative Easing (QE) policies, and different time-windows. Inside monetary unions, the Legal CBI penalizes growth for Low and Middle-income countries, whereas it potentiated growth in both 1980-2006 and 1990-2013 periods. For the full sample, using QE policies is harmful for economic growth, which may happen due to the fact that these kind of policies demand a stronger intervention of the Central Bank in the economy when economic growth is sluggish and a Central Bank with a high Legal Central Bank Independence index does not care for economic growth, only for inflation.

On the relationship between Central Bank independence and economic growth, further research might develop a new single measure of independence, combining the legal framework Central Banks are subject to and the actual level of independence, which would allow to capture independence as a whole.

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7 Appendix

The interpretation for each of the four components of the legal CBI is as follows:

- **Central Bank Chief Executive Officer (CEO)** – if the duration of the legal mandate of the CEO is longer and the country's Government has low authority, in legal terms, to appoint and dismiss the CEO, the Central Bank is considered to have more independence.

- **Policy Formulation** – a Central Bank that has a high authority in policy formulation, maintaining it and resisting possible pressures by the government, is considered an independent Central Bank.

- **Objectives** – if the statutory law of the Central Bank defines as its own goal price stability, a Central Bank will be more independent when compared to others that have another objective (besides the first one), even if the second goal does not offset the first. On the other hand, this last type of Central Bank will be more independent than one that includes a contradictory goal with the pursuit of price stability.

- **Limitations on Lending to the Government** – a Central Bank with a higher degree of limitations on lending to the public sector (e.g., advances, securities, and maturities) is considered to be more independent.

Table A1 - Legal CBI - Summary Statistics

	Obs	Mean	Std. Dev.	Min	Max
Full Sample	5659	0.49	0.20	0.02	0.98
Subsamples					
Monetary Union Countries	892	0.71	0.14	0.50	0.86
Non-Monetary Union Countries	4767	0.45	0.19	0.02	0.98
Low-Medium Income Countries	3018	0.53	0.19	0.10	0.98
High Income Countries	906	0.54	0.23	0.12	0.89
Crisis	3550	0.50	0.21	0.02	0.90
No Crisis	1547	0.48	0.21	0.12	0.98
Using QE	890	0.54	0.24	0.10	0.89
Not Using QE	4769	0.49	0.19	0.02	0.98
1990-2013	3665	0.55	0.20	0.12	0.98
1980-2006	3716	0.49	0.20	0.10	0.98
Monetary Union and Low-Medium Income Countries	444	0.66	0.12	0.50	0.80
Monetary Union and High Income Countries	215	0.83	0.08	0.50	0.86
Non-Monetary Union and Low-Medium Income Countries	2574	0.51	0.19	0.10	0.98
Non-Monetary Union and High Income Countries	691	0.45	0.18	0.12	0.89
Monetary Union and Crisis Countries	597	0.70	0.15	0.50	0.86
Monetary Union and No Crisis Countries	199	0.46	0.11	0.64	0.86
Non-Monetary Union and Crisis Countries	2953	0.46	0.19	0.02	0.90
Non-Monetary Union and No Crisis Countries	1348	0.44	0.16	0.12	0.98
Monetary Union and 1990-2013 Time Window	631	0.73	0.13	0.50	0.86
Monetary Union and 1980-2006 Time Window	580	0.70	0.13	0.50	0.86
Non-Monetary Union and 1990-2013 Time Window	3034	0.51	0.19	0.12	0.98
Non-Monetary Union and 1980-2006 Time Window	3136	0.45	0.18	0.10	0.98

Table A2 - Irregular Turnover - Summary Statistics

	Obs	Mean	Std. Dev.	Min	Max
Full Sample	7045	0.11	0.32	0	1
Subsamples					
Monetary Union Countries	323	0.11	0.31	0	1
Non-Monetary Union Countries	4913	0.13	0.34	0	1
Low-Medium Income Countries	3086	0.13	0.34	0	1
High Income Countries	1216	0.07	0.25	0	1
Monetary Union and Low-Medium Income Countries	76	0.13	0.34	0	1
Monetary Union and High Income Countries	189	0.08	0.27	0	1
Non-Monetary Union and Low-Medium Income Countries	2471	0.14	0.35	0	1
Non-Monetary Union and High Income Countries	660	0.07	0.25	0	1

Table A3 - Limitations on Lending to the Government - Summary Statistics

	Obs	Mean	Std. Dev.	Min	Max
Full Sample	5690	0.48	0.26	0	1
Subsamples					
Monetary Union Countries	892	0.67	0.25	0.28	1
Non-Monetary Union Countries	4798	0.44	0.25	0	1
Low-Medium Income Countries	3049	0.51	0.25	0	1
High Income Countries	906	0.57	0.33	0.01	1
Crisis	3571	0.47	0.24	0	1
No Crisis	1547	0.48	0.29	0.01	1
Using QE	890	0.56	0.33	0	1
Not Using QE	4800	0.46	0.24	0	1
1990-2013	3696	0.53	0.27	0	1
1980-2006	3735	0.47	0.25	0	1
Monetary Union and Low-Medium Income Countries	444	0.57	0.19	0.28	0.73
Monetary Union and High Income Countries	215	0.96	0.14	0.28	1
Non-Monetary Union and Low-Medium Income Countries	2605	0.49	0.25	0	1
Non-Monetary Union and High Income Countries	691	0.45	0.27	0.01	1
Monetary Union and Crisis Countries	597	0.61	0.26	0.28	0.73
Monetary Union and No Crisis Countries	199	0.83	0.18	0.63	1
Non-Monetary Union and Crisis Countries	2974	0.45	0.24	0	1
Non-Monetary Union and No Crisis Countries	1348	0.43	0.26	0.01	1
Monetary Union and 1990-2013 Time Window	631	0.71	0.25	0.28	1
Monetary Union and 1980-2006 Time Window	580	0.65	0.24	0.28	1
Non-Monetary Union and 1990-2013 Time Window	3065	0.50	0.26	0	1
Non-Monetary Union and 1980-2006 Time Window	3155	0.43	0.24	0	1