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Understanding the dichotomy of financial development: credit deepening versus credit excess

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Abstract

The Private Credit-to-GDP ratio could have both a positive and a negative interpretation, since it represents both the level of financial development and the aggregate private sector's indebtness. This makes the relationship with its determinants, such as income per capita, more complicated to understand and harder to model. We propose an empirical methodology based on the idea that the long-term relationship between the two follows an s-shaped type of relationship, with a saturation level at the highest levels of income. The shape of the relationship also depends on several institutional and regulatory determinants. Importantly, the observed level of the credit ratio could deviate from its structural level due to the differential effects of medium- and short-term deviations of income, investment, interest rates and other macroeconomic variables. We apply this methodology to a large panel of 83 countries and we find clear evidence supporting a Gompertz-curve type of relationship. We also find different and sometimes opposing effects of different macroeconomic variables in the long, medium and short-run, such as income per capita and interest rates. Remarkably, deviations of the actual credit ratio from the long-term level suggested by the model appear to be an excellent leading indicator of banking crises.

Keywords: credit deepening, financial development, leverage, credit excess, Credit-to-GDP ratio.

JEL: JEL: C33, E43, E44, E51, E58, F47, E61, G01, G18, G20, G21.

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1 Introduction and motivation

It is widely acknowledged in modern economics that a country's level of financial development is closely related to its economic development level, i.e. to its income per capita. The literature on financial deepening is grounded on microeconomic theories about market imperfections that abound in financial and credit markets, particularly at earlier stages of economic development. Consequently, several empirical studies have estimated a positive relationship between different measures of financial development and income per capita. For instance, it is quite usual to measure financial development by the amount of private credit relative to output, i.e. by the Private Credit-to-GDP ratio of a country. Yet, if this is the case, and if there is a linear positive relation between the credit ratio and income per capita, it should follow that such ratio could keep on growing indefinitely if income per capita grows forever as well[1].

However, the Private Credit-to-GDP ratio is also a measure of the private sector's leverage, and thus, it could also be interpreted as a measure of risk. A high Private Credit-to-GDP ratio could both be a sign of a highly developed credit sector and a sign of a highly leveraged private sector as well. Hence, an important question that arises is, how much credit should a country have given its economic development level and how much should be considered risky? And furthermore, how do we account for this duality in the interpretation of the Credit-to-GDP level in an empirical model that relates credit to income per capita?

The literature on financial constraints has primarily focused on informational asymmetries and contracts' incompleteness problems which are more acute in undeveloped institutional and legal environments. More recently, and following De la Torre et al (2013), we can additionally identified collective frictions, which are those frictions that hinder participation and are related to reduced economies of scale, short liquidity and limited risk diversification that are also typical of low income economies.

The relationship-lending literature and the literature on firms' life cycle and investment could also shed some light on the evolution of financial development and its connection to income per capita. If an undeveloped economy is characterized by small, young and opaque firms (or borrowers in general), banks do not have enough information to screen among them and credit should be extremely scarce since informational asymmetries cannot be overcome by any mechanism. As countries start developing and creditors and borrowers build new relationships banks could start lending, thanks to a learning process based on the accumulation of soft information. Different theories and evidence suggest[2] that at the initial stages of a firm-bank relationship, credit is not necessarily too costly (relative to its high intrinsic risk), but is highly dependent on collateral, and therefore, on the existing legal and contractual environment.

Additionally, since the value of pledgeable assets is low in low-income economies, so is the supply of bank credit. As economies become richer and more developed, more firms are able to survive and grow, and thus, the value of their assets increases and they could obtain higher amounts of credit thanks to the higher value of collateral. Furthermore, as firms' relationships with their creditors consolidate, the latter could have more access to verifiable information and longer credit histories. This eases the screening and monitoring processes and firms start having access to unsecured lending. The access to unsecured loans should highly increase firms' leverage and therefore, at this point, the growth in the Private Credit-to-GDP ratio should start accelerating as well. If additionally, the informational and contractual environment improves, and other types

1: This is true, even if we assume a non-linear relationship of the type $Y = \beta(lnX)$, because the elasticity of the credit ratio to income would still be constant. A kind of relationship in which this would not occur is a quadratic-form, such as $Y = \beta_1 X + \beta_2 X^2$, but this type of relationship would imply the unrealistic feature that credit disappears when countries attain very high-income levels.
2: For a review of the literature on financial constraints see Stein (2003), for small business finance and relationship lending see, for instance, Berger et al (1998,2000).

of collateral become available and tradable, credit markets start moving from relationship-based finance to arms-length finance.

At the latest stages of financial development, the growth in credit reinforces itself because it generates the necessary economies of scale and scope necessary to reduce collective frictions. For instance, the appearance of wholesale funding allows banks to increase lending beyond the limits imposed by retail deposits, allowing further increases in leverage and thus, in the Credit-to-GDP ratio. However, as agents increasingly rely on financial markets rather than in banks' lending, the growth in the credit ratio finally starts vanishing. Additionally, provided that banks have to provide more capital the riskier their assets are, they cannot allow that leverage grows indefinitely and the Private Credit-to-GDP ratio should approach an upper limit.

This described evolution of financial development clearly suggests that the relationship between the Private Credit-to-GDP ratio and income per capita should follow a non-linear form with a lower and an upper bound: At the lowest levels of income, the ratio should be close to zero and its sensitivity to income should also be low. At a certain point, the ratio starts growing fast and the sensitivity to income starts growing as well. Then, at a more advanced level, the sensitivity starts decreasing, until the credit ratio approaches a saturation level at the highest levels of income. Therefore, we propose that the relationship between the Private Credit-to-GDP ratio and income per capita follows a non-linear function (S-shaped) that can be well approximated by a Gompertz-curve.

Besides such non-linear S-shaped function, there could be further complications in the estimation of the relation between the credit ratio and income per capita. Firstly, as the recent global financial crisis and several other crises have shown, the financial development process has a "dark side", which is the financial instability related to credit booms/bubbles periods in which credit grows excessively in response to changes in income, investment, interest rates or other variables.

Secondly, the fact that GDP appears in the denominator of the Private Credit-to-GDP ratio suggests that there must be some "negative" effect of a change in output (GDP) in the ratio. Although we have only posted arguments in favor of a positive relationship, there are also reasons to think that not every change in income should have the same effect. If an increase in output (GDP) is perceived by economic agents to be only a short-term temporary change, there should be no reasons for them to increase their leverage in order to invest or consume more. Thus, a short-term increase in output should only affect the denominator in the Credit/GDP ratio and thus, it should have a "negative" impact on it. Similarly, there could be a negative relation if households increase credit levels to smooth consumption at times when their income is temporarily below expected levels.

In order to account for all these possible issues in an empirical estimation, our methodology take advantage of the cross-section and time series characteristic of a panel data and aims to estimate a Gompertz-curve type of relationship using the following assumptions about the relationship between credit depth and income per capita:

1. The Financial development level of a country is related to the most "structural" part of income per capita, i.e. to its long-term level[3]. Thus, we estimate a specific sensitivity of the credit ratio to such long-term component of income.
2. In the medium term, there could be periods of time in which the observed credit ratio is more/less sensitive to deviations of income per capita and investment. We thus assume that there could be a different sensitivity of the ratio to medium-term deviations of macroeconomic variables.

3: We measure the long-term component of income using a long-term (15 years) moving average. We measure medium-term deviations as the difference between the 5-years moving average and the long-term "structural" average, and short-term deviations as the difference between the observed level of the variable and the medium-term (5-years) moving average.

3. Agents may react differently to short-term deviations in income and other variables and thus, we may also observe a different sensitivity in this case.

Additionally, the saturation level and the shape of the relationship between financial deepening and income may also depend on institutional and regulatory determinants such as the degree of creditors' protection, information sharing, banking structure, the long-term evolution of interest rates and so on. Therefore, within the Gompertz-curve framework, we allow each country to have a different saturation level that depends on the long-term level of institutional and structural variables.

Finally, one characteristic of the credit ratio that has usually been ignored by most empirical models is that it cannot take on negative values. Considering the different methodological alternatives to deal with this problem[4], we follow Nichols (2010), Wooldridge (2010) and others and we assume a Poisson-like distribution of the dependent variable[5].

We can summarize the advantages of our methodology with respect to previous studies in the following three assumptions:

1. A more realistic type of relationship between the credit ratio and income per capita (Gompertz-curve).
2. We allow for different sensitivities to macroeconomic variables depending on the time-horizon.
3. We account for the non-negativity of the dependent variable.

We apply this methodology to a large panel of 83 countries between 1990 and 2012. We control for more than 15 institutional and regulatory variables using principal component analysis to reduce multi-collinearity problems. In the same fashion that in the income per capita case, we also allow for different sensitivities of the credit ratio to other macroeconomic variables depending on the time-horizon component (long, medium and short run).[6]

Through our methodology, we find clear evidence in support of a Gompertz-curve kind of relationship and evidence in favor of different sensitivities to income per capita depending on the time-frequency that is considered. First, long-term levels of income per capita have a positive effect on the credit ratio but with an upper-limit; second, mid-term deviations have also a positive, but smaller effect; and finally, short-term deviations have a negative impact on the credit ratio. The difference in these sensitivities is highly robust to the use of other methodologies and specifications. Moreover, we find that the investment ratio has similar effects to those of income per capita, and furthermore, the effects of income and investment reinforce each other in the medium-term.

With respect to the institutional and regulatory determinants included in our empirical specification, we can summarize our main findings as the following:

- Higher information sharing (higher private bureaus coverage, higher quality of information and higher public registries agencies' coverage) has a clear positive sign on credit deepening.
- A better legal environment has an important positive impact on credit deepening.
- A higher restriction on banking activities seems to have a positive effect on the credit ratio.
- We do not find conclusive evidence on the effect of banking concentration on the level of credit deepening. However, the effect of a higher difficulty to the entry of new banks is indeed negative and significant.

4: Log-regression, tobit-regression, negative-binomial regression and Poisson regression
5: We assume the following specification: $Y = \exp(\beta' X)\,\epsilon$. However, we do not specifically use Poisson regression, but we directly use non-linear estimation techniques.
6: The macroeconomic variables include the investment ratio, short-term real interest rates, real banks' spread and the inflation rate.

- A higher degree of inequality has a negative and significant effect on the credit ratio.
- As expected, higher regulatory capital-to-risk weighted assets have a strong negative effect on financial deepening. A higher capital requirement ratio has a negative, although non-significant impact.
- Financial openness (specially deviations from the long-term average) has a positive impact.

The importance of our results can be summarized as follows:

1. We find evidence supporting a Gompertz-curve relationship between the credit ratio and income per capita, including a saturation level.
2. We find evidence supporting different sensitivities of the credit ratio to income per capita in the long, medium and short run.
3. We also find new interesting effects of interest rates on the credit-to-GDP ratio. More specifically, we find that the short-term interest rate (money-market) have a positive and significant effect in the long and medium term, and a negative and non-significant effect in the short run. These effects are not only counterintuitive but they could be important to understand some unwanted effects of monetary policy.
4. The different sensitivities allow us to estimate a "structural" level of the credit ratio related to the long-term components of the explanatory variables and by the institutional framework of each country.
5. This estimated "credit gap" appears to be an extremely good predictor of banking crises as we show through an empirical exercise.
6. Despite the large heterogeneity of countries included in the analysis, the model does an excellent job in terms of goodness of fit compared to other alternatives.

The rest of the paper is organized as follows: Section 2 reviews the main theoretical and empirical literature related to our study. Section 3 describes our methodological strategy. Section 4 shows and discusses the main findings. Section 5 discusses some implications of our empirical findings. Section 6 describes a series of robustness exercises. Section 7 relates the estimated "credit gaps" to the probability of a banking crisis. Section 8 concludes.

2 Literature review

2.1 The relationship between financial and economic development

The economic literature portraying financial development as a determinant of economic growth is abundant and could be traced back to Bagehot (1873), Schumpeter (1911) and Goldsmith (1969)[7]. However, the literature explaining the inverse causal relationship is more scarce, particularly the theoretical one. Additionally, most of the theoretical literature on the determinants of bank credit has a microeconomic rather than a macroeconomic nature, and the one explaining credit at an aggregate level has only flourished recently after the onset of the global financial crisis[8]. For that reason, in this section we only concentrate in the most recent studies that have explored the relationship between credit and income per capita at an aggregate structural level, which are, Beck et al (2008), De la Torre et al (2013) and Barajas et al (2013). Additionally, we review some paradigms in the firm's financial growth cycle in order to construct an analogy with a country's financial development.

De la Torre et al (2013) is the study that focus more on explaining the financial development process itself and its inter-relation with economic development. They argue that the sequence and shape of financial development reflects the intensity and mix of four fundamental frictions that raise the risks and costs of financial transacting (asymmetric information, costly enforcement, collective action, and collective cognition). Based on this frictional environment, a financial system is more or less successful depending on the stage of development, the effectiveness of public policy, and the forces of competition, innovation and regulatory arbitrage. They argue that financial development evolves basically due to the gradual easing of finance frictions. The easing of collective action frictions through increased participation, interconnectedness and network effects gives rise to increasing returns, suggesting that the path of development is characterized by convexity and critical mass effects. At the same time, demand effects (differential growth rates), supply effects or financial crashes, affect the path followed by undeveloped countries.

They also point out that financial development has a dark side, as reducing the frictions associated with one paradigm can exacerbate the failures associated with the same paradigm or with another paradigm. Thus, financial development can of itself lead to financial instability. For instance, resolving the frictions that limit participation in the good times can lead to collective action failures when agents withdraw in the bad times. Or by promoting short-term, wholesale lending, the easing of information frictions can exacerbate exposure to free riding and other collective action failures.

A closely related paper is the one by Barajas, A., Beck, T., Dabla-Norris, E, and Yousefi, R. (2013) which is based on an earlier work by Beck et al (2008). They introduce the concept of the financial possibility frontier as an optimum level of financial development. This frontier is based on institutional, macroeconomic, structural characteristics (e.g., income, size, and demographic characteristics) and other fundamental factors that impact financial system deepening. They define the financial possibility frontier as a constrained equilibrium of realized supply and demand, affected by market frictions. In other words, it is the maximum sustainable depth, outreach or breadth of a financial system that can be achieved at a given point in time.

They argue that the main reasons why the financial possibility frontier may be low relative to countries at similar levels of economic development are low population density, small market size, informality, the absence of an adequate legal, contractual and institutional environment and persistent macroeconomic instability. For instance, limited capacity to enforce contracts and poor protection of property rights can

7: Arcand, Berkes, Panizza (2011).
8: To the best of our knowledge, literature is still lacking a theoretical, mathematical-based model on this issue.

discourage long-term investments and arms-length financial contracting. Similarly, persistent macroeconomic instability can prevent deepening of markets for long-term financing.

Additionally, they identify reasons that make that a financial system lies below the frontier. On the demand-side the number of loan applicants could be low due to self-exclusion or to the lack of viable investment projects in the economy. On the supply-side, there are factors such as the lack of competition, regulatory restrictions or barriers, weak creditor information or opacity of financial information about firms. Finally, the financial system can move beyond the frontier, indicating an unsustainable expansion of the financial system beyond its fundamentals. For instance, "boom-bust" cycles in economies can occur in the wake of excessive investment and risk taking.

Moving beyond the recent literature, and given that the economic literature has not yet fully explained the determinants of financial development at an aggregate level, we can borrow ideas from microeconomic and finance theory. Since the credit-to-GDP ratio in an economy is conceptually similar to a leverage ratio at the firm level, we can rely on the literature on firms' life cycle and investment and the relationship-lending literature to draw a parallel between the evolution of the capital structure of a firm as it grows and that of a country as it develops[9].

When firms are young and small, they usually do not have any credit record that can be used by banks to screen among them, they usually do not have audited financial statements that can be shared with possible creditors, and they usually lack any kind of assets that could be pledged as collateral. As a consequence, they finance basically through internal funds and informal sources of credit. Thus, if an economy is characterized by small, young and informal (opaque) firms (or borrowers in general) as is the case of undeveloped economies, credit should be extremely scarce since informational asymmetries cannot be overcome by any mechanism.

As countries start developing and creditors and borrowers build new relationships (initially through current accounts and payment services) banks could start lending, thanks to a learning process based on the accumulation of soft information. Different theories and evidence suggest[10] that at the initial stages of relationship-lending, bank credit is not necessarily too costly (relative to its high intrinsic risk), but is highly dependent on pledgeable (and tangible) collateral, This clearly suggests that an aggregate level, the legal environment could be extremely important, i.e. how strongly regulation protects creditors, how easy the judicial system allows the enforcement of contracts and how easy or costly is to verify the existence and property rights of collaterizable assets.

Additionally, since the aggregate value of pledgeable assets is low in low-income economies, so is the supply of bank credit. As economies become richer and more developed, more firms are able to survive and grow, and thus, the value of their assets increases and they could obtain higher amounts of credit thanks to the higher value of collateral. Furthermore, as the relationships of firms with their creditors consolidate, the latter could have more access to verifiable information and longer credit histories. This eases the screening and monitoring processes and firms start having access to unsecured lending. The access to unsecured loans highly increases firms' leverage since the amount of granted loans could grow beyond the book value of assets. Therefore, at a certain intermediate point of economic and financial development, the growth in the Private Credit-to-GDP ratio should start accelerating as well. If additionally, the informational and contractual environment improves (private bureaus), private information becomes public, and other types of collateral become available and tradable, financial markets start moving from relationship-based finance to arms-length finance.

9: For an extensive review on the economics of small business finance see Berger and Udell (1998).
10: See for instance Rajan and Petersen (1995), Kim, Kristiansen and Vale (2008) and Ugarte (2011).

At the latest stages of financial development, the growth in credit reinforces itself because it generates the necessary economies of scale and scope to reduce collective frictions. As credit markets become deeper, the higher number of participants and transactions turn them more liquid, interconnected and it becomes easier to diversify risk. For instance, the appearance of wholesale funding allows banks to increase lending beyond the limits imposed by retail deposits, allowing further increases in leverage and thus, in the Credit-to-GDP ratio.

However, mature and large firms increasingly rely on the sale of equity through financial markets rather than on banks' lending thanks to the increasingly amount of public available information. For instance, they enter into contracts with their labor force, suppliers and customers that are publicly visible or reported in the press, they have long track records and audited financial statements. Therefore, firms' leverage ratio level usually stabilizes and, if they are financially successful, it converges to firms' optimal capital structure.

In the aggregate level this suggests the growth in the credit ratio finally starts vanishing when countries are in an advanced stage of economic development. If countries are able to optimize their "capital structure", their private credit-to-GDP ratio should also stabilize at some point. Additionally, provided that banks have to provide more capital the riskier their assets are, they cannot allow (at least in theory) that leverage grows indefinitely and the private credit-to-GDP ratio should approach an upper limit.

This described evolution of financial development clearly suggests that the relationship between the private credit-to-GDP ratio and income per capita should follow a non-linear form with a lower and an upper bound: At the lowest levels of income, the ratio should be close to zero and its sensitivity to income should also be low. At a certain point, the ratio starts growing fast and the sensitivity to income starts growing as well. Then, at a more advanced level, the sensitivity starts decreasing, until the credit ratio approaches a saturation level at the highest levels of income. Therefore, we propose that the relationship between the Private Credit-to-GDP ratio and income per capita follows a non-linear function (S-shaped) that can be well approximated by a Gompertz-curve.

2.2 Empirical studies

Most of the recent work related to the determinants of credit or financial development could be broadly classified in three branches: 1) Models fitting individual time series or panel cointegration techniques 2) Panel data models focused on policy or regulatory determinants and 3) A recent line of research that intends to estimate a certain benchmark or structural level of financial development and to explain the observed gaps with respect to such benchmark levels with a different set of variables.

The first group of studies is, in general, worried about estimating equilibrium levels of credit and possible short-term disequilibria taking advantage of cointegration techniques, usually by relating credit and the respective explanatory variables in levels. For instance, Hoffman, B. (2001), analyses the determinants of credit to the private sector in 16 industrialized countries since 1980. He identifies long-run relationships linking real credit positively to real GDP and real property prices and negatively to the real interest rate. Other studies argued that the private credit-to-GDP ratio is itself non-stationary and have thus applied panel cointegration methodologies. These models usually rely on data from developed economies and on a relative small group of macroeconomic explanatory variables[11]. For instance, Kiss, G., Nagy, M., and Vonnák, B. (2006), study whether the strong observed growth in credit in several eastern European economies was an equilibrium convergence process or whether they could pose stability risks. Egert, B., Backé, P. and Zumer, T. (2006) use estimation results from a panel of small open OECD economies (out-of-

11: The estimation of a panel dataset with a small number of countries (small N) and a large number of time-observations (large T) should warrant a careful treatment of a possible non-stationarity of the dependent and explanatory variables. However, as some of these studies recognize, the different panel unit-root tests of the Credit-to-GDP ratio seem to provide mixed and inconclusive results at best.

sample panel) to derive the equilibrium credit levels for a panel of transition economies (in-sample panel). As any other methodology based on time series, an obvious caveat of this line of analysis is that it cannot take into account variables that are time-invariant or with very little time variation.

A second vein of research more related to ours, is interested in estimating the impact of different policy or institutional variables which in general display a rather low or null time-variation. They therefore rely on panel-data or cross-country methodologies. For instance, Jankov, S., McLiesh, C., and Shleifer, A. (2007) fit cross-country regressions, and both fixed and random-effects models to estimate the impact of information and legal structure in the level of Private Credit. Theirs is the first empirical exercise that studies the effects of the legal creditor protection and of information sharing institutions, Cottarelli, C., Dell.Ariccia, G., and Vladkova-Hollar, I. (2005) estimate a random effects model to determine the structural level of financial deepening in a number of eastern european countries. They include as determinants the public debt ratio, the log of GDP per capita, the inflation rate, a liberalization index, an indicator of bank entry restricitions, an indicator of the quality of accounting standards and a dummy variable for legal origin. Becerra, O., Cavallo, E., and Scartascini, C. (2010) choose to use a simple cross-section specification.

Finally, and especially after the outset of the global financial crisis, a third line of research has emerged trying to estimate a structural level of financial development according to a benchmark based on cross-country information. They also explore what determines that a country is below or above such level. Our work could be clearly classified into this strand of the literature. One of the earliest works is that of Beck, T., Feyen, E., Ize, A., and Moizeszowicz, F. (2008) who propose a standard methodology for benchmarking the policy component of financial development. They run pooled OLS regressions of different indicators of financial development on a set of controls GDP per capita, poverty gap, population size, population density, fuel exports to GDP and a dummy for offshore countries. They do not include other policy indicators in the regressions assuming that their effect would be recovered in the residuals (gaps) which are then analyzed as a function of different policy variables.

Barajas, A., Beck, T., Dabla-Norris, E, and Yousefi, R. (2013) derive a benchmarking model that relates a country's level of financial development over time to a statistical benchmark, obtained from a large panel regression. Later on, they relate the difference between the actual level of financial development and the level predicted by structural characteristics, to an array of policy variables. They are able to show that an overshooting of the financial system significantly beyond levels predicted by its structural fundamentals is associated with credit booms and busts.

De la Torre, A., Feyen, E. and Ize, A. (2013) use a battery of indicators of financial markets and institutions to explore whether the data supports the theoretical predictions derived from their four financial frictions paradigms. They use a panel data approach with a set of structural controls, including per capita income, and the size, density and age distribution of a country's population, to create a uniform benchmark that facilitates comparisons across countries. Then, they explore possible reasons underlying gaps in financial development relative to the benchmark. They find that financial crashes, rather than financial volatility per se, can account for large and lasting lags in private credit depth. Demand effects, as proxied by past output growth, can also account for substantial cross-country differentials in financial depth. Enabling environment factors such as enforcement costs, and creditor or property rights also play an important role, albeit more limited than stability or demand effects. They also find that informational frictions are easier to overcome than contractual frictions.

2.3 Other determinants of financial deepening

In this section we briefly described what the economic literature says about other determinants of credit deepening, financial frictions or credit in general, beyond income per capita:

- Creditors' legal protection: On the one hand, a strong creditor protection can mitigate the cost of contracts incompleteness, Beck et al (2006), Jankov et al (2007), Ugarte (2011), Perea et al (2013), Barajas et al (2013), but on the other hand, it could also generate "lazy-banks" behavior, inducing banks to offer only cheap collateralized credit and to reduce screening, Manove, Padilla and Pagano (2007).
- Registering Property: If registering property is too costly or too difficult it is also difficult for financial institutions to verify the existence and true property rights of collateralizable assets, Beck et al (2006), Jankov et al (2007), Ugarte (2011), Perea et al (2013).
- Contracts enforcement cost: If judicial institutions are not efficient and enforcing contracts is too costly or too difficult, credit should be more costly or more difficult to access as predicted by diverse incomplete contracts theories, see Demirguç-Kunt and Maksimovic (1998), Beck et al (2006), Jankov et al (2007), Ugarte (2011).
- Credit Information Quality: A higher quality of information should reduce informational asymmetries and facilitate screening. Beck et al (2006), Jankov et al (2007), Ugarte (2011), Perea et al (2013).
- Private and public bureaus coverage: Private bureaus should help reducing informational asymmetries. However, a higher availability of information without an appropriate quality of information (details) could simply reduce the number of eligible borrowers. Beck et al (2006), Jankov et al (2007), Ugarte (2011), Perea et al (2013).
- Restrictions on New Participants Entry: High regulatory entry barriers might reduce the contestability and thus competitiveness of the banking system, independent of the actual market structure, Cotarelli (2003).
- Restrictions on Banking Activities: Regulatory restrictions in the intermediation process, on the other hand, do not have apriori clear relation with access to credit. These restrictions might decrease the competitiveness and efficiency in the banking system. Restricting banks' activities, however, might also increase their competition in the area they are limited to, increasing the acces to credit, Beck et al (2006).
- Banking Sector Concentration: The structure-performance hypothesis predicts a negative relation between bank concentration and access to credit due to market power inefficiencies, while the information-based hypothesis predicts a positive or nonlinear relation, Petersen and Rajan (1995), Pagano (1993), Guzman (2000), Boot and Thakor (2000).
- Regulatory Capital & Capital Requirements Higher capital should reduce the funds available to lend.
- Bank Spread: Besides representing the price of bank credit, a higher spread is usually associated to less efficient banking systems and to a riskier environment. However, it has an endogenous component that could be positively correlated to credit.
- Inflation: Countries with lower inflation rates experience higher levels of financial development, meanwhile higher inflation rates are associated to a higher probability of systemic banking crises, Barajas et al (2013), Demirguç-Kunt and Detragiache, (1998,2005).
- Short-term interest rates (money market): At first, we would expect that the level of credit or its growth rate decreases after an increase in interest rates (because of a price effect on the demand for credit. However, the effect on the aggregate credit-to-GDP ratio could be more involved and its effect on the ratio is actually not clear-cut defined in the literature.

- Investment: is one of the main drivers of the demand for credit and investment booms usually require or induce credit booms.
- Inequality: In countries with a highly unequal income distribution there could be a large part of the population without opportunities to access credit or investment.
- Financial Openness: It allows a higher flow of foreign capital and liquidity into the local credit market, Laeven (2003) and Gelos and Werner (2002).
- Population Density: According to the relationship banking literature, tighter relationships between lenders and creditors due to a closer distance could highly improve the access to credit, Degryse and Ongena (2005).

3 Methodology and model specification

We propose a methodology based on the idea that the long-term relationship between the Private Credit-to-GDP ratio and income per capita follows a logistic type of relationship with a saturation level at the highest levels of income, i.e. a Gompertz-curve type of relationship.

We prefer this specification since other alternatives present several caveats. Defining C/Y as the private credit ratio, and Ypc as the income per capita we have that a simple linear specification, or a regression of the type $C/Y = \beta(\ln \mathrm{Ypc})$ would imply that the credit ratio could increase indefinitely as long as income per capita keeps on growing, since the elasticity β is constant. Every extra dollar would increase private sector's leverage up to infinity. This problem would not disappear even if we measure income per capita in real and PPP-adjusted terms (as we do in our empirical exercise).

A kind of relationship in which this would not occur is a quadratic form, such as $C/Y = \beta_1 Ypc + \beta_2 Ypc^2$, but this type of relationship would imply the unrealistic feature that credit disappears when countries attain very high-income levels. Another possibility for dealing with non-linearities is to perform split-sample regressions, but in this case we would need to know ex-ante the threshold points of income per capita where the sensitivity changes. A Gompertz-curve has the advantage of providing a smooth path for financial development with an explicit upper limit (saturation) and to obtain an estimation of the possible levels of economic development where the relationship between the variables changes.

Thus we first assume the following relationship between the credit ratio and income per capita:

$$\frac{C}{Y} = \alpha \cdot \exp(\gamma \cdot \exp(\beta \mathrm{Ypc}) \quad (1)$$

Where α is the constant "maximum" saturation level. If there were no other variables in place, this is the level that a country will approach as long-term per capita income tends to infinity. γ is the parameter that defines the curvature of the Gompertz curve and β defines the sensitivity to income per capita, We estimate the regression using non-linear maximum likelihood techniques. One caveat of this methodology is that there are no specific techniques designed to deal with panel data. However, we rely on the fact that using robust standard errors clustered by countries we are able to account for the possible serial-correlation within country-panels, and thus we are applying a similar approach to that of the GLS random-effects estimator. Thus, our methodological strategy is similar to using OLS with robust-cluster standard errors[12].

Another advantage of using a non-linear estimation technique is that we are able to account for an additional characteristic of the credit ratio that has usually been ignored by most of previous empirical studies, which is the fact that the ratio cannot take negative values. Considering the different methodological alternatives to deal with this problem[13], we follow Nichols (2010), Wooldridge (2010) and others and we assume a Poisson-like distribution of the dependent variable. Thus, we assume the following specification:

$$\frac{C}{Y} = \exp[\alpha \cdot \exp(\gamma \cdot \exp(\beta \mathrm{Ypc})] \quad (2)$$

However, we do not specifically use Poisson regression, since the applied methodology already allows us to deal with non-linearities in the specification.

As explained in the introduction, besides the described non-linearities problems, we are also interested in estimating and testing whether the sensitivity of the credit ratio to income per capita and to other explanatory

12 Although this may look initially as a caveat, it could actually be an advantage, since we are interested in estimating long-term structural coefficients that depend on the cross-country (between) variation that is swept away when using a Within-estimator. Or, in the case of using a GLS random-effects, it is known that the cross-country information contained could be ignored if the "between" variance is much higher than the "within" variance because in such case the GLS random-effect estimator tends to the "within" estimator. That would clearly be the case of the Private Credit-to-GDP ratio, since the cross-country variance accounts for nearly 85% of the total variance.
13 Log-regression, tobit-regression, negative-binomial regression and Poisson regression.

variables could differ in the long run versus the medium or the short run. The idea that there could be different sensitivities is based on the notion that the structural relationship between credit depth and income per capita originates in a long-term process of development, whereas the actual credit ratio could diverge from such structural relation in the medium-term and in the short-run. For instance, episodes of credit booms/bubbles are medium-term processes in which credit grows excessively in response to changes in income, investment, interest rates or other variables. Therefore, the sensitivity of the credit ratio to such changes in the medium term may differ from the sensitivity to these variables' long-term levels.

Similarly, the fact that GDP appears in the denominator of the Private Credit-to-GDP ratio suggests that there must be some "negative" effect of a change in output (GDP) in the ratio. For instance, if an increase in output (GDP) is perceived by economic agents to be only a short-term temporary change, there should be no reasons for them to increase their leverage in order to invest or consume more. Thus, a short-term increase in output should only affect the denominator in the Credit/GDP ratio and thus, it should have a "negative" impact on it. Similarly, there could be a negative relation if households increase credit levels to smooth consumption at times when their income is only temporarily below expected levels.

Consequently, we take advantage of the cross-section and time series characteristic of a panel data and estimate the Gompertz-curve type of relationship using the following assumptions about the relationship between the dependent variable and income per capita:

1. The Financial development level of a country is related to the most "structural" part of income per capita, i.e. to its long-term level. We measure the long-term component of income using a long-term (15 years) moving average[14]. Thus, we estimate a specific sensitivity of the credit ratio to such long-term component of income.
2. In the medium term, there could be periods of time in which the observed credit ratio is more sensitive to deviations of income per capita and investment. We thus assume that there could be a different sensitivity of the ratio to medium-term deviations of macroeconomic variables. We measure medium-term deviations as the difference between the 5-years moving average and the long-term "structural" average.
3. Agents may react differently to short-term deviations in income and other variables and thus, we may also observe a different sensitivity in this case. We measure short-term deviations as the difference between the observed level of the variable and the medium-term (5-years) moving average.

Therefore, we extend the specification shown in (2) and include different sensitivities to income per capita:

$$\frac{C}{Y} = \exp[\alpha \cdot \exp(\gamma \cdot \exp(\beta_{LT}\overline{Ypc}_{it}^{15yr} + \beta_{MT}\widetilde{Ypc}_{it} + \beta_{ST}\widehat{Ypc}_{it})] \quad (3)$$

Where $\overline{Ypc}_{it}^{15yr}$ represents the long-term (15 years) moving average of GDP per capita, $\widetilde{Ypc}_{it}$ represents the medium-term deviation of income per capita with respect to its long-term level, i.e. $\widetilde{Ypc}_{it} = (\overline{Ypc}_{it}^{5yr} - \overline{Ypc}_{it}^{15yr})$, and $\widehat{Ypc}_{it}$ represents the short-term deviation of the observed income per capita with respect to its medium-term (5-years) moving average, i.e. $\widehat{Ypc}_{it} = (Ypc_{it} - \overline{Ypc}_{it}^{5yr})$. Therefore, β_{LT} , β_{MT} and β_{ST} represent the long, medium and short-term sensitivities to per-capita income respectively.

In addition to the different sensitivities of the credit ratio to income per capita, we also estimate different sensitivities to other macroeconomic variables according to the time-horizon components. Moreover, the saturation level and the shape of the relationship between financial deepening and income should depend on institutional and regulatory determinants such as creditors' protection, information sharing, banking structure, the long-term evolution of interest rates and so on. Therefore, within the Gompertz-curve framework, we

14 Initially, we could think of the structural or long-term part of financial development to be determined by "between" countries differences, and therefore, we could estimate such structural relationship using a "between" estimator, i.e. by a "cross-section" regression on country means. However, given the dynamic characteristic of income per capita, we keep the same idea of estimating the structural relationship using long-term means, but allowing them to change in time, simply using a long-term moving average.

allow each country to have a different saturation level that depends on the long-term level of institutional and structural variables:

$$\frac{C}{Y} = \exp[\{\alpha\} \cdot \exp(\gamma \cdot \exp(\beta_{LT}\overline{Ypc}_{it}^{15yr} + \beta_{MT}\widetilde{Ypc}_{it} + \beta_{ST}\widehat{Ypc}_{it}) + \emptyset_{LT}\bar{X}_{it}^{15yr} + \emptyset_{MT}\tilde{X}_{it} + \emptyset_{ST}\hat{X}_{it} + \eta_i + \upsilon_{it}] \quad (4)$$

Where $\bar{X}_{it}^{15yr}$ represents the long-term (15 years) moving average of an explanatory variable across all sample years, $\tilde{X}_{it}$represents the medium-term deviation of a variable with respect to its long-term level, i.e. $\tilde{X}_{it} = (\bar{X}_{it}^{5yr} - \bar{X}_{it}^{15yr})$ and $\hat{X}_{it}$represents the short-term deviation of the observed variable with respect to its medium-term (5-years) moving average, i.e. $\hat{X}_{it} = (X_{it} - \bar{X}_{it}^{5yr})$. Therefore, ϕ_{LT} , ϕ_{MT} and ϕ_{ST} represent the long, medium and short-term sensitivities to an explanatory variable respectively.

An important clarification is that in the case of the macroeconomic determinants we include as the long-term component the 15-years moving average, whereas for the institutional or structural variables we only include their simple country average ($\bar{X}_i$) and their deviation from such country-average. This different treatment of variables derives from the fact that the institutional and structural variables have a lower availability of data and because most of them display a very low or almost null variability across time. In some cases, the between-countries variance represents nearly 99% of the total variance.

Finally, η_i represents some specific country-dummies that we include in order to control for unobserved country variables. It is important to clarify that we are not estimating a LSDV model, since we do not include one dummy variable per country, but only a selected set of them. If we were to include one dummy variable per country we would not be able to estimate the long-term (between) effects of the institutional variables. We choose which country dummies to include depending on their statistical significance and on whether the obtained residuals display a time-constant non-zero mean.

Another important feature of our model is that we include a set of interaction terms between the medium and short-term components of income per capita and the investment rate. These interactions terms aim to capture possible reinforcement effects of a contemporaneous boom of income and investment which characterizes any bubbly episode. Besides including an interaction term for each component, we estimate different coefficients depending on the sign of the interaction. For instance, we expect a boom in investment to have a larger effect if it is accompanied by a boom in income per capita, but to have a smaller or null effect if they are not contemporaneous, i.e. a positive deviation of investment in the medium-term coincides with a negative deviation of income in the same period.

Finally, one of the main difficulties we face in the estimation is the large number of control variables, the high correlation among many of them and the high correlation with many institutional variables with income per capita. As a result, there is a very high degree of multi-collinearity in the data. Therefore, we decided to follow two complementary strategies. First, we regress those variables with an especially high correlation with income per capita against this variable and we use the estimated residuals instead of the original variables. However, in many cases the transformed variables and the rest of original variables still present a very high correlation among them. In this case, we perform a principal component analysis on those theoretically more affine variables in order to reduce the number of regressors and to retain only those that were orthogonal to each other.

We apply our proposed methodology to a large (unbalanced) panel dataset of 83 countries between 1990 and 2012 and a total of 1683 observations. The analysis includes around 20 explanatory variables that can be broadly classified into macroeconomic determinants, regulatory and institutional variables and structural determinants. As explained in the methodology section, the macroeconomic variables are the ones that are decomposed into three time components, whereas in the case of the institutional, regulatory and structural variables we only include their long-term (country) average and its deviation.

In Appendix A1 we described in detail our dataset and other transformations to the variables used in the analysis.

As a conclusion, we can summarize the main advantages of our methodology with respect to previous empirical exercises exploring the determinants of credit depth in the following three assumptions:

a. A more realistic type of relationship between the credit ratio and income per capita (Gompertz-curve);

b. We allow for different sensitivities to macroeconomic variables depending on the time-horizon (frequency).

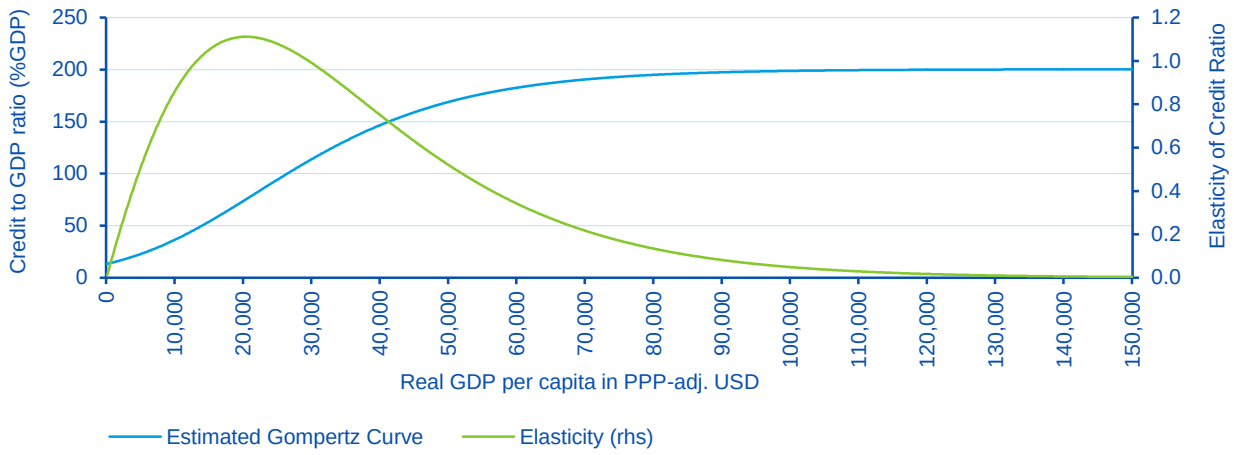
c. We account for the non-negativity of the dependent variable.

4 Summary of results and empirical findings

In Table 1 we show the results of our final model specification described by equation (4) versus the results of relaxing two important methodological assumptions in the estimation: the Gompertz-curve functional form and the non-negativity of the dependent variable in the estimation methodology.

The first thing to notice about the results is that the parameters that determine the shape of a Gompertz curve, i.e. alpha, gamma and the GDP per capita coefficient are all significant and they have the correct expected sign. It is important to explain that in order to obtain an s-shaped Gompertz-curve, the parameter gamma must be negative and the coefficient of GDP per capita must have the opposite sign to its final impact, i.e. if the impact is positive, we must obtain a negative coefficient in the estimation. In Figure 1 we can see a depiction of the Gompertz Curve that we would obtain according to the estimated parameters, alpha, gamma and the sensitivity to the long-term component of GDP per capita.

Figure 1
Shape of Gompertz curve according to estimated parameters



Source: BBVA Research

Additionally, the sign of the sensitivities to GDP per capita are clearly different in the long, medium and short run. The sensitivities are both positive in the long run and medium term, but negative in the short run. This result indicates that, as expected, credit deepening is positive and significantly correlated to the income per capita level in the long-term. They also indicate that credit is sensitive to medium-term deviations of income, but differently from what we initially expected it is less sensitive in the medium than in the long run.

Finally, the sensitivity to short-term deviations of income is clearly negative, which supports the theory that agents react differently if they perceive that a change in income is only a short-lived temporary one. It is important to mention that it would not be possible to find these results if we had not decomposed the effects of macroeconomic variables into long, medium and short-term effects, as we can see in Table 23 of the following section where we compare the results from our final specification to other four more basic methodologies which assume a unique sensitivity per variable.

Summarizing, we find clear evidence in support of a Gompertz-curve kind of relationship and evidence in favor of different sensitivities to income per capita depending on the time-horizon that is considered. First, the long-term level of income have a positive correlation with the credit ratio but with an upper-limit; second, medium-term deviations have a positive, but smaller impact on the credit ratio; and finally, short-term

deviations have a negative impact. The difference in these sensitivities is highly robust to the use of other methodologies and specifications, as it can be seen in the robustness checks shown in Appendix A2.

A second important result is that we find that the impact of the investment ratio in the long and medium-term are positive and significant and the medium-term sensitivity is clearly higher than the long-term one, supporting the view that investment booms are also important to explain credit booms themselves. Investment does not seem to be significant in the short-term. Moreover, the interactions between income per capita and investment are clearly positive and significant in the medium and short run, which suggests that investment may reinforce income during credit booms/bust episodes. Even though these results may look pretty intuitive, to the best of our knowledge this is the first study to include the investment ratio as a determinant of the private credit ratio. This could be due to the fact that if we had estimated only one sensitivity to investment, it would have turned out non-significant, as it can be seen in Table 2 in the next section.

With respect to the institutional, structural and regulatory determinants included in our empirical specification, we can summarize our main findings as the following:

- A higher quality of information in a country has a clear positive sign on credit deepening in the long run. Interestingly, a higher availability of information seems to have a negative effect in the short run, although altogether the effect is clearly positive.
- A higher coverage of both private bureaus and public registries agencies' are found to have a positive effect on credit deepening. However, the effects of public registries seem to be much larger than that of private bureaus.
- A better legal environment, i.e. a higher "rule of law" together with a stronger creditors' protection is found to have a strong positive effect, especially in the long run.
- A higher restriction on banking activities seem to have a positive effect on the credit ratio, possibly due to a higher concentration of banking activities in the credit market (core business).
- A higher restriction on the entry of new participants (new banks' entry) appears to have a negative effect on financial deepening. In the same fashion, a less competitive banking structure (higher concentration) seems to be harmful to financial deepening, although its effect is non-significant.
- Higher inequality (a higher Gini coefficient) have a clear negative and significant effect on the credit deepening level.
- Again, as expected, higher capital requirements have a strong negative effect on financial deepening.
- We find a positive effect of financial openness, but only in the short run.

Table 1

Regression results: final model vs. models without main assumptions: without Gompertz Curve, or without poisson assumption

VARIABLES	Number of countries=83 Number of obs=1683 R2 = 0.9807 Adjusted R2 = 0.9805			Number of countries=83 Number of obs=1683 R2 = 0.9759 Adjusted R2 = 0.9746			Number of countries=83 Number of obs=1683 R2 = 0.9568 Adjusted R2 = 0.9545		
	Long-Term	*Mid-term*	*Short-term*	*Long-Term*	*Mid-term*	*Short-term*	*Long-Term*	*Mid-term*	*Short-term*
Gompertz Curve Determinants	FINAL MODEL			GDP PC IN LOGS			NO POISSON ASSUMPTION		
Alpha	5.456***			-2.93***			164.6***		
	0.164			0.270			10.798		
Gamma	-0.7678***								
	0.034								
GDP per capita PPP	-0.0417***	-0.0237***	0.0574***	0.7085***	0.6503***	-1.53***	-0.0534***	-0.0276**	0.192***
	0.004	0.005	0.010	0.028	0.123	0.212	0.005	0.014	0.030
Interaction between GDP pc and Investment		-0.2906	-2.17***		0.0107***	16.97***		-1.13***	-2.84***
		0.200	0.429		0.002	5.940		0.373	0.750
Macro Variables									
ST Real Interest Rate	0.1710***	0.1710***	-0.0115	0.1184**	0.1533***	-0.0173	-3.01	0.8701	-2.83
	0.053	0.044	0.026	0.060	0.051	0.029	2.617	3.141	1.931
Banks' Real Interest Rate Spread	-0.1233***	-0.0632*	0.0228	-0.2196***	-0.1005***	0.0111	-8.99***	-5.74***	-4.11***
	0.027	0.032	0.025	0.031	0.034	0.026	2.214	1.962	1.577
Inflation Rate	-0.0522*	-0.1235**	-0.0407	-0.1407***	-0.1475**	-0.0698**	-7.03***	-2.87	-7.92***
	0.031	0.055	0.031	0.031	0.058	0.035	1.409	2.947	2.178
Investment to GDP Ratio	2.075***	2.091***	-0.4423	0.5722**	1.882***	0.5998	41.52**	18.40	-25.7
	0.264	0.261	0.305	0.255	0.288	0.554	20.099	19.835	16.685
VARIABLES	FINAL MODEL			GDP PC IN LOGS			NO POISSON ASSUMPTION		
Structural Determinants				Structural Determinants			Structural Determinants		
Information Quality Index	0.1898***	-0.0537***		0.1816***	-0.1122***		14.55***	-2.74***	
	0.017	0.0121		0.017	0.0144		1.740	0.8305	
Private Bureau Coverage	0.0021***	0.0012*		0.0005	0.0018**		-0.0639	-0.0349	
	0.000	0.0007		0.000	0.0008		0.049	0.0535	
Public Registries Coverage	0.0147***	0.0021*		0.0095***	0.0008		0.6084***	0.2049*	
	0.001	0.001		0.001	0.001		0.100	0.112	
Legal Environment	0.2756***	0.0284		0.2420***	0.0468		15.36***	7.742***	
	0.016	0.035		0.018	0.038		1.151	2.097	
Legal Costs	0.0064	-0.1130***		-0.0399***	-0.1252***		-0.9617	1.348	
	0.013	0.025		0.014	0.029		1.231	2.083	
Restrictions to Activity	0.0159***			0.0303***			2.019***		
	0.005			0.005			0.628		
Restrictions to Entry	-0.0256*			0.0235			-11.7***		
	0.015			0.016			1.486		
Financial Openness indicator	0.0344	0.0394***		0.0150	0.0554***		-5.85***	2.886***	
	0.024	0.011		0.028	0.012		1.253	0.694	
Gini Coefficient	-0.0207***			-0.0144***			-0.6394***		
	0.002			0.002			0.156		
Banking Concentration	-0.0004			0.0003			-0.2960***		
	0.001			0.001			0.059		
Regulatory Capital to Assets Ratio	-3.49***			-3.03***			-140.***		
	0.437			0.496			20.560		
Capital Requirements	-0.9055			-4.14***			-20.4		
	1.054			1.034			56.721		
Population Density	0.0295***			0.0378***			-1.47*		
	0.007			0.008			0.799		

***,**,* indicate significance at 1%, 5% and 10% respectively. Standard errors are shown below the coefficients
Source: BBVA Research

The importance of our results can be summarized as follows:

1. We find evidence supporting a Gompertz-curve relationship between the credit ratio and income per capita, including a saturation level.
2. We find evidence supporting different sensitivities of the credit ratio to income per capita in the long, medium and short run. This is quite important in terms of determining what the structural level of financial development is, i.e. what level of credit is supported by the fundamental values of an economy and to determine which levels of the credit ratio should be considered "excessive". For instance, some recent studies try to estimate the "benchmark" level of financial development as the level determined by income per capita and other variables. However, if the sensitivity of the credit ratio to income per capita was higher in the medium or short run than in the long run, we would estimate a much higher structural level if the economy was going through a temporary period of strong growth, even though a temporary increase in income should not warrant a higher level of credit. For instance, this would be the case of an economy going through a bubbly experience.
3. The different sensitivities allow us to estimate a "structural" level of the credit ratio related to the long-term components of the explanatory variables and by the institutional framework of each country. Furthermore, the difference between the observed level of the credit ratio and the estimated "structural" level allows us to evaluate how far/close an economy is from a long-term equilibrium.
4. This estimated "credit gap" appears to be an extremely good predictor of banking crises as we show through an empirical exercise.
5. We find new interesting effects of interest rates on the credit-to-GDP ratio. More specifically, we find that the short-term interest rate (money-market) have a positive and significant effect in the long and medium term, and a negative and non-significant effect in the short run. These effects are quite robust to several robustness tests and they may have interesting theoretical implications. They are not only counterintuitive but could be important to understand some effects of monetary policy. For instance, it is usually expected that central banks increase interest rates in order to deter excessive credit growth rates. However, according to our results, the private credit ratio increases in the long and medium term after an increase in short-term rates, which may suggest that the latter could have undesirable effects in some cases.
6. Despite the large heterogeneity of countries included in the analysis, the model does an excellent job in terms of goodness of fit compared to other alternatives.

5 Discussion of theoretical implications and further research

The results related to the different effects of income per capita and interest rates in the long run vs. the medium or short run are probably the ones that could be the most controversial or less intuitive in terms of the current literature. In this section we will discuss the implication of these results and possible derivations for further research.

5.1 Relation between credit ratio and income per capita

With respect to the effects of income per capita on the credit ratio there are two important results to be highlighted. First of all, the long-term income per capita level has a positive effect on the credit ratio even after controlling for several institutional and regulatory variables. This is important because it points to an independent effect of a higher income per capita which is not related to the overall developing process. This implies that the credit ratio increases as a country develops but not only because the institutional and regulatory framework improves and thus credit market imperfections decrease, but also because there is an important effect of income alone.

According to the discussion in the introduction and the literature review there are several ways in which the income per capita level could be related to credit development beyond the presence of market frictions. One way is through the value of collateral. The supply of credit should be low if it is limited by the value of pledgeable assets and if such value is low in low-income economies. Hence, the supply of credit should increase as the value of assets increases together with income per capita as a country grows and develops.

Moreover, the value of available loans is usually limited by the borrowers' income because of risk-management regulations. For instance, mortgages are usually considered too risky if the value of the loan exceeds a certain number of times the annual income of a potential borrower (usually three to five times the annual income). Thus, if the average income of the potential pool of borrowers is much lower than the average loan required for buying a house, this implies that most borrowers would be denied a mortgage loan. However, as income per capita (average income) grows and surpasses the minimum risk level, the amount of conceded loans might increase significantly. Consequently, the credit ratio level would also grow together with the income per capita.

This described process could be extended to several other assets (such as general machinery) or even consumption products such as cars and other consumption goods such as refrigerators, washing machines or other expensive durable products. This process should be reinforced by the well-known fact that as countries develop and their income per capita grows, the composition of their consumption demand shifts from basic products (food and clothing) to more expensive durable goods and services that are more prone to be financed through credit.

Secondly, with respect to the different effects of the different time-components of income per capita (long, medium and short-term) there are several possible explanations. The relationship between the credit ratio and income per capita described before should only applied to long-term levels of income per capita. If an increase in output (GDP) is perceived by economic agents to be only a short-term temporary change, there should be no reasons for them to increase their leverage in order to invest or consume more. Thus, a short-term increase in output should only affect the denominator in the credit to GDP ratio and thus, it should have a "negative" impact on it. Similarly, there could be a negative relation if households increase credit levels to smooth consumption at times when their income is temporarily below expected levels.

Furthermore, since any loan is an obligation to be repaid with future income streams, it should follow that at least a portion of current income should be used to repay previously acquired (existing) obligations and their corresponding interest rates. If we assume a unique sensitivity of the credit ratio to income per capita, we might be assuming that every dollar of current income is generating a dollar of new obligations and that no amount of income is devoted to the repayment of the existing loans. This may imply that leverage and the credit ratio could be growing forever and that a country could be allowed to be immersed in a Ponzi-scheme.

5.2 Relation between credit ratio and interest rates

With respect to the relation between the credit ratio and the different components of interest rates we could offer some tentative explanations for the different effects of interest rates in the long, medium and short term. First of all it is important to remember that what we are trying to explain in this empirical exercise is not the effect of a variable on the value of credit, but the effect of a variable on the ratio between credit and GDP. Thus, any change in credit as a response to a change in an explanatory variable should be higher/lower than the change in GDP derived from the same change in the explanatory variable in order for the total effect to be positive/negative.

Secondly, it is also important to remember that the observed level of credit is a stock variable that is the result of the following sum:

$$C_t = C_{t-1} + C_t^{New} - \rho_t C_{t-1}$$

Where C_t is the observed level of credit, C_{t-1} is the previous period level of credit, C_t^{New} is the current new supply/demand of credit and ρ_t is the proportion of the previous level of credit that is repaid in the current period *t*, i.e. the amortization of the previous level of credit.

It is clear that an increase in interest rates should impact the demand of new credit, and it is clear that we expect this effect to be negative. However, an increase in interest rates also changes the amortization schedule of existing loans, and thus has an impact on the proportion of the previous loans that is repaid today. In every amortization schedule an increase in interest rates not only increases the amount of interest rates but also changes the composition of every payment between interest and principal balance. Since an increase in interest rates decreases the proportion of the current payment that goes into reducing the principal balance, it decreases ρ_t and thus, it *increases* the current level of credit. Therefore, the final effect of a change in interest rates could be positive or negative depending on which effect dominates.

Since the effect of interest rates on the amortization schedule of a loan is higher in the medium and long run, we should expect that the total effect is more likely to be positive in those horizons, something which is consistent with our findings that the relation between short-term interest rates and the credit ratio is positive in the long and medium term, and negative in the short run.

Additionally, as explained before, a change in interest rates may not only change the value of credit, but it may also affect the value of GDP. If the latter effect is negative, this will also have a positive impact on the credit-to-GDP ratio.

In a separate, more theoretical paper, we will focus on these described effects of income per capita and interest rates on the credit ratio.

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6 Robustness exercises

In order to verify the robustness of the main results to different methodologies we have perform a series of robustness exercises. In Table 2 we can observe the regression results of different exercises assuming much simpler specifications and methodologies. In Models 1 to 4 we have relaxed the three main new assumptions of our model, i.e. the Gompertz-curve, the differential effect of the different time-frequency components and the non-negativity of the dependent variable. After relaxing these assumptions, in the column named “Model 1” we show the results of a random-effects model; in column “Model 2” we show the results of a random-effects model but with some specific country dummies (same dummies included in our final specification); in column “Model 3” we show the results of a fixed-effects model; and in column “Model 4” we show the results of an Arellano-Bond estimation.

In Table 3 we show the comparison between our base model and some models in which we relax one of our main assumptions, in this case, the assumption related to the decomposition of variables into different time-components, in order to see what would be the effect of each variable in only one effect had been estimated.

In Appendix A2 we show the results of other additional robustness exercises non-related to our three main assumptions. We first estimate a model without using PCA (i.e. using all the original institutional variables). We also check how our final estimation changes when we either do not include any country-dummy or when we include the whole set of possible country-dummies (similar to a fixed-effects or LSDV model).

Finally, we also check how much our results change if we restrict the sample to a period including only observations between 2002 and 2012. This last robustness exercise is quite important since many of our institutional variables are actually unobservable before this year, and in our final model we are imputing all the older missing values using the earliest available data. Thus it is quite important to verify that our results are not driven by this imputation of missing data.

In general most of the our main results are quite robust to the different methodological options, although the cases in which the results change more are when we do not take into account the non-negativity of the dependent variable, including the Arellano-Bond case. It is also very important to highlight that despite the fact we are imputing some missing data before 2004 for some variables, the results are quite robust across different time periods as we can see in Table 3 of Appendix A2, which guarantees that our results are not dependent on the imputation of missing data.

In summary, we can highlight how the results change across the different methodological options in the following summary:

- **GDP per capita:** The different effects of the different time-frequency components (positive in the long run, positive but smaller in the medium term and negative in the short run) are robust through all robustness exercises, with the exception of the Arellano-Bond estimation. In those cases in which we do not decompose this variable in different components, the effect is always positive and smaller than the estimated long-term coefficient. Additionally, the coefficients defining a Gompertz-curve type of relationship are always significant and have the correct expected sign whenever this option is estimated.
- **Short-term interest rate:** Similarly, the different effects of the short-term interest rate (positive in the long and medium term, negative in the short run) are also robust across almost all methodological variations. In the cases in which we do not decompose this variable, the effect is usually positive, something that is in principle against what we should expect in theory.

- **Bank Spread:** The differential effects are generally robust (negative in the long and medium term, positive in the short run). In the cases in which the effect is not decomposed the result is negative and significant.
- **Inflation Rate:** In this case the effect is in almost every case negative and in most cases is significant. The effect tends to be larger in the medium term than in the long or short run.
- **Investment Ratio:** The effects in the long and medium term are generally robust, positive and significant. In the short run the sign and significance changes widely, although the effect is all the cases quite small.
- **Interaction between GDP per capita and Investment:** The interaction is always positive but it is usually only significant in the short run.
- **Information Quality:** The effect is in general positive and significant in the long run, but its deviation is usually negative. Such negative effect is also found whenever "fixed-effects" are estimated, even in the Arellano-Bond case. However, its long-term positive effect is robust in all the cases in which it is estimated.
- **Private Bureaus Coverage:** Its effect is usually positive, although there are some cases in which it turns out negative (no-poisson case and when no-dummy variables are included).
- **Public Registries Coverage:** Usually positive and significant in both the long- and short run.
- **Legal Environment:** Its positive effect is robust to most specifications. If we estimate separately the effect of the variables included in this PCA index, we find that the Rule of Law effect is quite strong, significant and positive, meanwhile the effect of the strength of legal variables is less robust, sometimes is negative and other times positive.
- **Legal Costs:** This is the variable with the less robust effect. It changes widely across different options and also if we estimate separately the effect of the three underlying variables (Enforcing Contracts Difficulty, Registering Property Difficulty and Insolvency Costs).
- **Activity Restrictions:** Its positive effect is robust through all variations, although in some few cases it is non-significant.
- **Entry Restrictions:** Its effect is in most cases negative and significant, although not completely robust to every possibility.
- **Financial Openness:** Its effect in the short run is always positive and significant. Its long-term effect seems less robust and it turns out negative in several occasions.
- **Gini (inequality):** Its negative effect is robust throughout all methodologies and only in a couple of cases is non-significant. However, it is interesting to notice that in an early version of the model in which the Rule of Law was not included, its effect tend to be positive although non-significant.
- **Banking Concentration:** Its effect is always negative, although most of the times it is non-significant. This could be due to the fact that there already two other variables that could be capturing the effect of the lack of competition: the banking spread and the restrictions to entry.
- **Regulatory Capital:** Its sign is always negative and significant.
- **Capital Requirement:** Its sign is always negative, although it is only significant about half of the times.
- **Population Density:** It is positive and significant in most of the cases, although not completely robust (No-poisson assumption and Arellano-Bond cases).

Table 2

Regression results: final model versus results with more basic functional forms

VARIABLES	Number of countries=83 Number of obs=1683 R2 = 0.9807 Adjusted R2 = 0.9805			WR2 = 0.320 BR2 = 0.7098 R2 = 0.6406	WR2 = 0.326 BR2 = 0.8332 R2 = 0.7469	WR2 = 0.331 BR2 =0.534 R2 = 0.5023	R2 = 0.9206
	Long-Term	*Mid-term*	*Short-term*	Model 1	Model 2	Model 3	Model 4
Gompertz Curve Determinants	FINAL MODEL			*Income per Capita*			
Alpha	5.456***						
	0.164						
Gamma	-0.7678***						
	0.034						
GDP per capita PPP	-0.0417***	-0.0237***	0.0574***	24.95***	32.22***	40.61***	8.727**
	0.004	0.005	0.010	7.419	8.674	0	3.366
Interaction between GDP pc and Investment		-0.2906	-2.17***	0.002	0.002	0.0018	0.0018
		0.200	0.429	0.002	0.003	0.484	0.001
Macro Variables				*Macro Variables*			
ST Real Interest Rate	0.1710***	0.1710***	-0.0115	5.610***	5.776***	5.730***	0.8272
	0.053	0.044	0.026	2.029	2.094	0.008	0.894
Banks' Real Interest Rate Spread	-0.1233***	-0.0632*	0.0228	-5.61**	-5.93***	-6.20***	-0.0953
	0.027	0.032	0.025	2.214	2.241	0.007	0.792
Inflation Rate	-0.0522*	-0.1235**	-0.0407	-1.5949	-1.0216	-0.6121	-2.97***
	0.031	0.055	0.031	1.563	1.578	0.703	0.821
Investment to GDP Ratio	2.075***	2.091***	-0.4423	-33.6	-38.8	-33.2	18.97
	0.264	0.261	0.305	28.532	30.378	0.262	12.145
Credit/GDP (t-1)							0.7777***
							0.105
VARIABLES	FINAL MODEL			Model 1	Model 2	Model 3	Model 4
Structural Determinants	*Structural Determinants*			*Structural Determinants*			
Information Quality Index	0.1898***		-0.0537***	-3.32*	-4.04*	-5.63**	-0.2909
	0.017		0.0121	1.927	2.207	2.479	0.521
Private Bureau Coverage	0.0021***		0.0012*	0.149	0.153	0.1163	0.0488
	0.000		0.0007	0.108	0.130	0.157	0.047
Public Registries Coverage	0.0147***		0.0021*	0.2163	0.2344	0.1953	-0.2455***
	0.001		0.001	0.192	0.214	0.223	0.084
Legal Environment	0.2756***		0.0284	10.19**	11.03**	9.268	-0.8797
	0.016		0.035	4.099	5.177	6.764	2.726
Legal Costs	0.0064		-0.1130***	-4.3374	-2.6436	-1.31	0.8273
	0.013		0.025	3.376	4.048	4.667	1.432
Restrictions to Activity	0.0159***			0.385503	0.420873		
	0.005			1.473	2.619		
Restrictions to Entry	-0.0256*			0.860323	2.548818		
	0.015			3.675	5.534		
Financial Openness indicator (t-1)	0.0344		0.0394***	3.195002**	3.425169**	3.599**	-0.5473
	0.024		0.011	1.447	1.513	0.02	0.564
Gini Coefficient	-0.0207***			0.2761	-0.630		
	0.002			0.341	0.594		
Banking Concentration	-0.0004			-0.05669	-0.02728		
	0.001			0.082	0.083		
Regulatory Capital to Assets Ratio	-3.49***			-43.1159	-41.5243		
	0.437			28.426	27.762		
Capital Requirements	-0.9055			-112.844	-90.6091	-73.0	66.15
	1.054			148.071	166.527	0.69	110.93
Population Density	0.0295***			3.30621	2.713757	13.82	-3.47
	0.007			2.907	4.045	0.434	5.629

***,**,* indicate significance at 1%, 5% and 10% respectively. Standard errors are shown below the coefficients. Model 1: Variables without decomposition, linear model, GDP pc in logs, RE. Model 2: Variables without decomposition, linear model, GDP pc in logs, some country dummies. Model 3: Variables without decomposition, linear model, GDP pc in logs, FE. Model 4: Variables without decomposition, linear model, GDP pc in logs, Arellano-Bond
Source: BBVA Research

Table 3

Regression results: final model versus results without decomposing macro variables

VARIABLES	Number of countries=83 Number of obs=1683 R2 = 0.9807 Adjusted R2 = 0.9805			R2 = 0.9619 Adj.R2 = 0.9603	R2 = 0.9246 Adj.R2 = 0.9235	R2 = 0.968 Adj.R2 = 0.9661
	Long-Term	*Mid-term*	*Short-term*	Model 1	Model 2	Model 3
Gompertz Curve Determinants	FINAL MODEL			*Gompertz Curve Determinants*		
Alpha	5.456***			5.493***	5.297***	5.271***
	0.164			0.232	0.326	0.258
Gamma	-0.7678***			-0.5359***	-0.3412***	-0.7066***
	0.034			0.030	0.041	0.045
GDP per capita PPP	-0.0417***	-0.0237***	0.0574***	-0.0404***	-0.0462***	-0.0415***
	0.004	0.005	0.010	0.012	0.016	0.012
Interaction between GDP pc and Investment		-0.2906	-2.17***	0.0058	0.0881**	0.0068
		0.200	0.429	0.042	0.044	0.038
Macro Variables				*Macro Variables*		
ST Real Interest Rate	0.1710***	0.1710***	-0.0115	0.1551***	0.0928***	0.1427***
	0.053	0.044	0.026	0.036	0.036	0.031
Banks' Real Interest Rate Spread	-0.1233***	-0.0632*	0.0228	-0.1175***	-0.1112***	-0.0998***
	0.027	0.032	0.025	0.018	0.022	0.018
Inflation Rate	-0.0522*	-0.1235**	-0.0407	-0.1133***	-0.2126***	-0.0949***
	0.031	0.055	0.031	0.031	0.038	0.032
Investment to GDP Ratio	2.075***	2.091***	-0.4423	0.7050	2.062***	0.6143
	0.264	0.261	0.305	0.568	0.456	0.576
VARIABLES	FINAL MODEL			Model 1	Model 2	Model 3
Structural Determinants				*Structural Determinants*		
Information Quality Index	0.1898***		-0.0537***	0.0891***	0.0857***	-0.1273***
	0.017		0.0121	0.011	0.011	0.017
Private Bureau Coverage	0.0021***		0.0012*	0.0014***	0.0002	-0.0023***
	0.000		0.0007	0.000	0.000	0.001
Public Registries Coverage	0.0147***		0.0021*	0.0110***	0.0060***	0.0039**
	0.001		0.001	0.001	0.001	0.002
Legal Environment	0.2756***		0.0284	0.2096***	0.1370***	0.2175***
	0.016		0.035	0.019	0.014	0.039
Legal Costs	0.0064		-0.1130***	-0.0247*	-0.0655***	-0.0897***
	0.013		0.025	0.014	0.014	0.032
Restrictions to Activity	0.0159***			0.0262***	0.0210***	
	0.005			0.005	0.005	
Restrictions to Entry	-0.0256*			0.0042	-0.0119	
	0.015			0.020	0.017	
Financial Openness indicator (t-1)	0.0344		0.0394***	0.0462***	0.0203**	0.0451***
	0.024		0.011	0.011	0.010	0.012
Gini Coefficient	-0.0207***			-0.0125***	0.0028*	
	0.002			0.002	0.002	
Banking Concentration	-0.0004			-0.0014***	-0.0025***	
	0.001			0.001	0.001	
Regulatory Capital to Assets Ratio	-3.49***			-1.71***	-2.19***	
	0.437			0.378	0.378	
Capital Requirements	-0.9055			-5.67***	-4.57***	2.570*
	1.054			1.055	0.937	1.415
Population Density	0.0295***			0.0123	0.0265***	0.0919***
	0.007			0.0103821	0.0069945	0.0236702

***,**,* indicate significance at 1%, 5% and 10% respectively. Standard errors are shown below the coefficients. Model 1: Gompertz Curve, Poisson, without decomposing variables, some country dummies. Model 2: Gompertz Curve, Poisson, without decomposing variables, random effects. Model 3: Gompertz Curve, Poisson, without decomposing variables, "fixed-effects".
Source: BBVA Research

7 Using credit gaps as a banking crisis predictor

One of the most valuable outputs from our model is the possibility of estimating the gap between the actual credit ratio and the structural credit level defined by the long-term components of the explanatory variables. This estimated credit gap provides a clear picture of whether a financial system is going through an unsustainable credit boom or whether is growing in a healthy and sustainable way. In order to evaluate the value of the credit gap as a predictor of possible financial crises derived from a previous unsustainable credit growth, we run a basic empirical exercise in which we regress a binary variable of banking crises (Laeven and Valencia 2012) against our estimated credit gap and other control variables[15].

In this paper we are not interested in performing a complete comparison of the predictive power of our indicator against that of other more traditional indicators of disequilibria in the credit market, since this requires a quite extensive empirical exercise. However, we focus on showing that our estimated credit gap is both highly significant on its own and after controlling for other variables, and that its predictive power is quite high.

In a separate empirical work, we do perform a formal comparison of the predictive capabilities of the newly estimated credit gap, and we are able to show that its performance is indeed superior to most similar indicators traditionally used by previous researchers and IFIs, such as BIS and IMF. In that separate empirical paper we also develop and evaluate a complete Early Warning System based on our new measure of credit excess and other common early indicators.

In order to evaluate the relationship between systemic banking crises and our estimated credit excess or gap, we perform a series of regressions in which the dependent variable is a dummy variable equal to one whenever there is a crisis (according to the definition in Laeven and Valencia) and to zero when there is no crisis. Since we want to show that our credit excess measure does not only anticipate well the start of a crisis, but it also anticipates their duration (i.e. all the years in which a crisis is ongoing) we use two different definitions of dependent variable: one in which we only include the first years of a crisis and exclude all the following years, and one in which we include all the years in which a crisis is said to occur.

We run both univariate and multivariate regressions. In the multivariate regressions we control for other common leading indicators of a crisis, such as the growth in equity prices, the international interest rate (Libor), the volatility in financial markets (VIX) and a measure of the banking system financial and liquidity needs (credit-to-deposits ratio).

In each one of our regressions we estimate the AUROC (area under receiving operator curve) as the optimal indicator of predictive power taking into account the trade-off between true and false positive signals.

It is quite important to highlight that in this simple exercise we are stricter than other empirical studies when evaluating the performance of the indicators (AUROC), since we define a signal to be correct only if a crisis occurs in the same year a positive signal is emitted, and to be false if a crisis does not occur, independently of what happens in the previous or coming years. Other studies consider a signal to be correct if a crisis occurs in a certain window of two to five years before and/or after the crisis. If we had used a window to evaluate the accuracy of the signal, the estimated AUROCs would be higher.

In **¡Error! No se encuentra el origen de la referencia.** and **¡Error! No se encuentra el origen de la referencia.** we show the results of the univariate Logit Regressions including all years in the sample in which there is a banking crisis (without restricting the dependent variable). We can see that in all the cases the

15 The banking crisis binary dependent variable takes 1 for the crisis years and 0 otherwise. We have taken this variable directly from Laeven and Valencia (2012).

credit gap is highly significant, introducing it with one lag to three lags. Its statistical significance does not vary much with the use of fixed-effects rather than random effects Logit.

Furthermore, it is highly significant whether we restrict the dependent variable to the first years of a crisis (Table 4) or not (Table 3). In all the cases, the AUROC indicates that the credit gap possesses an important predictive power, especially when included with a two years lag. (As explained before, the AUROCs estimated here are much stricter than the ones estimated in other empirical studies in which the accuracy of the signals is evaluated in a window of 2 to 5 years, whereas here we only take into account what happens in the same contemporaneous year, i.e. a "1-year" window).

Again, in a separate paper we compare these results with those obtained using other traditional indicators of credit excess or disequilibrium and we are able to show that our credit gap has a much higher predictive power.

Table 4
Univariate logit regression results. Unrestricted dependent variable

	Random Effects			Fixed Effects		
Banking Crisis (=1 if in year t there is a banking crisis, =0 otherwise)	Countries=68 Obs=1316 Pseudo-R2 = 0.180 AUROC = 0.759	Countries=68 Obs=1248 Pseudo-R2 = 0.214 AUROC = 0.785	Countries=68 Obs=1180 Pseudo-R2 = 0.191 AUROC = 0.778	Countries=68 Obs=1082 Pseudo-R2 = 0.226 AUROC = 0.765	Countries=68 Obs=1012 Pseudo-R2 = 0.275 AUROC = 0.795	Countries=68 Obs=959 Pseudo-R2 = 0.251 AUROC = 0.789
	(T-1)	(T-2)	(T-3)	(T-1)	(T-2)	(T-3)
Credit Gap with Respect to Structural Level	0.092***	0.107***	0.104***	0.091***	0.108***	0.105***
	12.260	12.250	11.490	11.720	11.740	11.080
Constant	-2.37***	-2.56***	-2.47***			
	-14.020	-13.450	-13.010			

***,**,* indicate significance at 1%, 5% and 10% respectively. Z-statistics are shown below the coefficients.
Source: BBVA Research

Table 5
Univariate logit regression results. Restricted dependent variable

	Random Effects			Fixed Effects		
Banking Crisis (=1 if in year t there is a banking crisis, =0 otherwise, second and further years of a crisis are not included)	Countries=68 Obs=1129 Pseudo-R2 = 0.121 AUROC = 0.746	Countries=68 Obs=1072 Pseudo-R2 = 0.079 AUROC = 0.723	Countries=68 1016 Pseudo-R2 = 0.041 AUROC = 0.694	Countries=68 Obs=842 Pseudo-R2 = 0.200 AUROC = 0.755	Countries=68 Obs=739 Pseudo-R2 = 0.139 AUROC = 0.741	Countries=68 Obs=659 Pseudo-R2 = 0.092 AUROC = 0.721
	(T-1)	(T-2)	(T-3)	(T-1)	(T-2)	(T-3)
Credit Gap with Respect to Structural Level	0.080***	0.070***	0.051***	0.098***	0.085***	0.073***
	7.540	5.870	4.190	6.990	5.640	4.700
Constant	-3.38***	-3.28***	-3.11***			
	-18.540	-18.360	-18.640			

***,**,* indicate significance at 1%, 5% and 10% respectively. Z-statistics are shown below the coefficients.
Source: BBVA Research

In Table 6 and Table 7 we show the results of the same regressions shown before, but in this case we control for four other possible leading indicators of a systemic banking crisis:

- The Credit-to-Deposits ratio (Liquidity) in country i. Source: Financial Structure Dataset World Bank and Haver Statistics.
- The annual growth rate of the stock market. Source: Haver Statistics and Oxford Economics Analysis.
- The Libor interest rate. Annual rate. Source: Haver Statisitics.
- The S&P volatility index (VIX). Source: Oxford Economics Analysis.

We can see that in all the cases, our credit gap remains highly significant and its coefficient actually increases in every case with respect to the respective univariate ones.

Again, in a second paper, we develop and evaluate more formally a complete Early Warning System (EWS) for systemic banking crises in which we compare the performance of different indicators and different models, through the use of multivariate tools such as Bayesian Model Averaging (BMA) and evaluating both the in-sample and out-of-sample performance of our credit gap and the resulting models.

Table 6
Multivariate logit regression results. Unrestricted dependent variable

	Random Effects			Fixed Effects		
Banking Crisis (=1 if in year t there is a banking crisis, =0 otherwise)	Countries=68 Obs=1035 Pseudo-R2 = 0.249 AUROC = 0.802	Countries=68 Obs=978 Pseudo-R2 = 0.285 AUROC = 0.825	Countries=68 Obs=922 Pseudo-R2 = 0.259 AUROC = 0.815	Countries=68 Obs=835 Pseudo-R2 = 0.322 AUROC = 0.803	Countries=68 Obs=785 Pseudo-R2 = 0.376 AUROC = 0.819	Countries=68 741 Pseudo-R2 = 0.356 AUROC = 0.802
	(T-1)	(T-2)	(T-3)	(T-1)	(T-2)	(T-3)
Credit Gap with Respect to Structural Level	0.108***	0.124***	0.115***	0.105***	0.121***	0.114***
	10.710	10.600	9.730	10.200	10.040	9.110
Equity Growth	0.263	-0.006	0.214	0.196	-0.11	0.057
	1.050	-0.030	0.790	0.750	-0.500	0.210
Credit-to-Deposits Ratio	0.003	0.007*	0.013***	0.008**	0.015***	0.023***
	1.090	1.930	3.110	2.060	3.100	4.400
Libor	0.079	0.172***	0.173***	0.078	0.168***	0.171**
	1.640	3.000	2.660	1.600	2.880	2.580
VIX	0.033***	0.008	-0.01*	0.032***	0.006	-0.02**
	3.760	0.840	-1.820	3.570	0.660	-2.000
Constant	-3.92***	-4.01***	-3.46***			
	-9.540	-8.480	-7.000			

***,**,* indicate significance at 1%, 5% and 10% respectively. Z-statistics are shown below the coefficients.
Source: BBVA Research

Table 7
Multivariate logit regression results. Restricted dependent variable

	Random Effects			Fixed Effects		
Banking Crisis (=1 if in year t there is a banking crisis, =0 otherwise, second and further years of a crisis are not included)	Countries=68 Obs=878 Pseudo-R2 = 0.252 AUROC = 0.862	Countries=68 Obs=833 Pseudo-R2 = 0.309 AUROC = 0.885	Countries=68 788 Pseudo-R2 = 0.216 AUROC = 0.852	Countries=68 Obs=620 Pseudo-R2 = 0.392 AUROC = 0.837	Countries=68 Obs=566 Pseudo-R2 = 0.446 AUROC = 0.884	Countries=68 Obs=514 Pseudo-R2 = 0.388 AUROC = 0.863
	(T-1)	(T-2)	(T-3)	(T-1)	(T-2)	(T-3)
Credit Gap with Respect to Structural Level	0.105***	0.106***	0.079***	0.119***	0.119***	0.111***
	6.660	5.860	4.680	5.400	4.540	4.340
Equity Growth	1.145***	0.823**	0.802**	1.058**	0.439	0.506
	4.010	2.130	2.030	2.370	0.860	1.000
Credit-to-Deposits Ratio	-0.000	-0.001	0.003	0.020*	0.010	0.018**
	-0.010	-0.310	0.700	1.700	1.130	2.120
Libor	0.312***	0.530***	0.206	0.313***	0.414***	0.310**
	3.140	3.390	1.640	2.780	2.670	2.120
VIX	0.020	-0.22***	-0.21***	0.023	-0.20***	-0.24***
	1.050	-5.260	-4.960	1.180	-4.480	-4.810
Constant	-6.00***	-2.54***	-0.83			
	-7.960	-3.090	-1.120			

***,**,* indicate significance at 1%, 5% and 10% respectively. Z-statistics are shown below the coefficients.
Source: BBVA Research

8 Conclusions

The private credit-to-GDP ratio is a variable that is by its very nature very difficult to understand and to explain through an empirical model. First of all, it is a ratio of two variables that may depend on each other. Secondly, there is a widespread confusion between the effects that certain variables can have on credit versus the effects that the same variables can have on the credit ratio. The credit ratio varies only if either credit or GDP grow faster/slower than the other. Credit can grow at a 20% rate but if GDP grows at the same rate the credit ratio remains the same. Thus, what we are trying to explain is not what makes credit to change, but what makes the relationship between the two variables to change.

This becomes more complicated for several reasons. The credit-to-GDP ratio is a ratio between a stock variable and a flow variable, which generates complicated dynamics. But even more importantly the credit ratio measures both a good and a potentially bad thing. It measures both the financial development level of a country and also its leverage. In other words, it may be good for a country to have a higher ratio if it is an appropriate level, but it could be dangerous if it has too much. This is something that econometric models are not prepared to deal with. For instance, if you estimate that a certain variable has a positive effect on the credit ratio that could mean a higher level of such variable could take you closer to your optimal ratio, but it could also increase your leverage too much and put you in risk of having a credit crisis.

Furthermore, we cannot rely on the economic literature to help us out of this conundrum because, to the best of our knowledge, there are no theoretical models that explain the behavior of this aggregate ratio. The recent literature that tries to explain the relationship between financial and economic development and the process of financial development itself has a more descriptive and qualitative stance rather than a formal mathematical one. Most of the literature is grounded on microeconomic theories rather than on an aggregate perspective. Moreover, the empirical research is actually scarce, although is flourishing rapidly after the onset of the financial crisis.

Nevertheless, understanding the determinants of the credit ratio could be really important for different reasons. The evidence portraying financial development as one of the key drivers of economic development is indeed quite abundant and pretty conclusive. Additionally, it is becoming more and more evident that understanding the disequilibria in credit markets is fundamental to understand the origins and consequences of financial and banking crises such as the one we are still recovering from. And although more controversial, understanding the relationship between financial and real variables could also be crucial to understand what drives business cycles in a modern economy.

In this paper, we try to make a contribution to this growing strand of the literature by introducing some new improving assumptions in a large empirical model of the determinants of the private credit ratio. Our results are not only important because of the methodological contribution but much more importantly because we present evidence of various effects of certain macroeconomic on the credit ratio variables that have not been identified previously by any other empirical study, such as the differential effect of the income per capita and short-term interest rates in the long, medium and short run.

More specifically, we have found that the effect of income per capita and interest rates have different effects on the credit ratio depending on the horizon considered. We find that the effect of income per capita is positive in the long run, positive but lower in the medium term, and negative in the short run. Similarly, the effect of money-market interest rates is positive in the long and medium term, but negative (although non-significant) in the short run. Moreover, it is also important to highlight that the positive effect of income per capita in the long run is found even after controlling for several institutional and regulatory variables, which

implies that the effect we find is not related to the overall economic development process, but is explicitly related to the income per capita level.

Most of these results are novel in the literature and could have important implications in our understanding of the dynamics of credit deepening and leverage. Although these results should be further explored, we offer some initial, tentative explanations.

On the one hand, the positive relationship between the credit ratio and income per capita in the long run could be related to the evolution of the value of pledgeable assets as countries become richer. It could also be related to risk-management limits and regulations regarding the ratio between the value of a loan and the borrower's disposable income. On the other hand, the negative relationship between the credit ratio and income per capita in the short run could be related to the fact that at least a portion of current income should be used to repay previously acquired obligations and their corresponding interest rates and/or simply to a different reaction of agents when a change in income is perceived as a short-term temporary one.

Secondly, the differential effects of interest rates on the credit ratio could be derived from the differential effects of interest rates on the demand of new loans versus the amortization schedule of existing loans, and also to second round effects of interest rates on GDP.

Finally, but not less important, we show that correctly modeling the determinants of the credit ratio is indeed quite important if we want to understand what drives credit or banking crises. The different sensitivities allow us to estimate a "structural" level of the credit ratio related to the long-term components of the explanatory variables and by the institutional framework of each country.

We then estimate the difference between the structural level and the actual level of the credit ratio in every country. This difference is called "credit gap" and we are able to show through an associated empirical exercise that such estimated "credit gap" appears to be an extremely good predictor of banking crises.

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Appendix A1: description of data

Macroeconomic Determinants:

- **Income per capita** is the GDP per capita in PPP terms and in constant US dollars. Source: IMF-WEO and own calculations.
- **Bank Spread** is included as the log of the difference between the interest rate charged by banks on loans to prime customers minus the interest rate paid by commercial or similar banks for demand, time, or savings deposits. Source: IMF-IFS, World Bank-WDI and own calculations.
- **Short-term interest rate** is included as the log of the short-term money-market rate (or the Treasury-bill rate when money-market rate is not available) expressed as the difference between the country's rate and the US bill rate. Source: IMF-IFS, World Bank-WDI and own calculations.
- **Investment ratio** is the total investment to GDP ratio. Source: IMF-WEO and own calculations.
- **Inflation rate** is included as the log of the inflation rate. We also include a 10-year standard deviation of the log of inflation to account for the instability of macroeconomic policy. Source: IMF-WEO and and own calculations.

Institutional and Regulatory Determinants:

- **Creditor Protection** is the country average over time of the World Bank's Strength of Legal Rights index. This index measures the degree to which collateral and bankruptcy laws protect the rights of borrowers and lenders and thus facilitate lending. Source: World Bank-Doing Business and own calculations
- **Contracts Difficulty** It measures the difficulty of enforcing a contract in a given country. Is included as the country average over time of a PCA of the number of days, the required number of procedures and the cost of enforcing a contract. Source: World Bank-Doing Business and own calculations
- **Registering Property Difficulty** It measures the difficulty of registering a property. Is included as the country average over time of a PCA of the number of days, the required number of procedures in order to register a property. Source: World Bank-Doing Business and own calculations.
- **Information Quality Index** is the country average over time of the World Bank's Credit depth of information index. Source: World Bank-Doing Business and own calculations.
- **Private Bureau Coverage** is the country average over time of a principal component between the Private credit bureau coverage (% of adults) and the Public Registry coverage (% of adults). Source: World Bank-Doing Business and own calculations.
- **Activity Restrictions Index** is a measure of a bank's ability to engage in securities underwriting, insurance and real estate and of the regulatory restrictiveness of banks to own shares in non-financial firms. Activities could be prohibited, restricted, permitted or unrestricted. Source: Own calculations based on World Bank's Banking Regulation Survey (2000, 2003 and 2007).
- **Entry Difficulty Index** is the country average over time of an index that measures the regulatory burden in the process of applying for a banking license. Source: Own calculations based on World Bank's Banking Regulation Survey (2000, 2003 and 2007.

Structural Determinants:

- **Rule of Law Index** is the country average over time of the percentage of the informal over the total economy of each country. Source: World Bank-Doing Business and and own calculations. Schneider, Buehn and Montenegro (2010).
- **Gini Index:** Is the country average over time of the Gini index. World Bank-WDI

- **Banking Concentration** is the country average over time of the share of the assets of three largest banks as a share of assets of all commercial banks. Source: Financial Structure Dataset, World Bank 2012.
- **Financial Openness** is an indicator of the degree of financial openness in each country. It is expressed as the deviation of the observed variable to the world's average at each time t. Source: Chinn-Ito Index of financial openness (2008),
- **Regulatory Capital/Risk-Weighted Assets** is the country's average over time of its regulatory capital to risk-weighted assets ratio. It is included as the difference to the capital requirement level. Source: IMF-FSI, World Bank-WDI and own calculations.
- **Capital Requirements** is the regulatory minimum capital requirement. It is included as the deviation against the standard 8% BIS ratio. Source: World Bank's Banking Regulation Survey (2000, 2003 and 2007).
- **Population Density** is the number of inhabitants per square kilometre. It is included in relative terms to the ratio of urban population in order to reduce the number of outliers originated by the presence of small-urban countries.

Appendix A2: other robustness exercises

Table A.1
Regression results: final model versus results without PCA indexes

VARIABLES	Number of countries=83 Number of obs=1683 R2 = 0.9807 Adjusted R2 = 0.9805			VARIABLES	Number of countries=83 Number of obs=1683 R2 = 0.9811 Adjusted R2 = 0.98		
	Long-Term	*Mid-term*	*Short-term*		*Long-Term*	*Mid-term*	*Short-term*
Gompertz Curve Determinants	FINAL MODEL			*Gompertz Curve Determinants*	WITHOUT PRINCIPAL COMPONENTS		
Alpha	5.456***			Alpha	5.097***		
	0.164				0.273		
Gamma	-0.7678***			Gamma	-0.7378***		
	0.034				0.045		
GDP per capita PPP	-0.0417***	-0.0237***	0.0574***	GDP per capita PPP	-0.0345***	-0.0174***	0.0537***
	0.004	0.005	0.010		0.005	0.006	0.011
Interaction between GDP pc and Investment		-0.2906	-2.17***	Interaction between GDP pc and Investment		-0.4085*	-2.37***
		0.200	0.429			0.217	0.394
Macro Variables				*Macro Variables*			
ST Real Interest Rate	0.1710***	0.1710***	-0.0115	ST Real Interest Rate	0.1357***	0.1504***	-0.0027
	0.053	0.044	0.026		0.049	0.041	0.026
Banks' Real Interest Rate Spread	-0.1233***	-0.0632*	0.0228	Banks' Real Interest Rate Spread	-0.1001***	-0.1048***	0.0167
	0.027	0.032	0.025		0.029	0.033	0.026
Inflation Rate	-0.0522*	-0.1235**	-0.0407	Inflation Rate	-0.0729**	-0.1421***	-0.0367
	0.031	0.055	0.031		0.030	0.052	0.033
Investment to GDP Ratio	2.075***	2.091***	-0.4423	Investment to GDP Ratio	1.997***	1.820***	-0.5930**
	0.264	0.261	0.305		0.253	0.267	0.277
VARIABLES	FINAL MODEL			VARIABLES	WITHOUT PRINCIPAL COMPONENTS		
Structural Determinants				*Structural Determinants*			
Information Quality Index	0.1898***	-0.0537***		Information Quality Index	0.1974***	-0.0427***	
	0.017	0.0121			0.018	0.0119399	
Private Bureau Coverage	0.0021***	0.0012*		Private Bureau Coverage	0.0012**	0.0014**	
	0.000	0.0007			0.001	0.0006993	
Public Registries Coverage	0.0147***	0.0021*		Public Registries Coverage	0.0121***	0.0031***	
	0.001	0.001			0.001	0.001	
Legal Environment	0.2756***	0.0284		Creditors' Protection (Strenght Legal Rights)	0.0598***	-0.0250*	
	0.016	0.035			0.010	0.014	
				Rule of Law	0.4198***	0.1781***	
					0.079	0.040	
Legal Costs	0.0064	-0.1130***		Enforcing Contracts Difficulty	0.0313**	-0.1701***	
	0.013	0.025			0.016	0.063	
				Registering Property Difficulty	0.0035	-0.0520***	
					0.016	0.017	
				Costs of Insolvency	-0.0003	0.0031***	
					0.001	0.001	
Restrictions to Activity	0.0159***			Activity Restrictions	0.0130***		
	0.005				0.005		
Restrictions to Entry	-0.0256*			New Participants Entry Difficulties	-0.0201		
	0.015				0.016		
Financial Openness indicator	0.0344	0.0394***		Financial Openness indicator	0.0048	0.0399***	
	0.024	0.011			0.030	0.011	
Gini Coefficient	-0.0207***			Gini Coefficient	-0.0151***		
	0.002				0.003		
Banking Concentration	-0.0004			Banking Concentration	-0.0012**		
	0.001				0.001		
Regulatory Capital to Assets Ratio	-3.49***			Regulatory Capital to Assets Ratio	-3.84***		
	0.437				0.472		
Capital Requirements	-0.9055			Capital Requirements	-0.4107		
	1.054				1.082		
Population Density	0.0295***			Population Density	0.0394***		
	0.007				0.010		

***,**,* indicate significance at 1%, 5% and 10% respectively. Standard errors are shown below the coefficients.
Source: BBVA Research

Table A.2

Regression results: final model versus results with no country dummies and a country-dummy for each country

VARIABLES	Number of countries=83 Number of obs=1683 R2 = 0.9807 Adjusted R2 = 0.9805			Number of countries=83 Number of obs=1683 R2 = 0.95 Adjusted R2 = 0.9494			Number of countries=83 Number of obs=1683 R2 = 0.9779 Adjusted R2 = 0.9764		
	Long-Term	*Mid-term*	*Short-term*	*Long-Term*	*Mid-term*	*Short-term*	*Long-Term*	*Mid-term*	*Short-term*
Gompertz Curve Determinants	FINAL MODEL			NO COUNTRY DUMMIES			POISSON DUMMY-VARIABLES		
Alpha	**5.456*** **			**4.868*** **			**7.255*** **		
	0.164			0.177			0.855		
Gamma	**-0.7678*** **			**-0.4253*** **			**-0.7809*** **		
	0.034			0.054			0.111		
GDP per capita PPP	**-0.0417*** **	**-0.0237*** **	**0.0574*** **	**-0.0385*** **	**-0.0075**	**0.1482*** **	**-0.0175*** **	**-0.0050**	**0.026*** **
	0.004	0.005	0.010	0.007	0.026	0.038	0.004	0.004	0.008
Interaction between GDP pc and Investment		**-0.2906**	**-2.17*** **		**-2.77*** **	**-3.23*** **		**-0.3217****	**-1.42*** **
		0.200	0.429		0.960	1.003		0.154	0.364
Macro Variables									
ST Real Interest Rate	**0.1710*** **	**0.1710*** **	**-0.0115**	**-0.0098**	**0.0201**	**-0.0814****	**0.1015***	**0.1783*** **	**0.0081**
	0.053	0.044	0.026	0.129	0.089	0.033	0.061	0.046	0.026
Banks' Real Interest Rate Spread	**-0.1233*** **	**-0.0632***	**0.0228**	**-0.1694***	**-0.1218***	**0.0089**	**-0.2030*** **	**-0.0787****	**0.0687****
	0.027	0.032	0.025	0.089	0.063	0.042	0.037	0.038	0.028
Inflation Rate	**-0.0522***	**-0.1235****	**-0.0407**	**-0.1785****	**-0.3813*** **	**-0.1380*** **	**-0.1507*** **	**-0.1541*** **	**-0.0111**
	0.031	0.055	0.031	0.081	0.123	0.050	0.033	0.055	0.034
Investment to GDP Ratio	**2.075*** **	**2.091*** **	**-0.4423**	**0.5446**	**1.098**	**-0.0660**	**1.963*** **	**1.817*** **	**-1.12*** **
	0.264	0.261	0.305	0.660	0.703	0.555	0.372	0.312	0.270
VARIABLES	**FINAL MODEL**			**NO COUNTRY DUMMIES**			**POISSON DUMMY-VARIABLES**		
Structural Determinants									
Information Quality Index	**0.1898*** **		**-0.0537*** **	**0.1524*** **		**-0.0637***			**-0.0445*** **
	0.017		0.0121	0.040		0.033			0.012
Private Bureau Coverage	**0.0021*** **		**0.0012***	**-0.0004**		**-0.0006**			**0.0010**
	0.000		0.0007	0.001		0.0015			0.0010
Public Registries Coverage	**0.0147*** **		**0.0021***	**0.0057*** **		**0.0021**			**0.0013**
	0.001		0.001	0.002		0.004			0.001
Legal Environment	**0.2756*** **		**0.0284**	**0.1228*** **		**0.1782**			**0.0485**
	0.016		0.035	0.038		0.109			0.037
Legal Costs	**0.0064**		**-0.1130*** **	**-0.0859****		**-0.0888***			**-0.1467*** **
	0.013		0.025	0.038		0.050			0.034
Restrictions to Activity	**0.0159*** **			**0.0161**					
	0.005			0.012					
Restrictions to Entry	**-0.0256***			**-0.0279**					
	0.015			0.043					
Financial Openness indicator (t-1)	**0.0344**		**0.0394*** **	**-0.0486**		**0.0232**			**0.0451*** **
	0.024		0.011	0.046		0.020			0.014
Gini Coefficient	**-0.0207*** **			**0.0029**					
	0.002			0.004					
Banking Concentration	**-0.0004**			**-0.0018**			**0.0023*** **		
	0.001			0.001			0.001		
Regulatory Capital to Assets Ratio	**-3.49*** **			**-4.31*** **			**-9.73*** **		
	0.437			1.022			0.896		
Capital Requirements	**-0.9055**			**-3.39**					
	1.054			2.473					
Population Density	**0.0295*** **			**0.0445****			**0.0159**		
	0.007			0.018			0.010		

***,**,* indicate significance at 1%, 5% and 10% respectively. Standard errors are shown below the coefficients.
Source: BBVA Research

Table A.3

Regression results: final model versus results restricting the sample to 2002 onwards

VARIABLES	Number of countries=83 Number of obs=1683 R2 = 0.9807 Adjusted R2 = 0.9805			VARIABLES	Number of countries=83 Number of obs=1622 R2 = 0.9803 Adjusted R2 = 0.9792		
	Long-Term	*Mid-term*	*Short-term*		*Long-Term*	*Mid-term*	*Short-term*
Gompertz Curve Determinants	FINAL MODEL			*Gompertz Curve Determinants*	SAMPLE AFTER 2002		
Alpha	5.456***			Alpha	5.777***		
	0.164				0.238		
Gamma	-0.7678***			Gamma	-0.7582***		
	0.034				0.042		
GDP per capita PPP	-0.0417***	-0.0237***	0.0574***	GDP per capita PPP	-0.0362***	-0.0143**	0.0478***
	0.004	0.005	0.010		0.005	0.006	0.010
Interaction between GDP pc and Investment		-0.2906	-2.17***	Interaction between GDP pc and Investment		-0.2858	-2.44***
		0.200	0.429			0.234	0.428
Macro Variables				*Macro Variables*			
ST Real Interest Rate	0.1710***	0.1710***	-0.0115	ST Real Interest Rate	0.1348*	0.2442***	-0.0060
	0.053	0.044	0.026		0.072	0.059	0.029
Banks' Real Interest Rate Spread	-0.1233***	-0.0632*	0.0228	Banks' Real Interest Rate Spread	-0.0541	0.0027	0.1116***
	0.027	0.032	0.025		0.042	0.048	0.039
Inflation Rate	-0.0522*	-0.1235**	-0.0407	Inflation Rate	0.0623*	-0.0879	0.0331
	0.031	0.055	0.031		0.033	0.082	0.040
Investment to GDP Ratio	2.075***	2.091***	-0.4423	Investment to GDP Ratio	1.457***	1.531***	-0.5388
	0.264	0.261	0.305		0.315	0.399	0.462
VARIABLES	FINAL MODEL			VARIABLES	SAMPLE AFTER 2002		
Structural Determinants				*Structural Determinants*			
Information Quality Index	0.1898***	-0.0537***		Information Quality Index	0.1863***	-0.0105	
	0.017	0.0121			0.021	0.0123	
Private Bureau Coverage	0.0021***	0.0012*		Private Bureau Coverage	0.0021***	0.0024***	
	0.000	0.0007			0.000	0.0006	
Public Registries Coverage	0.0147***	0.0021*		Public Registries Coverage	0.0154***	0.0027**	
	0.001	0.001			0.001	0.001	
Legal Environment	0.2756***	0.0284		Legal Environment	0.2244***	0.0709**	
	0.016	0.035			0.018	0.031	
Legal Costs	0.0064	-0.1130***		Legal Costs	-0.0340**	-0.0887***	
	0.013	0.025			0.016	0.023	
Restrictions to Activity	0.0159***			Restrictions to Activity	0.0003		
	0.005				0.005		
Restrictions to Entry	-0.0256*			Restrictions to Entry	-0.0365**		
	0.015				0.017		
Financial Openness indicator	0.0344	0.0394***		Financial Openness indicator	-0.0058	0.0714***	
	0.024	0.011			0.022	0.023	
Gini Coefficient	-0.0207***			Gini Coefficient	-0.0192***		
	0.002				0.003		
Banking Concentration	-0.0004			Banking Concentration	-0.0011		
	0.001				0.001		
Regulatory Capital to Assets Ratio	-3.49***			Regulatory Capital to Assets Ratio	-4.12***		
	0.437				0.578		
Capital Requirements	-0.9055			Capital Requirements	-3.66*		
	1.054				2.043		
Population Density	0.0295***			Population Density	0.0353***		
	0.007				0.008		

***,**,* indicate significance at 1%, 5% and 10% respectively. Standard errors are shown below the coefficients.
Source: BBVA Research

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