European Commission

Impact of the Capital Requirements Regulation (CRR) on the access to finance for business and long-term investments

Final report

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Abstract

The Capital Requirements Regulation (CRR) considerably strengthens the quantity and quality of the minimum capital that banks in Europe are required to hold. The present study assesses whether increased minimum capital requirements, through observed changes in banks' regulatory capital ratios, impact bank lending using data on a broad sample of banks in Europe, including for the period since the entry into force of the CRR on 1 January 2014.

In the short run we find that an increase in the Total Capital Ratio leads to a statistically significant reduction in bank lending flows, and the estimated effect is robust to a wide range of robustness tests.

In the long run, simulation results based on a calibrated model indicate a negative relationship between bank lending stocks and regulatory capital ratios. However, contrary to the simulation results, our key finding, derived empirically using panel cointegration models, is that the impact of the Total Capital Ratio on bank lending stocks is not statistically different from zero.

Finally, we find no clear evidence of a relationship between increases in the Total Capital Ratio and bank financing of infrastructure through project finance across the models tested. This finding is corroborated by the results of a consultation and survey of banks providing infrastructure finance.

Court Résumé

Le règlement sur les fonds propres (CRR) renforce considérablement la quantité et la qualité du capital minimum que les banques en Europe sont tenues de détenir. En s'appuyant sur les changements observés dans les ratios de fonds propres réglementaires des banques, la présente étude évalue si les exigences accrues de fonds propres minimums on eut un impact sur les prêts bancaires en utilisant des données pour un large échantillon de banques en Europe, y compris pour la période écoulée depuis l'entrée en vigueur du CRR le 1er Janvier 2014.

À court terme, nous constatons que l'augmentation du ratio du capital total conduit à une réduction statistiquement significative des flux de prêts bancaires, et l'effet estimé est robuste pour une large gamme de tests de robustesse.

À long terme, des résultats de simulation utilisant un modèle calibré montrent une relation négative entre les stocks de prêts bancaires et les ratios de fonds propres réglementaires. Cependant, contrairement aux résultats de simulation, notre résultat-clé, obtenu empiriquement en utilisant des modèles panel de co-intégration, montre que l'impact du ratio du capital total sur les stocks de prêts bancaires n'est pas statistiquement différent de zéro.

Enfin, les différents modèles que nous avons estimés n'apportent aucune preuve claire d'une relation entre l'augmentation du ratio du capital total et le financement bancaire d'infrastructures par le biais du financement de projets. Ces résultats sont corroborés par ceux d'une consultation et d'une enquête auprès de banques finançant des projets d'infrastructures.

Executive summary

Policy background

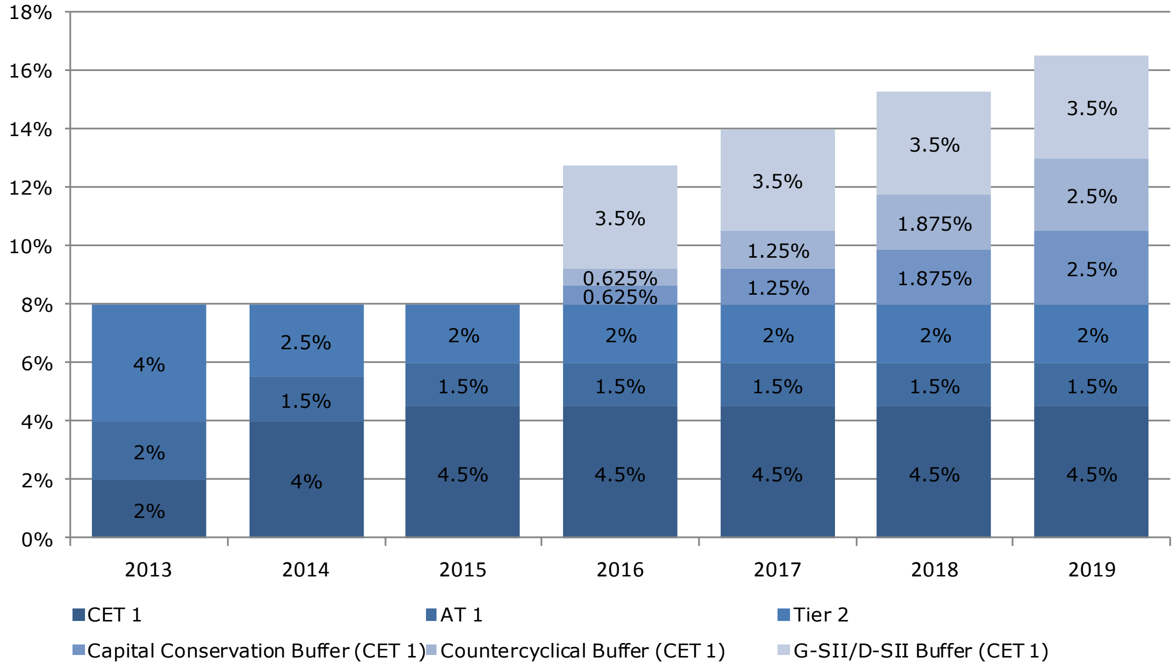
On 20 July 2011, the Commission adopted a new legislative package to strengthen the regulation of the banking sector. The proposal replaced the Banking Consolidation Directive and Capital Adequacy Directive with the Capital Requirements Directive IV (CRD IV) and the Capital Requirements Regulation (CRR). The new framework came into force on 1 January 2014, however various transitional arrangements apply until 2019.

The CRD IV/CRR framework considerably strengthens the quantity and quality of the minimum capital that banks are required to hold. Capital requirements must be met through financial resources consisting of equity or equity-like instruments (although some debt instruments are also included), retained earnings and certain reserves. Financial resources are split into two categories, Tier 1 and Tier 2 capital, depending on their characteristics and quality as capital. Tier 1, the higher quality capital, is further subdivided into Common Equity Tier 1 (CET 1) and Additional Tier 1 (AT1). The new framework tightened the eligibility requirements for items to be included as regulatory capital under both Tiers. Under the new legislation package, banks are required to maintain Tier 1 capital of at least 6% of RWA, and the proportion of the highest quality capital required, Core Equity Tier 1 (CET 1), has been increased to 4.5% of RWA.

In addition, the CRD IV/CRR framework supplements the three pillars with requirements for capital buffers that apply in addition to the capital requirements outlined above, thereby effectively increasing the proportion of overall capital required as a percentage of risk-weighted assets. These capital buffers have to consist of CET 1 capital. The CRD IV/CRR framework includes a capital conservation buffer[1] designed to ensure that banks build up capital buffers outside periods of stress which can be drawn down as losses are incurred, a discretionary countercyclical capital buffer, which may be imposed at a range between 0% and 2.5% when authorities judge credit growth is resulting in an unacceptable build-up of systematic risk, and a systemic risk buffer[2] at the option of Member States (and therefore not shown in the figure below) in order to prevent or mitigate long-term non-cyclical systemic or macro prudential risks. In addition, Member States will be able to impose a risk buffer on systemically important institutions of up to 3.5% of RWA for banks which are considered to be systemically important banks, either globally (known as G-SIIs) or domestically (known as O-SIIs in Europe)[3].

[1] Article 129 CRR
[2] Article 133 CRR
[3] Article 131 CRR

Figure 1: Capital structure of a bank under CRD IV and CRR



Note: the highest possible capital requirements are reported for the Countercyclical and G-SII/O-SII Buffers.
Source: Allen & Overy (2014a)

Economic justification and impacts of increased capital requirements

In general, higher bank capital is expected to reduce the frequency and cost of bank failure (Dewatripont and Tirole, 1994).

From a microeconomic perspective, increased capital requirements are intended to limit banks' risk taking incentives ex-ante and increase their ability to absorb losses ex-post, thereby increasing their financial stability.

From a macroeconomic perspective, the additional capital requirements on systemically important institutions (G-SII/O-SII Buffer) recognise the contribution of such banks to financial stability (or potentially financial fragility).

Further, the additional countercyclical capital requirements are intended to increase financial stability by allowing for the build-up of capital under favourable funding conditions that can be drawn down, if needed, when funding conditions deteriorate.

Typically broader economic analyses of the benefits of higher capital requirements focus on a) the reduction in probability of a financial crisis and b) the reduction the cost of financial crises (for example, European Commission, 2011; Basel Committee on Banking Supervision, 2010; and Brooke et al., 2015).

Increasing regulatory capital may also lead to costs. For instance, raising regulatory capital, particularly, by equity, may be subject to adverse selection costs, as it may signal to investors that banks are presently over-valued (Myers and Majluf, 1984).

Further, a bank adjusting its regulatory capital to meet increased regulatory capital requirements may also reduce the volume of lending, that is, it chooses to reduce assets in order to avoid the costs of increased regulatory capital in total liabilities. This particular concern is the subject of the present study.

However, before proceeding, it should be noted that reductions in lending may be beneficial if that lending was excessively risky (for example, excessive lending to the real estate sector or within the financial sector).

After considering the bank-level data used in the analysis, and the relationship between the *requirements* for regulatory capital ratios of interest and the *actual* regulatory capital ratios studied, an overview is provided of the analysis of the impacts of increased capital requirements on bank lending flows, in terms of their:

- transitional effects;
- structural effects; and
- infrastructure financing effects.

The bank-level database

The main source of the bank-level microdata used is Bankscope. A second source of bank-level microdata used is Bloomberg, which supplemented the data drawn from Bankscope. The resultant bank-level database sampled, on average, 38.1% of EU banking sector assets for the transitional effects analysis; and 36.9% for the structural effects analysis; and form a basis for generalising the conclusions to the EU as a whole.

On the relationship between *requirements* for and *actual* regulatory capital ratios

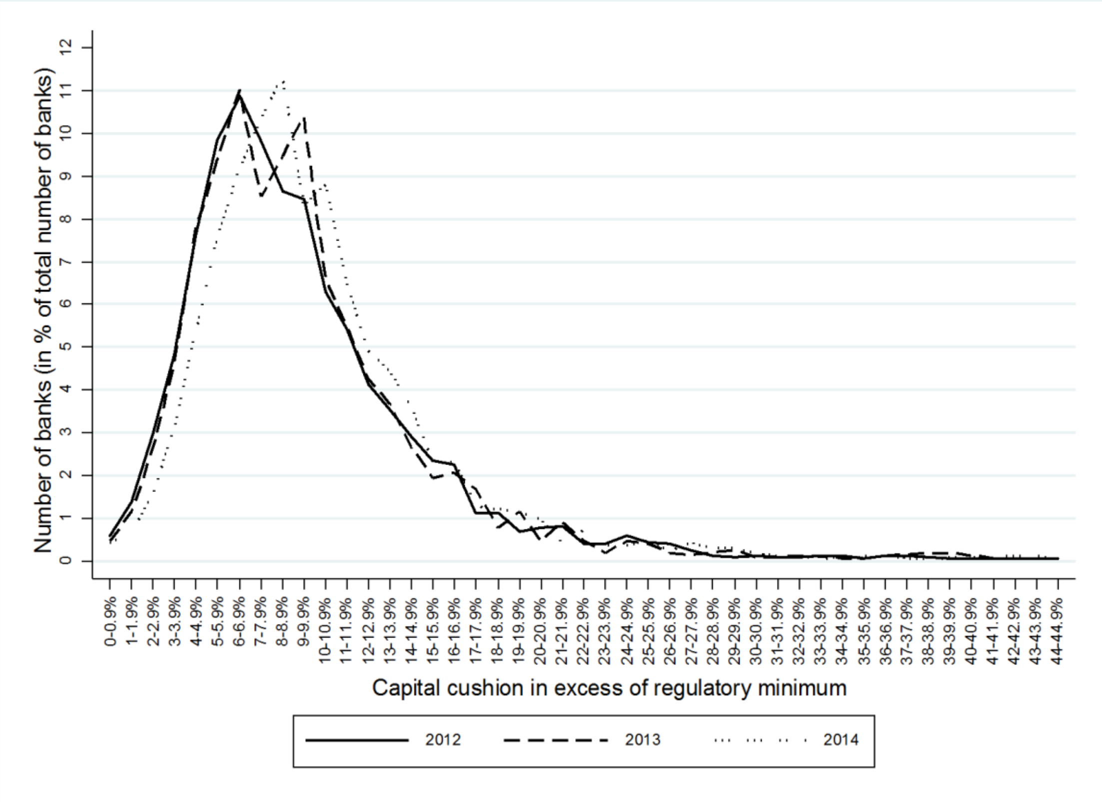
As the impact of increased capital requirements under the CRR cannot be observed directly, it is necessary, in making an assessment of their impacts on bank lending, to consider actual capital ratios.

Actual capital ratios are influenced by regulatory factors (including, increased capital requirements) and other, non-regulatory factors.

A concern with making an assessment of the impact of *requirements* for regulatory capital ratios on the basis of *actual* capital ratios is that actual capital ratios could be driven purely by non-regulatory factors. Indeed, one observes that banks maintain a capital ratio "cushion" above the regulatory minimum, giving rise to the possibility that they could simply decrease the size of this cushion in response to increased regulatory capital requirements and maintain lending levels.

However, one also observes that banks increased actual capital ratios at key capital regulation dates, indicating that actual capital ratios do respond to changes in capital regulation. The figure below shows, for instance, that since the application of the CRR in Europe since the 1st of January 2014, there is a statistically significant shift to the right in the distribution of banks' capital ratios in excess of the regulatory minimum.

Figure 2: Distribution by banks of capital cushion, year-ends 2012, 2013 and 2014



Notes: Percentage of banks in Europe maintaining a Total Capital Ratio in excess of the minimum requirement for Total Capital Ratio of 8% ("capital cushion") at year-end 2012, 2013 and 2014. *Sample of banks reporting their Total Capital Ratio (2012, 2013 or 2014)
Source: Bankscope and LE Europe calculations

Further, the empirical analysis discussed below shows that lending impacts are larger for banks with smaller capital cushions, which is further evidence that actual regulatory capital ratios are likely affected by requirements for regulatory capital ratios.

In conclusion, although one cannot observe the impact on bank lending of increased capital *requirements* under the CRR per se, the impact of actual capital ratios provide a guide to their likely effects. With this background in mind, the results of the quantitative analysis undertaken are discussed.

Transitional effects

Since the application of the Capital Requirements Regulation in 2014, banks in Europe have had to meet increased capital requirements, including requirements to maintain a *greater quantity* of *higher quality* capital as a proportion of risk-weighted assets than previously.

Banks are presently in a period of change, as the capital requirements under the CRR that they are subject to are being phased in gradually up to 2019.

However, banks had the opportunity to anticipate the application of the new capital regulation regime because the Basel III Accord was adopted in 2011, at which point its transposition and implementation in Europe could be foreseen. Also, banks may have been pressed by markets to front-load to a large extent the future capital requirement increases.

In effect, banks may have been adjusting their capital structures to meet the new capital requirements at the full, 2019 level early on, and it is the objective presently to assess whether adjustments to regulatory capital in response to (anticipated and actual) increase in capital requirements under the CRR had an effect on lending.

"Transitional effects" are defined as the short-term effects of increased capital requirements on bank lending, that is, the effects that prevail contemporaneously or over a short number of periods after adjustments to higher capital requirements take place. In the main empirical exercises undertaken, transitional effects are measured over a period of three years.

Our main estimate of the transitional effect, derived in this study using data for the period 1985-2014, shows that for a one percentage point increase in the Total Capital Ratio[4] the impact on lending flows[5] of banks in the EU is -0.8% over one year with the implied impact over a three-year period being -1.5%.

Further, while the Total Capital Ratio has an economically significant impact on bank lending flows, the result should be read within the context of the fact that other bank-level and macroeconomic drivers matter to lending flow developments such as past lending flows and the output gap. Indeed, the estimation results of the baseline model indicate that a 1% increase in lending flows one year ago is related to a 0.34% increase in lending flows in the present year. In the case of the output gap, a one percentage point increase in the output gap results in a 0.95% reduction in bank lending flows.

Additional analysis shows that the impact of changes in the Total Capital Ratio on bank lending flows arises mainly through corporate and consumer loans, with mortgage loans being unaffected. These results are consistent with the notion that mortgages receive a relatively generous capital treatment under the CRR compared to the other loan categories and therefore do not show a negative relationship with the Total Capital Ratio. While the sizes of the samples of banks used in this more granular analysis of loan categories are relatively small due to lack of data, especially on

[4] The Total Capital Ratio is the sum of the Tier One (T1) Ratio and the Tier Two (T2) Ratio

[5] Lending flows are measured by a net lending measure (that is, new lending minus repayments)

consumer loans, the empirical results do suggest that the transitional effects arise mainly through corporate and consumer lending.

The size of the effect is within the same range as estimates from previous studies for single European Member States and the euro area. However, it is important to note that the present study includes sample data covering the period since the adoption of Basel III, whereas the majority of others do not.

A series of robustness tests have been undertaken to check the sensitivity of the effect sizes estimated. The models estimated indicate that a one percentage point change in the Total Capital Ratio has a statistically significant impact on bank lending flows in the same confidence interval as the main estimate.

Lastly, an analysis was carried out for subsamples of banks based on pre-crisis business models proxied by size, capitalisation, and funding. This showed that the impact of the Total Capital Ratio on bank lending flows was greater for banks that have historically been less capitalised and are funded to a greater extent through non-deposit liabilities.

Structural effects

"Structural effects" are defined here as the long-term effects of increased capital requirements on bank lending, that is, the effects that prevail once adjustments to higher capital requirements have taken place, and the economy is in a new long-term equilibrium.

The analysis of structural effects involved an assessment of simulation results and empirical results, which are each discussed in greater detail below.

Simulation results

Using a model of the credit market featuring banks of different size, potential long-term implications of increased capital requirements are discussed. Given that there is a lack of historical evidence on increases in bank capital requirements affecting all banks in an economy to such an extent, the potential long-term credit market implications are discussed in a theoretical framework.

Stricter bank capital requirements can affect bank lending not only through an increase in bank funding costs, but also through changes in the competitive structure of the credit market. This, in turn, can affect the market power of the incumbent banks and finally the lending rates for firms. Thus, in order to illustrate potential structural implications of tighter bank capital requirements, a model featuring imperfect bank competition and market structure in the credit market is used.

Similar to findings from other models, the simulation results show that higher capital requirements can lead to an increase in banks' funding costs. This, in turn, translates into higher bank lending rates, so that credit demand and credit to output ratios tend to fall. If all banks are affected by the capital requirement alike, credit market concentration remains unchanged in the model presented below. Yet, if the largest banks face higher capital requirements than the other ones, concentration may decline, as the funding costs and the lending rates of the large banks rise, so that their credit market share falls, all other things constant. The simulation exercises also illustrate that the implications of higher capital requirements depend on the prevailing market structures and, for example, on the response of the return on bank capital to higher bank capital ratios. Overall, the simulation results reveal that increased capital requirements can lead to higher bank lending rates due to the related funding cost increases.

Related studies which have assessed the economic importance of the effect of higher bank capital ratios on bank lending have come to the same qualitative conclusion. Regarding the long-run costs of higher capital ratios, the literature concludes that they are modest however. Moreover, the costs related to credit market outcomes, have to be weighed against the benefits of reduced macroeconomic volatility and a lower risk of crises. Depending on the specific frictions included in the theoretical models, some recent studies have also found positive long-term effects of increased capital requirements on bank lending, for example, in the case where bank capital requirements are increased from an initially rather low level.

Overall, the discussion of the diverse theoretical predictions on the long-term effects of increased capital requirements highlights that it ultimately remains an empirical question how credit markets react to changes in capital regulations in the long-run. It also suggests that identifying the socially optimal level of capital requirements is inherently difficult: the lending impact of capital requirement changes is just one side of the coin and neglects any potential offsetting benefits in terms of reduced risk-taking and increased loss-absorption.

Empirical results

The impact of regulatory capital ratios on bank lending stocks in the long run is estimated empirically in an error correction framework. Developments in bank lending stocks is the relevant measure for capturing lending developments in the long-run as it reflects the sum of flows over time.

Empirically, a long-run relationship between regulatory capital ratios and bank lending stocks estimated using data on *a panel of banks* is unlikely to be found because banks of different size maintain a given capital ratio, which supports a wide range of bank lending stocks. As such, it is important to control for the influence of size on the relationship between regulatory capital ratios and bank lending stocks in the long run. This observation motivates our consideration of a possible long-run relationship between regulatory capital ratios, bank lending stocks *and bank size*.

The sample of banks focuses on those more involved in traditional lending activities, that is, those with an average ratio of lending stocks to total assets greater or equal to 40%. The cut-off at 40% is justified by the tests for cointegration, which reject a cointegrating relationship between lending stocks, the Total Capital Ratio and bank size for those banks with a ratio of bank lending stocks to total assets less than 40%.

The choice of estimation method addresses key issues that may arise in the current setting. In particular, the model specification allows for heterogeneity in the equilibrium relationship between bank lending stocks, the Total Capital Ratio and bank size at the bank level and mitigates the impact of cross-sectional dependence across banks.

Model specification and sample changes are also made to the baseline model to test the robustness of the results. More specifically, the inclusion of additional bank characteristics and macroeconomic controls, the potential for a structural break in the long-run relationship between bank lending stocks, the Total Capital Ratio and bank size and the exclusion of Italian banks, which form a substantial proportion of banks in the estimation samples, are tested separately.

Overall, the following key findings emerge from the estimation of the various error correction models, derived using data for the period 1985-2014:

- The estimated impact of the Total Capital Ratio on bank lending stocks in long-run is negative (of -2.2%) in the baseline estimation; however the effect is not statistically different from zero once the assumption of strict exogeneity amongst the variables is relaxed.
- During the transition phase to a new equilibrium, an increase in the Total Capital Ratio has a statistically significant negative impact (of -1.1%) on the change in bank lending stocks, which is consistent with results obtained in the analysis of transitional effects.
- The baseline estimation is unaffected by the inclusion of other (statistically significant) bank characteristics and macroeconomic controls.
- A structural break in 2011 is introduced in the modelled long-run relationship between bank lending stocks, the Total Capital Ratio and bank size. This corresponds to the announcement of Basel III. However, the statistical significance of a break is rejected at conventional significance levels.
- Italian banks represent a large proportion of banks (63%) in the estimation samples used. The estimated short-run impact of the Total Capital Ratio in the

estimation excluding Italian banks is statistically insignificant and smaller in magnitude when compared to the baseline estimation including Italian banks. However, the short-run impact excluding Italian banks is still economically significant despite being statistically insignificant, with a p-value of 20%.

The preferred estimation results are different to the simulation results discussed above and to previous studies, which find a negative relationship between lending stocks and regulatory capital ratios. For example, taking results for 38 models across 15 countries, the Macroeconomic Assessment Group (MAG) (2011) report a 1.4% decrease in lending volume given a one percentage point increase in the target capital ratio over 8 years.

Infrastructure financing effects

The value and quantity of EU infrastructure projects (funded wholly or in part by banks) grew rapidly from 2000 to 2006 when it reached its peak in terms of value to date. This was supported by economic growth in the EU, the willingness of banks to lend to infrastructure investors and the volume of PPPs in countries such as the UK and France.

However, from 2006, the value of EU infrastructure projects fell and crashed in 2009 as a result of the financial crisis and the reluctance of banks to offer infrastructure loans.

Since then and following the 2009 trough, both the number of deals and total deal value have recovered markedly with the number of deals in 2014 being well above and the value of deals only slightly below their respective 2006 peaks.

These developments occurred in a context of a growing role and funding contribution of institutional investors in the EU infrastructure sector. As a result, the proportion of the total value of infrastructure deals financed through bank debt in the EU has declined in recent years from 82.7% in 2007 to 65.9% in 2014. This development reflects the growing role of non-bank infrastructure investors.

However, while the overall volume of infrastructure funding provided by banks and non-banks has more or less recovered from the financial crisis, the current state of affairs is characterised by the paradoxical situation of a combination on one side of very large infrastructure needs (estimated by some observers to total about €1 trillion over the period 2016-2019) and large pools of potential infrastructure funding, and on the other side an actual level of infrastructure financing that remain well below potential needs. According to market commentators and infrastructure finance specialists, this paradoxical situation reflects at the present time mainly a lack of a strong pipeline of high quality, investable infrastructure projects.

Obviously, this state of affairs raises the issue of whether the increased capital requirements and the capital charging methodologies that can be used for infrastructure projects have had a negative impact on the level of infrastructure funding provided by banks. A small consultation and a small survey of 14 banks (of which nine were in the top 25 banks providing infrastructure finance) suggest that this is not generally the case.

Among the survey respondents, only two felt that the CRR had a negative impact while the others were of the opinion that it had no impact. However, the consultations also suggest that the CRR has led banks to focus on shorter tenor projects and often prefer less risky projects with capacity or availability payments. The consultation also highlights the view that the CRR as it stands does not take into account the particular risk specificities of the various infrastructure projects, especially of those projects involving either availability or capacity payments with no or little demand risks or special risk mitigation measures such as guarantees or insurance. In particular, the slotting approach was viewed as not being sensitive and granular enough to take account of particular risk characteristics of infrastructure projects. This situation is viewed by the consultation participants as having a negative impact on banks' appetite for longer tenor projects.

As a complement to the more qualitative assessment of the impact of the CRR on bank infrastructure finance, an econometric analysis of the potential impact of the CRR was also undertaken.

In the empirical analysis, infrastructure financing transactions data at the bank-level are used, covering both PPP and non-PPP projects and infrastructure projects funded across the transport, telecommunications, power, renewables, environment and social sectors. An econometric model similar to the one used for estimating transitional effects of increased capital requirements was estimated. However, as transaction level data are available in the case of infrastructure, specific variables relating to particular infrastructure financing deals are included in the model.

The key result, derived in this study using data for the period 1985-2014, is that while a one percentage point increase in the Total Capital Ratio is estimated to have a negative impact on bank financing of infrastructure, the size of the impact is in a relatively wide range and the 95% confidence interval around the estimated impact is very close to zero or crosses zero at the upper end. Therefore, one can draw the conclusion that there is not clear evidence of a major negative impact of increased capital requirements under the CRR on bank financing of infrastructure, a result which is consistent with findings from the consultations and survey. The results highlight further that the impact of changes in the Total Capital Ratio on bank lending flows in general (as per the transitional effects analysis) are economically more significant than on bank financing of infrastructure in particular.

Sommaire

Contexte

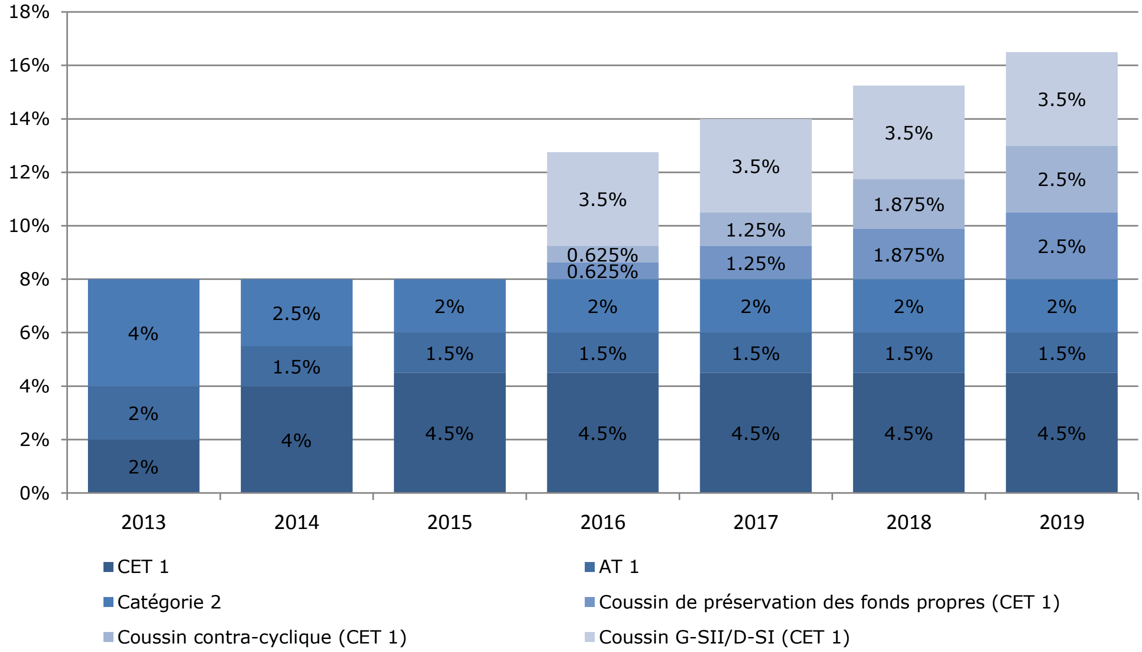
Le 20 Juillet 2011, la Commission a adopté un nouveau paquet législatif visant à renforcer la réglementation du secteur bancaire. La proposition a remplacé la directive concernant l'accès à l'activité des établissements de crédit et son exercice et la directive sur l'adéquation des fonds propres des entreprises d'investissement et des établissements de crédit par la directive sur les exigences de fonds propres IV (CRD IV) et le règlement sur les exigences de fonds propres (CRR). Le nouveau cadre est entré en vigueur le 1er Janvier 2014, mais diverses dispositions transitoires sont applicables jusqu'en 2019.

L'ensemble de la CRD IV et du CRR renforce considérablement la quantité et la qualité du capital minimum que les banques sont tenues de détenir. Les exigences de capital doivent être couvertes par des ressources financières, comprenant des actions ou des instruments similaires à des actions (bien que certains instruments de dette soient également inclus), les bénéfices non répartis et certaines réserves. Les ressources financières sont divisées en deux catégories, c'est-à-dire les catégories 1 et 2, en fonction de leurs caractéristiques et de leur qualité en tant que fonds propres. De plus, la catégorie 1, celles des fonds propres de la plus haute qualité est encore subdivisé en fonds propres de base de catégorie 1 (CET 1) et fonds propres additionnels de catégorie 1 (AT1). Le nouveau cadre a resserré les conditions d'admissibilité d'instruments qui peuvent être inclus dans le capital réglementaire au titre des deux catégories. Dans le cadre des mesures de la nouvelle législation, les banques sont tenues de maintenir un montant de fonds propres de catégorie 1 égal à au moins 6% d'actifs pondérés en fonction du risque (RWA), et la proportion du capital de la plus haute qualité requise, c'est-à-dire les fonds propres de base (CET 1), a été augmentée à 4,5% des RWA.

En outre, le cadre CRD IV / CRR complète les trois piliers avec des exigences pour des coussins de capital applicables en plus des exigences de fonds propres décrites ci-dessus, ce qui de fait augmente la proportion du capital total requis en pourcentage des actifs pondérés en fonction du risque. Ces coussins de capitaux doivent être composés de capital de catégorie 1. Le cadre CRD IV / CRR comprend a) un coussin de conservation de fonds propres[6] visant à assurer que les banques accumulent des coussins de capitaux en dehors des périodes de stress qui peuvent être prélevées en cas de perte, un coussin de fonds propres contra-cyclique, qui peut être imposé de façon discrétionnaire dans une fourchette comprise entre 0% et 2,5% lorsque les autorités estiment que la croissance de crédit résulte en une accumulation inacceptable de risque systématique, et b) un coussin pour risque systémique[7] dont l'imposition est laissée à la discrétion des États membres (et donc n'est pas représenté dans la figure ci-dessous) afin de prévenir ou d'atténuer des risques non-cycliques, systémiques ou des risques macro-prudentiels. En outre, les États membres seront en mesure d'imposer un coussin pour institutions d'importance systémique jusqu'à 3,5% des RWA pour les banques qui sont considérées comme des banques d'importance systémique, soit globalement (connu sous le nom G-SII) ou nationalement (connu sous le nom O -SIIs en Europe).[8]

[6] Article 129 CRR
[7] Article 133 CRR
[8] Article 131 CRR

Figure 3: Structure du capital d'une banque sous CRD IV et CRR



Note: les exigences de fonds propres les plus élevées possibles sont utilisées pour les coussins contra-cyclique et pour les G-SII/O-SII.
Source: Allen & Overy (2014a)

La justification économique et les impacts des exigences de fonds propres accrues

En général, un niveau de capital bancaire plus élevé devrait réduire la fréquence et le coût de défaillance bancaire (Dewatripont et Tirole, 1994).

D'un point de vue micro-économique, des exigences de fonds propres plus élevés sont destinées à limiter ex-ante les incitatifs de prise de risque par les banques et accroître leur capacité à absorber les pertes ex-post, augmentant ainsi leur stabilité financière.

Du point de vue macro-économique, les exigences contra-cycliques supplémentaires de fonds propres imposées aux institutions d'importance systémique (le coussin pour les G-SII / O SII) reconnaissent la contribution de ces banques à la stabilité financière (ou, potentiellement, à la fragilité financière).

En outre, les exigences supplémentaires de fonds propres contra-cycliques sont destinées à accroître la stabilité financière en permettant l'accumulation de capital lorsque les conditions de financement sont favorables pour être utilisées, si nécessaire, lorsque les conditions de financement se détériorent.

L'analyse économique plus générale typiquement se concentre sur les avantages des exigences de fonds propres plus élevés en termes de a) une réduction de la probabilité d'une crise financière et b) une réduction du coûts des crises financières (par exemple, Commission Européenne, 2011; Comité de Bâle sur le contrôle bancaire, 2010; and Brooke et al., 2015).

L'augmentation du capital réglementaire peut également entraîner des coûts. Par exemple, une augmentation du capital réglementaire, en particulier par actions, peut entraîner des coûts de sélection adverse, car elle peut signaler aux investisseurs que les banques sont actuellement surévaluées (Myers et Majluf, 1984).

En outre, une banque qui ajuste son capital réglementaire pour répondre à l'augmentation requise de fonds propres peut également réduire le volume des prêts. C'est-à-dire, elle choisit de réduire ses actifs afin d'éviter les coûts d'un capital réglementaire plus élevé dans le total de son passif. Cette possibilité est l'objet de la présente étude.

Cependant, avant de continuer, il convient de noter que des réductions de crédit peuvent être bénéfiques si le crédit était trop risqué (par exemple, prêts excessifs au secteur de l'immobilier ou au sein du secteur financier).

Après avoir examiné les données au niveau des banques utilisées dans l'analyse, et la relation entre les ratios requis de capital réglementaire et les ratios de capital réglementaire observés et étudiés, ce sommaire donne un aperçu de l'analyse des impacts des exigences de fonds propres accrues sur les flux de prêts bancaires, en termes:

- d'effets de transition;
- d'effets structurels; et
- d'effets de financement des infrastructures.

La base de données bancaires

La principale source de micro-données bancaires utilisée par l'étude est Bankscope. Une deuxième source de micro-données bancaires est Bloomberg qui a complété les données tirées de Bankscope. La base de données au niveau des banques individuelles résulte d'un échantillon couvrant, en moyenne, 38,1% des actifs du secteur bancaire de l'UE pour l'analyse des effets de transition; et 36,9% pour l'analyse structurelle des effets, et constitue une base pour généraliser les conclusions de l'analyse à l'UE dans son ensemble.

A propos de la relation entre les exigences en termes des ratios de fonds propres réglementaires et les ratios de fonds propres réglementaires observés

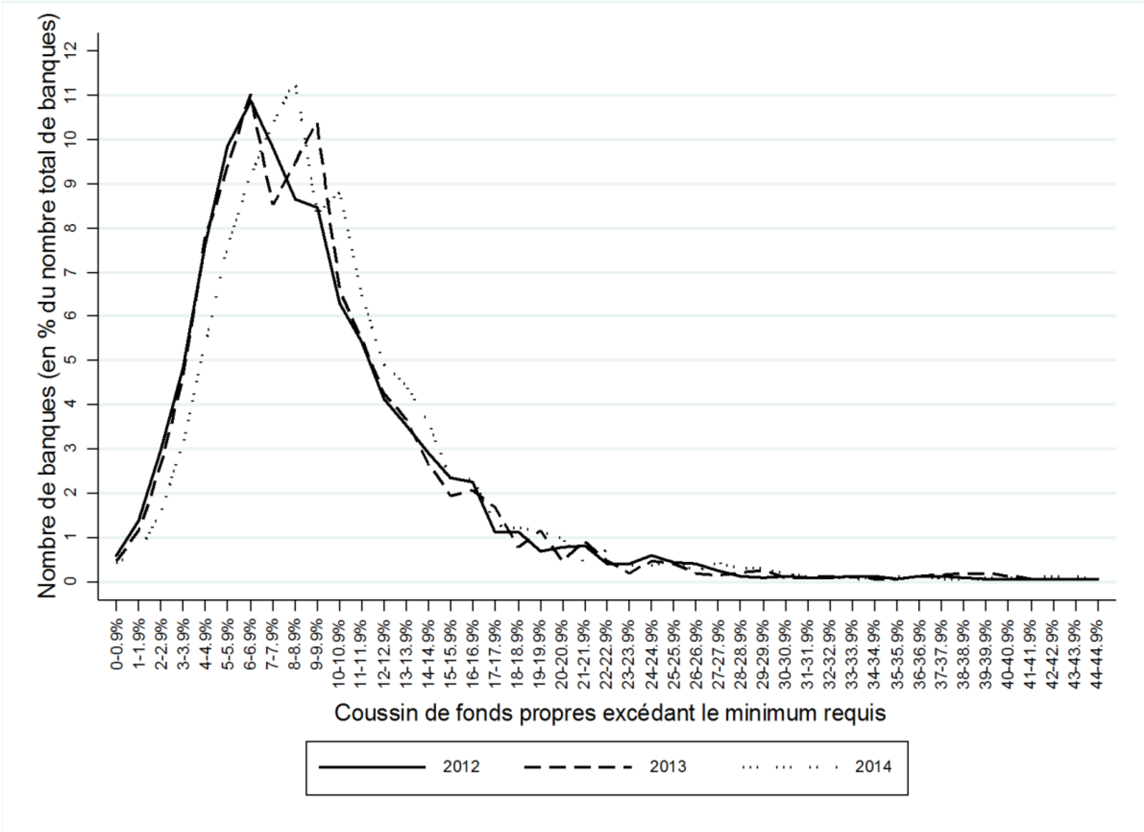
Comme l'impact des exigences accrues de fonds propres sous le CRR ne peut être observé directement, pour évaluer leurs impacts sur les prêts bancaires il est nécessaire de considérer les ratios de capital réglementaire effectivement observés.

Ces ratios de capital observés ou réels sont influencés par des facteurs réglementaires (y compris, les exigences de capital accrues) et d'autres facteurs, non réglementaires.

Une préoccupation lors d'une évaluation de l'impact des exigences en matière de ratios de fonds propres réglementaires sur la base de ratios de fonds propres réels est le fait que les ratios de capital réels pourraient être affectés par des facteurs purement non-réglementaires. En effet, on observe que les banques maintiennent un coussin de ratio de fonds propres au-dessus du minimum réglementaire, donnant lieu à la possibilité qu'elles pourraient simplement diminuer la taille de ce coussin en réponse à l'augmentation des exigences de fonds propres réglementaires et de maintenir les niveaux de prêt.

Cependant, on observe également que les banques ont augmenté les ratios de capital réels à des dates clés de la régulation du capital, ce qui indique que les ratios de fonds propres réels répondent aux changements dans la réglementation du capital. Le graphique ci-dessous montre, par exemple, que depuis l'application du CRR en Europe depuis le 1er Janvier 2014, il y a un déplacement statistiquement significatif vers la droite de la distribution des ratios de fonds propres des banques au-delà du minimum réglementaire.

Figure 4: Distribution par banques du coussin de capital à la fin d'année pour les années 2012, 2013 et 2014



Notes: Pourcentage de banques en Europe maintenant un ratio de capital total excédant l'exigence minimale de 8% pour le ratio du capital total ("coussin de capital") en fin d'année 2012, 2013 et 2014. * Échantillon de banques pour lesquelles le ratio du capital total (2012, 2013 ou 2014) est disponible.
Source: Bankscope et calculs LE Europe

En outre, l'analyse empirique présentée ci-dessous montre que les impacts sur les prêts sont plus grands pour les banques avec de plus petits coussins en capital, ce qui est une preuve supplémentaire que les ratios de fonds propres réglementaires réels sont susceptibles d'être affectés par les exigences de ratios de fonds propres réglementaires.

En conclusion, bien que l'on ne puisse pas observer en soi l'impact sur les prêts bancaires des exigences accrues de fonds propres dans le cadre du CRR, l'impact des ratios de fonds propres réels fournit un guide de leurs effets probables. C'est dans ce contexte que les résultats de l'analyse quantitative qui a été réalisée sont discutés.

Effets transitionels

Depuis l'application du règlement sur les exigences de fonds propres en 2014, les banques en Europe ont dû répondre à des exigences accrues en capital, y compris des exigences de maintenir une plus grande quantité de capital de meilleure qualité en proportion des actifs pondérés par risques que précédemment.

Les banques sont actuellement en période de changement, car les exigences de fonds propres dans le cadre du CRR qu'elles doivent rencontrer sont mises en œuvre graduellement jusqu'en 2019.

Cependant, les banques ont eu l'occasion d'anticiper l'application du nouveau régime de réglementation des fonds propres car l'accord de Bâle III a été adopté en 2011, ce qui permettait de prévoir sa transposition et mise en œuvre en Europe. En outre, les banques peuvent avoir été mises sous pression par les marchés d'accélérer dans une large mesure les augmentations futures des exigences de fonds propres.

En effet, les banques ont pu adapter dès le début leurs structures de capital pour rencontrer pleinement les nouvelles exigences de fonds propres en 2019, et l'objectif de cette partie de l'étude est de déterminer si des ajustements au capital réglementaire en réponse à l'augmentation (prévue et effective) des exigences de capital par le CRR ont eu un effet sur les prêts.

Les « effets transitoires » sont définis comme les effets à court terme des exigences accrues de fonds propres sur les prêts bancaires, c'est-à-dire les effets qui résultent instantanément ou sur un nombre limité de périodes après que les ajustements aux exigences accrues de fonds propres aient eu lieu. Dans les principaux travaux empiriques entrepris pour cette étude, les effets de transition sont mesurés sur une période de trois ans.

Notre principale estimation de l'effet de transition, obtenue dans cette étude en utilisant des données pour la période 1985-2014, montre que, pour une augmentation d'un point de pourcentage du ratio total du capital9, l'impact sur le flux des prêts bancaires10 dans l'UE est -0.8% sur une année et que l'impact implicite sur une période de trois ans est de -1,5%.

En outre, alors que le ratio du capital total a un impact, qui du point de vue économique est significatif, sur les flux de prêts bancaires, le résultat doit être vu dans un contexte où d'autres facteurs spécifiques aux banques et macro-économiques importent pour expliquer l'évolution des flux de prêts ; entres autres, ces facteurs sont les flux précédents de prêts et l'écart entre les niveaux de production potentielle et production observée. En effet, les résultats de l'estimation du modèle de référence montrent qu'une augmentation de 1% dans le flux de prêts bancaires il y a un an est liée à une augmentation de 0,34% des flux de crédit au cours de l'année courante. Dans le cas de l'écart de production, une augmentation d'un point de pourcentage de l'écart de production se traduit par une réduction de 0,95% du flux de prêts bancaires.

[9] Le ratio total du capital est la somme du ratio des catégorie 1 (T1) et catégorie 2 (T2).

[10] Les flux de prêts bancaires sont mesurés sur base d'une mesure de prêts nette (c'est les nouveaux prêts moins les remboursements)

Une analyse supplémentaire montre que l'impact des changements dans le ratio du capital total sur le flux de prêts bancaires est observé principalement au niveau des prêts aux entreprises et du crédit à la consommation, les prêts hypothécaires n'étant pas affectés. Ces résultats sont cohérents avec le fait qu'en termes de capital réglementaire requis, les prêts hypothécaires sont traités relativement généreusement par rapport aux autres catégories de prêts, et donc ne présentent pas une relation négative avec le ratio du capital total. Bien que la taille des échantillons des banques utilisées dans cette analyse plus fine des catégories de prêts soit relativement petite en raison d'un manque de données, en particulier pour les prêts à la consommation, les résultats empiriques suggèrent que les effets transitoires se matérialisent principalement par les prêts aux entreprises et consommateurs.

La taille de l'effet est du même ordre de grandeur que les estimations des études précédentes se concentrant sur des États membres individuels et la zone euro. Cependant, il est important de noter que la présente étude comprend dans l'échantillon des données couvrant la période post-adoption de Bâle III, alors que la majorité des autres études ne le font pas.

Une série de tests de robustesse ont été entrepris pour vérifier la sensibilité de la grandeur des effets estimés. Les modèles estimés indiquent qu'une variation d'un point de pourcentage du ratio du capital total a un effet sur les flux de prêts bancaires qui est statistiquement significatif et se situe dans le même intervalle de confiance que l'estimation principale.

Enfin, une analyse a été effectuée pour des sous-échantillons qui regroupent des banques ayant suivi des modèles d'affaires différents avant la crise ; ces différences sont captées par des variables suivantes : taille, capitalisation et financement. Cette analyse montre que l'impact du ratio du capital total sur les flux de prêts bancaires a été plus importante pour les banques qui historiquement été moins capitalisées et financées dans une large mesure par des instruments autres que des dépôts.

Effets structurels

Les « effets structurels » sont définis ici comme les effets à long terme des exigences accrues de fonds propres sur les prêts bancaires, c'est-à-dire les effets qui prévalent une fois que les ajustements aux exigences de fonds propres accrues ont eu lieu, et l'économie est à nouveau en équilibre de long terme.

L'analyse des effets structurels consiste en une évaluation des résultats de simulation et des résultats empiriques, qui sont chacun discutés plus en détail ci-dessous.

Résultats de simulations

Les simulations utilisent un modèle du marché du crédit, avec des banques de taille différente, ce qui permet d'évaluer les implications potentielles à long terme des exigences en fonds propres accrues. Étant donné un manque de preuves historiques sur l'effet d'une augmentation des exigences de fonds propres des banques de telle importance et touchant toutes les banques dans une économie, les effets de répercussions à long terme sur le marché du crédit sont discutés dans un cadre théorique.

Des exigences de fonds propres bancaires plus strictes peuvent affecter les prêts bancaires non seulement par une augmentation des coûts de financement des banques, mais aussi par des changements dans la structure concurrentielle du marché du crédit. Ceci, à son tour, peut affecter le pouvoir de marché des banques en place et enfin les taux de prêt pour les entreprises. Ainsi, afin d'illustrer les implications structurelles potentielles des exigences de fonds propres des banques plus strictes, un modèle incorporant une concurrence imparfaite dans le secteur bancaire et dans la structure de marché dans le marché du crédit est utilisé.

Comme les résultats d'autres modèles, les résultats de simulation montrent que les exigences de fonds propres plus élevés peuvent conduire à une augmentation des coûts de financement des banques. Ceci, à son tour, se traduit par une hausse des taux sur les prêts des banques, de sorte que la demande de crédit et le ratio du crédit par rapport à la production ont tendance à tomber. Si toutes les banques sont affectées de la même façon par l'exigence accrue de fonds propres, la concentration du marché du crédit reste inchangée dans le modèle présenté ci-dessous. Cependant, si les plus grandes banques font face à des exigences de fonds propres plus élevées que les autres, la concentration peut diminuer lorsque les coûts de financement et les taux sur les prêts des plus grandes banques augmentent de sorte que leur part du marché du crédit diminue, toutes choses égales. Les exercices de simulation montrent également que les conséquences des exigences de fonds propres plus élevées dépendent des structures de marché existantes et, par exemple, de la réponse du rendement sur le capital de la banque à des ratios de fonds propres plus élevés. Globalement, les résultats des simulations révèlent que les exigences de capital accrues peuvent entraîner une hausse des taux sur les prêts des banques en raison des augmentations de leur coût de financement.

Les études similaires qui ont évalué l'importance économique de l'effet des ratios de fonds propres des banques plus élevés sur les prêts bancaires en sont venues à la même conclusion qualitative. En ce qui concerne les coûts à long terme de ratios de fonds propres plus élevés, la littérature conclut qu'ils sont modestes cependant. De plus, les coûts accrus sur le marché du crédit doivent être mis en balance avec les avantages d'une volatilité macro-économique réduite et un moindre risque de crises. Selon les frictions spécifiques incluses dans les modèles théoriques, certaines études récentes ont également trouvé des effets positifs à long terme sur les prêts bancaires résultant des exigences accrues en capital sur les prêts bancaires, par exemple dans le cas où les exigences de fonds propres des banques sont augmentées à partir d'un niveau initial plutôt faible.

Globalement, la discussion des diverses prédictions théoriques sur les effets à long terme des exigences en fonds propres accrues montre qu'en fin de compte la question de savoir comment les marchés de crédit réagissent à long terme à l'évolution des fonds propres réglementaires est une question empirique. Elle suggère également que l'identification du niveau socialement optimal des exigences en capital est intrinsèquement difficile: l'impact sur les prêts des modifications des exigences en capital n'est qu'un côté de la médaille et néglige les avantages compensatoires potentiels en termes de réduction de la prise de risque et l'augmentation de la capacité d'absorber des pertes.

Résultats empiriques

L'impact à long terme des ratios de fonds propres réglementaires sur les stocks de prêts bancaires est estimé empiriquement à l'aide d'un modèle de correction d'erreur. L'évolution des stocks de prêts bancaires est la mesure pertinente pour saisir l'évolution des prêts à long terme, car elle reflète la somme des flux au fil du temps.

Empiriquement, il est peu probable de trouver une relation à long terme entre les ratios de fonds propres réglementaires et les stocks de prêts bancaires à l'aide des données d'un panel de banques parce que des banques de taille différente peuvent maintenir un même ratio de capital qui sous-tend un large éventail de stocks de prêts bancaires. C'est pourquoi, il est important de tenir compte de l'effet de la taille des banques sur la relation à long terme entre les ratios de fonds propres réglementaires et les stocks de prêts bancaires. Cette observation motive notre examen d'une relation à long terme potentielle entre les ratios de capital réglementaire, les stocks de prêts bancaires et la taille de la banque.

L'échantillon des banques se concentre sur les plus impliquées dans les activités de prêt traditionnelles, c'est-à-dire celles qui montrent un ratio moyen de prêts au total des actifs supérieur ou égal à 40%. Le seuil de 40% est justifié par les tests de co-intégration qui rejettent une relation de co-intégration entre les stocks de prêt, le ratio du capital total et la taille de la banque pour les banques avec un ratio des stocks de prêts bancaires au total des actifs de moins de 40%.

Le choix de la méthode d'estimation tient compte des défis-clés qui peuvent survenir dans le contexte de l'estimation. En particulier, la spécification du modèle permet de tenir compte au niveau de la banque de l'hétérogénéité dans la relation d'équilibre entre les stocks de prêts bancaires, le ratio du capital total et la taille de la banque, et atténue l'impact de la dépendance en coupe transversale entre banques.

Des modifications de la spécification du modèle et des échantillons sont également apportées au modèle de référence pour tester la robustesse des résultats. Plus précisément, l'inclusion des caractéristiques bancaires supplémentaires et de variables macro-économiques, la possibilité d'une rupture structurelle dans la relation à long terme entre les stocks de prêts bancaires, le ratio du capital total et la taille de la banque et l'exclusion des banques italiennes, qui forment une part importante des banques incluses dans les échantillons d'estimation, sont testés séparément.

Globalement, les principales conclusions qui se dégagent de l'estimation des différents modèles de correction d'erreur utilisant des données pour la période 1985-2014 sont les suivantes:

- L'impact estimé du ratio du capital total sur les stocks de prêts bancaires à long terme est négatif (-2,2%) dans l'estimation de base; mais l'effet n'est pas statistiquement différent de zéro une fois que l'hypothèse d'exogénéité stricte entre les variables est relâchée.
- Pendant la phase de transition vers un nouvel équilibre, une augmentation du ratio du capital total a un impact négatif statistiquement significatif (de -1,1%) sur la variation des stocks de prêts bancaires, ce qui est cohérent avec les résultats obtenus dans l'analyse des effets de transition.
- L'estimation de base n'est pas affectée par l'inclusion d'autres caractéristiques (statistiquement significatives) de la banque et des variables macro-économiques.
- Une rupture structurelle en 2011 est introduite dans la relation à long terme entre les stocks de prêts bancaires, le ratio du capital total et la taille de la banque. Cela correspond à l'annonce de Bâle III. Cependant, la signification statistique d'une rupture est rejetée au niveau conventionnel de signification.
- Les banques italiennes représentent une proportion importante des banques (63%) dans les échantillons d'estimation. L'impact à court terme estimé du ratio du capital total dans une estimation excluant les banques italiennes est statistiquement non significatif et de plus petite amplitude par rapport à l'estimation de base qui inclut les banques italiennes. Cependant, l'impact à court terme de l'estimation excluant les banques italiennes est encore économiquement significatif en dépit d'être statistiquement non-significatif, avec une p-valeur de 20%.

Les résultats d'estimation préférés diffèrent des résultats de simulation décrits ci-dessus et de ceux d'études précédentes qui trouvent une relation négative entre les stocks de prêts et les ratios de fonds propres réglementaires. Par exemple, en prenant les résultats pour 38 modèles couvrant 15 pays, le Groupe macro-économique d'évaluation (MAG) (2011) rapporte une baisse de 1,4% en volume de prêts pour une augmentation d'un point de pourcentage du ratio cible de capital sur une période de plus de 8 ans.

Effets de financement des infrastructures

La valeur et le volume des projets d'infrastructure dans l'UE (financés en totalité ou en partie par les banques) ont augmenté rapidement de 2000 à 2006 quand ils ont atteint son apogée en termes de valeur à ce jour. Cette croissance était soutenue par la croissance économique dans l'UE, la volonté des banques de prêter aux investisseurs en infrastructure et le volume des partenariats public-privé (PPP) dans des pays tels que le Royaume-Uni et la France.

Cependant, à partir de 2006, la valeur des projets d'infrastructure de l'UE a diminuée et s'est écrasée en 2009 à la suite de la crise financière et la réticence des banques à offrir des prêts d'infrastructure.

Depuis lors, et après le creux de 2009, le nombre de transactions et la valeur totale des transactions ont récupéré de façon marquée. Le nombre de transactions en 2014 était bien au-dessus de son pic de 2006 tandis que la valeur des transactions n'était que légèrement en dessous de son pic de 2006.

Ces développements ont eu lieu dans un contexte où le rôle et la contribution des investisseurs institutionnels au financement des infrastructures de l'UE ont crû. En conséquence, la proportion de la valeur totale des transactions d'infrastructure financées par la dette bancaire dans l'UE a diminué au cours des dernières années, passant de 82,7% en 2007 à 65,9% en 2014. Cette évolution reflète le rôle croissant des investisseurs d'infrastructure non-bancaires.

Cependant, alors que le volume global de financement des infrastructures par les banques et non-banques s'est plus ou moins remis de la crise financière, la situation actuelle est caractérisée par un paradoxe avec d'une part de très grands besoins en infrastructures (estimés par certains observateurs au total à environ 1 € milliards d'euros sur la période 2016-2019) et de grandes disponibilités financières pour financer des infrastructures potentielles, et d'autre part un niveau de financement effectif des infrastructures qui reste bien en deçà des besoins potentiels. Selon les commentateurs de marché et spécialistes de la finance d'infrastructure, cette situation paradoxale reflète à l'heure actuelle principalement l'absence d'un solide pipeline de projets d'infrastructure de haute qualité et dans lesquels on peut investir.

Evidemment, cet état de choses soulève la question de savoir si les exigences de fonds propres accrues et les méthodes pour déterminer les fonds propres requis qui peuvent être utilisées pour des projets d'infrastructure ont eu un impact négatif sur le niveau de financement des infrastructures par les banques. Une petite consultation et une petite enquête auprès des 14 banques (dont neuf figurent parmi les principales 25 banques qui financent des infrastructures) suggèrent que cela n'est généralement pas le cas.

Parmi les personnes ayant répondu à l'enquête, seulement deux ont estimé que le CRR a eu un impact négatif tandis que les autres étaient d'avis qu'il n'a eu aucun impact. Toutefois, les consultations suggèrent également que le CRR a conduit les banques à se concentrer sur des projets de durée plus courte et à préférer souvent des projets moins risqués avec des paiements de capacité ou de disponibilité. La consultation fait également ressortir le point de vue que le CRR tel qu'il est ne prend pas en compte les spécificités des risques particuliers des divers projets d'infrastructure, en particulier des projets impliquant soit des paiements de disponibilité ou de capacité et donc sans ou avec peu de risques de demande ou des mesures spéciales d'atténuation des risques tels que garanties ou assurances. En particulier, l'approche d'allocation par créneau est considérée comme n'étant pas suffisamment sensible et granulaire pour tenir compte des caractéristiques particulières de risque des projets d'infrastructure. Cette situation est considérée par les participants à la consultation comme ayant un impact négatif sur l'appétit des banques pour des projets de longue durée.

En complément de l'évaluation plus qualitative de l'impact du CRR sur le financement par les banques des projets d'infrastructure, une analyse économétrique de l'impact potentiel du CRR a également été entreprise.

Dans l'analyse empirique, des données de transactions avec financement bancaire de projets d'infrastructures PPP et non-PPPs dans le transport, les télécommunications, l'énergie, les énergies renouvelables, l'environnement et les secteurs sociaux ont été utilisées. Un modèle économétrique similaire à celui utilisé pour l'estimation des effets transitoires des exigences accrues de fonds propres a été estimé. Cependant, comme les données sont disponibles au niveau des transactions individuelles, des variables spécifiques à ces transactions sont incluses dans le modèle.

Le principal résultat, obtenu dans cette étude en utilisant des données pour la période 1985-2014, est qu'une augmentation d'un point de pourcentage du ratio du capital total est estimée avoir un impact négatif sur le financement bancaire des projets d'infrastructure, mais l'intervalle de confiance de 95% est relativement large et sa borne supérieure est très proche de zéro ou dépasse zéro. Par conséquent, on peut tirer la conclusion qu'il n'y a pas de preuve claire d'un impact négatif majeur des exigences de fonds propres accrues dans le cadre du CRR sur le financement bancaire de l'infrastructure, un résultat qui concorde avec les résultats de la consultation et de l'enquête. En outre, les résultats mettent en évidence que l'impact des changements dans le ratio du capital total sur les flux de prêts bancaires en général (selon l'analyse des effets transitoires) est d'un point de vue économique plus important que sur le financement bancaire de l'infrastructure en particulier.

Introduction

Economic growth and job creation are supported by access to finance for business and long-term investments, including in infrastructure assets.

With regard to the EU banking capital framework, Regulation 575/2013 of the European Parliament and of the Council on prudential requirements for credit institutions and investment firms (CRR) provides a single rulebook establishing a single set of harmonised prudential rules which banks throughout Europe must respect. The main focus of this legislation is on laying down a prudential framework ensuring the resilience of banks and financial stability.

The CRR requires that the Commission report to the Council and Parliament on whether some features of this new prudential framework might reduce the flow of financing to the real economy: Article 505 foresees a report on the appropriateness of the CRR requirements in light of the need to ensure adequate levels of funding for all forms of long-term financing for the economy, including critical infrastructure projects. Article 516 foresees a report on the impact of the CRR on the encouragement of long-term investments in growth-promoting infrastructure.

The purpose of the present study is to provide the Commission with evidence and relevant conclusions on the impact of the CRR on bank lending flows, including the provision of financing to infrastructure projects by banks.

The rest of this introduction presents further background on the study. The following two chapters discuss in turn the bank-level data used in the analysis, and the relationship between the *requirements* for regulatory capital ratios of interest and the *actual* regulatory capital ratios studied. The remainder of the report provides an analysis of the impact of increased capital requirements on bank lending flows, in terms of their:

- transitional effects;
- structural effects; and
- infrastructure financing effects.

Policy background

On 20 July 2011, the Commission adopted a new legislative package to strengthen the regulation of the banking sector. The proposal replaced the Banking Consolidation Directive[11] and Capital Adequacy Directive[12] with the Capital Requirements Directive IV (CRD IV)[13] and the Capital Requirements Regulation (CRR)[14]. The new framework came into force on 1 January 2014, however various transitional arrangements apply until 2019 (see figure below).

[11] 2006/48/EU
[12] 2006/49/EU
[13] 2013/36/EU
[14] Regulation 575/2013

The CRD IV/CRR framework implements the Basel III standards that have been established by the Basel Committee on Banking Supervision in 2010/2011[15] at the European level. The Basel Accords are founded upon three pillars:

- Pillar I establishes minimum capital requirements for banks and other financial institutions, allocating percentage capital requirements for individual assets based on their credit, operational and market risk. Assets are weighted according to their risks to ensure that the regulatory capital required for a specific asset reflects the actual risk profile of that asset, with riskier assets requiring higher or better quality capital reserves
- Pillar II is concerned with risk management and supervision, establishing processes relating to the internal control procedures of an institution
- Pillar III entails the compulsory disclosure of a number of risk items, among them capital structure, capital adequacy, credit risk, scope of regulation, equities in the non-trading book, credit risk mitigation, securitisation, market risk, operational risk and interest rate risk in the non-trading book (Allen & Overy, 2014b)

The purpose of the present study is to provide the Commission with evidence and relevant conclusions on the impact of the capital requirements established under Pillar I on bank lending, including the provision of financing to infrastructure projects by banks.

The CRD IV/CRR framework[16] has already considerably strengthened the quantity and quality of minimum capital requirements. Capital requirements have to be met by financial resources that consist of equity or equity-like instruments (although some debt instruments are also included), retained earnings and certain reserves. Financial resources are split into two categories, Tier 1 and Tier 2 capital[17], depending on their characteristics and quality as capital. Tier 1, the higher quality capital, is further subdivided into Common Equity Tier 1 (CET 1) and Additional Tier 1 (AT1). The new framework tightened the eligibility requirements for items to be included as regulatory capital under both Tiers. Under the new legislation package, banks are required to maintain Tier 1 capital of at least 6% of RWA[18], and the proportion of the highest quality capital required, Core Equity Tier 1 (CET 1), has been increased to 4.5% of RWA[19].

In addition, the Basel III and CRD IV/CRR frameworks supplement the three pillars with requirements for capital buffers that apply in addition to the capital requirements outlined above, thereby effectively increasing the proportion of overall capital required as a percentage of risk-weighted assets. These capital buffers have to consist of CET 1

[15] A draft of the Basel III standards has first been published in December 2010, followed by revisions in June 2011

[16] The rules and prudential requirements on capital are primarily contained in the CRR, which allows for the imposition of a single set of rules for banks across the EU. While EU members have some discretion regarding capital buffers and deductions, and will be allowed to make exceptions to the CRR in some instances, they have to prove that the exceptions comply with the rules on flexibility and capital buffers laid down in the CRD IV Directive

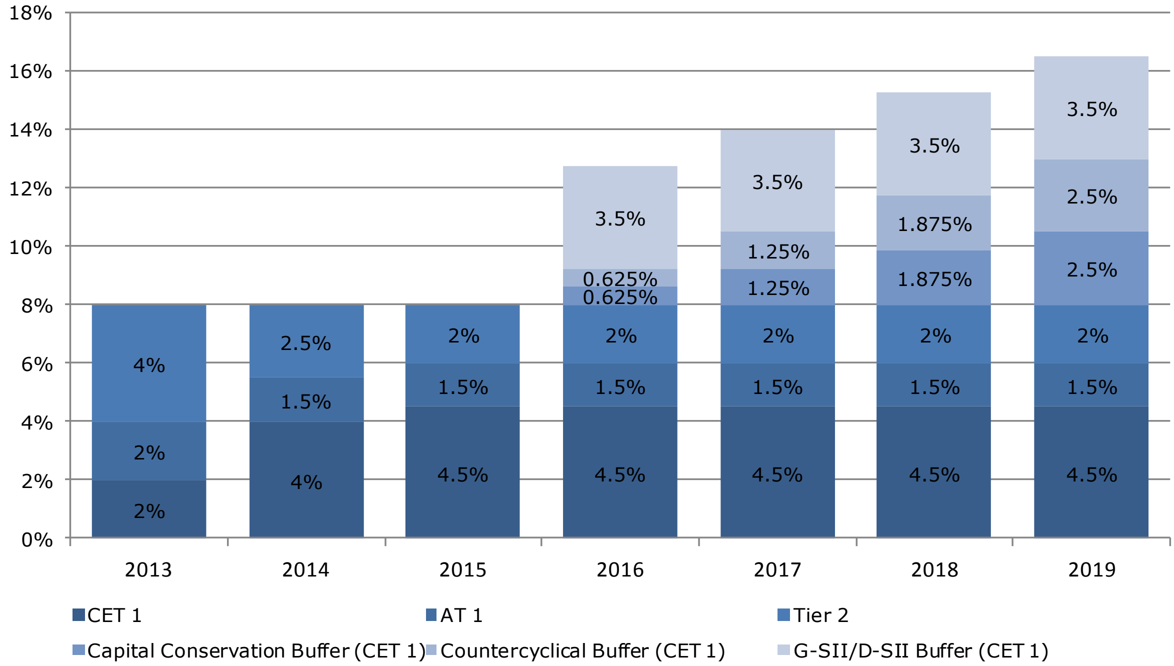
[17] Tier 3 capital, a feature of Basel II, has been abolished by Basel III

[18] Under transitional provisions, only 5.5% was required until 2015

[19] Under transitional provisions, only 4% was required until 2015

capital. The CRD IV/CRR framework includes a capital conservation buffer[20] designed to ensure that banks build up capital buffers outside periods of stress which can be drawn down as losses are incurred, a discretionary countercyclical capital buffer, which may be imposed at a range between 0% and 2.5% when authorities judge credit growth is resulting in an unacceptable build-up of systematic risk, and a systemic risk buffer[21], at the option of Member States (and therefore not shown in the figure below), in order to prevent or mitigate long-term non-cyclical systemic or macro prudential risks. In addition, Member States will be able to impose a risk buffer on systemically important institutions of up to 3.5% of RWA for banks which are considered to be systemically important banks, either globally (known as G-SIIs) or domestically (known as O-SIIs in Europe)[22].

Figure 5: Capital structure of a bank under CRD IV and CRR



Note: the highest possible capital requirements are reported for the Countercyclical and G-SII/O-SII Buffers.
Source: Allen & Overy (2014a)

Economic justification and impacts of increased capital requirements

In general, higher bank capital is expected to reduce the frequency and cost of bank failure (Dewatripont and Tirole 1994).

From a microeconomic perspective, increased capital requirements are intended to limit banks' risk taking incentives ex-ante and increase their ability to absorb losses ex-post, thereby increasing their financial stability.

From a macroeconomic perspective, the additional capital requirements on systemically important institutions (G-SII/O-SII Buffer) recognise the contribution of such banks to financial stability (or potentially financial fragility).

[20] Article 129 CRR
[21] Article 133 CRR
[22] Article 131 CRR

Further, the additional countercyclical capital requirements are intended to increase financial stability by allowing for the build-up of capital under favourable funding conditions that can be drawn down, if needed, when funding conditions deteriorate.

Typically broader economic analyses of the benefits of higher capital requirements focus on a) the reduction in probability of a financial crisis and b) the reduction the cost of financial crises (for example, European Commission, 2011; Basel Committee on Banking Supervision, 2010; and Brooke et al., 2015).

As noted by the Basel Committee study of 2010 (the long-term economic impact study or LEI study), economic history suggests that the average annual probability of a financial crisis is 4% to 5% (that is, a financial crisis is expected to occur every 20 to 25 years).

Moreover, the median estimate from all the studies considered by the Basel Committee in their analysis is that a one percentage point reduction in the likelihood of a banking crisis is estimated to yield on average a benefit per year of about 0.6% of output if one considers that the output losses caused by banking crises are permanent (that is, the level of GDP never returns to its pre-crisis trend level even if eventually returns to its pre-crisis trend growth rate) and 0.2% of output when the banking crisis effect only temporarily depresses the level of economic activity.

As already noted above, higher capital requirements are not only expected to reduce the probability of a financial crisis but also the magnitude of such crisis as banks will have more capital to absorb losses and may have taken on less risk prior to the crisis due to the higher capital charges associated with more risky assets.

In addition to reducing the probability of banking crises and the magnitude of the financial and economic losses associated with such crises, higher capital requirements (and liquidity requirements) may also reduce the amplitude of typical credit and business cycles (European Commission, 2011) and bring about less volatile economic growth. Such an increase in stability of the expansion path of the economy benefits all economic agents, especially those which are particularly exposed to the vagaries of the credit cycle such as SMEs and households. Greater stability also helps monetary policy in achieving its objectives as the magnitude of any required changes in policy instruments is reduced.

In addition to improved financial stability and the associated benefits, increasing regulatory capital in the structure of bank liabilities brings about social benefits in the form of a reduction of: i) the tax subsidy associated with debt (arising due to the deductibility of interest); and ii) implicit government guarantees (as the increased regulatory capital increases the level of “bail-in-able” liabilities) (see for example Admati and Hellwig, 2013).

The materialisation of all these broad economic benefits, however, depends crucially on the risk-taking behaviour of banks. Higher capital requirements should reduce risk-taking by financial intermediaries or, at a minimum, have no impact on banks’ risk appetite.

A number of *theoretical* studies however have shown that, in the specific models and analytical frameworks used by these studies, higher capital requirements may in fact encourage greater risk taking. Such studies include:

- Baker and Wurgler (2015) who note that, because of the "low-risk anomaly" in stock markets (that is, returns and thus realised costs of equity are higher, not lower, for less risky equity), the cost of equity of banks may be lower than it should actually be because of stronger capital buffers, and may encourage greater yield chasing and risk taking
- Blum and Hellwig (1995) who show in their analysis that the anticipation of higher capital requirements in the future may lead to more risk taking today to offset the effect of higher capital charges
- Boot and Greenbaum (1993) who highlight that if increased capital requirements result in a more diluted ownership of banks, bank equity owners may have less of an incentive to monitor bank activities. However, evidence suggests that in the lead up to crises shareholder activism in general actually increases risk-taking (Roman, 2015)
- Boot (2001) who argues that because bankers view equity capital as being more expensive than debt finance they will be inclined to take on more risks to earn higher yields to offset the higher cost of capital
- Flannery (1989), Blum (1999) Hellman et al. (2000) and Repullo (2004) who argue that higher capital requirements may reduce overall returns on assets and, therefore, leads to yield chasing and greater risk taking
- Martynova (2014) who notes that higher capital requirements increase the franchise value of core banking which attracts funds which can go to more risky activities
- Perotti et al. (2011) who note that higher capital requirements may allow or encourage banks to take on more tail risk without breaching these requirements as by definition the materialisation of such tail risk is considered very low
- Perotti and Suarez (2009) who argue that well-capitalised banks may want to “lever up” their capital by taking on more risk and not through traditional leverage which is constrained by the capital ratio

Overall, there exist few very empirical studies on the question of riskiness and risk-taking by banks and capital requirements, leading Martynova (2015) to conclude in her survey of the effect of bank capital requirements on economic growth that *“…both theoretical and empirical studies are not conclusive as to whether more (stringent) capital (requirements) reduces banks’ risk-taking and makes lending safer*”.

Increasing regulatory capital may also lead to social costs, which the theoretical literature considers. Firstly, raising regulatory capital, particularly, by equity, may be subject to adverse selection costs, as it may signal to investors that banks are presently over-valued (Myers and Majluf, 1984).

Secondly, greater regulatory capital may lead to agency costs: a greater share of equity capital in bank funding can generate agency problems between equity owners and managers, as it insulates managers from market pressures (Kashyap, Rajan and Stein, 2008).

It is also sometimes agreed that an increase in capital requirements reduces the relative importance of the bank monitoring and disciplining function of bank debt holders (for example, Calomiris, 2013).

Importantly, the costs of increasing regulatory capital may have an impact on the volume of lending, whereby banks choose to reduce assets in order to avoid the costs of increased regulatory capital in total liabilities. This particular impact is the subject of the present study.

However, it should be noted that social costs may not arise with reductions in the volume of lending that is excessively risky (for example, excessive lending to the real estate sector or within the financial sector).

While bearing these theoretical arguments in mind, Admati and Hellwig (2013) observe that it is not clear whether the social cost arguments noted by the theoretical literature are very strong or even present at all.

Before reviewing the findings of relevant empirical literature, it is important to recall that the most recent capital requirement changes occurred in the aftermath of the great financial crisis, and that the economic and financial circumstances and environment facing banks at that time were very special. Therefore, one should be very cautious in extrapolating any empirical results from that period to typical bank behaviour. However, most of the empirical studies reported below focus either on periods prior to the onset of the financial crisis or make use of calibrated models populated with parameters reflecting a longer economic period.

Finally, it is important to note that while higher capital requirements aim to increase the capacity of each bank to deal with credit counterparty shocks, they may not in themselves be sufficient to reduce markedly systemic risk in the financial system.

Adjustment to increased capital requirements

Banks have a number of options in adjusting to increased capital requirements.[23]

One option is to fund the increased capital requirements through retained earnings. This may involve increasing lending spreads, which would bring about lending impacts; increasing profit margins on other business lines; reducing operating expenses; or finally, reducing the share of profits distributed to shareholders.

A second option is to fund the increased capital requirements by raising equity.

A third option is to undertake asset side adjustment in order to meet the increased capital requirements: by reducing assets while maintaining the existing regulatory capital level, thereby increasing the regulatory capital ratio. Lending impacts may arise through asset side adjustment if loan portfolios are run down or sold-off. Asset side adjustment, and therefore lending impacts, may be more gradual, whereby the rate of lending growth is set to be lower than regulatory capital growth, boosting the regulatory capital ratio over time.

Finally, banks may reduce risk-weighted assets by substituting riskier loans, with higher risk weights, with safer loans; or by reducing risk weights through other means such as using IRB approaches instead of the standardised approach for calculating assets' risk weights, as the IRB approaches allow for discretion on the part of banks in choosing their risk weights[24].

[23] Discussion based on Cohen and Scatigna (2014)

[24] Mariathasan and Merrouche (2012) for instance find evidence consistent with the strategic use of internal risk models under the Basel II advanced approaches. The authors compare the predictive power of risk-weighted asset ratios in explaining bank failures when the financial crisis was not anticipated (at the end of 2005) compared to when it may have been anticipated (at the end of 2006). They find that risk-weighted asset ratios did predict future bank failure in 2005 but not in 2006, which is consistent with the strategic use of Basel II risk-weights

The costs of increasing regulatory capital may have an impact on lending through a mix of the abovementioned channels. However, banks reducing lending in response to increased capital requirements in some time periods is also an expected and desired outcome, given the objective of increased capital requirements limiting risk taking.

Related literature

Transitional effects

There is an extensive literature that estimates the transitional impacts of capital or capital requirements on bank lending econometrically (Kashap, Stein and Hanson, 2010).

The key issue that econometric research on the impact of capital or capital requirements on lending has to address is that deteriorating economic conditions often bring about loan losses (that reduces capital) as well as contractions in loan demand (that reduces lending), making it difficult to distinguish the independent effect of capital on lending.

Europe

Focusing on the adjustment of bank assets and lending to changes in the capital ratio from the end of 2009 to the end of 2012, Cohen and Scatigna (2014) find that a one percentage point increase in the capital ratio was associated with a decrease of 0.36 percentage points in loan growth. The study covered major banks in Austria, Belgium, France, Germany, Ireland, Italy, Netherlands, Poland, Portugal, Russia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Euro area

Focusing on a subset of Euro area countries (Austria, Belgium, France, Germany, Italy, Portugal and Spain), Maurin and Toivanen (2012) use a similar framework to Francis and Osborne (2009) (see below) and show that a one percentage point increase in capital requirements leads to a medium-term reduction in lending growth of 2pp to 2.3pp. The authors' estimates are particularly interesting because they cover the period up to the last quarter of 2011, therefore include some of the impacts of the financial crisis on capital adjustments.

Mésonnier and Monks (2014) consider the surprise increase in Core Tier 1 capital ratios to 9% of risk-weighted assets for major European banking groups imposed by the European Banking Authority (EBA) in 2012 as an exogenous shock to capital in affected banks. The authors find that banks that had to increase capital by one percentage point tended to have annualised loan growth of 1.2 percent less than banks that were not affected by the increased capital requirement. Interestingly, the authors find that banks that were not capital constrained as a result of the EBA requirement did not increase lending as capital constrained banks reduced lending. The effects of the increased capital requirements across affected and unaffected banks were not offset therefore, and had macroeconomic effects.

France

Fraisse, Lé, and Thesmar (2015) assess the transition from Basel I to Basel II, which reduced French banks' regulatory capital by approximately 1pp. The authors use the fact that a shift in the capital regulation regime involved a change in capital requirements at the borrower-level, dependent on the borrower's risk, as a source of exogenous variation: comparing borrowing across firms within individual banks, the impact of the change in capital requirements is identified. The authors find that a one percentage point decrease in capital requirements leads to an increase in bank lending to firms of about 10%.

While not providing a direct estimate of the impact of changes in the regulatory capital ratio, Labonne and Lamé (2014) show that, over the period 2003 to 2009, the positive impact on bank lending of an increase in bank capital is very much smaller when banks are close to their regulatory capital limits.

United Kingdom
In the UK several studies consider time-varying bank-specific minimum capital requirements imposed on UK banks between 1998 and 2007 (for example, Francis and Osborne, 2009; Bridges et al., 2014; and Aiyar, Calomiris and Wieladek 2014b).

The authors of the abovementioned studies argue that these capital requirements were not related to lending *per se* (and were therefore exogenous) as they were intended to fill gaps in the early Basel I system that did not consider variation in *inter alia* legal, reputational and operational risks. They corroborate this view regarding the exogeneity of capital requirements through observations such as a lack of association between the capital requirements and past/future credit risk (see, for example, Aiyar, Calomiris and Wieladek, 2014b).

Each of the studies considering the time-varying bank-specific minimum capital requirements imposed on UK banks finds that, over the period 1998 to 2007, an increase in capital requirements is linked to a reduction in lending/lending growth, at least temporarily.

- The estimates of Aiyar, Calomiris and Wieladek (2014b) indicate that a one percentage point increase in capital requirements is linked to between a 6.5 and 7.2 percentage point reduction in lending growth.

- Francis and Osborne (2009) find that a one percentage point increase in capital requirements leads to a 1.2% decline in the stock of loans over a period of four years. In their framework, estimates of the impact of deficits/surpluses of capital relative to the regulatory minimum on lending are generated. Based on their estimates, the authors simulated the impact of an increase in capital requirements on lending stocks.

- Bridges et al. (2014) consider the impact of an increase in capital requirements sector by sector. The authors find that increased capital requirements lead to a reduction in bank lending growth temporarily, recovering after three years. A one percentage point increase in capital requirements leads to a reduction in household secured lending growth by 0.8 percentage points at its low point one year later, but lending growth returns to its long-run average over time, as banks restore capital buffers to above the regulatory minimum.

  Lending growth to commercial real estate and private non-financial corporates (excluding, commercial real estate) follows similar patterns, although the one quarter reduction in lending growth is larger than for household secured lending, at four percentage points for commercial real estate and 2.1 percentage points for private non-financial corporates (excluding, commercial real estate) respectively.

Aiyar, Calomiris and Wieladek (2014c) also examined whether, over the period 1998 to 2007, the responses of large banks to changes in capital requirements and interest rate policy differs from those of smaller banks and found no statistically significant differences in the estimated responses of large and small banks while only small banks are responsive to changes in interest rate policy.

However, the same authors (Aiyar, Calomiris and Wieladek, 2014d) also find that over the same period, branches of foreign banks increased their lending in response to increases in capital requirements on UK banks and UK subsidiaries of foreign banks with the response of branch lending being about twice as large for increases in capital requirements on subsidiaries of the same banking group as for increases in capital requirements on UK bank or subsidiaries unrelated to the banking group to which the branch belonged.

Finally, Aiyar, Calomiris, Hooley, Korniyenko and Wieladek (2014) find that overall, over the period 1999 to 2006, the growth rate of cross-border lending of UK banks fell by 5.5 percentage points for every one percentage point increase in minimum capital requirements. But, cross-border lending to countries with which the banks had a close relationship typically fell by less.

While the studies discussed above focused on a period ending before the financial crisis, Noss and Toffano (2014) using a VAR estimation to examine the response of lending growth in the UK to changes in the aggregate capital-to-asset ratio of the UK banking sector over the period 1986 to 2010 and find that a cumulative increase in the capital ratio of one percentage point is associated with a two percentage point reduction in lending growth after two quarters. But the impact on lending growth is nil after 20 quarters.

Japan and US

Peek and Rosengren (1997) consider the impact of capital changes to parent banks in Japan on the lending of their US branches. In order to distinguish capital shocks from demand conditions, they use the fact that the Japanese stock market lost half its value over the three-year period between 1989 and 1992 and this translated into regulatory capital losses that were unrelated to demand conditions in the US. They find that a one percentage point decline in the Japanese parent's capital ratio results in a six percent decline in loans at the US branch.

USA

Finally, Houston, James and Marcus (1997) show that loan growth at all banks owned by a single bank holding company are affected by capital shocks at particular banks owned by the bank holding company, and use this fact to identify changes in capital that are plausibly exogenous to demand. They find that if the capital level of the holding company is below the regulatory minimum, lending growth is five percentage points lower at subsidiaries than it otherwise would be for well-capitalised banks.

In the absence of natural/policy experiments providing exogenous variation in capital/capital requirements (such as used by the UK studies and Houston, James and Marcus (1997)), a number of studies consider differences in responses across banks to common capital shocks. Bernanke and Lown (1991) is a typical example of a study using this approach. They compare lending between large and small banks in the context of capital losses incurred during the 1990-1 recession in New Jersey in the US. Assuming large banks have better access to capital and observing that both sets of banks are subject to the same demand conditions, they attribute the difference in lending growth across large and small banks to a "capital crunch". The authors find that lending is significantly affected by capital losses for smaller banks.

An issue with the Bernanke and Lown (1991) approach is that differences in lending across large and small banks could be due to factors other than capital. In particular, the large and small banks may be lending to different customers. Jiménez et al. (2010) address the issue of differences in demand across banks using detailed loan-level information, comparing borrowing across banks for firms that borrow from two or more banks – loan demand is therefore controlled for through within-firm comparisons. The authors find that banks operating with relatively low levels of capital reduce loan granting by more than other banks, especially in response to a slowdown in economic activity or a monetary tightening.

The results of the studies above[25] suggest that capital shocks have lending impacts in the short run: all of the studies above show lending impacts of capital shocks consistently despite differences in methodology. This is the conclusion of other reviews also (Kashyap, Stein and Hanson, 2010; and VanHoose, 2008). VanHoose (2008) in Francis and Osborne (2009) observes, for instance, that almost all research on the impacts of bank capital regulation shows that the short-run effects of binding capital requirements are reductions in bank lending; indeed, reductions in bank lending are larger for banks that are more capital constrained.

However, Kashyap, Stein and Hanson (2010) also note that as the magnitude of effects varies, one cannot conclude in general as to what the size of effects may be. This observation is corroborated by considering a summary of key estimates from the abovementioned studies (where available).

[25] See also Brinkmann and Horvitz (1995); Ediz, Michael and Perraudin (1998); Hancock, Laing and Wilcoz (1995) and Ito and Sasski (2002) in Kashyap, Stein and Hanson (2010)

Table 1: Summary of findings on the transitional impacts of increased capital requirements on bank lending flows/growth

	Geography	Lending impacts	Time period
Cohen and Scatigna (2014)	**Europe** (AT, BE, CH, DE, ES, FR, IE, IT, NL, PL, PT, RU SW, TK, UK)	-0.36pp	
Mésonnier and Monks (2014)	**Euro area**	-1.2%	One year
Maurin and Toivanen (2012)	**Sub-set of euro area** (AT, BE, DE, ES, FR, IT, PT)	-2- -2.3pp	"Medium term"
Fraisse, Lé and Thesmar (2015)	**FR**	10%**	"Short term"
Aiyar, Calomiris and Wieladek (2014b)	**UK**	-7.2pp – -6.5pp‡	
Francis and Osborne (2009)	**UK**	-1.2%†	Four years
Bridges et al. (2014)	**UK**	-0.8pp – -4.0pp*	One year
Noss and Toffano (2014)	**UK**	2pp/0pp	Two quarters / 20 quarters
Houston, James and Marcus (1997)	**US**	5pp	

Note: *0.8 (household secured lending), 2.1 (private non-financial corporate lending), 4.0 (commercial lending), **in response to a reduction in capital requirements, †lending stocks, ‡cross-border lending
Source: Various studies cited above

It is important to emphasise that the results presented by Bridges et al. (2014) indicate that effects may differ across sectors.

With regard to the studies that use post-financial crisis data, it is important to note that the estimates represent an upper-bound insofar poor economic conditions may make adjustments through capital raising particularly difficult (Jiménez et al., 2010).

Moreover, the micro-econometric approach does not take into account general equilibrium effects that other studies are able to. Indeed, the majority of these latter studies suggest relatively modest impacts of increased capital requirements in the long run, as discussed below.

Structural effects

Simulation approach

While a number of studies have used a model-based simulation approach to assess the potential impact of capital requirement regulations on bank lending, their result vary greatly and are largely model dependent. Typically such models are calibrated general equilibrium models and the results are very sensitive to the underlying model assumptions. In particular, the calibrated models differ with regards to:

- Assumptions on the adjustment channel, that is, whether banks raise new capital or reduce RWA (and thus whether the model looks at only lending prices or also direct supply-side reductions of lending volumes)
- Assumptions on the amount of additional capital required
    - Assumption on the baseline, that is, the starting point from which the effects of regulation on bank capital raising are calculated
    - Assumption on the size of voluntary capital buffers banks will hold above the regulatory minimum
- Assumptions on the funding costs for banks, in particular
    - whether the model incorporates the Modigliani-Miller theorem, that is, whether it is assumed that the funding structure has no impact on overall funding costs
    - Assumptions on the elasticity of equity and/or debt funding markets: whether funding costs are constant (elastic market) or increase over time with rising volumes of issuance (inelastic market)
    - Assumptions on the required return on bank equity and debt costs
- Assumptions on the extent of pass-through of bank financing costs onto bank lending costs
    - Assumptions on the scope for banks to reduce other costs to offset potential cost increases in funding
    - Assumptions on whether RROE is constant or decreasing (related to Modigliani-Miller Theorem)
    - Assumptions on the scope for banks to increase non-interest income
- Incorporations of and assumptions on the likely response of monetary authorities (assumptions on the period length over which regulations are introduced
- Incorporation of additional liquidity requirements that apply in addition to capital requirements
- The data used to calibrate the model naturally has an important effect on the final results

A number of the main simulation studies are summarised in the table below. Of note is the fact that very few of the simulation studies provide an estimate of the impact of changes in capital requirements on the level or the growth rate of bank lending.

Table 2: Summary of existing model-based investigations of the impact of capital requirement regulations on bank lending behaviour

	Key results		Key assumptions									
	Change in lending spread per pp increase in capital ratios	**Change in lending volume per pp increase in capital ratios**	**ST / LT**	**Regional focus**	**Required increase in capital ratio**	**Adjust-ment channel**	**Initial RROE[26]**	**M-M[27]**	**Elasticity of funding markets [28]**	**Off-setting expenses cuts**	**Off-setting monetar y policy**	**Liquidity requirem ents**
European Commissi on (2011)	+10 – 0 basis points	-0.60% - +0.03	SR/MT/LT	EU (no country level informatio n)	2.5pp	Full pass-through of higher capital costs	n/a	0% offset to 100% offset	Inelastic	No	No	Yes
MAG (2010)[29]	+15-17 basis points	-1-2%, average of -1.4%	ST / MT	15 countries (No disaggreg ated country-level informatio n)	1.3 pp; Baseline: end-2009; No buffer[30]	Equity ↑ (loan price ↑)	n/a	No	Elastic	No	No	Yes
BCBS	+13 basis	n/a	LT	13 OECD	No buffer	Equity ↑	15%[32]	No	Elastic	No		Yes

[26] = Required Rate of Return on Equity for investors
[27] = Modigliani-Miller effects, i.e. funding costs are unaffected by financing structure of a bank (higher debt financing costs offset by reduced equity costs thanks to increased bank safety)
[28] If funding markets are elastic, funding costs do not increase as volume of issuance rises and funding costs are constant over time. If funding markets are inelastic, funding costs increase as the volume of issuance rises, resulting in likely increases of funding costs in the aftermath of capital requirement regulations.
[29] MAG results are the median of the simulation results of 97 different economic models with different structures
[30] = the size of the buffer held above regulatory minimum capital ratio at the end of the forecast period

	Key results		Key assumptions									
	Change in lending spread per pp increase in capital ratios	Change in lending volume per pp increase in capital ratios	ST / LT	Regional focus	Required increase in capital ratio	Adjust-ment channel	Initial RROE[26]	M-M[27]	Elasticity of funding markets [28]	Off-setting expenses cuts	Off-setting monetary policy	Liquidity requirements
(2010)	points[31]			countries (No disaggregated country-level information)		(loan price ↑)						
IIF (2010)	+30-80 basis points	-0.8-1%	ST / MT	US, Euro Area and Japan (No disaggregated country-level information)	4.8 pp; Baseline: pre-crisis norms; Buffer:	Equity ↑ (loan price ↑); RWA ↓ (loan supply ↓)	10%	No	Inelastic	Limited	No	Yes
Cournede & Slovik, OECD (2011)	+8-20 basis points (14.4 on average)	n/a	ST / MT	US, Eurozone, Japan (No disaggregated country-level informatio	3.7 pp; Baseline: end-2009; Buffer: small	Equity ↑ (loan price ↑)	n/a	No	Elastic	No	Version 1 : No; Version 2: Yes	No

[32] The BIS notes the importance of this assumption, estimating that a lower RROE of 10% would mean that a 1 percentage point rise in the CET1 ratio would be recoverable with a rise in lending spreads of only 7 bps (see also Oxford Economics, 2013, p. 16)
[31] Plus an additional 14-25 basis points if liquidity requirements are considered as well

	Key results		Key assumptions									
	Change in lending spread per pp increase in capital ratios	**Change in lending volume per pp increase in capital ratios**	**ST / LT**	**Regional focus**	**Required increase in capital ratio**	**Adjust-ment channel**	**Initial RROE[26]**	**M-M[27]**	**Elasticity of funding markets[28]**	**Off-setting expenses cuts**	**Off-setting monetary policy**	**Liquidity requirements**
				n)								
Elliott et al., IMF (2012)	+5-15 basis points	n/a	LT	US, Europe, Japan (No disaggregated country-level information)	1.2-2.7 pp; Baseline: end-2010; Buffer: 4.7-3%	Equity ↑ (loan price ↑)	12%	Partially: 50% offset	Elastic	10%	No	Yes
Miles et al. (2013/ 2011)	+5.5 basis points	n/a	LT	UK	3.3 pp; Baseline: 2006-2009; No buffer	Equity ↑ (loan price ↑)	15%	Partially: 45% offset	Elastic	n/a	No	No

	Key results		Key assumptions									
	Change in lending spread per pp increase in capital ratios	**Change in lending volume per pp increase in capital ratios**	**ST / LT**	**Regional focus**	**Required increase in capital ratio**	**Adjust-ment channel**	**Initial RROE[26]**	**M-M[27]**	**Elasticity of funding markets [28]**	**Off-setting expenses cuts**	**Off-setting monetary policy**	**Liquidity requirements**
King (2010)	+15 basis points[33]	n/a	ST/MT	13 OECD countries (No disaggregated country-level information)	n/a	Equity ↑ (loan price ↑)		No	Elastic	No	No	Yes
Oxford Economics (2013)	+15 basis points	n/a		US	4-10 pp							
Kashyap et al. (2010)	+2.5-4.5 basis points			US				Yes				

[33] To recover the additional cost of meeting the NSFR, lending spreads are estimated to increase by 24 basis points when RWA are left unchanged (King, 2010, p. 3)

	Key results		Key assumptions									
	Change in lending spread per pp increase in capital ratios	**Change in lending volume per pp increase in capital ratios**	**ST / LT**	**Regional focus**	**Required increase in capital ratio**	**Adjust-ment channel**	**Initial RROE[26]**	**M-M[27]**	**Elasticity of funding markets [28]**	**Off-setting expenses cuts**	**Off-setting monetary policy**	**Liquidity requirements**
Baker & Wurgler (2013)	+6-9 basis points			No disaggregated country-level information				Yes				

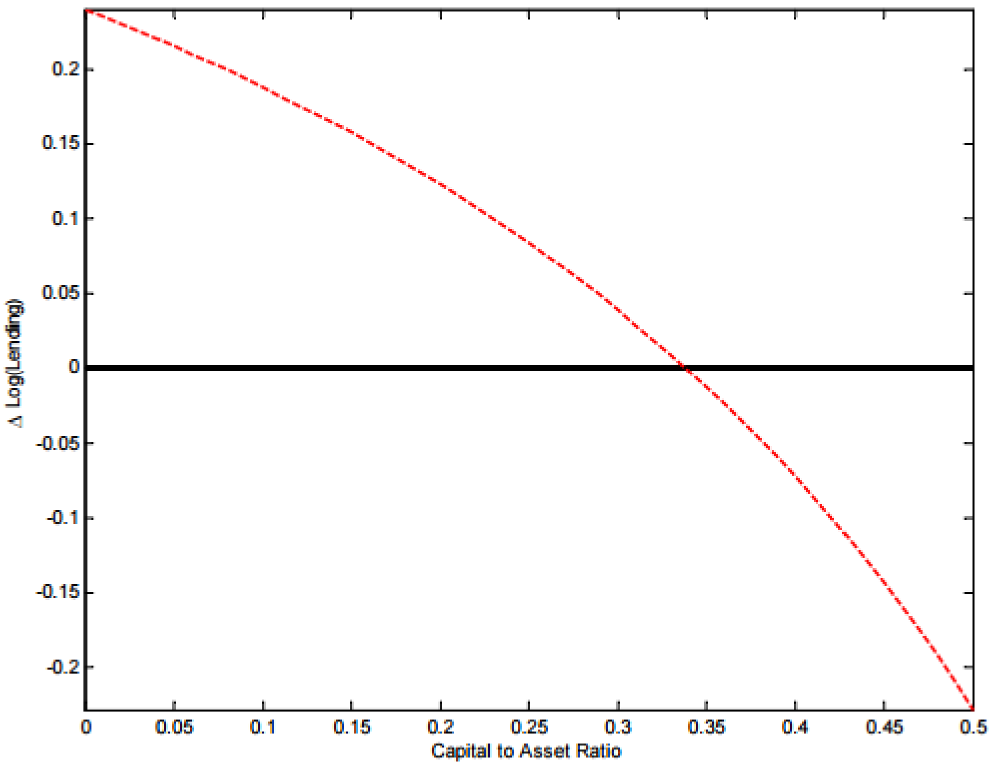
Source: LE Europe

Estimation approach

Buch and Prieto (2014) is the only study that considers the impact of bank capital on bank lending in the long run, econometrically.[34] They find no evidence of a negative relationship between bank capital and bank lending in the German economy based on evidence covering the past 60 years and for realistic capital requirement starting positions: a one percent increase in bank capital is estimated to increase bank lending by 0.22%.

Evidence of an increase in the capital-to-asset ratio being associated only with a decline in bank lending at high unweighted capital-to-asset ratios (more than 33%) is also provided by Buch and Prieto (2014), as depicted in the figure below.

Figure 6: Long-run effect of increasing the capital-to-asset ratio



Note: This figure is based on the estimates of the long-run cointegration vector presented in Buch and Prieto (2014) and they give the change in log loans for an increase in bank capital that is compensated by a decline in deposit funding. See source for details.
Source: Buch and Prieto (2014)

Considering the long-run relationship between bank capital and bank lending extended to government, banks and non-financial corporates specifically, Buch and Prieto (2014) find that there is no clear long-run relationship between bank capital and lending to government and banks, and a positive long-run relationship between bank capital (and bank capital ratios) and lending to non-financial corporates.

In summary, the literature surveyed above, indicates that there are short-run costs in terms of lending impacts linked to capital raising in light of increased capital

[34] All other studies consider long-run impacts using model calibrations as described above

requirements but greater capital in total funding does not negatively impact lending in the long-run, and may even support greater lending.

The remainder of the report considers the transitional and structural impacts of increased capital requirements, as well as the impacts on bank financing of infrastructure, in the present context of the introduction of the CRR in Europe.

The bank-level database

Overview

The present study provides an assessment of the impacts of increased capital requirements under the CRR on bank lending based on bank-level microdata (on bank lending and its explanatory factors, including regulatory capital ratios) and macroeconomic data. The main source of the bank-level microdata is Bankscope. A second source of bank-level microdata used is Bloomberg, which supplemented the data drawn from Bankscope.

This chapter provides an overview of the construction of the bank-level database for the study, which required addressing a number of challenges with care. The chapter also shows that despite careful consideration of the issues, the resulting panel dataset is still unbalanced and data are "patchy": There is great variability across banks (and Member States) in the number of observations available *over time*, that is, banks have shorter/longer time-series resulting in an unbalanced panel dataset. In addition, the data are patchy, which means that continuous time-series are not available for many banks and, the pattern of patchiness differs for bank lending, capital ratios and other variables.

Despite the abovementioned data issues, the resultant sample coverage in terms of EU banking sector assets is 38.1% for the transitional effects analysis and 36.9% for the structural effects analysis. Quantitative estimates based on these data inform the assessment of the impacts of increased capital requirements under the CRR.

Database construction

Constructing the bank-level database involved addressing two key issues.

Firstly, the economic literature on the relationship between bank capital and lending shows that capital allocation decisions made at parent banks affects lending behaviour at subsidiary banks (see for example, Berrospide and Edge, 2009) and it is therefore important to narrow the scope of the bank-level database to banks making the capital allocation decisions. The implication of focusing on parent banks is that it reduces the potential sample size in terms of number of banks, however these banks account for the great majority of EU banking sector assets.

Secondly, if a parent bank is identified as having being involved in a merger or an acquisition (as the acquirer), it is important to create a new time-series for the bank post-M&A because of the possibility that the lending behaviour of the bank pre-M&A differs substantially to lending behaviour post-M&A (see for example, Bridges et al., 2014). This treatment of M&A transactions addresses one source of potential structural breaks at the bank level. However, the treatment of M&A transactions also leads to the creation of relatively short time-series, especially in Member States in which banking sector consolidation is, or has been, taking place.

In practice, identifying parent banks, and whether they have been involved in M&A transactions involved matching banks in Bankscope to: i) other banks in Bankscope's ownership database that clarifies whether a bank is a parent or a subsidiary; and ii) M&A transactions in Zephyr's M&A database that indicates whether a bank has been party to a merger or an acquisition (as the acquirer).[35]

[35] Further details of the database construction are provided in Annex 1

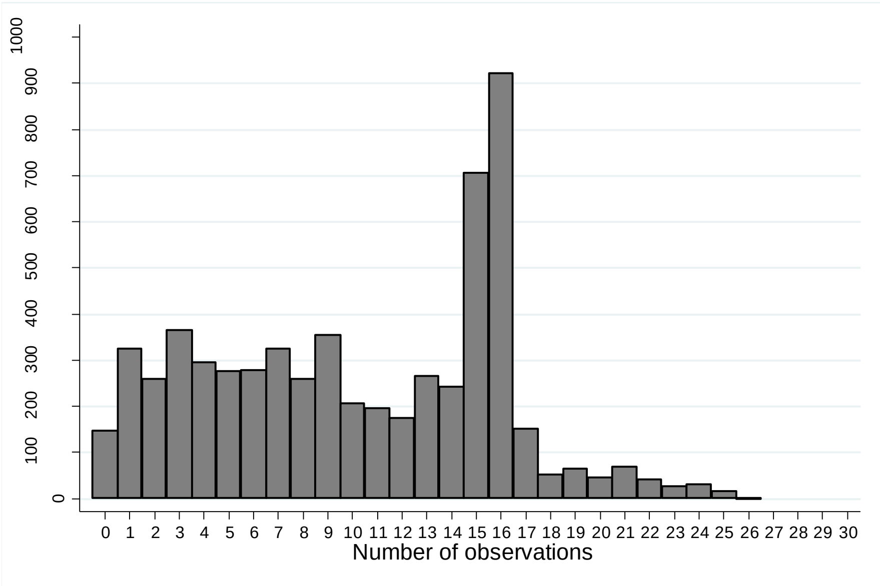
Data were collected from Bankscope for the final list of parent banks identified following the steps above. An unbalanced panel of 5,955 banks over the period 1985-2014 was constructed, with data at an annual frequency.[36]

The remainder of this chapter focuses on data availability within the Bankscope database.[37]

Availability of bank lending and capital ratios time-series

The bank-level database yields information on 5,955 banks. However, the figures below show that there is great variation in the lengths of the time-series of bank lending and capital ratios at the bank level. Moreover, complete data covering the period 1985-2014 (30 observations) is not available for a single bank. The empirical methodologies, elaborated in subsequent sections, take this feature of the data into account.

Figure 7: Frequency distribution of number of bank lending observations (potential maximum is 30 yearly observations) by bank

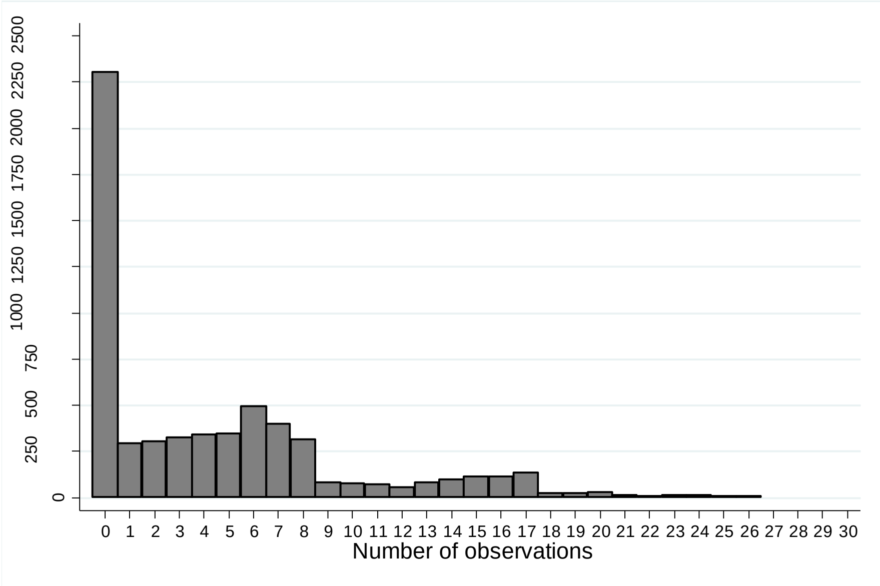


Note: Bank lending is measured by net lending. The number of banks with net lending time-series of different lengths is reported above, some of which are non-contiguous. The maximum possible number of observations a bank can have is 30, covering the period 1985-2014
Source: Bankscope and LE Europe calculations

[36] Data were also collected from Bloomberg to construct a bank-level database for listed banks only, which was used in the transitional effects analysis (as a robustness check). An unbalanced panel of 208 banks over the period 1995:H1-2015:H2 was constructed with data at a half-yearly frequency. Using data at a quarterly frequency was also an option but sample coverage was small, especially in some Member States so a half-yearly frequency was used

[37] Similar information is provided for the Bloomberg database at Annex 2

Figure 8: Frequency distribution of number of Total Capital Ratio observations (potential maximum is 30 years) by bank



Note: Capital ratios are measured by the Total Capital Ratio. The number of banks with (non-contiguous) Total Capital Ratio time-series of different lengths is reported above. The maximum possible number of observations a bank can have is 30, covering period 1985-2014
Source: Bankscope and LE Europe calculations

"Patchiness" in availability of bank-level data

The figures in the previous section showed great variation in the bank lending and capital ratios time-series lengths available at the bank level. In addition however, data at the bank level are "patchy", that is, the data are not contiguous; and the pattern of patchiness differs for bank lending, capital ratios and other variables.

Importantly, in order for a bank to be included in the samples for the empirical analyses, *all* bank-level variables as well as any monetary and macroeconomic variables (with the exception of lagged bank lending flows) being used in an econometric model must be specified *in at least one period* (and the two previous periods for the lagged bank lending flows) in the transitional effects analysis and *every period* in the structural effects analysis. Given the patchiness of the available data, this leads to significant sample attrition.

The table below shows how the requirement for bank-level data to be present for all variables in at least one period in the transitional effects analysis reduces the number of banks entering the estimation sample substantially.

One observes for instance, a reduction in the number of banks in the sample from 5,955 to 5,305 (a reduction of 650 banks) as the econometric models require data in at least one period for both current bank lending (as the dependent variable) and past values of bank lending (as explanatory variables), that is, at least three consecutive bank lending observations.

A further reduction in the number of banks by 1,851 banks is seen once the Total Capital Ratio (CAP) is included in the sample showing that, for the 1,851 banks concerned, data are not available on the Total Capital Ratio in any given period and bank lending for the same period and the two previous periods.

Table 3: Sample attrition, number of banks by Member State

	$ln(NL)_{it}$	$ln(NL)_{it-1}$	$ln(NL)_{it-2}$	CAP_{it}	$ln(SIZE)_{it}$	LIQ_{it}	$WHOLE_{it}$	$PROFIT._{it}$	LEV_{it}	*FINAL MODEL*
AT	340	318	296	97	97	82	80	79	79	73
BE	103	96	92	31	31	13	13	13	13	7
BG	27	27	24	18	18	17	17	16	16	12
CY	31	28	26	14	14	6	6	6	6	6
CZ	28	27	25	14	14	7	7	7	7	4
DE	2,667	2,519	2,408	1,628	1,627	1,192	1,191	1,191	1,191	1,190
DK	142	137	128	123	122	84	81	81	81	69
EE	18	15	14	12	12	6	6	6	6	4
EL	34	31	31	21	21	14	14	14	14	14
ES	234	221	215	101	101	51	48	47	47	47
FI	28	24	20	19	19	10	8	8	8	8
FR	390	368	348	139	139	62	62	61	61	23
HR	50	48	44	23	23	19	19	19	19	17
HU	41	38	36	20	20	20	18	18	18	14
IE	43	35	35	18	18	7	6	5	5	5
IT	884	820	779	745	743	706	698	698	698	639
LT	13	12	12	10	10	9	9	9	9	6
LU	118	114	109	34	34	14	14	14	14	11
LV	28	27	25	23	22	16	14	14	14	14
MT	8	8	8	7	7	6	5	5	5	4
NL	73	64	59	40	40	27	27	27	27	19
PL	61	55	51	26	26	13	13	13	13	13
PT	55	53	49	34	34	18	17	17	17	17
RO	29	27	23	17	17	10	10	10	10	3
SE	128	123	116	115	110	18	14	14	14	9
SI	30	23	22	17	17	14	14	13	13	13
SK	22	20	17	12	12	10	10	10	10	9
UK	330	314	293	96	96	36	33	33	33	28
EU	**5,955**	**5,592**	**5,305**	**3,454**	**3,444**	**2,487**	**2,454**	**2,448**	**2,448**	**2,278**

Note: Each column reports the number of banks in the sample by Member State, for which data is available: i) for the variable the column relates to; and ii) *all the variables the previous columns (to the left) relate to.* The last column reports the number of banks in the sample for the final model specification, which includes the country-level variables $\Delta lnCB_{it}$, ΔIB_{it}, $\Delta lnGDP_{it}$, Π_{jt} and $OUTPUT\ GAP_{it}$. *NL* stands for net lending. Variable details provided in Table 7

Source: Bankscope and LE Europe calculations

However, it should be noted that better data is available for the larger banks and therefore, a relatively large proportion of banking sector assets is covered, as reported in the table below. Coverage of EU banking sector assets is 38.1% based on 2,278 banks. The majority of banks are in Germany and Italy, given the presence of a large number of small banks such as savings ("Sparkassen") and cooperative banks ("Volksbanken" and Raiffeisenbanken) in Germany serving local customers; and cooperative credit banks ("banche di credito cooperative"), rural savings banks ("casse rurale") and cooperative Raiffeisen banks in Italy. The findings of the transitional effects analysis are robust to the presence of a large number of banks in a few Member States[38].

Table 4: Number of banks and asset coverage in the transitional effects analysis, by Member State

	Number of banks	Asset coverage
AT	73	61.5
BE	7	49.1
BG	12	87.6
CY	6	92.4
CZ	4	90.2
DE	1,190	41.6
DK	69	95.8
EE	4	34.9
EL	14	68.8
ES	47	22.9
FI	8	86.8
FR	23	50.5
HR	17	92.1
HU	14	81.6
IE	5	48.1
IT	639	32.0
LT	6	97.8
LU	11	70.3
LV	14	77.8
MT	4	97.2
NL	19	12.0
PL	13	80.0
PT	17	97.6
RO	3	49.7
SE	9	21.1
SI	13	95.9
SK	9	72.5
UK	28	31.0
EU	2,278	38.1

Notes: The table reports the number of banks and asset shares at the Member State level covered in the sample used in estimating the baseline econometric model. The percentage of assets covered is based on reported 2013 assets
Source: Bankscope and LE Europe calculations

[38] Robustness tests are presented in Table 64

The following table show the same results but for the analysis of structural effects.

Table 5: Number of banks by variable

	$ln(NETLENDING)_{it}$	$ln(NETLENDING)_{it-1}$	$ln(NETLENDING)_{it-2}$	CAP_{it}	$ln(SIZE)_{it}$	LIQ_{it}	$WHOLE_{it}$	$PROFIT._{it}$	LEV_{it}	*FINAL MODEL*
AT	340	318	296	97	97	82	80	79	79	73
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FI	28	24	20	19	19	10	8	8	8	8
FR	390	368	348	139	139	62	62	61	61	23
HR	50	48	44	23	23	19	19	19	19	17
HU	41	38	36	20	20	20	18	18	18	14
IE	43	35	35	18	18	7	6	5	5	5
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LV	28	27	25	23	22	16	14	14	14	14
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NL	73	64	59	40	40	27	27	27	27	19
PL	61	55	51	26	26	13	13	13	13	13
PT	55	53	49	34	34	18	17	17	17	17
RO	29	27	23	17	17	10	10	10	10	3
SE	128	123	116	115	110	18	14	14	14	9
SI	30	23	22	17	17	14	14	13	13	13
SK	22	20	17	12	12	10	10	10	10	9
UK	330	314	293	96	96	36	33	33	33	28
EU	**5,955**	**5,592**	**5,305**	**3,454**	**3,444**	**2,487**	**2,454**	**2,448**	**2,448**	**2,278**

Note: Each column reports the number of banks in the sample by Member State, for which data is available: i) for the variable the column relates to; and ii) *all the variables the previous columns (to the left) relate to.* The last column reports the number of banks in the sample for the final model specification, which includes the country-level variables $\Delta lnCB_{it}$, ΔIB_{it}, $\Delta lnGDP_{it}$, Π_{jt} and $OUTPUT\ GAP_{it}$.
Source: Bankscope and LE Europe calculations

Concluding remarks

Bankscope provides comparable microdata on a large number of banks affected by the Capital Requirements Regulation.

However, constructing a bank-level database that is suitable for econometric analysis has required careful consideration of a number of issues, chief among these have been: identifying parent banks given the literature showing that decision-making over bank capital allocation at the parent level has an influence on lending behaviour at subsidiary banks; and treating banks that have been party to mergers and acquisitions (as acquirer) as separate units of observation to avoid structural breaks in bank lending series that may arise due to banks' lending behaviour differing pre- and post-M&A.

The resulting bank-level panel database, while carefully constructed, is unbalanced. There is great variability across banks in the number of observations available over time: banks have shorter/longer time-series, implying that the econometric methods applied to the data have to be able to address unbalanced panels.

Further, the need for data on all variables of interest to be present at a given point in time (in the case of the transitional effects analysis) / or for all time periods (in the case of the structural effects analysis) in order for a bank to be included in the estimation samples has resulted in notable sample attrition. However, it is important to bear in mind that the banks in the dataset used for the empirical analysis represent a good proportion of EU banking sector assets.

On the relationship between *requirements for* and *actual* regulatory capital ratios

Overview and key results

The impact of requirements for increased regulatory capital ratios on bank lending cannot be observed per se. All that can be observed are changes in actual regulatory capital ratios that are presumably affected by changes in formal regulatory requirements and, at times, informal pressure from regulatory authorities. For the analysis undertaken, evidence on the relationship between *actual* regulatory capital ratios ("actual capital ratios" for the remainder of this chapter) and bank lending is therefore used to assess the impact of *requirements* for increased regulatory capital ratios ("increased capital requirements" for the remainder of this chapter) on bank lending.

It is recognised that banks' actual capital ratios change for regulatory as well as non-regulatory reasons. Evidence presented below shows that banks in Europe maintain actual capital ratios in excess of regulatory minima. Banks' Total Capital Ratios tend to be in order of 12%-18%[39], while the regulatory minimum is 8%. On the one hand, banks may prefer to maintain actual capital ratios in excess of the minimum required by capital regulation so that in the event of losses they still do not breach minimum capital requirements. On the other hand, the extent to which actual regulatory capital ratios exceed minimum regulatory requirements may mean that banks choose their actual capital ratios with greater weight placed on non-regulatory considerations.

The fact that banks maintain a "cushion" between their actual capital ratios and regulatory minima gives rise to the possibility that they simply decrease the size of this cushion in response to increased regulatory capital requirements and maintain lending levels.

A concern with the analysis undertaken is therefore that actual capital ratios could be driven purely by non-regulatory factors (and regulatory factors are not at play) and the impact of increased capital requirements under the CRR on bank lending could be zero.

However, as this chapter shows, one does observe that the timing of adoption of the Basel III Accord and subsequent application of the CRR have been coincident with an increase in actual capital ratios of banks in Europe, which is consistent with banks responding to changes in capital regulation.

Further, evidence is also provided in the present study on how the impacts estimated through this report differ depending on the size of the cushion banks maintain above minimum regulatory capital requirements. It shows that impacts are greater for banks with actual capital ratios closer to the regulatory minimum, which is consistent with banks responding to changes in capital regulation.

The remainder of this chapter provides details of the evidence relating to the abovementioned discussion. Firstly, evidence on the differences between actual capital ratios and minimum requirements for European banks is presented. Secondly, developments of actual capital ratios over time are considered with regard to changes in capital regulation. Finally, evidence is presented on differences in the responses of bank lending to changes in actual capital ratios, depending on the size of the capital cushion banks maintain.

[39] For instance, the Total Capital Ratio was in this range for the majority of banks in the sample

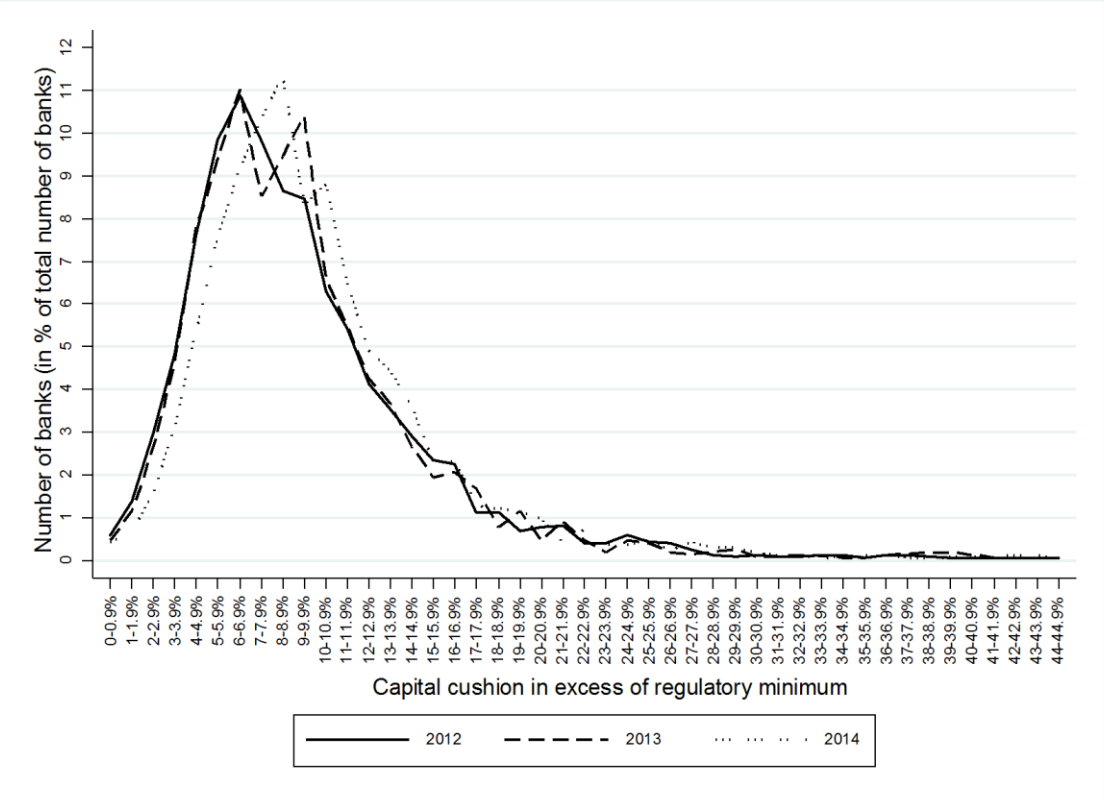
Differences between actual regulatory capital ratios and minimum requirements

The figure below shows what capital cushions (that is, actual Total Capital Ratios in excess of the regulatory minimum of 8%) banks maintained at year-end 2012 (18 months after the adoption of the Basel III Accord), at year-end 2013 (on the eve of the application of the CRR) and at year-end 2014 (one year on from the application of the CRR).

The majority of banks (57%) maintained a cushion of between 4% and 10% at year-end 2013, with a minority having a significantly larger cushion. Banks' cushions may be driven by a mix of regulatory and non-regulatory factors.

However, there is a statistically significant shift to the right in the distribution of capital cushions[40], particularly at year-end 2014, which is consistent with banks responding to increased capital requirements by maintaining higher actual capital ratios.

Figure 9: Distribution by banks of capital cushion, year-ends 2012, 2013 and 2014



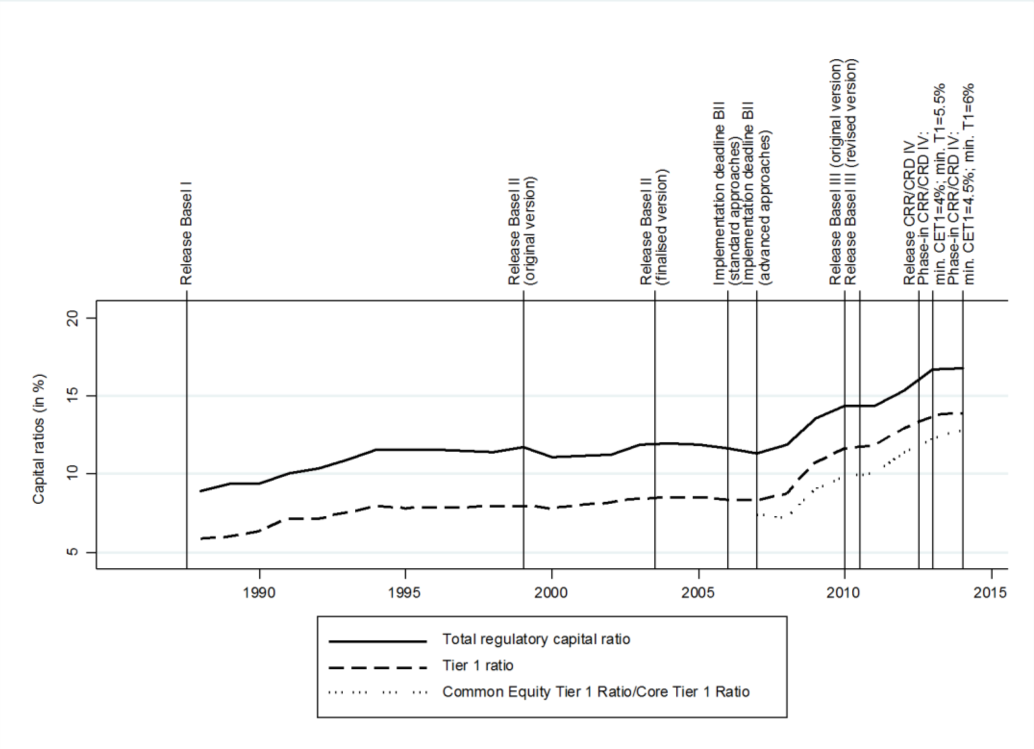
Notes: Percentage of banks in Europe maintaining a Total Capital Ratio in excess of the minimum requirement for Total Capital Ratio of 8% ("capital cushion") at year-end 2012, 2013 and 2014. *Sample of banks reporting their Total Capital Ratio (2012, 2013 or 2014)
Source: Bankscope and LE Europe calculations

[40] Wilcoxon sign rank tests show a statistically significant difference in the median capital cushions over 2012 and 2013 and 2013 and 2014 at less than the 1% level

Responses of actual regulatory capital ratios to changes in capital regulation

The figure below shows, in a different way, that certainly coincident to the adoption of the Basel III Accord and the subsequent introduction of the Capital Requirements Regulation, there has been a notable increase in actual capital ratios on average in comparison to previous levels. The increase in actual capital ratios reflects the possibility that banks are attempting to meet the new regulatory standards quickly, despite the long phase-in period. This evidence provides some further support for the assumption that actual capital ratios respond to changes in capital requirements, despite banks holding capital cushions.

Figure 10: Developments of capital ratios in the EU and key capital regulation dates



Source: Bankscope and LE Europe calculations

Variation in lending impacts by size of capital cushion

Evidence provided in detail in the next chapter shows that an increase in actual capital ratios has a negative impact on bank lending.

Variation in lending impacts is also considered, based on the size of the capital cushion banks maintain. The key result is that the impacts are larger for banks with a smaller cushion, indicating that regulatory requirements matter to banks choosing their actual capital ratios.

Importantly, the results are based on estimation of econometric models that control for non-regulatory and market factors that may influence the relationship between actual capital ratios and bank lending.

Discussion

As the impact of increased capital requirements under the CRR cannot be observed directly, it is necessary, in making an assessment of their impacts on bank lending, to consider actual capital ratios.

Actual capital ratios are influenced by regulatory factors (including, increased capital requirements) and non-regulatory factors.

A concern is that actual capital ratios could be driven purely by non-regulatory factors, that is, regulatory factors are not at play, and therefore the impact of increased capital requirements under the CRR on bank lending may be zero. One observes that banks maintain a capital cushion above the regulatory minimum, giving rise to the possibility that they simply decrease the size of this cushion in response to increased regulatory capital requirements and maintain lending levels.

However, one also observes that banks increased actual capital ratios at key capital regulation dates, indicating that actual capital ratios do respond to changes in capital regulation. Further, the empirical analysis presented in the following chapter show that lending impacts are larger for banks with smaller capital cushions, which is further evidence that actual capital ratios are affected by regulatory minima.

In conclusion, although one cannot observe the impact on bank lending of increased capital requirements under the CRR per se, the impact of actual capital ratios provide good estimates of their likely effects.

Transitional effects

Overview and key results

Since the application of the Capital Requirements Regulation in 2014, banks in Europe have had to meet increased capital requirements, including requirements to maintain a *greater quantity* of *higher quality* capital as a proportion of risk-weighted assets than previously.

Banks are presently in a period of change, as the capital requirements under the CRR that they are subject to are being phased in gradually up to 2019.

Moreover, banks had the opportunity to anticipate the application of the new capital regulation regime because the Basel III Accord was adopted in 2011, at which point its transposition and implementation in Europe could be foreseen.

In effect, banks may have been adjusting their capital structures to meet new capital requirements from 2011 onwards, and it is the objective of the present chapter to provide an assessment of whether adjustments to regulatory capital in response to (anticipated and actual) increases in capital requirements under the CRR had transitional effects on lending.

"Transitional effects" are defined as the short-term effects of increased capital requirements on bank lending, that is, the effects that prevail contemporaneously or over a short number of periods after adjustments to higher capital requirements take place. In the main empirical exercises undertaken, transitional effects are measured over a period of three years.

Quantifying the impacts of increased capital requirements on lending is challenging because they cannot be observed directly. All that can be observed are changes in the actual regulatory capital ratios (including, particularly the Total Capital Ratio) that are presumably under the influence of changes in formal regulatory requirements, and at times, informal pressure from regulatory authorities, and their impacts on lending.

For the analysis undertaken, the assumption made is that actual regulatory capital ratios respond to capital requirements. However, it is also recognised that they respond to non-regulatory factors as well. For instance, bank managers may deem it prudent to operate at capital levels in excess of the regulatory minimum.[41]

The main estimate shows that for a one percentage point change in the Total Capital Ratio[42] the impact on bank lending flows is -0.8% over one year with the implied impact over a three-year period being -1.5%.

Further, while the Total Capital Ratio has an economically significant impact on bank lending flows, the result should be read within the context of the fact that other bank-level and macroeconomic drivers matter to lending flow developments such as past lending flows and the output gap. Indeed, the results of the baseline model indicate that a 1% increase in lending flows experienced last year is related to a 0.34% increase in

[41] See discussion in chapter 'On the relationship between *requirements for* and *actual* regulatory capital ratios' for further details

[42] The Total Capital Ratio is the sum of the Tier One (T1) Ratio and the Tier Two (T2) Ratio

lending flows in the present year. In the case of the output gap, a one percentage point increase in the output gap results in a 0.95% reduction in bank lending flows.

The size of the effect is within the same range as estimates from previous studies for single European Member States and the euro area, for example: Mésonnier and Monks (2014) estimate a one-year impact of -1.2% for the euro area over 2005-2011 and Bridges et al. (2014) estimate a one-year impact of -0.8pp for household lending and -2.1pp for private non-financial corporate lending in the UK over 1990-2011. Some studies find larger impacts, although in different contexts. Aiyar Calomiris and Wieladek (2014b), for instance, found larger impacts, in the range -7.2pp to -6.5pp for the impact on cross-border bank lending. It is also important to note that the present study includes the period since the adoption of Basel III.[43]

A series of robustness tests have been undertaken to check the sensitivity of the effect sizes estimated. The majority of the models estimated indicate that one percentage point change in the Total Capital Ratio has a statistically significant impact on bank lending flows of between -0.8% to -0.6%.

A concern is that actual capital ratios could be driven purely by non-regulatory factors, that is, regulatory factors are not at play, and therefore the impact of increased capital requirements under the CRR on bank lending may be zero. However, the robustness test reported show that lending impacts are larger for banks within smaller capital cushions, which is evidence that bank lending flows are affected by regulatory minima.

The impact of changes in the Total Capital Ratio on bank lending flows arose mainly through corporate and consumer loans, with mortgage loans being unaffected. These results are consistent with the notion that mortgages receive a relatively generous capital treatment under the CRR compared to the other loan categories and therefore do not show a negative relationship with the Total Capital Ratio. While the sizes of the samples of banks used in this more granular analysis of loan categories are relatively small due to lack of data, especially on consumer loans, the empirical results do suggest that the transitional effects arise mainly through corporate and consumer lending.

In terms of regional variation, the impacts of changes in the Total Capital Ratio on bank lending flows appeared to be strongest for bank-based, non-crisis countries (Austria Denmark and Germany) and New Member States.

Effects are not observed for market-based countries (The Netherlands, United Kingdom, Belgium, France, Finland and Sweden) and bank-based crisis countries (Greece, Italy, Portugal, and Spain). For the bank-based EU crisis countries this may be expected because of the financial market turmoil disturbing the economic relationships one would expect to observe under normal economic conditions. For market-based EU countries, capital ratios are not as informative about bank lending flows as elsewhere, with bank size and profitability being the key determinates of bank lending. The importance of bank size and profitability to lending in market-based EU countries may be because banks use capital markets for their funding in these countries to a greater extent than elsewhere and investors scrutinise metrics such as profitability when choosing which banks to fund, which in turn affects their ability to lend.

Lastly, analysis was carried out for subsamples of banks based on pre-crisis 'business models' proxied by size, capitalisation, and funding. This showed that the impact of the

[43] Studies of the short-run impact of capital requirements on bank lending are reviewed in greater detail in the literature review presented in the introduction

Total Capital Ratio on bank lending flows was greater for banks that have historically been less capitalised and are funded to a greater extent through non-deposit liabilities.

The remainder of this chapter is structured as follows:

- the first section provides a theoretical motivation for the relationship between capital requirements and bank lending that informs the empirical approach;
- the second section describes the data and estimation methodology;
- the third section provides estimation results; and,
- the final section presents conclusions.

Theoretical motivation

The empirical methodology examining the impact of increased capital requirements on bank lending is motivated by a simple banking model adapted from Khwaja and Mian (2008).

Assume that in period *t*, bank *i* in country *j* finances its loan flows, ΔL_{ijt}, by issuing deposits, D_{ijt}, and other sources of funding, F_{ijt} (for example, equity capital). This can be represented as a simple linear relationship, as follows:

$$\Delta L_{ijt} = D_{ijt} + F_{ijt} \quad \text{......} \quad (1)$$

On the demand side, the marginal return on loans is assumed to be a decreasing function of the volume of the loan: $\bar{r} - \gamma_1 \Delta L_{ijt}$, where $\bar{r}$ and γ_1 are positive constants.

Assuming the supply of deposits is limited (up to a costless limit, $\overline{D}$) and raising additional funding is subject to a variable cost ($\gamma_2 > 0$), the optimal quantity of loans is determined by the first-order condition below.

$$\gamma_2 F_{ijt} = \bar{r} - \gamma_1 \Delta L_{ijt} \quad \text{......} \quad (2)$$

That is, the marginal cost of funds is equal to the marginal revenue on loans.

Solving for ΔL_{ijt} the long-term relationship between loan supply and demand is given by the equation below, where ΔL^*_{ijt} represents equilibrium in the market for bank loans.

$$\Delta L^*_{ijt} = \frac{1}{\gamma_1}(\bar{r} - \gamma_2 F_{ijt}) \quad \text{......} \quad (3)$$

This model can be extended by introducing macroeconomic and bank-specific shocks that affect the supply and demand for loans in the short-run.

$\gamma_2 F_{ijt} = (\bar{r} - \gamma_1 \Delta L_{ijt} + \eta_t + \eta_i)$, where η_t and η_i are macroeconomic and bank-specific shocks, respectively.

Hence, the first-order condition at *t* is shown below.

$$\Delta L^*_{ijt} = \frac{1}{\gamma_1}(\bar{r} - \gamma_2 F_{ijt} + \eta_t + \eta_i) \quad \text{......} \quad (4)$$

The equilibrium level of loan flows, ΔL^*_{ijt}, is influenced by: i) bank funding (F_{ijt}), ii) macroeconomic shocks and iii) bank-specific shocks.

Bank funding especially is influenced, among other factors, by increased regulatory capital requirements.

Empirically, the equation above can be represented as shown below.

$$\Delta L_{ijt} = \alpha_0 + \beta F_{ijt} + \delta(\eta_t + \eta_i) \qquad (5)$$

where $\alpha_0 = \frac{\bar{r}}{\gamma_1}$ is a constant term, $\beta = -\frac{\gamma_2}{\gamma_1}$ and $\delta = \frac{1}{\gamma_1}$.

Bank funding characteristics, F_{ijt}, can be captured by measures of changes in bank capital, wholesale funding and liquid, short-term funding; macroeconomic shocks can be captured by relevant variables such as GDP and inflation (that influence demand for loanable funds) and the interbank rate (that influences the supply of loanable funds); and bank-specific shocks, η_i, can be captured by fixed effects.

In addition, dynamics in the dependent variable are also relevant as bank loan flows may be persistent, as observed by Carlson (2013), for example.

The discussion above motivates an empirical model of loan flows, and suggests variables that could proxy for the drivers of lending flows suggested by the model. Details of the empirical methodology, including the motivation for the choice of estimator and variables are described below with reference to the existing literature.

Data and methodology

Sample data

Sample selection

Two samples will be considered for the analysis of transitional effects: i) a sample of banks sourced from Bankscope; and ii) a sample of listed banks only sourced from Bloomberg.

Parent banks are considered, given that decision-making over bank capital at the group level has an influence on lending behaviour throughout the group[44]; in addition, independent banks are also considered.[45]

The table below shows the number and banking sector assets coverage per Member State for the Bankscope sample.[46] The sample data period is 1985-2014.[47] Coverage of EU banking sector assets is 38.1% based on 2,278 banks. The majority of banks are in

[44] See Berrospide and Edge (2010) for example

[45] See chapter on 'The bank-level database' for further discussion

[46] Figures relate to each bank headquartered in a given Member State, but for each of these banks, banking activity may occur in a number of Member States. The number of banks and total assets data therefore do not relate only to domestic banking activity

[47] Similar information is provides for the Bloomberg sample at Annex 2

Germany and Italy, given the presence of a large number of small banks such as savings ("Sparkassen") and cooperative banks ("Volksbanken" and Raiffeisenbanken) in Germany serving local customers; and cooperative credit banks ("banche di credito cooperative"), rural savings banks ("casse rurale") and cooperative Raiffeisen banks in Italy. The findings of the transitional effects analysis, reported below, are robust to the presence of a large number of banks in a few Member States.

The sample of banks sourced from Bankscope provides extensive coverage of banks in the EU and is the focus of the analysis. However, the sample of listed banks sourced from Bloomberg (see Annex 2 for sample details) is also considered to check the robustness of the main results.

Table 6: Number of banks and asset coverage in the transitional effects analysis, by Member State

	Number of banks	Asset coverage
AT	73	61.5
BE	7	49.1
BG	12	87.6
CY	6	92.4
CZ	4	90.2
DE	1,190	41.6
DK	69	95.8
EE	4	34.9
EL	14	68.8
ES	47	22.9
FI	8	86.8
FR	23	50.5
HR	17	92.1
HU	14	81.6
IE	5	48.1
IT	639	32.0
LT	6	97.8
LU	11	70.3
LV	14	77.8
MT	4	97.2
NL	19	12.0
PL	13	80.0
PT	17	97.6
RO	3	49.7
SE	9	21.1
SI	13	95.9
SK	9	72.5
UK	28	31.0
EU	2,278	38.1

Notes: The table reports the number of banks and asset shares at the Member State level covered in the sample used in estimating the baseline econometric model. The percentage of assets covered is based on reported 2013 assets
Source: Bankscope and LE Europe calculations

Variables

This section describes the variables in the baseline econometric model, as well as the rationale for the inclusion of the variables chosen.

Additional variables are used in alternative econometric models that test the robustness of the results from the baseline econometric model. The additional variables are described in the relevant sections below.

Bank lending

The key dependent variable is the natural logarithm of *net lending*.

The rationale for the choice of the key dependent variable is provided below.

Terminology and definitions

Gross lending: Gross lending equals new lending. Gross lending is a flow measure

Net lending: Net lending equals new lending minus repayments. Net Lending is a flow measure

Gross loans: Gross loans is an accounting measure of outstanding loans, not reflecting reserves for impaired loans/non-performing loans. Gross loans is a stock measure

Net loans: Net loans is an accounting measure of outstanding loans, reflecting gross loans minus reserves for impaired loans/non-performing loans. Net loans is a stock measure

In broad terms, variation in bank lending flows will be related to variation in regulatory capital ratios over time to capture the possible impact of increased capital requirements on bank lending empirically.[48] In particular, empirical evidence will be based on the estimates of coefficients on the regulatory capital ratio variables derived from econometric models of bank lending flows on regulatory capital ratios.

A choice has to be made between whether a gross or net lending measure of bank lending flows should be used in the analysis.

A net lending measure of bank lending flows is attractive because it captures all lending stock adjustments, at both the intensive and extensive margins, that is, new lending (to existing and new borrowers) and repayments.

However, a gross lending measure of bank lending flows is perhaps more useful given the focus in the present study on lending stock adjustments arising due to increased capital requirements: increased capital requirements are expected to affect bank lending flows through new lending and gross lending captures new lending only, while net lending captures new lending and repayments.

[48] The methodology section below defines the empirical strategy more precisely

But, data limitations necessitate that bank lending flows be measured on a net lending basis as net lending can be calculated using bank financial statements that are publicly available[49] while gross lending cannot[50].

With regard to the inclusion of repayments in the measure of bank lending flows, the impact of regulatory capital ratios on net lending are identified as long as variation in repayments can be attributed to demand side factors such as GDP growth and inflation in the econometric models estimated.[51]

Of note is the fact that net lending is used widely in the literature on the impact of capital shocks on bank lending (see for example, Houston, James and Marcus, 1991; Bernanke and Lown, 1997; and Peek and Rosengren, 1997).

The key dependent variable in the empirical model is the natural logarithm of the difference in gross loans[52], which captures bank lending flows on a net basis. Each coefficient estimate in the econometric models will therefore reflect the impact of a unit change in the associated independent variable on bank lending flows in percentage terms (for example, a one percentage point increase in the Total Capital Ratio leads to a one percent decrease in net lending).

Regulatory capital ratios

There are a number of regulatory capital ratios in the CRR, including the Total Capital Ratio, the Common Equity Tier One (CET1) Ratio and the Tier One (T1) Ratio.

The Total Capital Ratio is the preferred regulatory capital ratio because it captures regulatory capital most broadly.

However, the impact of changes in other regulatory capital ratios on bank lending flows are important to consider given the possibility that during the crisis these regulatory capital ratios were monitored by market participants. Specifically, the baseline econometric model described below is re-estimated using the T1 ratio in place of the Total Capital Ratio. The CET1 ratio cannot be considered because it has not been in use for long enough to derive empirical results.

Differences in the definition of regulatory capital ratios over different capital regulation regimes over time will be accounted for through bank fixed-effects in the econometric models.

Bank characteristics

Bank characteristics are chosen on the basis of the literature on the "bank capital channel", on the impact of capital shocks on bank lending, and the wider literature on the "bank lending channel" of monetary policy transmission.

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[49] Net lending is calculated on the basis of gross loans data reported on the asset side of the balance sheet

[50] Gross lending is reported to supervisory authorities but is not made publicly available at the bank level required for the analysis

[51] See below for a detailed discussion of identification issues

[52] The difference in gross loans can be negative, and the natural logarithm of a negative value is undefined. To ensure both positive and negative values for the difference in gross loans are included, a constant of 1,342 for the Bankscope dataset (14,263.56 for the Bloomberg dataset) is added to all values for the difference in gross loans such that the minimum value of the difference in gross loans is just positive, as is common in the literature

The key bank characteristics are bank size, liquidity and capitalisation on the basis that such characteristics influence bank lending flows and may be independent of loan demand (Altunbas, Gambacorta and Marquez-Ibanez, 2009).

Specifically, bank size may affect a bank's ability to access funding (with larger banks more able to access funding than smaller banks) and therefore conditions the impact of increased regulatory capital ratios on bank lending flows (see for example, Peek and Rosengren, 1997). Bank size is captured by the natural logarithm of total assets.

Bank liquidity may also affect a bank's ability to access funding and therefore conditions the impact of increased capital requirements on bank lending flows (see for example, Brei, Gambacorta and Von Peter, 2013). Bank liquidity is captured through the liquidity ratio.

In addition, bank reliance on wholesale market funding, as opposed to customer deposits, could condition the impact of increased capital requirements on bank lending flows. Wholesale market funding is captured by the share of assets funded by non-deposit liabilities.

Finally, bank capitalisation is captured through regulatory capital ratios given the interest in the impact of increased capital requirements on bank lending flows. Further, it should be noted the standard equity-to-asset ratio typically used in the bank lending channel literature will not be used because there is evidence suggesting it does not properly capture bank capitalisation (Gambacorta and Mistrulli, 2004).

While bank size, liquidity and capitalisation are plausibly exogenous to loan demand, they are included as lags in the baseline econometric model to help mitigate endogeneity concerns (see for example Kashyap and Stein, 1995; Kashyap and Stein, 2000; Ehrmann et al., 2003; Gambacorta and Mistrulli, 2004; and Gambacorta and Marquez-Ibanez, 2011).

Additional bank characteristics will also be considered in testing for the robustness of the results in the baseline econometric model, including bank profitability and loan losses included as lags.

Bank profitability may influence the extent to which increased capital requirements affect bank lending flows. More profitable banks, for example, can use retained earnings to meet increased capital requirements, thereby dampening any lending adjustments they would otherwise have to make (see for example Heid, Porath and Stolz, 2004).

Current loan losses affect risk-weighted assets and therefore regulatory capital ratios and bank lending flows in turn: higher current loan losses imply that regulatory capital shortfalls are likely to be greater under increased capital requirements that could lead to a reduction in bank lending flows (see for example Rime, 2001).

Monetary and macroeconomic characteristics
Macroeconomic variables will be included to control for loan demand. Real GDP growth and inflation will be included as the key macroeconomic variables (see for example, Gambacorta and Mistrulli, 2004) because improvements in economic conditions and inflation increase the number of business investment projects with positive net present values and therefore credit demand (Kashyap, Stein and Wilcox, 1993). In addition, the output gap will be included as credit demand may be lower when there is greater spare capacity.

Changes in the monetary policy stance are measured by the change in the 3-month interbank rate, as per the literature on the bank lending channel (see for example, Bernanke and Blinder, 1992). Alternatively, the level of the monetary policy stance is also considered.

A number of unconventional monetary policy interventions were undertaken over the period under study. The growth rate of central bank assets will be used to capture these unconventional monetary policy interventions because the key feature of such policies has been the active use of the central bank's balance sheet to affect market prices and conditions (Borio and Disyatat, 2010). Unconventional monetary policy interventions are measured by the growth rate of total central bank assets to capture their impact on bank lending flows (see for example, Brei, Gambacorta and Von Peter, 2013).

Interestingly, the inclusion of a measure of *unconventional* monetary policy interventions in the analysis of bank lending carried out by Brei, Gambacorta and Von Peter (2013) improved the significance of the impact of *conventional* monetary policy (measured by the change in the 3-month interbank rate), suggesting the two variables capture the impact of monetary conditions on bank lending relatively well.

Descriptions for the lending variables and controls to be included in the baseline analysis of transitional effects are provided in the table below.

Table 7: Key variables for the analysis of transitional effects

Bank lending	
ln(NETLENDING)[53]	Natural logarithm of net lending
Regulatory capital ratios and regimes	
CAP	Quotient of Total Capital and Risk Weighted Assets at *t-1*
T1	Quotient of Tier One (T1) and Risk Weighted Assets at *t-1*
Bank characteristics	
ln(SIZE)	Natural logarithm of total assets at *t-1*
LIQ	Quotient of Cash and trading securities, and total assets at *t-1*
WHOLE	Quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets at *t-1*
PROFITABILITY	Quotient of net income and total assets at t-1 (expressed as percentage)
LEV	1 – quotient of equity and total assets at t-1 (expressed as percentage)

[53] The difference in gross loans can be negative, and the natural logarithm of a negative value is undefined. To ensure both positive and negative values for the difference in gross loans are included, a constant is added to all values for the difference in gross loans such that the minimum value of the difference in gross loans is just positive, as is common in the literature

Table 7: Key variables for the analysis of transitional effects

Monetary and macroeconomic characteristics	
Δln(CB)	Difference in the natural logarithm of central bank assets
ΔIB	Change in the 3-month interbank rate
Δln(GDP)	Difference in logarithm of real GDP
Π	Inflation rate
Output gap	Difference between actual and potential GDP as a percentage of potential GDP

Note: Detailed list of variables used in the analysis of transitional effects, their definitions and data sources provided at Annex 3
Source: Bankscope (or, Bloomberg), ECB, Eurostat and national central banks

Summary statistics

The table below provides averages of individual bank characteristics. There is wide variation across Member States in many regards. Banks lend, for instance, as little as €41m in Germany to as much as €1.5bn in France. This relates to a degree, to the size distribution of banks in the Member States as, one notes, there are many banks in Germany and fewer banks in France. Capital ratios tend to be in a relatively narrow range, with the Total Capital Ratio ranging from 14% to 19% in most Member States; the exception is Estonia where the Total Capital Ratio is 31% on average. Nonetheless, this means most banks hold in the range of 6% to 11% more than the regulatory minimum Total Capital Ratio, which is discussed in greater detail in a previous chapter. Other interesting features of the data are the fact that across Member States, banks' shares of liquid and wholesale funding in total funding and profitability varies widely.

Table 8: Average bank characteristics by Member State, 1985-2014

	NETLENDING (€m)	*CAP (%)*	*SIZE (€m)*	*LIQ (%)*	*WHOLE (%)*	*PROFITABILITY (%)*	*LEV (%)*
AT	232	16	8,080	5	41	0.3	93
BE	3,093	19	97,658	10	30	0.7	93
BG	106	15	1,097	20	17	1.2	89
CY	774	16	8,290	13	22	0.7	94
CZ	34	16	2,291	13	32	0.8	91
DE	41	17	1,589	2	19	0.3	93
DK	166	18	3,744	21	19	0.4	88
EE	42	31	202	17	27	0.3	79
EL	500	14	11,618	4	26	-1.0	91
ES	1,223	13	23,547	4	45	0.4	92
FI	1,211	16	24,464	7	38	0.6	92
FR	1,464	16	56,557	9	58	0.6	92
HR	35	17	1,024	18	15	0.2	88
HU	133	15	4,582	18	40	0.5	91
IE	4,230	15	72,385	13	52	1.6	88
IT	75	18	1,450	13	36	0.6	89
LT	114	14	2,166	13	27	0.1	90
LU	266	17	27,798	9	54	0.4	94
LV	68	15	1,047	10	19	0.6	91
MT	93	17	3,051	20	12	0.8	93
NL	399	16	15,442	7	38	0.2	92
PL	935	14	11,073	8	25	1.2	90

	NETLENDING (€m)	*CAP (%)*	*SIZE (€m)*	*LIQ (%)*	*WHOLE (%)*	*PROFITABILITY (%)*	*LEV (%)*
PT	426	16	10,685	7	54	0.9	90
RO	116	14	2,866	19	15	0.7	89
SE	2,308	16	36,570	5	31	0.7	92
SI	69	15	2,187	12	30	0.3	90
SK	159	15	2,080	16	20	0.8	91
UK	2,236	18	85,911	10	35	0.5	92

Notes: The table reports average bank characteristics for the banks used in estimating the baseline econometric model
Source: Bankscope and LE Europe calculations

The correlation matrix for the lending variables and contemporaneous explanatory variables is provided in the table below. It shows that an increase in the Total Capital Ratio (*CAP*) is correlated with a reduction in net lending, as the correlation coefficient is -0.14. Regarding other bank characteristics specifically, size (*SIZE*) is positively related to net lending, as is the share of non-deposit liabilities in total funding (*WHOLE*), profitability (*PROFIT*) and leverage (*LEV*). Whether these relationships are causal and apply once other factors are controlled for, is investigated through the econometric analysis presented later in this chapter.

Table 9: Correlation matrix for main variables, 1985-2014

	NETLENDING	*CAP*	*SIZE*	*LIQ*	*WHOLE*	*PROFIT.*	*LEV*	*ΔlnCB*	*ΔIB*	*ΔlnGDP*	*Π*	*OUTPUT GAP*
NETLENDING	1.00											
CAP	-0.14	1.00										
SIZE	0.43	-0.07	1.00									
LIQ	-0.02	0.27	0.01	1.00								
WHOLE	0.14	-0.29	0.14	0.07	1.00							
PROFIT.	0.13	0.16	0.00	0.17	0.02	1.00						
LEV	0.08	-0.57	0.09	-0.38	0.05	-0.31	1.00					
ΔlnCB	0.05	-0.04	0.01	-0.09	0.03	0.01	0.05	1.00				
ΔIB	0.10	0.04	0.02	0.12	0.09	0.12	-0.13	0.54	1.00			
ΔlnGDP	0.11	0.04	0.02	0.11	-0.05	0.16	-0.03	0.42	0.78	1.00		
Π	0.09	0.01	0.01	0.22	0.13	0.12	-0.15	0.45	0.53	0.4	1.00	
OUTPUT GAP	-0.15	-0.07	-0.01	-0.22	-0.04	-0.27	0.15	-0.46	-0.71	-0.68	-0.56	1.00

Notes: The table reports coefficients of correlation for the lending variables and contemporaneous explanatory variables based on the observations used in estimating the baseline econometric model
Source: Bankscope and LE Europe calculations

Identification challenges

Distinguishing supply and demand

Overall bank lending flows are an equilibrium outcome of supply and demand in the market for bank loans.

The main challenge in identifying causally the drivers behind bank lending flows is distinguishing changes in supply and demand, as poor economic conditions that cause shocks to the supply of bank credit also cause shocks to credit demand (Kashyap, Stein and Hanson, 2010). This issue is particularly important in studies of European countries since the onset of the financial crisis, as weak economic conditions, loan losses and depressed loan demand have been seen.

Conceptually, if the demand and supply curves for bank lending shift over time, the observed data on quantities and prices reflect a set of equilibrium points on both curves. Consequently, a regression of quantities on prices, say, cannot distinguish drivers from either the supply or demand side.

In order to identify the supply and demand side drivers therefore, one must identify observed factors that independently cause the supply and demand curves to shift and use these as explanatory factors in a regression of the variables of interest (in this case, bank lending flows).

Three main approaches have been used to distinguish supply and demand in the literature. Some studies have considered the international transmission of capital shocks, arguing that capital shocks to parent banks affect bank lending flows of foreign subsidiaries and branches unrelated to demand in the foreign country (see for example, Peek and Rosengren, 1997). This approach cannot be used in the present study, given the interest in both the domestic and international transmission of capital shocks.

Other studies have used policy experiments in which capital shocks are not related to demand. In the UK for instance, several studies have used variation in bank-specific capital requirements to identify capital shocks independent of demand (Francis and Osborne, 2012; Aiyar, Calomiris and Wieladek, 2014b; Bridges et al., 2014). This approach cannot be used in the present study because increased capital requirements have been applied in the same way – in terms of the Total Capital Ratio – across all banks.

Finally, a number of studies proxy demand directly based on macroeconomic conditions, including GDP and inflation, to preserve the identification of the coefficients on supply side variables (see for example, Ehrmann et al, 2003 and Gambacorta, 2005; and Brei et al, 2013). This is the approach taken in the baseline econometric model below.

With regard to identifying drivers of supply – in cases where the research interest is not in international transmission of capital shocks or policy experiments only – the literature addresses the identification problem based on the assumption that certain bank-specific characteristics (size, liquidity and capitalisation) influence bank lending supply and that these characteristics are exogenous of demand for bank credit, as described in Altunbas, Gambacorta and Marquez-Ibanez (2009).[54]

[54] The bank-specific characteristics of size, liquidity and capitalisation that will be used in the econometric models are described in the previous section

The drivers of supply enter as lags to help mitigate further the endogeneity problem (see for example Kashyap and Stein, 1995; Kashyap and Stein, 2000; Ehrmann et al., 2003; Gambacorta and Mistrulli, 2004; and Gambacorta and Marquez-Ibanez, 2011).

In summary, the identification assumptions with regard to distinguishing bank lending supply and demand are: i) the bank-specific characteristics chosen to capture bank lending supply are plausibly exogenous as lags; and ii) the macroeconomic characteristics control sufficiently for loan demand.

It should be noted the identification assumptions do not hold if changes in regulatory capital ratios coincide systematically with changes in demand for bank credit not otherwise captured by macroeconomic characteristics.

Measuring the impact of increased capital requirements
Quantifying the impacts of increased capital requirements on lending is challenging because they cannot be observed directly. All that can be observed are changes in the actual regulatory capital ratios that are presumably under the influence of changes in formal regulatory requirements, and at times, informal pressure from regulatory authorities, and their impacts on lending.

For the analysis undertaken, the assumption made is that actual regulatory capital ratios respond to capital requirements. However, it is also recognised that they respond to non-regulatory factors as well. For instance, bank managers may deem it prudent to operate at capital levels in excess of the regulatory minimum.[55]

Regulatory capital ratios over different capital regulation regimes
The definition of regulatory capital ratios differ over different capital regulation regimes. Such differences are captured through bank-specific fixed effects, on the basis that they result in a level shift in the relationship between actual capital ratios and bank lending. In robustness tests, time-specific and country-specific dummies are also included in the estimation model to pick up any effect of changes in capital regulation regimes that may be common to banks in particular countries or in specific years.

Capturing the impact of increased capital requirements over time
Bank lending flows may also be persistent over time, that is, bank lending flows at one point in time are closely related to bank lending flows in the past. To account for this feature, a dynamic econometric model that includes lagged bank lending flows as explanatory variables will be used (see for example, Bridges et al., 2014). The use of a dynamic econometric model also allows for one to compute the one-period and multi-period impact of capital ratios.

Anticipation of changes to regulatory capital regimes
There may be a concern that banks anticipate changes to regulatory capital regimes and therefore start to adjust regulatory capital ratios and lending prior to their strict entry into force (for example, when a regime change is announced). This would cause a problem for the identification of impacts if the identification strategy relied on looking at a narrow event window. However, as the baseline econometric model described below identifies the relationship between regulatory capital ratios and bank lending more generally rather than over a narrow window, the issue of anticipation does not arise – a

[55] A discussion of this issue with regard to the identification of the impacts of increased capital requirements on bank lending are provided in the section 'On the relationship between *requirements for* and *actual* regulatory capital ratios'

bank may adjust its capital ahead of the introduction of CRR but any lending impact would still be captured over subsequent periods.

Baseline econometric model

The baseline econometric model is specified in view of the discussion in the previous section on the sample, variables and identification issues.

$$\ln(NETLENDING)_{ijt} = \mu_i + \sum_{s=1}^{N} \alpha_s \cdot \ln(NETLENDING)_{ijt-s} + \beta \cdot \ln(SIZE)_{ijt} + \chi \cdot CAP_{ijt} + \delta LIQ_{ijt} + \phi WHOLE_{ijt} + \Gamma M_{jt} + \varepsilon_{ijt} \quad \text{.....................} (6)$$

- $ln(NETLENDING)_{ijt-s}$ is the natural logarithm of net lending for bank i, in Member State j, at time t-s (s=0 for the dependent variable)[56]
- μ_i are bank-specific effects
- $ln(SIZE)_{ijt}$ is the natural logarithm of total assets for bank i, in Member State j, at time t
- CAP_{ijt} is the quotient of Total Capital and Risk Weighted Assets for bank i, in Member State j, at time t
- LIQ_{ijt} is the quotient of cash and trading securities and total assets for bank i, in Member State j, at time t
- $WHOLE_{ijt}$ is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets at t for bank i, in Member State j
- M_{jt} is a vector of monetary and macroeconomic characteristics in Member State j, at time t (detailed in Table 7)
- ε_{ijt} is an error term for bank i, in Member State j, at time t
- α, β, χ, δ, ϕ are coefficients
- Γ is a vector of coefficients

The lagged dependent variables, $ln(NETLENDING)_{ijt-s}$, where s>0, capture autocorrelation in the sense of the impact of past values of bank lending flows on current bank lending flows. The number of lags will be determined empirically to ensure each additional lag adds explanatory power and, more generally, the model is correctly specified.

The Total Capital Ratio, CAP_{ijt}, captures the impact of increased capital requirements and is instrumented for by using lags to mitigate endogeneity concerns (as per Gambacorta and Marquez-Ibanez, 2011; Brei, Gambacorta and Von Peter, 2013; and others).

Estimates of the impact of regulatory capital ratios on bank lending flows, $\delta \text{Ln(NETLENDING)}_{ijt}/\delta \text{CAP}_{ijt}$, are captured by β for the one-period impact. The dynamic impact, $\delta \text{Ln(NETLENDING)}_{ij}/\delta \text{CAP}_{ij}$, is captured by $\beta/(1-(\alpha_1+\alpha_2+...\alpha_s)$.

Bank size, liquidity and wholesale funding, captured respectively by $ln(SIZE)_{ijt}$, LIQ_{ijt} and $WHOLE_{ijt}$, reflect the other plausibly exogenous bank characteristics that could influence

[56] The difference in gross loans can be negative, and the natural logarithm of a negative value is undefined. To ensure both positive and negative values for the difference in gross loans are included, a constant is added to all values for the difference in gross loans such that the minimum value of the difference in gross loans is just positive, as is common in the literature

bank lending flows, which are also instrumented for using lags as a response to endogeneity concerns.

Monetary and macroeconomic characteristics are captured by vector M_{jt}. The bank lending channel of monetary policy transmission is captured by changes in the 3-month interbank rate (see for example Bernanke and Blinder, 1992). Unconventional monetary policy interventions are captured by the difference in the natural logarithm of central bank assets (as suggested by Brei, Gambacorta and Von Peter, 2013). Influences on loan demand are captured by the logarithm of the difference in real GDP, the inflation rate (see for example, Ehrmann et al, 2003; Gambacorta, 2005; and Brei et al, 2013) and the output gap (the difference between actual and potential GDP as a percentage of potential GDP).

A system GMM estimator will be used to estimate the baseline econometric model. Details of the choice of estimation method are provided at Annex 4. Standard errors will be clustered at bank level (Cameron and Miller, 2015). The baseline econometric model is estimated over an unbalanced panel of banks in Europe over 1985-2014 and, as a robustness check, also an unbalanced panel of banks in Europe over 1995:H1-2015:H2.

Results

Baseline results

The models specified in the table below each regress bank lending flows on their lags, bank size and funding characteristics (including, the Total Capital Ratio), and a number of macroeconomic controls. The two-step system GMM estimator is used to estimate the models, with bank characteristics entering the model as instruments. All lags of bank characteristics are considered as potential instruments. The properties of the estimated models are generally good.[57]

The baseline results are reported in the table below. The estimated coefficient on the Total Capital Ratio across the models is highly statistically significant, negative and indicates in column (4) that for a one-percentage point change in the Total Capital Ratio the impact on bank lending flows is -0.8%, with the implied impact over a three-year period being -1.5%.

The effect sizes are generally within the range of estimates from previous studies for single European Member States and the euro area, for example: Maurin and Toivanen (2012) estimate a one-year impact in the range -2.3% to -2.0% for the euro area over 2005-2011 and Bridges et al. (2014) estimate an impact of-0.8% for household lending and -2.1% for private non-financial corporate lending in the UK over 1990-2011.

Some studies find larger impacts, although in different contexts. Aiyar Calomiris and Wieladek (2014b), for instance, found larger impacts, in the range -7.2% to -6.5% for the one-year impact on cross-border bank lending. It is also important to note that the present study includes sample data on the period since the adoption of Basel III, whereas many previous studies (including those cited above) are carried out using pre-2011 data.

[57] There are two key tests of the system GMM estimator: the test for the presence of second-order autocorrelation and the difference-in-Hansen test for the exogeneity of instruments. Regarding these tests, second-order autocorrelation in the residuals is absent, as the associated p-value for the test is very large, and the difference-in-Hansen test for the exogeneity of the instruments is passed, albeit it marginally at the 5% significance level in the model specified in column (4).

With regard to other variables the following can be noted. Past bank lending is a statistically significant determinate of current-period flows, although lending this year has more of an economically significant impact next year than in the subsequent year.

Larger banks lend more. However, the estimated effect of bank size on lending is relatively small, which may reflect a countervailing effect whereby very large banks diversify their assets and, therefore, an incremental increase in bank size only results in a small increase in bank lending, on average.

Interestingly, other bank funding characteristics, namely the shares of short-term and wholesale funding in total liabilities, are not statistically significant (with the exception of the former in column (1) at the 10% level). This is consistent with persistence in bank lending flows and past lending explaining the majority of the observed evolution of bank lending flows.

Of note also is that bank profitability, included in the models in the columns (2) to (4), is highly statistically significant and positively related to bank lending because more profitable banks are perhaps better able to identify greater lending opportunities.[58]

A number of macroeconomic variables are relevant explanatory factors of bank lending. In particular, increases the GDP growth rate and rate of inflation both positively affect bank lending flows while an increase in the output gap (included in column (4)) is linked to a reduction in bank lending. The relationships between bank lending flows and the macroeconomic variables are consistent with a demand side interpretation, which is encouraging as regards distinguishing supply and demand drivers through the variables included in the estimation models.[59]

In terms of monetary variables, an increase in the growth rate of the size of assets of the central bank is related to a statistically significant reduction in bank lending flows. However, a change in the interbank interest rate does not affect bank lending flows.[60]

Overall, while the Total Capital Ratio has an economically significant impact on bank lending flows, the result should be read within the context of the fact that other bank-level and macroeconomic drivers matter to lending flow developments such as past lending flows and the output gap. Indeed, the results of the baseline model indicate that a 1% increase in lending flows experienced last year, results in a 0.34% increase in lending flows in the present year. In the case of the output gap, a one percentage point increase in the output gap results in a 0.95% reduction in in bank lending flows.

[58] As an additional check of the results, a model is estimated with net charge-offs as a control reported in Table 57, Annex 5. The results remain the same

[59] See discussion on ‘Identification challenges’ above for further information

[60] As an alternative to the monetary variables used, a robustness check with the levels of the size of central bank assets and the interbank interest rate variables is reported in Table 58, Annex 5. The results are not affected by this change

Table 10: Baseline results – 1985-2014

Dependent variable: *ln(NETLENDING)*	(1)	(2)	(3)	Baseline (4)
$ln(NETLENDING)_{it-1}$	0.375***	0.353***	0.347***	0.339***
$ln(NETLENDING)_{it-2}$	0.134*	0.140**	0.135**	0.131**
$ln(SIZE)_{it}$	0.031**	0.039***	0.036***	0.038***
CAP_{it}	-0.011***	-0.010***	-0.008***	-0.008***
LIQ_{it}	0.111*	0.032	0.014	-0.018
$WHOLE_{it}$	-0.020	-0.050	-0.037	-0.033
$\Delta ln(CB)_{jt}$	-0.089***	-0.055**	-0.053**	-0.067**
ΔIB_{jt}	-0.006	-0.005	-0.003	-0.009
$\Delta ln(GDP)_{jt}$	0.903***	0.698***	0.688***	0.559***
Π_{jt}	0.027***	0.020***	0.018***	0.012*
$PROFITABILITY_{it}$		0.049***	0.047***	0.043***
LEV_{it}			0.000	0.000
$OUTPUT\ GAP_{jt}$				-0.958***
C	3.489***	3.534***	3.639***	3.683***
Number of observations	11,068	10,720	10,719	10,719
Cross-sectional units	2,371	2,364	2,364	2,364
AR(2) (p-value)	0.793	0.685	0.698	0.710
Diff-in-Hansen test (p-value)	0.477	0.154	0.301	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets; *CAP is the Total Capital Ratio; LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; п is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, with bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1. Results with p-values presented in Table 48, Annex 5.
Source: Bankscope and LE Europe calculations

Robustness tests

A number of checks have been carried out to test the sensitivity of the final baseline results presented in column (4) in the table above (abbreviated to "baseline results" hereafter).

Firstly, the Tier 1 Capital ratio is tested in place of the Total Capital Ratio, to determine whether bank lending flows may be more sensitive to this measure.

Secondly, the sensitivity of the relationship between the Total Capital Ratio and bank lending flows is tested with regard to the impact of the crisis on banks and crisis interventions on banks.

Thirdly, the impact of cross-border lending activity at the Member State level on bank lending flows is considered.

Fourthly, the sensitivity of the results to further controls for the supply and demand for bank credit, through the inclusion of variables from the ECB's bank lending survey, are tested.

And finally, a check on whether banks are responding to changes in capital regulation or simply regulatory capital ratios (that are driven by other factors) is considered.

The findings of the robustness tests are discussed below.

Alternative regulatory capital ratio

There are a number of regulatory capital ratios in the CRR and it is interesting to investigate the impact of changes in each of these on bank lending flows.

However, in order to identify the impact of the different regulatory capital ratios on bank lending flows, it is important for alternative regulatory capital ratios to be considered separately because they capture similar economic concepts and therefore may not separately be identified if they were all included in the same econometric model (see for example, Gambacorta and Marquez-Ibanez, 2011).

Data availability has restricted our consideration of alternative regulatory capital ratios to the Tier 1 ratio. The CET1 ratio in particular is not considered because it has not been in use for long enough to derive empirical results.

With the above considerations in mind, the table below presents in column (1) the baseline model with the Tier 1 ratio in place of the Total Capital Ratio; and in column (2), the baseline results are reproduced for comparison.

The key finding is that the Tier 1 ratio and the Total Capital Ratio have a similar impact on bank lending flows, with the remainder of the explanatory variables also maintaining the same sign, general size and statistical significance, with the exception of the change in the interbank rate, which is significant at the 5% level in column (1). A one percentage point increase in the Tier 1 ratio leads to a contemporaneous impact on bank lending flows of -0.5%.

Table 11: Robustness checks: Alternative regulatory capital ratio – 1985-2014

Dependent variable: *ln(NETLENDING)*	(1)	Baseline (2)
$ln(NETLENDING)_{it-1}$	0.323***	0.339***
$ln(NETLENDING)_{it-2}$	0.132**	0.131**
$ln(SIZE)_{it}$	0.038***	0.038***
CAP_{it}		-0.008***
$T1_{it}$	-0.005*	
LIQ_{it}	-0.052	-0.018
$WHOLE_{it}$	-0.025	-0.033
$\Delta ln(CB)_{jt}$	-0.109***	-0.067**
ΔIB_{jt}	-0.015**	-0.009
$\Delta ln(GDP)_{jt}$	1.283***	0.559***
Π_{jt}	0.032***	0.012*
$PROFITABILITY_{it}$	0.043***	0.043***
LEV_{it}	0.001	0.000
$OUTPUT\ GAP_{jt}$	-1.200***	-0.958***
C	3.574***	3.683***
Number of observations	7,665	10,719
Cross-sectional units	2,065	2,364
AR(2) (p-value)	0.600	0.710
Diff-in-Hansen test (p-value)	0.000	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *CAP* is the Total Capital ratio; *T1* is the Tier One Capital ratio; *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; п is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1. Results with p-values presented in Table 49, Annex 5.
Source: Bankscope and LE Europe calculations

Impact of the crisis and crisis interventions

The possible impact of the crisis is to cause a structural shift in the relationship between regulatory capital ratios and bank lending flows. The robustness test regarding the impact of the crisis investigates this possibility. A crisis dummy – set to 1 from 2008 onwards – is interacted with bank characteristics (including regulatory capital flows) as per the equation described below.

$$\ln(NETLENDING)_{ijt} = \mu_i + \sum_{s=1}^{N} \alpha_s \cdot \ln(NETLENDING)_{ijt-s} + (\beta + \beta \cdot Crisis) \cdot \ln(SIZE)_{ijt} + (\chi + \chi \cdot Crisis) \cdot CAP_{ijt} + (\delta + \delta \cdot Crisis) \cdot LIQ_{ijt} + (\phi + \phi \cdot Crisis) \cdot WHOLE_{ijt} + \ldots + M_{jt} + \varepsilon_{ijt} \quad ..(7)$$

The results of estimating this model are presented in column (1) in the table below, with the baseline results presented for comparison in column (5).

The main finding is that there is a structural shift in the relationship between the Total Capital Ratio and bank lending flows, with the coefficient on the Total Capital Ratio only becoming significant since the crisis. This may reflect the fact that there has been little observed variation in the Total Capital Ratio in the EU prior to the crisis, as shown in Figure 10 above, so while an underlying relation between bank lending flows and the Total Capital Ratio may have always been present, it is only become easily detectable more recently.

While controlling for potential structural shifts in the relationship between bank lending flows and other explanatory variables reduces the size of the impact of changes in the Total Capital Ratio on bank lending flows[61], the difference in the effect sizes is not statistically significant.

Interestingly, a number of bank characteristics that had, prior to the crisis, a particular effect on bank lending have since had the opposite effect. Firstly, an increase in bank size was associated with an increase in bank lending prior to the crisis, whereas it has since been associated with a decrease. This may reflect the fact that diversification effect is dominating the size effect: since the crisis, as banks grow, they prefer other assets to loans.

Secondly, while leverage prior to the crisis was associated with less bank lending, it has since been linked to greater bank lending. One possible reason for this is that since the crisis, lending offers greater returns to other assets that banks may have previously been funding through debt.

Another aspect of the crisis to investigate is what the impact of the significant financial sector interventions undertaken had been, distinct from increased capital requirements. To investigate this issue measures of recapitalisations, asset relief, guarantees and liquidity support of the financial sector provided at the Member State level are included in models through variables developed on the basis of the EC State Aid Scoreboard.[62] The results are presented in columns (2) to (4) and are quite consistent with the baseline results in column (5), The main implication of which is that increased capital

[61] In particular, the one-period impact of a one percentage point increase in the Total Capital Ratio on bank lending flows is -0.4% instead of -0.8%

[62] See http://ec.europa.eu/competition/state_aid/scoreboard/financial_economic_crisis_aid_en.html

requirements operating through the Total Capital Ratio impact bank lending independently of other financial sector interventions taking place at the time.

Table 12: Robustness checks: Impact of the crisis and crisis interventions – 1985-2014

Dependent variable: *ln(NETLENDING)*	(1)	(2)	(3)	(4)	Baseline (5)
ln(NETLENDING)$_{it-1}$	0.281***	0.338***	0.337***	0.334***	0.339***
ln(NETLENDING)$_{it-2}$	0.130**	0.131**	0.130**	0.130**	0.131**
ln(SIZE)$_{it}$	0.113***	0.039***	0.037***	0.040***	0.038***
ln(SIZE)$_{it}$*CRISIS*	-0.112***				
CAP$_{it}$	-0.001	-0.008***	-0.007***	-0.006***	-0.008***
CAP$_{it}^{*}$*CRISIS*	-0.003**				
LIQ$_{it}$	-0.046	-0.012	-0.071	-0.091	-0.018
LIQ$_{it}$*CRISIS*	-0.074				
WHOLE$_{it}$	-0.177**	-0.029	-0.064	-0.074	-0.033
WHOLE$_{it}$*CRISIS*	0.086				
Δln(CB)$_{jt}$	-0.029	-0.075**	-0.037	-0.046	-0.067**
ΔIB$_{jt}$	-0.007	-0.008	-0.009	-0.005	-0.009
Δln(GDP)$_{jt}$	0.407**	0.530***	0.654***	0.611***	0.559***
Π_{jt}	0.019***	0.013**	0.010	0.014**	0.012*
PROFITABILITY$_{it}$	-0.006	0.042***	0.043***	0.043***	0.043***
PROFITABILITY$_{it}$*CRISIS*	0.052***				
LEV$_{it}$	-0.007**	0.000	0.002	0.002	0.000
LEV$_{it}$*CRISIS*	0.007***				
OUTPUT GAP$_{jt}$	0.013	-1.011***	-0.549	-0.437	-0.958***
C	4.279***	3.719***	3.550***	3.591***	3.683***
RECAP AND ASSET REL$_{j}$	N	Y	N	Y	N
GUAR AND LIQ SUPP$_{j}$	N	N	Y	Y	N
STRUCTURAL SHIFTS$_{i}$	Y	N	N	N	N
Number of observations	10,719	10,719	10,719	10,719	10,719
Cross-sectional units	2,364	2,364	2,364	2,364	2,364
AR(2) (p-value)	0.604	0.712	0.724	0.744	0.710
Diff-in-Hansen test (p-value)	0.476	0.126	0.270	0.208	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets; *CAP* is the Total Capital ratio; *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; *RECAP AND ASSET REL* is the value of recapitalisations and asset relief provided to the financial sector by Member State; *GUAR AND LIQ SUPP* is the value of state guarantees and liquidity support provided to the financial sector by Member State; and *STRUCTURAL SHIFTS* are interactive terms between bank characteristics and an indicator variable equal to 1 from 2008 onwards (*CRISIS*); and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1. Results with p-values presented in Table 50, Annex 5.

Source: Bankscope and LE Europe calculations

Impact of cross-border lending

Cross-border lending may have intensified the international transmission of financial shocks over the recent years: banks lending cross-border may have reduced these flows since the crisis (Claessans and van Horen, 2014), possibly extending greater credit domestically.

Cross-border loans are accounted for through inclusion of a variable for cross-border lending flows (from domestic country to banks abroad) using the BIS Locational (that is, non-consolidated) banking statistics.[63] A variable for cross-border flows included in the baseline econometric model as an additional country-level control. The results, presented below, show that the coefficient on the Total Capital Ratio is stable, indicating that international transmission mechanism did not affect the relationship between bank capital and lending. The coefficient on the cross-border flows variable is insignificant suggesting that an increase in this share does not reduce bank lending flows.

[63] See Table A5 of the BIS Locational banking statistics

Table 13: Robustness checks: Impact of cross border lending – 1985-2014

Dependent variable: *ln(NETLENDING)*	(1)	Baseline (2)
ln(NETLENDING)$_{it-1}$	0.350***	0.339***
ln(NETLENDING)$_{it-2}$	0.109	0.131**
ln(SIZE)$_i$	0.046***	0.038***
CAP$_i$	-0.007***	-0.008***
LIQ$_i$	-0.042	-0.018
WHOLE$_i$	-0.037	-0.033
Δln(CB)$_i$	-0.091***	-0.067**
ΔIB$_i$	-0.004	-0.009
Δln(GDP)$_i$	0.067	0.559***
Π$_i$	0.026***	0.012*
PROFITABILITY$_i$	0.040***	0.043***
LEV$_i$	0.000	0.000
OUTPUT GAP$_i$	-1.070***	-0.958***
CROSS-BORDER$_i$	-0.002	
C	3.727***	3.683***
Number of observations	10,203	10,719
Cross-sectional units	2,233	2,364
AR(2) (p-value)	0.631	0.710
Diff-in-Hansen test (p-value)	0.278	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *CAP* is the Total Capital ratio; *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; *CROSS-BORDER* is cross-border lending from domestic banks abroad; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. . Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1. Results with p-values presented in Table 51, Annex 5.
Source: Bankscope and LE Europe calculations

Non-linear responses to capital shocks

The possibility of non-linear responses to capital shocks is assessed by including – in the baseline econometric model – a second-order term for the regulatory capital ratio, CAP^2_{ijt}. The results, presented in the table overleaf show that the coefficient on CAP^2_{ijt} is statistically significant, and hence, the relationship between lending and the capital ratio is non-linear.

However, the coefficient on CAP^2_{ijt} is small economically. The table below shows that, as proportion of the total impact of changes in the Total Capital Ratio on bank lending flows, the linear effect is several orders of magnitude larger than the non-linear effect. For instance, only for a 0.4 percentage point change in the Total Capital Ratio does the non-linear effect (of 0.01%) slightly offset the linear effect (of -1.34%)

Table 14: Decomposition of the impact of the Total Capital Ratio on bank lending flows, percentage of one-year bank lending flows

ΔCAP	Total impact	Linear effect	Non-linear effect
0.1 pp	-0.34%	-0.34%	0.00%
0.2pp	-0.67%	-0.67%	0.00%
0.3pp	-1.01%	-1.01%	0.00%
0.4pp	-1.33%	-1.34%	0.01%
0.5 pp	-1.67%	-1.68%	0.01%

Notes: ΔCAP is a one-year change in the Total Capital Ratio of 0.1-0.5 percentage points (pp). With the application of the CRR, the Total Capital Ratio has remained unchanged but, for example, the T1 Capital Requirement has increased by 0.5 percentage points. The Total impact, linear effect and non-linear effects are reported are a percentage of one-year bank lending flows
Source: LE Europe calculations

Table 15: Robustness checks: Non-linear responses to capital shocks – 1985-2014

Dependent variable: *ln(NETLENDING)*	(1)	Baseline (2)
$ln(NETLENDING)_{it-1}$	0.328***	0.339***
$ln(NETLENDING)_{it-2}$	0.121*	0.131**
$ln(SIZE)_{it}$	0.034***	0.038***
CAP_{it}	-0.034***	-0.008***
CAP^2_{it}	0.001***	
LIQ_{it}	-0.055	-0.018
$WHOLE_{it}$	-0.088	-0.033
$\Delta ln(CB)_{jt}$	-0.086***	-0.067**
ΔIB_{jt}	-0.009	-0.009
$\Delta ln(GDP)_{jt}$	0.631***	0.559***
Π_{jt}	0.013**	0.012*
$PROFITABILITY_{it}$	0.044***	0.043***
LEV_{it}	0.001	0.000
$OUTPUT\ GAP_{jt}$	-0.998***	-0.958***
C	4.016***	3.683***
Number of observations	10,719	10,719
Cross-sectional units	2,364	2,364
AR(2) (p-value)	0.732	0.710
Diff-in-Hansen test (p-value)	0.055	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital ratio; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; CAP^2 is a second-order term for the Total Capital Ratio; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1. Results with p-values presented in Table 52, Annex 5.
Source: Bankscope and LE Europe calculations

Demand for bank credit

In addition to using macroeconomic variables to control for credit demand, this section tests for the impact of controlling for credit demand more thoroughly through additional variables.

Variables influencing bank credit from the ECB Bank Lending Survey data were included in the baseline econometric model to control for the effect of credit demand factors more explicitly than through the use of macroeconomic variables alone.

The table below presents the results of the robustness checks on capturing the demand for bank credit in greater detail. The main finding is that the impact of the Total Capital Ratio on bank lending flows is similar when the estimated model includes different credit demand measures drawn from the ECB Bank Lending Survey. The one-period effect, for example, is in the range -0.7% to -0.6% while it is -0.8% in the baseline model, with differences not being statistically significantly different from one another.

Table 16: Robustness checks: Demand for bank credit – 1985-2014

Dependent variable: *ln(NETLENDING)*	(1)	(2)	(3)	Baseline (4)
ln(NETLENDING)$_{it-1}$	0.303***	0.298***	0.298***	0.339***
ln(NETLENDING)$_{it-2}$	0.179***	0.158**	0.159**	0.131**
ln(SIZE)$_{it}$	0.038***	0.049***	0.049***	0.038***
LIQ$_{it}$	-0.139	-0.474***	-0.463***	-0.018
WHOLE$_{it}$	-0.045	-0.239**	-0.222***	-0.033
CAP$_{it}$	-0.007**	-0.006*	-0.006*	-0.008***
Δln(CB)$_{jt}$	-0.067**	-0.190***	-0.183***	-0.067**
ΔIB$_{jt}$	-0.020**	0.013	0.011	-0.009
Δln(GDP)$_{jt}$	0.297	0.730***	0.669***	0.559***
Π$_{jt}$	0.046***	0.046***	0.048***	0.012*
PROFITABILITY$_{it}$	0.046***	0.038***	0.038***	0.043***
LEV$_{it}$	0.000	0.003	0.003	0.000
OUTPUT GAP$_{jt}$	-0.106	-0.447	-0.350	-0.958***
FINANCING NEEDS$_{jt}$	0.002***		0.000	
USE OF ALT FINANCE$_{jt}$		0.017***	0.016***	
C	3.574***	3.481***	3.465***	3.683***
Number of observations	8,460	8,451	8,451	10,719
Cross-sectional units	1,975	1,971	1,971	2,364
AR(2) (p-value)	0.387	0.326	0.326	0.710
Diff-in-Hansen test (p-value)	0.008	0.006	0.033	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital Ratio; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; *FINANCING NEEDS* relates to the underlying reasons for credit demand; *USE OF ALT FINANCE* relates to borrowers use of other sources of funding than that provided by banks; and C is a constant. The model is estimated using the two-step system GMM estimator and robustness standard errors, bank-level variables are instrumented for using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1. Results with p-values presented in Table 53, Annex 5.
Source: Bankscope and LE Europe calculations

Supply of bank credit

To test further for the influence of supply side factors on bank lending flows, the following checks are conducted.

Firstly, drivers of supply of bank credit from the ECB Bank Lending Survey data were included in the baseline econometric model to control further for supply factors. The coefficient estimates of the impact of the Total Capital Ratio on bank lending flows are in the same range as for the baseline estimates. These estimates are shown in the table below, comparing columns (1) to (4) – in which supply variables are included one by one and then all together – and column (7).

Secondly, sovereign bond yields were included in the baseline econometric model to take into account different funding conditions faced by banks headquartered in different Member States. Again, the estimated coefficient of the Total Capital Ratio is not affected by this change in the model specification relative to the baseline, as shown in column (5).

Thirdly, a market volatility measure, the V2X index, is used to control for market expectations of volatility. The basis of the index is the volatility of the Euro Stoxx 50 option prices. A high VSTOXX implies expectations of high volatility in the market. Similar to previous results, the estimated impact of the Total Capital Ratio on bank lending is within the range of the baseline estimates, as shown in column (6) and column (7).

Table 17: Robustness checks: Supply of bank credit – 1985-2014

Dependent variable: *ln(NETLENDING)*	(1)	(2)	(3)	(4)	(5)	(6)	Baseline (7)
ln(NETLENDING)$_{it-1}$	0.312***	0.296***	0.313***	0.301***	0.343***	0.339***	0.339***
ln(NETLENDING)$_{it-2}$	0.158**	0.152**	0.164**	0.165**	0.165***	0.131**	0.131**
ln(SIZE)$_{it}$	0.039***	0.039***	0.035***	0.037***	0.044***	0.037***	0.038***
CAP$_{it}$	-0.009***	-0.007***	-0.010***	-0.007***	-0.006***	-0.008***	-0.008***
LIQ$_{it}$	-0.041	-0.182*	0.058	-0.082	0.017	-0.016	-0.018
WHOLE$_{it}$	-0.071	-0.226*	-0.032	-0.167	-0.023	-0.033	-0.033
Δln(CB)$_{jt}$	-0.010	-0.041	-0.061**	-0.061**	-0.085***	-0.052**	-0.067**
ΔIB$_{jt}$	-0.012	-0.034***	-0.031***	-0.053***	-0.012*	-0.010*	-0.009
Δln(GDP)$_{jt}$	0.130	1.048***	0.593***	1.221***	0.575***	0.513***	0.559***
Π$_{jt}$	0.043***	0.050***	0.045***	0.064***	0.028***	0.013**	0.012*
PROFITABILITY$_{it}$	0.043***	0.036***	0.043***	0.035***	0.041***	0.042***	0.043***
LEV$_{it}$	-0.001	0.001	-0.002	0.000	-0.001	0.001	0.000
OUTPUT GAP$_{jt}$	-0.002	0.787	-0.444	0.834	-0.622*	-1.027***	-0.958***
ΔSOV YIELD					0.006		
MKT VOL						-0.001**	
COST OF FUNDS	-0.004***			0.001			
COMPETITION		-0.015***		-0.016***			
RISK PERCEPTIONS			-0.002***	-0.002***			
C	3.752***	3.674***	3.844***	3.623***	3.372***	3.648***	3.683***
Number of observations	8,467	8,467	8,467	8,467	10,230	10,719	10,719
Cross-sectional units	1,974	1,974	1,974	1,974	2,250	2,364	2,364
AR(2) (p-value)	0.323	0.248	0.319	0.217	0.673	0.714	0.710
Diff-in-Hansen test (p-value)	0.013	0.206	0.079	0.055	0.189	0.181	0.110

Notes: See overleaf

ln(NETLENDING) is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; *ΔSOV YIELD* is the difference in the sovereign yield at Member State level; *MKT VOL* measures market volatility; *COST OF FUNDS* measures banks' perceptions of funding costs; *COMPETITION* measures banks' perceptions of competition to supply credit; *RISK PERCEPTIONS* measures banks' perceptions of risks; and C is a constant. The model is estimated using the two-step system GMM estimator and robustness standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Results with p-values presented in Table 54, Annex 5.
Source: Bankscope and LE Europe calculations

Country and year fixed effects

To account more generally for factors that may be at play in particular Member States and years, the baseline model is re-estimated including country fixed effects in column (1) and year fixed effects in column (2) in the table below. The baseline results are re-presented in column (3) for purposes of comparison.

The coefficient on the Total Capital Ratio is negative, statistically significant and in the same order of magnitude in the model results provided in column (1) and column (2) as the baseline results.

Interestingly, other funding characteristics captured by the variables *LIQ* and *WHOLE* are negative and statistically significant in the models including, respectively, country and year fixed effects, whereas they are not in other specifications.

Consistent with other results, the macroeconomic variables that are significant in the regression including time fixed effects are the growth in the size of central bank assets, inflation and the output gap. Other macroeconomic and monetary variables are not significant suggesting that, when events taking place in particular years are accounted for, they do not explain variation in bank lending.

Table 18: Robustness checks: Country and year fixed effects – 1985-2014

Dependent variable: *ln(NETLENDING)*	(1)	(2)	Baseline (3)
ln(NETLENDING)$_{it-1}$	0.241***	0.320***	0.339***
ln(NETLENDING)$_{it-2}$	0.047	0.122*	0.131**
ln(SIZE)$_{it}$	0.032	0.046***	0.038***
LIQ$_{it}$	-0.243**	-0.318***	-0.018
WHOLE$_{it}$	-0.242**	-0.219**	-0.033
CAP$_{it}$	-0.010***	-0.005**	-0.008***
Δln(CB)$_{jt}$	-0.107***	-0.391***	-0.067**
ΔIB$_{jt}$	-0.020***	0.000	-0.009
Δln(GDP)$_{jt}$	0.863***	-0.986	0.559***
Π$_{jt}$	0.018**	0.018**	0.012*
PROFITABILITY$_{it}$	0.040***	0.037***	0.043***
LEV$_{it}$	0.006*	0.003	0.000
OUTPUT GAP$_{jt}$	-1.441***	-0.918	-0.958***
C	4.379***	3.508***	3.683***
COUNTRY FIXED EFFECTS	Y	N	N
YEAR FIXED EFFECTS	N	Y	N
Number of observations	10,719	10,719	10,719
Cross-sectional units	2,364	2,364	2,364
Number of banks			
AR(2) (p-value)	0.988	0.617	0.710
Diff-in-Hansen test (p-value)	0.986	0.178	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital Ratio; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robustness standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1. Results with p-values presented in Table 55, Annex 5.
Source: Bankscope and LE Europe calculations

Capital ratio cushion

The main estimate shows that an increase in the Total Capital Ratio has a negative impact on bank lending. However, a concern is that actual capital ratios could be driven purely by non-regulatory factors and therefore the impact of increased capital requirements through actual capital ratios under the CRR on bank lending could be zero.

To investigate whether regulatory minima for capital ratios matter to bank lending, the baseline econometric model is re-estimated with an interactive term between banks' actual Total Capital Ratios and their capital ratio cushions (the difference between their actual Total Capital Ratio and the 8% minimum for the Total Capital Ratio).[64]

The results show a negative coefficient on this variable. The interpretation of this is as follows: for a given Total Capital Ratio, the impact on bank lending of having a Total Capital Ratio closer to the regulatory minimum is larger. This is evidence that bank lending flows are affected by regulatory minima for capital ratios.

[64] Note, the models were estimated with three lagged dependent variables, due to superior model properties compared to the two lagged dependent variable model

Table 19: Robustness checks: Capital cushion – 1985-2014

Dependent variable: *ln(NETLENDING)*	(1)	(2)	Baseline (3)
ln(NETLENDING)$_{it-1}$	0.296***	0.294***	0.339***
ln(NETLENDING)$_{it-2}$	0.166**	0.165**	0.131**
ln(NETLENDING)$_{it-3}$	0.007	0.005	
ln(SIZE)$_{it}$	0.033***	0.034***	0.038***
LIQ$_{it}$	-0.069	-0.070	-0.018
WHOLE$_{it}$	-0.062	-0.061	-0.033
CAP$_{it}$	-0.022***	-0.032*	-0.008***
Δln(CB)$_{jt}$	-0.055**	-0.049**	-0.067**
ΔIB$_{jt}$	-0.011**	-0.011**	-0.009
Δln(GDP)$_{jt}$	0.516***	0.505***	0.559***
Π$_{jt}$	0.012**	0.010*	0.012*
PROFITABILITY$_{it}$	0.040***	0.042**	0.043***
LEV$_{it}$	0.001	0.001	0.000
OUTPUT GAP$_{jt}$	-0.935***	-0.952***	-0.958***
*CAPCUSHION*CAP*	0.000***	0.001	
*CAPCUSHION^2*CAP*		0.000	
C	3.799***	3.951***	3.683***
Number of observations	9,936	9,936	10,719
Cross-sectional units	2,254	2,254	2,364
AR(2) (p-value)	0.821	0.826	0.710
Diff-in-Hansen test (p-value)	0.351	0.211	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital Ratio; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; *CAPCUSHION* is *CAP* minus 8%; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1. Results with p-values presented in Table 56, Annex 5. Source: Bankscope and LE Europe calculations

Alternative sample

As a final check of the results, each of the models presented in the baseline results and robustness checks sections above is re-estimated using a sample of listed banks for which data at a half-yearly frequency is available. This test is carried out to see whether, considering a different set of banks and data frequency, the results hold. The table below presents the results.

Overall, the model properties are relatively good. Second-order autocorrelation in the residuals is absent and the Hansen test for over-identifying restrictions is comfortably passed as well.

The estimates of the coefficients of the Total Capital Ratio is somewhat larger when the baseline models are re-estimated using the sample of listed banks. The coefficient on the Total Capital Ratio is only marginally insignificant at the 10% level in column (2).[65] However, they are within the same range as the coefficient estimates from the econometric estimation over the wider, listed and non-listed sample of banks.

However, the general explanatory power of the models estimated using the sample of listed banks is weaker in that few other variables are statistically significant, with the exception of the output gap which is sometimes significant across the models estimates for the baseline results and robustness checks. This may be due to the use of only one lagged dependent variable in the model (as opposed to the two used in most other specifications presented) – as bank lending is persistent, additional lags may have helped to explain the main pattern of variation in the data.[66]

[65] The p-value is 0.13

[66] However, when additional lags were included in the model, the model properties were poor (for example, the difference-in-Hansen test was not passed), perhaps due to the presence of comparatively few data in the sample of listed banks. Due to its broader coverage of banks, the results based on the Bankscope sample are preferred but it is reassuring that, at least regarding the *CAP* coefficient, the main findings are qualitatively the same.

Table 20: Robustness checks: Alternative sample – 1985-2014

Dependent variable: *ln(NETLENDING)*	Baseline (1)	Profitability (2)	Leverage (3)	Output gap (4)	Baseline (5)
$ln(NETLENDING)_{it-1}$	-0.028	0.044	0.009	-0.068	0.339***
$ln(NETLENDING)_{it-2}$					0.131**
$ln(SIZE)_{it}$	0.000	0.008	0.022	0.021	0.038***
LIQ_{it}	0.620*	0.272	0.266	0.191	-0.018
$WHOLE_{it}$	-0.176	-0.271	-0.271	-0.324*	-0.033
CAP_{it}	-0.014*	-0.008	-0.017**	-0.014**	-0.008***
$\Delta ln(CB)_{jt}$	0.147	0.122	0.046	-0.088	-0.067**
ΔIB_{jt}	0.004	-0.012	-0.020	-0.037	-0.009
$\Delta ln(GDP)_{jt}$	2.590	0.623	0.444	0.336	0.559***
Π_{jt}	0.015*	0.008	0.010	-0.002	0.012*
$PROFITABILITY_{it}$		0.010**	0.005	-0.002	0.043***
LEV_{it}			0.015**	0.011**	0.000
$OUTPUT\ GAP_{jt}$				0.021***	-0.958***
C	9.991***	9.249***	9.441***	10.270***	3.683***
Number of observations	1,380	1,364	1,364	1,364	10,719
Cross-sectional units	293	287	287	287	2,364
AR(2) (p-value)	0.343	0.300	0.305	0.333	0.710

Notes: The model is estimated over the listed sample of banks in columns (1)-(4) and the wider sample of banks in column (5). *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital ratio; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; п is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1. Results with p-values presented in Table 59, Annex 5.
Source: Bloomberg and LE Europe calculations

Additional analysis

Sources of bank lending adjustments

The present section focuses on the potentially different impact of increases in capital ratios on three different types of lending (corporate loans, mortgages and other consumer loans) in order to determine whether one particular type of lending explains the overall adjustment in lending to changes in the capital ratio or whether all types of lending are equally impacted by increases in the capital ratio. Alternative dependent variables are used in the baseline econometric model, including:

- corporate and commercial loans capturing loan flows to non-financial corporates;
- Residential mortgage loans; and
- other consumer loans capturing loan flows to households

The results of the analysis are presented in the table below. The key result appears to be that the negative impact of the Total Capital Ratio on lending (following a one percentage point increase) is greatest on corporate loans (-0.4%)[67] followed by consumer loans (-0.3%), with the relationship between the Total Capital Ratio and mortgages being statistically insignificant. These results are consistent with the notion that mortgages receive a relatively generous capital treatment under the CRR compared to the other loan categories and therefore do not show a negative relationship with the Total Capital Ratio.

The results should be read with some caution however. Due to a frequent lack of data available on particular loan categories, the sample sizes are relatively small compared to the samples used in estimating the models of bank lending in general, which is particularly the case for the sample used to estimate the consumer loans model. In addition, it is notable that few other variables than capital ratios in the respective models have very good explanatory power, which is perhaps also due to the small sample sizes.

[67] However, the p-value (0.124) is just insignificant at the 10% level

Table 21: Sources of bank lending adjustments – 1985-2014

Dependent variable:	Consumer loans (1)	Mortgages (2)	Corporate loans (3)	All loans - Baseline (4)
ln(Dependent var)$_{it-1}$	0.116**	0.218**	0.435***	0.339***
ln(Dependent var)$_{it-2}$				0.131**
ln(SIZE)$_{it}$	-0.016	0.024	0.063**	0.038***
LIQ$_{it}$	-0.142	0.129	-0.038	-0.018
WHOLE$_{it}$	0.043	0.186	-0.128	-0.033
CAP$_{it}$	-0.003**	0.001	-0.004†	-0.008***
Δln(CB)$_{jt}$	-0.037	-0.011	-0.037	-0.067**
ΔIB$_{jt}$	0.003	0.003	0.008	-0.009
Δln(GDP)$_{jt}$	-0.053	-0.495	0.376	0.559***
Π$_{jt}$	-0.005	-0.008	-0.019**	0.012*
PROFITABILITY$_{it}$	0.009***	0.048**	0.048***	0.043***
LEV$_{it}$	-0.001	0.017*	0.000	0.000
OUTPUT GAP$_{jt}$	-0.313	-1.441**	-1.655***	-0.958***
C	8.473***	3.455***	3.920***	3.683***
Number of observations	443	4,752	3,957	10,719
Cross-sectional units	141	1,671	1,375	2,364
AR(2) (p-value)	0.194	0.340	0.913	0.710
Diff-in-Hansen test (p-value)	0.997	0.138	0.429	0.110

Notes: Each dependent variable is the natural logarithm of net lending of the loan category specified; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital Ratio; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robustness standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1, †p-value=0.124. Results with p-values presented in Table 60, Annex 5.
Source: Bankscope and LE Europe calculations

Bank business models

Banks operate a wide range of business models, which may mean that, far from the impacts of regulatory capital ratios on bank lending flows being uniform, they depend on their business model. The analysis of the impacts of regulatory capital ratios for different types of bank business models is therefore investigated in this section.

Bank business models are identified firstly based on the share of lending stocks to total assets banks have maintained prior to 2008, and focus will be placed on banks for which this share is at least 40%. The rationale for this exercise is that it is of particular interest from a policy perspective to identify what the impacts of increased capital requirements are on banks mainly engaged in extending credit compared to banks involved, to a large extent, in other banking activities, such as securities investments.

The baseline econometric model is re-estimated for the subsample of banks that maintain greater than 40% lending stocks-to-total assets and results are presented below. The main result is robust to this change.

Table 22: Estimates for banks for which lending represents at least 40% of total assets – 1985-2014

Dependent variable: *ln(NETLENDING)*	(1)	Baseline (2)
$ln(NETLENDING)_{it-1}$	0.338***	0.339***
$ln(NETLENDING)_{it-2}$	0.169***	0.131**
$ln(SIZE)_{it}$	0.031***	0.038***
LIQ_{it}	-0.002	-0.018
$WHOLE_{it}$	-0.009	-0.033
CAP_{it}	-0.007**	-0.008***
$\Delta ln(CB)_{jt}$	-0.082***	-0.067**
ΔIB_{jt}	-0.011*	-0.009
$\Delta ln(GDP)_{jt}$	0.630***	0.559***
Π_{jt}	0.011	0.012*
$PROFITABILITY_{it}$	0.055***	0.043***
LEV_{it}	0.002	0.000
$OUTPUT\ GAP_{jt}$	-1.114***	-0.958***
C	3.285***	3.683***
Number of observations	9,525	10,719
Cross-sectional units	2,086	2,364
AR(2) (p-value)	0.439	0.710
Diff-in-Hansen test (p-value)	0.392	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *CAP* is the Total Capital ratio; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1. Results with p-values presented in Table 61, Annex 5.
Source: Bankscope and LE Europe calculations

In addition, bank business models are identified based on bank characteristics selected to capture the risk of different bank business models.

The focus on the risk of different bank business models is interesting because it helps the interpretation of results on the impacts of regulatory capital ratios on bank lending flows, as described presently. If the impact of increased regulatory capital ratios on bank lending flows is negative for banks with riskier business models, for instance, this may relate to an increase in economic welfare because riskier-taking in the banking sector may have fallen.

Following Altunbas, Manganelli and Marques-Ibanez (2011), the risk of bank business models have been captured by the following characteristics – capital, asset and funding structures. The average value of the characteristics prior to the onset of the global financial crisis in 2007Q4 are used to overcome endogeneity concerns.

The baseline econometric model is re-estimated for subsamples of banks split by the median values for the different measures of risk of bank business models. The results are presented in columns (1) to (6) with the baseline results presented in column (7) for purposes of comparison.

The key result is that banks operating a riskier business model in terms of operating with relatively low capitalisation and greater use of wholesale funding, experience larger lending impacts as a result of an increase in its Total Capital Ratio. This suggests that the lending impacts may be welfare-improving, that is, riskier banks may reduce credit extension.

Moreover, there are few differences in lending impacts across larger and smaller banks, which is consistent with bank size not necessarily indicating very well the riskiness of the bank's business model.

While interesting, these results should be interpreted cautiously insofar as the riskiness of bank business models is not being observed directly but proxied. Banks with relatively low capitalisation do not necessarily have to be riskier, for instance, they may have better access to capital markets that allow them to operate with lower regulatory capital ratios in the first instance. Secondly, while the lending impacts are larger for the banks with business models that could be riskier, it is not clear that in response to increased regulatory capital ratios, they would fund safer loans.

Table 23: Bank business models – 1985-2014

Dependent variable: *ln(NETLENDING)*	Size (Low) (1)	Size (High) (2)	Cap (Low) (3)	Cap (High) (4)	Whole (Low) (5)	Whole (High) (6)	Baseline (7)
ln(NETLENDING)$_{it-1}$	1.352**	0.287***	0.300***	0.303**	0.274**	0.327***	0.339***
ln(NETLENDING)$_{it-2}$	0.490**	0.085	0.135**	-0.109	0.145	0.106	0.131**
ln(SIZE)$_{it}$	-0.006	0.081***	0.057***	0.027	0.028*	0.043***	0.038***
LIQ$_{it}$	0.003	-0.231*	-0.181	-0.035	0.007	-0.159	-0.018
WHOLE$_{it}$	-0.069*	-0.129	-0.256*	-0.069	-0.054	-0.034	-0.033
CAP$_{it}$	-0.001**	-0.011**	-0.011**	-0.005	-0.002*	-0.010***	-0.008***
Δln(*CB*)$_{jt}$	0.018	-0.101**	-0.192***	0.013	0.034	-0.157***	-0.067**
ΔIB$_{jt}$	-0.005***	-0.015	0.000	-0.005	-0.013**	-0.012	-0.009
Δln(GDP)$_{jt}$	0.172***	0.866***	0.580**	0.283	0.292**	0.912***	0.559***
Π_{jt}	0.000	0.018*	0.018*	0.001	-0.001	0.022***	0.012*
PROFITABILITY$_{it}$	0.002	0.061***	0.082***	0.014**	0.037**	0.039***	0.043***
LEV$_{it}$	-0.001**	-0.002	0.007	-0.004	-0.001	-0.002	0.000
OUTPUT GAP$_{jt}$	-0.011	-2.070***	-1.749***	-0.547	-0.595	-1.922***	-0.958***
C	-5.905	4.301***	3.252***	6.114***	4.140***	4.150***	-3.683***
Number of observations	5,546	5,114	3,765	4,487	4,808	5,852	10,719
Cross-sectional units	1,155	1,177	801	812	1,132	1,201	2,364
AR(2) (p-value)	0.095	0.832	0.525	0.299	0.278	0.477	0.710
Diff-in-Hansen test (p-value)	0.904	0.773	0.924	0.999	0.850	0.610	0.110

Notes: The model is estimated over subsamples based on having low/high values for bank characteristics over the period up to and including 2007 indicated over columns (1) to (6). *ln(NETLENDING)* is the natural logarithm of net lending; *CAP* is the Total Capital ratio; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1. Results with p-values presented in Table 62, Annex 5. Source: Bankscope and LE Europe calculations

Regional variation

The impact of regulatory capital ratios may vary across regions and this may be related to the structure of the financial system in the Member State.

To explore regional variation, the baseline econometric model is re-estimated for subsets of banks headquartered in different Member States, reflecting different financial systems, presence inside/outside of the euro area and geography more generally.

The following groupings of EU Member States will be used for the regional analysis:

EU15

- Market-based EU: The Netherlands, United Kingdom, Belgium, France, Finland and Sweden
- Bank-based EU: Austria, Denmark, Germany
- Bank-based EU crisis countries: Greece, Italy, Portugal, and Spain

New Member States

- Bulgaria , Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia

The justification for the grouping of Member States is based on the findings of Bijlsma & Zwart (2013) who group Member States on the basis of a principal components analysis (PCA) of financial systems in the EU.[68]

The results are presented in the table below. The coefficient on the Total Capital Ratio is negative and statistically and economically significant for the bank-based EU Member States and New Member States, which is consistent with the baseline estimate.

However, coefficient on the Total Capital Ratio is insignificant for the market-based EU and bank-based EU crisis countries. For the bank-based EU crisis countries this may be expected because of the financial market turmoil disturbing the economic relationships one would expect to observe under normal economic conditions. For market-based EU countries, capital ratios are not as informative about bank lending flows as elsewhere, with bank size and profitability being the key determinants of bank lending.

It should be noted that the analysis is based on banks headquartered in particular Member States, whereas banking activity may be taking place across a number of different Member States. Differences in impacts of regulatory capital ratios on bank lending therefore do not precisely capture the effect of Member State conditions.

Moreover, as the difference-in-Hansen test statistic takes a value of 1.00, the regional variation identified cannot be conclusively verified.

[68] A model for so-called outlier countries, Ireland, Malta, Cyprus and Luxembourg, is not estimated due to lack of data (that is, only 28 cross-sectional units)

Table 24: Regional variation in transitional effects – 1985-2014

Dependent variable: *ln(NETLENDING)*	Market-based EU (1)	Bank-based EU (2)	Bank-based EU crisis countries (3)	NMS (4)	Baseline (5)
ln(NETLENDING)$_{it-1}$	0.245***	0.347***	0.446***	0.217***	0.339***
ln(NETLENDING)$_{it-2}$	0.255***	0.044	-0.057	0.406***	0.131**
ln(SIZE)$_{it}$	0.145***	0.024**	0.049***	0.005	0.038***
LIQ$_{it}$	-0.355	-0.154	-0.204***	-0.103	-0.018
WHOLE$_{it}$	-0.129	0.166**	-0.166***	-0.123	-0.033
CAP$_{it}$	-0.005	-0.003**	0.000	-0.004*	-0.008***
Δln(CB)$_{jt}$	-0.161	0.063**	-0.101***	-0.068	-0.067**
ΔIB$_{jt}$	-0.002	0.025**	-0.025***	0.000	-0.009
Δln(GDP)$_{jt}$	3.427	-0.523*	1.579***	0.798**	0.559***
Π$_{jt}$	0.075***	-0.053***	0.042***	-0.003	0.012*
PROFITABILITY$_{it}$	0.087**	0.016*	0.016***	0.055**	0.043***
LEV$_{it}$	-0.012	-0.003	0.002	0.002	0.000
OUTPUT GAP$_{jt}$	3.426	-1.168	-1.308***	-0.284	-0.958***
C	3.494***	4.620***	3.924***	2.608***	3.683***
Number of observations	300	5,182	4,620	396	10,719
Cross-sectional units	103	1,348	758	102	2,364
AR(2) (p-value)	0.353	0.359	0.042	0.395	0.710
Diff-in-Hansen test (p-value)	1.000	1.000	1.000	1.000	0.110

Notes: The model is estimated over subsamples of countries in columns (1) to (4). ln(NETLENDING) is the natural logarithm of net lending; ln(SIZE) is the natural logarithm of total assets; LIQ is the quotient of cash and trading securities, and total assets; WHOLE is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; CAP is the Total Capital ratio; Δln(CB) is the difference in the natural logarithm of central bank assets; ΔIB is the change in the 3-month interbank rate; Δln(GDP) is the difference in the logarithm of real GDP; π is the inflation rate; PROFITABILITY is the quotient of profits before tax and total assets; LEV is one minus the quotient of equity and total assets; OUTPUT GAP is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1. Results with p-values presented in Table 63, Annex 5.
Source: Bankscope and LE Europe calculations

One should further note that in regressions presented in Annex 5, Table 64, one observes that stability of the negative impact of the Total Capital Ratio on bank lending flows when Member States with many banks (namely, Italy and Germany) are selectively removed from the sample. Additionally, Table 65 shows the results of estimating the baseline model for subsamples of banks in Italy only and Germany only and shows that the negative impact of the Total Capital Ratio on bank lending flows of the baseline model is preserved.

Conclusions

Banks have been subject to increased capital requirements since the application of the CRR in 2014, and have had the opportunity to anticipate them since the adoption of the Basel III accord in 2011. This chapter considered the impact of (anticipated and actual) increased capital requirements on bank lending flows through an analysis of the relationship between actual capital ratios and bank lending flows.

The main finding is that a one percentage point increase in the Total Capital Ratio has an impact on bank lending flows of -0.8% over one year with the implied impact over a three-year period being -1.5%. The main finding is insensitive to a wide range of robustness checks that were undertaken.

Further, while the Total Capital Ratio has an economically significant impact on bank lending flows, the result should be read within the context of the fact that other bank-level and macroeconomic drivers matter to lending flow developments such as past lending flows and the output gap. Indeed, the results of the baseline model indicate that a 1% increase in lending flows experienced in a given year is related to a 0.34% increase in lending flows in the following year. In the case of the output gap, a one percentage point increase in the output gap results in a 0.95% reduction in in bank lending flows.

A concern with the analysis is that actual capital ratios could be driven purely by non-regulatory factors, that is, regulatory factors are not at play, and therefore the impact of increased capital requirements under the CRR on bank lending could be zero. However, evidence is found that lending impacts are larger for banks with smaller capital cushions, and therefore bank lending flows are affected by regulatory minima.

The impact of changes in the Total capital Ratio on bank lending flows arises mainly through corporate and consumer loans, with mortgage loans being unaffected. These results are consistent with the notion that mortgages receive a relatively generous capital treatment under the CRR compared to the other loan categories and therefore do not show a negative relationship with the Total Capital Ratio. While the sizes of the samples of banks have been relatively small in this more granular analysis of loan categories, these results do suggest that the transitional effects arise mainly through corporate and consumer lending.

In terms of regional variation, the impacts of changes in the Total Capital Ratio on bank lending flows appeared to be strongest for bank-based, non-crisis countries (Austria Denmark and Germany) and New Member States.

Effects are not observed for market-based countries (The Netherlands, United Kingdom, Belgium, France, Finland and Sweden) and bank-based crisis countries (Greece, Italy, Portugal, and Spain). For the bank-based EU crisis countries this may be expected because of the financial market turmoil disturbing the economic relationships one would expect to observe under normal economic conditions. For market-based EU countries, capital ratios are not as informative about bank lending flows as elsewhere, with bank size and profitability being the key determinates of bank lending. The importance of bank size and profitability to lending in market-based EU countries may be because banks use capital markets for their funding in these countries to a greater extent than elsewhere and investors scrutinise metrics such as profitability when choosing which banks to fund, which in turn affects their ability to lend.

However, as the difference-in-Hansen test statistic takes a value of 1.00 for the models estimated for the regional analysis, the regional variation found cannot be conclusively verified.

Lastly, analysis was carried out for subsamples of banks based on pre-crisis 'business models' proxied by size, capitalisation, and funding. This showed that the impact of the Total Capital Ratio on bank lending flows was greater for banks that have historically been less capitalised and are funded to a greater extent through non-deposit liabilities.

Structural effects

Overview and key results

The analysis of structural effects involved an assessment of simulation results and empirical results discussed in greater detail below.

Simulation results

Using a model of the credit market featuring banks of different size, potential long-term implications of increased capital requirements are discussed. Given that there is a lack of historical evidence on increases in bank capital requirements affecting all banks in an economy to such an extent, it is important to theoretically discuss the potential long-term credit market implications.

Stricter bank capital requirements can affect bank lending not only through an increase in bank funding costs, but also through changes in the competitive structure of the credit market. This, in turn, can affect the market power of the incumbent banks and finally the lending rates for firms. Thus, in order to illustrate potential structural implications of tighter bank capital requirements, a model featuring imperfect bank competition and market structure in the credit market is used.

Similar to findings from other models, the simulation results show that higher capital requirements can lead to an increase in banks' funding costs. This, in turn, translates into higher bank lending rates, so that credit demand and credit to output ratios tend to fall. If all banks are affected by the capital requirement alike, credit market concentration remains unchanged in the model. Yet, if the largest banks face higher capital requirements than the other ones, concentration may decline, as the funding costs and the lending rates of the large banks rise, so that their credit market share falls, all other things constant.

The simulation exercises also illustrate that the implications of higher capital requirements depend on the prevailing market structures and, for example, on the response of the return on bank capital to higher bank capital ratios. Overall, the simulation results reveal that increased capital requirements can lead to higher bank lending rates due to the related funding cost increases.

Related studies which have assessed the economic importance of the effect of higher bank capital ratios on bank lending have come to the same qualitative conclusion. Regarding the long-run costs of higher capital ratios, the literature concludes that they are modest however. Moreover, these costs related to credit market outcomes, have to be weighed against the benefits of reduced macroeconomic volatility and a lower risk of crises.

Depending on the specific frictions included in the theoretical models, some recent studies have also found positive long-term effects of increased capital requirements on bank lending, for example, in the case where bank capital requirements are increased from an initially rather low level.

Overall, the discussion of the diverse theoretical predictions on the long-term effects of increased capital requirements highlights that it ultimately remains an empirical question how credit markets react to changes in capital regulations in the long-run. It also suggests that identifying the socially optimal level of capital requirements is inherently difficult: the lending impact of capital requirement changes is just one side of the coin and neglects any potential offsetting benefits in terms of reduced risk-taking and increased loss-absorption.

Empirical results

The impact of regulatory capital ratios on bank lending stocks in the long run is estimated empirically in an error correction framework. Changes in bank lending stocks is the relevant measure for capturing lending developments in the long-run as it reflects the sum of bank lending flows over time.

Empirically, a long-run relationship between regulatory capital ratios and bank lending stocks estimated using data on *a panel of banks* is unlikely to be found because banks of different size maintain a given capital ratio, which supports a wide range of bank lending stocks. As such, it is important to control for the influence of size on the relationship between regulatory capital ratios and bank lending stocks in the long run. This observation motivates our consideration of a possible long-run relationship between regulatory capital ratios, bank lending stocks *and bank size*.

The sample of banks focuses on those more involved in traditional lending activities, that is, those with an average ratio of lending stocks to total assets greater or equal to 40%. The cut-off at 40% is justified by the tests for cointegration, which reject a cointegrating relationship between lending stocks, the Total Capital Ratio and bank size for those banks with a ratio of bank lending stocks to total assets less than 40%.

The choice of estimation method addresses key issues that may arise in the current setting. In particular, the model specification allows for heterogeneity in the equilibrium relationship between bank lending stocks, the Total Capital Ratio and bank size at the bank level and mitigates the impact of cross-sectional dependence across banks.

Model specification and sample changes are also made to the baseline model to test the robustness of the results. More specifically, the inclusion of additional bank characteristics and macroeconomic controls, the potential for a structural break in the long-run relationship between bank lending stocks, the Total Capital Ratio and bank size and the exclusion of Italian banks, which form a substantial proportion of banks in the estimation samples, are tested separately.

Overall, the following key findings emerge from the estimation of the various error correction models:

- The estimated impact of the Total Capital Ratio on bank lending stocks in long-run is negative in the baseline estimation; however the effect is not statistically different from zero once the assumption of strict exogeneity amongst the variables is relaxed.
- During the transition phase to a new equilibrium, an increase in the Total Capital Ratio has a statistically significant negative impact on the change in bank lending stocks, which is consistent with results obtained in the analysis of transitional effects.
- The baseline estimation is unaffected by the inclusion of other (statistically significant) bank characteristics and macroeconomic controls.
- A structural break in 2011 is modelled in the long-run relationship between bank lending stocks, the Total Capital Ratio and bank size. This corresponds to the announcement of Basel III. However, the statistical significance of a break is rejected at conventional significance levels.
- Italian banks represent a large proportion of banks in the estimation samples used. The estimated short-run impact of the Total Capital Ratio in the estimation excluding Italian banks is statistically insignificant and smaller in magnitude when compared to the baseline estimation including Italian banks. Therefore, Italian banks have an impact on the estimated coefficients. However, with a p-value of 20%, the economic significance of this effect is not unimportant given a lack of statistical significance.

The preferred estimation results are different to the simulation results discuss above and of previous studies, which find a negative relationship between lending stocks and regulatory capital ratios. For example, taking results for 38 models across 15 countries, the Macroeconomic Assessment Group (MAG) (2011) report a 1.4% decrease in lending volume given a one percentage point increase in the target capital ratio over 8 years

The remainder of this chapter provides details of the simulation and empirical results.

Simulation analysis

This section uses a structural model to investigate how increased capital requirements can impact bank lending in the long run. The simulation results are linked to results from related models, like those summarized in Angelini et al. (2011). Given that there is a lack of historical evidence on increases in bank capital requirements affecting all banks in an economy, it is important to theoretically discuss potential long-term implications on the credit market.

Stricter bank capital requirements can affect bank lending not only through an increase in bank funding costs, but also through changes in the competitive structure of the credit market. For example, if bank profits decline, the least profitable banks in the market may exit. Consequently, concentration in the market for loans would increase in the long run. Or, if bank profits increase because banks pass higher funding costs through to their clients (see, for example, Angelini and Gerali 2012), concentration in the credit market may decline due to new entry. This, in turn, can affect the market power of the incumbent banks and finally lending rates. Thus, in order to illustrate potential structural implications of tighter bank capital requirements, a model featuring imperfect bank competition and market structure in the credit market is considered.

The model features a representative private household, a representative non-financial firm that produces output using labour, and a large number of banks that differ in their productivity of extending credit to firms. Productivity differences translate into different bank sizes, so that a bank size distribution with a few very large and very efficient banks and many small banks emerges – as observed for many economies (Amiti and Weinstein 2013, Bremus et al. 2013, Ghossoub and Reed 2015). The role of banks in the model economy is to channel the consumer savings to firms.

As structural effects of increased capital requirements are of interest, the focus is on the long-term equilibrium of the model economy. In the steady state, firms cannot retain earnings to finance their working capital, but have to pay out any profits to their owners in the form of dividends. As a consequence, firms have to finance the wage bill through external funds. Thus, they pay workers by taking loans from the banks before sales revenues accrue. In more detail, the three sectors modelled – consumers, firms, and banks – are described in Annex 6.

Simulation exercises for two different scenarios are presented below: First, how bank lending is affected if bank capital requirements are increased for all banks is investigated. Second, a scenario where the largest banks in the market have to fulfil higher capital requirements than the average bank is presented.

Model simulations

This section presents the features of simulations of an increase in bank capital requirements based on the model described in Annex 6.[69]

Comparing model equilibria before and after an increase in bank capital requirements, potential long-run implications of higher bank capital requirements on bank lending, lending rates, and credit market structures in the model economy are discussed.

The following steps are undertaken to derive the simulation results:

First, the model is calibrated. The table below summarises the parameter values used in the simulations. In benchmark simulations, the number of banks is set to J=100, the number of potential rivals in each credit market segment is fixed at n=10. To capture a higher cost of bank equity relative to deposits, the return on bank equity (r^e=6%) is assumed to exceed the deposit rate (r^d=2%). As in the literature (for example, Freixas and Ma 2014), the standard reason for bank equity to be more costly than deposits is the tax benefits of debt over equity. Regarding bank capital requirements, the ratio of bank capital to total assets, e, is fixed at 9% in the benchmark simulations, following Gerali et al. (2010). All other parameter values are taken from previous studies[70].

Table 25: Model calibration

(1) **Model parameter**	(2) **Value**	(3) **Description**
Household sector		
Β	0.98	Subjective discount factor
Γ	1	Elasticity of labour supply
Ρ	2	Coefficient of relative risk aversion
Non-financial firms		
ϵ	4.3	Elasticity of substitution between credits
1-ɑ	0.64	Labour market share
Banking sector		
n	10	Number of rivals per credit market segment
J	100	Number of banks
θ	4.3	Shape parameter of Pareto efficiency distribution
r^d	0.02	Interest rate on deposits
r^e	0.06	Return on bank capital
e	0.09	Bank capital as a fraction of total assets, benchmark

Notes: The table lists the parameter values that are used in the simulation exercises. Most parameter values are taken from De Blas and Russ (2013) and Bremus (2015)
Source: DIW Berlin

The loan rate r(j) is then computed according to the optimal pricing rule using random draws of the efficiency parameters for each bank from a Pareto distribution. It positively depends on the market power of banks, as measured by the net interest margin, on the bank's funding cost, and on its non-interest cost of lending. Thus, the pricing rule for loans is similar to the ones presented in the models by Angelini and Gerali (2012), Dib (2010), and Gerali et al. (2010). Knowing the individual lending rates for each bank and the aggregate lending rate, the aggregate equilibrium wage *w* can be computed. This allows aggregate labour input, h; output, y; and credit l=wh to be determined. The previously mentioned procedure is repeated 1,000 times – that is, 1,000 model

[69] The model is based on De Blas and Russ (2013), Bremus, Buch, Russ and Schnitzer (2013), and Bremus (2015)
[70] De Blas and Russ (2013) and Bremus (2015)

economies are simulated, and the average across all repetitions is taken. This yields the equilibrium values of the variables of interest for the benchmark economy.

Second, it is evaluated how the credit market is affected if the capital requirement increases in comparison to the benchmark case. That is, it is shown how bank lending, lending rates and bank market structures change in response to an increase in the capital-to-asset ratio by one percentage point.

Third, a scenario where the largest banks in the economy have to fulfil a higher capital requirement than all other banks is considered. This exercise aims at discussing potential competitive effects in the credit market that can emerge from a capital surcharge for systemically important financial institutions.

Model results

The table below summarises the simulation results for the two scenarios.

Table 26: Scenario analyses

	(1) Increase in bank capital	**(2) SIFI surcharge**
Average mark-up m	unchanged	unchanged
Average lending rate r	↑	↑
Total credit volume l	↓	↓
Total credit / output	↓	↓
Herfindahl-index	unchanged	↓

Note: The table presents changes in mark-ups, lending rates, credit, credit to output, and concentration relative to the benchmark model presented above. Column 1 shows changes in the different credit market variables for the scenario of an increase in capital requirements for all banks. Column 2 summarises how the variables change in response to a capital surcharge for the largest three banks in the economy
Source: DIW Berlin

Column (1) shows how different credit market variables change in the model when comparing the equilibrium in the benchmark scenario (e=9%) with a situation where capital requirements are increased (e_{high}=10%).

Given that all banks face the same (increase in) capital requirements, funding costs increase for all institutions alike. This is due to the fact that the return on bank capital is higher than the rate banks have to pay on deposits, and all banks have the same balance sheet structure. An increase in the capital share, in turn, increases all banks' lending rates r(j) in the model. All banks pass the higher funding cost through to their clients, as in the model by Dib (2010). Mark-ups remain unaffected, because the non-interest cost of lending is unaffected by the new regulations, and the increase in funding costs is the same for all banks in the model. Overall, the aggregate bank lending rate increases. Note that this model prediction presents an upper bound for the effect of increased capital requirements on lending rates. It is unlikely that banks will fully pass increased costs on to their clients. In addition, there are other ways for banks to comply with increased capital requirements which are not modelled here (like fresh capital injections or retained earnings, see Angelini and Gerali 2012).

The higher cost of extending loans leads to a reduction in credit demand, so that the aggregate credit volume falls. The simulations reveal that not only does absolute credit decrease, but also the ratio of credit to total output. Hence, the banking sector gets smaller relative to the size of the economy. Bank market structure, as measured by the Herfindahl index of concentration and the three bank concentration ratio, does not change. The latter is due to the fact that in the model simulations, there is a fixed number of active banks, like in the Dixit-Stiglitz-setup used by Gerali et al. (2010). Entry and exit of banks, depending on the change in bank profits which are key in the free entry condition laid out in Annex 6, can be qualitatively discussed here: If profits decrease in response to the increase in the capital requirement, the number of banks in the economy, J, will fall, given that a smaller number of banks will be profitable enough to cover the fixed cost of entry. This will increase concentration. If bank profits increase with higher lending rates in response to the higher capital requirement, like in the model by Angelini and Gerali (2012), more banks could enter the market, and concentration would fall.

It has to be noted that the model assumes a fixed interest rate on bank deposits and a fixed return on equity, which are independent of bank risk like in Martinez-Miera and Repullo (2010). On the one hand, as laid out in the literature[71], banks that hold higher equity shares can profit from lower return on equity due to a reduction in insolvency risk and hence in risk premiums. In the model by Begenau (2015), deposit rates decrease in response to higher capital requirements such that banks' overall funding costs decline. On the other hand, in times of increases in capital requirements, the cost of capital can increase because more banks demand fresh capital.[72] The model used here does not feature an endogenous link between the equity share a bank holds and the return it has to provide to its shareholders or depositors. As the effect of an increase in bank capital on loan rates and credit runs through changes in bank funding costs in this model, if the returns on bank capital decreased with the capital ratio in the long run, the loan rate increase and hence the contraction in loan demand would be mitigated.

How are credit markets affected if the largest banks have to hold a higher equity share than the other banks? To evaluate the model implications of this capital surcharge for the largest banks, the benchmark outcomes are compared to a scenario where the top three banks (in terms of total assets) have to hold an equity-to-assets ratio of 10%, whereas the requirement for the remaining banks is lower (9%).

Column (2) of the table above reveals that the average mark-up in the credit market remains unchanged, such that the largest three banks pass the increase in the funding cost on to their customers. The lending rates by the remaining banks are unchanged. Still, also keeping the skewed bank size distribution with a few very large banks and many small ones in mind, the increase in the lending rates by the top three banks translates into a rise in the aggregate lending rate. In response to the rising costs of external bank financing, the clients of the largest banks reduce their credit demand. Thus, aggregate credit, as well as the ratio of credit to output falls.

Regarding market structure, the model simulations show a reduction in credit market concentration, even if the number of active banks is again held fixed. Both the Herfindahl index and the market share of the largest three banks decline. This is due to the fact that the loan volume of the largest banks declines with the rise in lending rates, while the loan volumes of the smaller banks remain unchanged. Consequently, the dispersion in banks' market shares in the economy falls, and therefore the Herfindahl index declines as well.[73]

[71] For example, Babihuga and Spaltro (2014)
[72] For example Hellmann et al. (2001)
[73] The reduction in concentration comes from the fact that SIFI-lending rates increase due to their increased funding costs, while all other banks' interest rates remain unchanged. As a consequence, loan demand for credit from SIFIs falls, so that their market share gets smaller relative to the scenario with equal capital requirements for all banks. Thus, concentration falls even if competitive pressure in the market segment the

The result that mark-ups remain unchanged relies on the assumption that the second best bank in a given market segment is also affected by the increased capital requirement. The second best bank's marginal cost of lending limits the best bank's mark-up. If, in contrast, the best bank's rival has to fulfil the lower capital requirement only, the gap between the marginal cost of lending between the best bank and its closest rival gets smaller (and could even vanish or reverse, depending on how close the two banks non-interest cost of lending are, and depending on the height of the capital surcharge). The mark-up the best bank can charge would then get smaller because the increase in funding costs is absorbed, at least partially, in a lower mark-up. Consequently, the lending rate does not increase or increases to a lower extent. In this case, the credit market effects of a capital surcharge for the largest banks would be mitigated.

Overall, the simulation results reveal that increased capital requirements can lead to higher lending rates and lower credit to output ratios due to the related funding cost increases. When large banks are subject to tighter capital requirements, this may reduce concentration in the credit market. Yet, having discussed the stylised model and the simulation results, it has been clarified that the implications of an increase in capital requirements depend, among others, on the prevailing bank market structures in an economy, and frictions that affect the return on bank equity. Moreover, quantitative results, for example on the pass-through of higher bank funding costs into lending rates, cannot be taken from the simple model setup presented above.

Sensitivity analyses

First of all, no matter which level of capital-to-asset ratios we start from (between 0 and 0.99), the qualitative effects of an increase in capital requirements remain the same as those presented in the table above: Higher capital requirements increase banks' funding costs, which are passed through to clients in the form of higher lending rates. Consequently, loan demand declines. Concentration and mark-ups remain unaffected.[74]

Similarly, when changing other parameter values, for example, the elasticity of substitution between credit varieties or the labour share of income, an increase in capital requirements leads to an increase in funding costs, loan rates, and hence to a reduction in credit demand. Thus, the results discussed above are qualitatively robust to changing the values of different model parameters.[75]

To get an idea how the credit market in the model economy is affected by changes in the various model parameters, the following paragraphs summarise the results from further sensitivity checks:

If the coefficient of relative risk aversion (ρ) or the elasticity of labour supply (γ) are varied, only the volume of credit in the economy and output are affected. All other variables of interest that relate to credit market structure and the competitive environment – that is, mark-ups, lending rates, and concentration - remain unaffected. Also, the ratio of credit to GDP remains the same for different values of ρ or γ. In

SIFI operates in is unaffected – the SIFI keeps the same mark-up over marginal costs as before; mark-ups do not shrink even though concentration falls

[74] See Annex 7 for a summary of the simulation results for a stepwise increase in capital requirements between zero and one

[75] Hence, even if the parameters from Table 25 are varied, so that the model simulations yield different equilibrium values for the variables in the model, an increase in capital requirements leads to increased funding costs for banks, lending rates increase, credit demand falls, and bank market structure remain unaffected

contrast, if the labour share of income, $(1-\alpha)$, is reduced, less credit is needed because the wage bill that has to be paid to workers declines. The banking sector gets smaller in relation to total output, that is, the credit to GDP ratio falls. The remaining variables of interest do not change in response to changes in the labour share of income.

Regarding the subjective discount factor, β, an increase means that consumers get more patient. They discount future consumption by less. As a consequence, the deposit rate that banks have to pay on savings decreases, as $r^d = (1-\beta)/\beta$. Funding costs for all banks fall, such that the average lending rate is reduced and total credit demand increases. The same reasoning applies if the return on bank equity decreases.

The shape parameter of the Pareto distribution of non-interest costs of lending, θ, affects the dispersion of the bank size distribution. The higher θ, the lower the dispersion of bank sizes (as measured by loan volumes), and hence the lower is concentration in the credit market. At the same time, lower dispersion means that there are less banks with very low non-interest costs of lending (extremely efficient banks). Thus, the average lending rate in the economy increases in θ, so that aggregate credit falls. In addition, average mark-ups – and hence competitive pressures – fall, because bank efficiency is more similar under a less dispersed cost-distribution. Moreover, the probability of observing the maximum mark-up falls as dispersion is reduced (θ increases), so that a smaller number of banks is able to set the maximum mark-up $\overline{m}$.

As a second parameter that impacts the structure of the credit market, the elasticity of substitution between credit varieties, ϵ, is changed. The higher the elasticity of substitution, the more loan demand reacts to changes in the interest rate of a specific credit variety, and the lower is banks' market power (for a related discussion, see also Gerali et al. 2010 and Angelini and Gerali 2012). The higher ϵ, the lower the maximum mark-up a bank can charge ($\overline{m}$). As a consequence, the average mark-up in the economy drops as ϵ increases. Even if mark-ups fall, the *aggregate* lending rate, $r = \left[\sum_{j=1}^{J} r(j)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}$, increases, due to the CES-aggregation. In turn, aggregate credit is reduced. For concentration, the simulations reveal an increase in the Herfindahl index and in 3-bank concentration. Thus, even if market power falls with a higher elasticity of substitution between credit varieties, this does not imply a simultaneous reduction in concentration.

And third, the number of active banks, J, as well as the number of potential rivals in each market segment, n, play an important role for credit market outcomes. For both parameters, an increase translates into a reduction in the average lending rate, so that aggregate credit increases. Mark-ups are reduced if the number of rivals in each market segment increases, as contestability increases which limits mark-ups (see also Claessens and Laeven 2004). Concentration decreases in both cases. The increase in the number of banks directly reduces concentration because more banks are present. For an increase in the number of rivals per niche, the reduction in concentration comes from the fact that banks become more similar across niches if there are more rivals within each niche and mark-ups are limited. Thus, market shares get more similar which reduces concentration.

Related results from the literature

Even though quantitative predictions of the long-term effects of increased capital requirements are inherently difficult, various theoretical models have been used in the literature to gauge potential macroeconomic implications. In this vein, Angelini et al. (2011) assemble estimation results from 10 different DSGE-models. The models are used to perform policy experiments and to evaluate long-run implications of changes in capital requirements by looking at changes in the steady state values of key macroeconomic and financial variables. As discussed in our model setup above, in the models collected by Angelini et al. (2011), increases in bank capital requirements impact the real economy via increases in bank funding costs. If the return on bank equity or debt remain unchanged, banks increase lending rates in response to tighter capital requirements such that credit demand declines. Yet, the authors conclude that, in terms of economic significance, the long-run effects of increased capital requirements on output are modest.[76]

Building on the model by Gerali et al. (2010), Angelini and Gerali (2012) study the question of which bank adjustment strategies to higher capital requirements are least costly. The adjustment choices they analyse comprise rising lending rates (and hence a reduction in credit), and building up capital via retained earnings or by taking up fresh capital. The authors point out that in terms of the banks' choices, the increase in loan rates dominates the other two choices due to profitability considerations. Thus, in the modelling exercise presented above, we have discussed the effects of a likely adjustment strategy by banks to higher capital requirements. Yet, even if the macroeconomic costs of increasing lending rates and declining credit are higher compared to a scenario where banks reduce leverage through retained earnings or increased external equity, according to Angelini and Gerali (2012), the long-term costs are still small. Moreover, these costs have to be weighed against the benefits of reduced macroeconomic volatility and a lower risk of financial distress.

Dib (2010) builds a model with banks that set interest rates and choose leverage. They have to fulfil a costly capital requirement imposed by regulators and operate under monopolistic competition. After an expansionary shock that increases loan demand, banks have to raise capital to fulfil the capital requirement. Consequently, the marginal cost of bank capital and the funding cost for each unit of new loans increase. Similar to the model presented above, banks pass this funding cost increase through to their clients, so that lending rates increase and credit demand is mitigated.

A model which also takes the effect of capital requirements on bank market structures into account is the one by Corbae and d'Erasmo (2014). Here, higher capital requirements lead to increased concentration, given that profits and hence the continuation value of banks falls, so that some banks exit the market. Moreover, bank lending rates rise and loan volumes decrease, as in the simulation exercise presented above.

In contrast to the findings discussed so far, some recent studies find positive long-run effects of increased capital requirements on credit volumes. De Nicolo et al. (2012) present a model which yields a relationship between capital requirements and bank lending that follows an inverted U-shape: If capital requirements are mild, an increase in bank capital leads to more bank lending. If capital requirements are rather high, a further increase in bank capital leads to less credit extension though.

In the model by Begenau (2015), households have a high preference for bank debt in the form of liquid deposits. As in our model presented above, banks exactly meet the regulatory capital requirement. If this requirement increases, banks lower the provision of liquidity in the form of deposits and deposit rates drop. This reduction in bank funding costs can make loan rates fall, such that loan demand rises. Hence, depending on the frictions included in the model, higher capital requirements can also lead to more lending in the long run.

[76] In quantitative terms, the study finds that a one percentage point increase in the capital requirement induces a median output loss of 0.09 percent

In a preliminary study, Klimenko et al. (2015) present a dynamic general equilibrium model which explicitly differentiates between short-run and long-run effects of tighter capital requirements. Similar to the findings by de Nicolo et al. (2012), they show that in the long run, if capital requirements are moderate, the economy is likely to see lower loan rates and higher bank capitalisation. By contrast, if capital requirements are so high that the capital constraint is always binding, credit crunches and increased loan rates result.

Given the diverse predictions from theoretical models, it ultimately still remains an empirical question how credit markets react to changes in bank capital in the long run. This is addressed in the empirical part of this section.

Empirical analysis

The objective of the empirical analysis of transitional effects described in the previous chapter was to generate evidence on the impact of regulatory capital ratios on bank lending flows in the short run. Using the methodology widely applied in related literature, estimates of the possible impact of regulatory capital requirements on bank lending based on broad and up-to-date coverage of the EU banking sector were provided that are comparable to previous findings.

The objective of the empirical analysis of structural effects is to generate further evidence on the impact of regulatory capital ratios on bank lending stocks in the long run, that is, to investigate the possibility that increased capital requirements may continue to impact the supply of financing by banks after they have fully adjusted to the new capital requirements.

The basic rationale for the analysis is that the possible impact of increased capital requirements on bank lending stocks may be different over the short and the long run. It is important to differentiate between transitional and long-term (structural) effects of higher capital requirements: as some of the current adjustments come during the recession and trough of the lending cycle, the transitional effects might be stronger than the long-term effects (Beck, 2015).

Empirically, a long-run relationship between regulatory capital ratios and bank lending stocks estimated using data on *a panel of banks* is unlikely to be found because banks of different size maintain a given capital ratio, which supports a wide range of bank lending stocks. As such, it is important to control for the influence of size on the relationship between regulatory capital ratios and bank lending stocks in the long run. This observation motivates our consideration of a possible long-run relationship between regulatory capital ratios, bank lending stocks *and bank size*.

If a long-run relationship between regulatory capital ratios, bank lending and bank size is present, bank lending stocks may move away from a long-term trend due to short-term factors. But, such deviations induce an error-correction mechanism that returns bank lending stocks to its long-term trend at a certain rate.

An error correction framework is useful for investigating the relationship between regulatory capital ratios, bank lending stocks and size because it accounts for the possible short-run and long-run responses of bank lending stocks to regulatory capital ratios, as well as the speed of adjustment of bank lending stocks in a unified framework. The error-correction framework will therefore provide additional evidence relevant to the analysis of transitional effects, as well as evidence for the analysis of structural effects.

The remainder of this chapter is structured as follows. Firstly, a summary of the related literature is provided. Secondly, a theoretical motivation is provided for the use of an error correction framework. Thirdly, the data are described. Finally, the methodology is presented.

Related literature

The majority of the related literature considers the impact of regulatory capital requirements or ratios on bank lending in the short-run (Kashyap, Stein and Hanson, 2010). An overview of which is provided in the previous chapter on the analysis of transitional effects.

Buch and Prieto (2014) is the only study the authors of the present study are aware of that considers the impact of bank capital on bank lending stocks in the long-run, econometrically.[77] The results of this paper are discussed in greater detail in the literature review presented in the introduction.

Theoretical motivation

The empirical methodology examining the impact of increased capital requirements on bank lending can be justified by a simple banking model adapted from Khwaja and Mian (2008), as per the theoretical motivation presented in the analysis of transnational effects chapter.

Assume that in period *t*, bank *i* in country *j* finances its loan flows, ΔL_{ijt}, by issuing deposits, D_{ijt} and other sources of funding, F_{ijt} (for example, equity capital). This can be represented as a simple linear relationship, as follows:

$$\Delta L_{ijt} = D_{ijt} + F_{ijt} \quad \text{.........} (8)$$

On the demand side, the marginal return on loans is assumed to be a decreasing function of the size of the loan: $\bar{r} - \gamma_1 \Delta L_{ijt}$.

Assuming the supply of deposits is limited (up to a costless limit, $\overline{D}$) and raising additional financing is subject to a variable cost ($\gamma_2 > 0$), the optimal quantity of loans is determined by the first order condition below.

$$\gamma_2 F_{ijt} = \bar{r} - \gamma_1 \Delta L_{ijt} \quad \text{.........} (9)$$

That is, the marginal cost of funds is equal to the marginal revenue on loans.

Solving for ΔL_{ijt} the long-term relationship between loan supply and funding is given by the equation below, where ΔL^*_{ijt} represents equilibrium in the market for bank loans.

$$\Delta L^*_{ijt} = \frac{1}{\gamma_1}(\bar{r} - \gamma_2 F_{ijt}) \quad \text{.........} (10)$$

This model can be extended by introducing macroeconomic and bank-specific shocks that affect the supply and demand for loans in the short-run.

$\gamma_2 F_{ijt} = (\bar{r} - \gamma_1 \Delta L_{ijt} + \eta_t + \eta_i)$, where η_t and η_i are macroeconomic and bank-specific shocks, respectively.

[77] All other studies consider long-run impacts using model calibrations (see for example Elliott et al., 2012)

Hence, the first-order condition at *t* is shown below.

$$\Delta L^{*}_{ijt} = \frac{1}{\gamma_1}(\bar{r} - \gamma_2 F_{ijt} + \eta_t + \eta_i) \quad \text{...}(11)$$

The equilibrium level of loan flows, ΔL^{*}_{ijt}, is influenced by increased regulatory capital requirements if they bind – that is, ex-ante regulatory capital ratio, K_{ijt-1}, must be lower than the minimum level of regulatory capital ratio needed under the new regulatory capital regime, $\overline{K}_{ijt}$, and raising additional regulatory capital is costly – that is, $\gamma_2 > 0$ (Aiyar, Calomiris and Wieladek, 2014b).

The equation above can be represented as shown below.

$$\Delta L_{ijt} = \alpha_0 + \beta F_{ijt} + \delta(\eta_t + \eta_i) \quad \text{..}(12)$$

where $F_{ijt} = f(K_{ijt}(\overline{K}_{ijt}, \ldots))$, $\alpha_0 = \frac{\bar{r}}{\gamma_1}$ is a constant term, $\beta = -\frac{\gamma_2}{\gamma_1}$ and $\delta = \frac{1}{\gamma_1}$.

In addition, dynamics in the dependent variable are also relevant as bank loan flows may be persistent, as observed by Carlson (2013), for example.

Details of the empirical methodology and the choice of variables for the empirical methodology, which will be use to estimate the equation above to identify structural effects of increased capital requirements, are described below.

Data and methodology

An error correction framework is adopted to capture the long-run relationship between regulatory capital ratios, bank lending stocks and bank size (if such a relationship exists). This framework accommodates short-run dynamics that may cause deviations in the long-run relationship and adjustment back to the long-run equilibrium. The data and variables are first described, followed by a description of the methodology.

Variables

This section briefly describes the variables in the baseline econometric model. The underlying rationale for the inclusion of the variables is provided above in the analysis of transitional effects chapter.

Bank lending

The key dependent variable is gross loans, which is the value of outstanding loans, not reflecting reserves for impaired loans/non-performing loans, that is, the bank lending stock. Gross loans is the relevant measure for capturing lending developments in the long-run as it is has a balance sheet relationship with capital, as opposed to net lending in the short-run. It indicates the change in the loans in response to the regulatory capital ratio and other explanatory factors.

Regulatory capital ratios

The Total Capital Ratio is the preferred regulatory capital ratio because it captures regulatory capital most broadly. The impact of changes in other regulatory capital ratios – the CET1 Ratio and the T1 Ratio – on bank lending stocks is not considered due to a lack of sufficient number of observations for these variables at the bank level.

Bank characteristics

Bank size is measured by total assets and is incorporated into the long-run relationship to anchor the relationship between bank lending stocks and the Total Capital Ratio. Other bank characteristics are also included to control for the short-run deviations and for the long-run equilibrium relationship between bank lending stocks, the Total Capital Ratio and bank size.

The key bank characteristics include liquidity, bank reliance on wholesale funding, bank profitability and bank leverage given that these characteristics influence bank lending stocks and are plausibly exogenous. These have been chosen based on the existing literature, which is detailed in the analysis of transitional effects.

Macroeconomic characteristics

Following Buch and Prieto (2014), macroeconomic characteristics are not included in the baseline econometric model because they argue that these variables are captured by time-invariant (bank-specific effects) and time-varying (bank-specific trends) factors, therefore allowing for a relatively parsimonious specification.

However, the baseline econometric model is extended with the inclusion of macroeconomic variables to ensure relevant omitted variables are not excluded and to test the robustness of the results obtained in the baseline model.

Descriptions of the variables are provided in the Table 27.

Sample data

The analysis of the structural effects utilises data from the Bankscope sample. General sample selection and representativeness are discussed in the analysis of transitional effects chapter.

The sample data period is 1985-2014 for the Bankscope sample. The data frequency is annual and the analysis is performed at the bank level.

Two key elements of the sampling procedure used in the analysis of structural effects are discussed below.

Cointegration test sample

In order to test for a cointegrating relationship between bank lending stocks, the Total Capital Ratio and bank size, a minimum of 16 continuous observations in each bank time series is required.[78] This reduces the number of banks in the sample and raises concerns over representativeness for the whole EU banking sector.

Figure 11 shows the distribution of banks by the number of consecutive observations for the variables; bank lending stocks, the Total Capital Ratio and bank size. A majority of the banks have eight or less consecutive values and hence, are not covered in the test for cointegration.

Assuming a long-run relationship exists, the issue of representativeness is addressed by performing the estimation methods over both the reduced and wider sample (despite not being able to empirically test for cointegration in the wider sample).

Bank business model

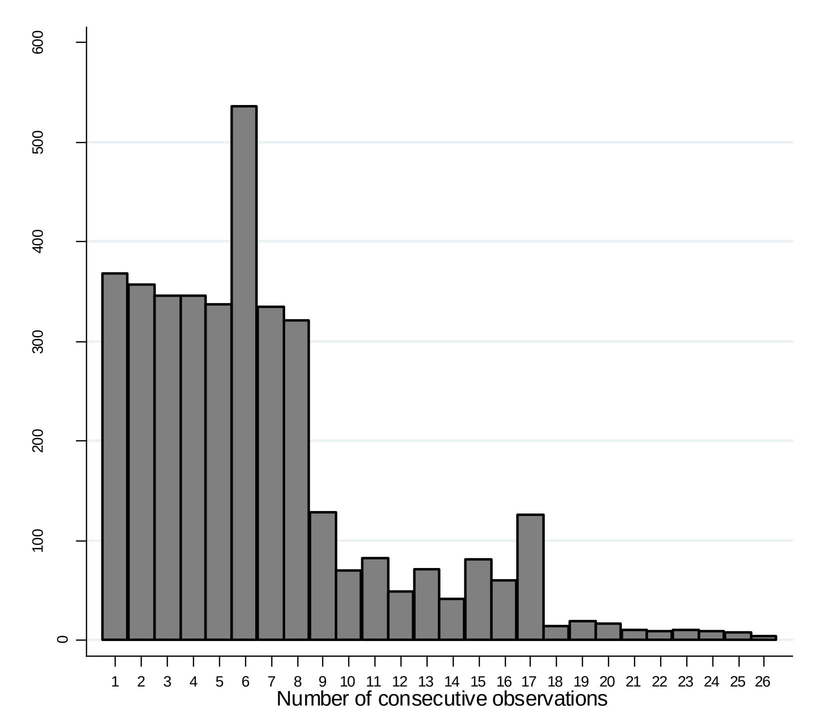
The existence of a long-run relationship between bank lending stocks, the Total Capital Ratio and bank size is likely to be more prominent for banks that are highly involved in

[78] This is the requirement to perform Westerlund's (2007) cointegration test in Stata with a maximum of 2 lags and a constant term. The inclusion of a time trend requires a minimum of 17 continuous observations

traditional lending activities, that is, banks with a higher quotient of bank lending stocks and total assets.

The average ratio of bank lending stocks to total assets from 1988 to 2007 is calculated for all banks in the sample.[79] Figure 12 shows the distribution of banks by the average ratio of lending stocks to total assets, where the average is calculated over the period from 1988 to 2007.

Figure 11: Number of consecutive values for bank lending stocks, bank size and Total Capital Ratio, by bank



Note: This figure is based on banks with a reported value for bank lending stocks, bank size and Total Capital Ratio. The maximum panel size is 30 years (1985-2014); however, data is only well-populated from 1988 onwards.
Source: Bankscope data and LE Europe calculations

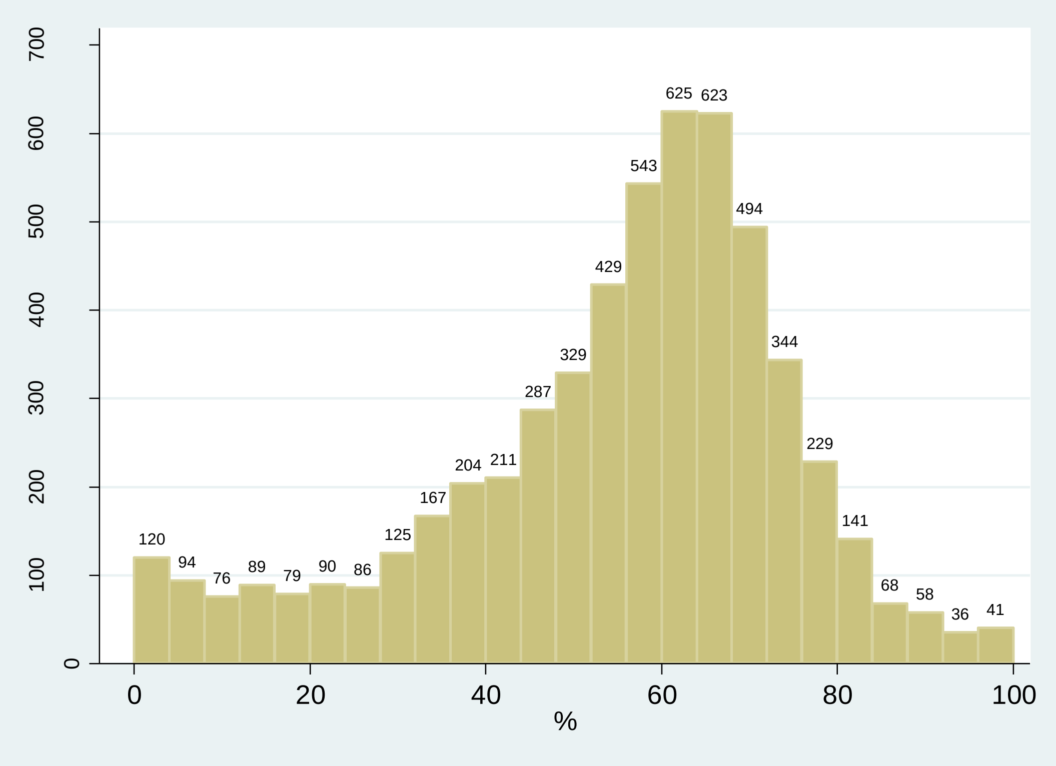
[79] Following Altunbas, Manganelli and Marques-Ibanez (2011), a pre-crisis period average is taken to minimise distortions in the ratio of bank lending stocks to total assets

Table 27: Key variables for the analysis of structural effects

Bank lending	
ln(GROSS LOANS)	Natural logarithm of outstanding loans, excluding reserves for impaired loans/non-performing loans
Regulatory capital ratios	
CAP	Quotient of Total Tier 1 and Tier 2 Capital and Risk Weighted Assets
Bank characteristics	
ln(SIZE)	Natural logarithm of total assets
LIQ	Quotient of cash, trading securities and interbank lending of maturities less than 3 months and total assets
WHOLE	Quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets
PROFIT	Quotient of net income and average total assets
LEV	Quotient of total equity and total assets
Macroeconomic characteristics	
Δln(CB)	Difference in the natural logarithm of central bank assets
ΔIB	Change in the 3-month interbank rate
Δln(GDP)	Difference in logarithm of real GDP
Π	Inflation rate
Output gap	Difference between actual and potential GDP as a percentage of potential GDP

Source: Bankscope; Note: Detailed list of variables used in the analysis, their definitions and data sources provided at Annex 3

Figure 12: Distribution of banks by the average ratio of bank lending stocks to total assets over the period 1988-2007



Note: This figure is based on banks with a reported value for bank lending stocks and total assets over the period from 1988 to 2007 (5,588 banks). Figure 33 in Annex 8 shows the distribution of banks by the average ratio of bank lending stocks to total assets in the cointegration test sample.
Source: Bankscope and LE Europe calculations

Across the EU, bank lending stocks represent over 50% of the total assets for a majority of banks (68% - 3,809 banks from a total of 5,588), with the EU average being 55%.

A closer examination of banks with low levels of lending stocks relative to total assets reveals that many are wholesale or investment banks, which are not the focus of this study. Moreover, cointegration tests (discussed below) suggest that there exists no cointegrating relationship for banks with an average ratio of bank lending stocks to total assets of less than 40%.

Therefore, the main analysis in this chapter focuses on banks with an average ratio of bank lending stocks to total assets of 40% or higher.

Summary statistics

In light of the discussion above, summary statistics for the bank sample used for the analysis of structural effects are provided in Table 28 and Table 29.

In total, there are 6,102 banks in the Bankscope sample from 1988 to 2014, with the largest number of banks in Germany (2,687, or 44% of the entire sample). When the sample is reduced to consider banks with a ratio of lending stocks to total assets greater or equal to 40%, 1,644 banks are excluded; nevertheless, the distribution by Member State remains relatively stable.

The cointegration test sample is substantially smaller with a total of 258 banks and roughly 70% of the sample represented by Italian (54.3%) and Danish (16.3%) banks.

This reduction in the sample results from the requirement of 16 continuous observations for each bank series in order to perform the Westerlund (2007) panel cointegration tests.

However, as already noted, the baseline estimation sample uses a wider sample of banks, which is larger than the cointegration test sample. But all 4,458 banks (that is, 6,102 banks minus 1,644 banks with a ratio of lending stock to assets of less than 40%) do not enter the estimation sample due the number of variables used in the baseline specification. With 25 years of data (given a lag length of one in the baseline specification) and nine variables in the baseline specification, only banks with a minimum of 14 observations are included in the sample. As shown in Figure 11 above, many banks have eight or less consecutive observations and therefore, do not enter the baseline estimation.

In terms of asset coverage, the baseline estimation sample captures 37% of total assets in the full Bankscope sample; although Member State representativeness ranges from 4 percent in Croatia and the Netherlands to 98 percent in Denmark and Lithuania.

Table 28: Number of banks by sample

Member State	Full sample		Sample of banks with a ratio of lending to total assets ≥40%		Cointegration test sample		Baseline estimation sample	
	Number of banks	*% of total assets*	*Number of banks*	*% of total assets*	*Number of banks*	*% of total assets*	*Number of banks*	*% of total assets*
AT	350	100.0	253	86.9	2	27.9	4	32.8
BE	111	100.0	40	48.9	2	36.0	2	36.4
BG	29	100.0	17	93.8	0	0.0	1	29.0
CY	32	100.0	19	95.9	1	7.8	3	7.8
CZ	30	100.0	17	98.5	2	54.8	4	90.2
DE	2,687	92.2	2,273	48.8	4	13.9	9	18.1
DK	144	100.0	102	98.4	42	92.5	66	97.9
EE	18	100.0	11	18.8	0	0.0	0	0.0
EL	35	100.0	25	69.3	1	0.0	3	21.5
ES	246	57.1	187	46.5	12	33.8	27	41.0
FI	30	100.0	14	86.1	2	82.0	4	85.2
FR	401	97.1	241	54.9	2	44.4	8	44.4
HR	55	100.0	46	98.9	1	3.7	1	3.7
HU	46	100.0	24	91.6	1	11.5	2	72.4
IE	47	53.7	25	44.9	3	18.5	4	39.3
IT	906	78.1	704	69.4	140	53.0	361	62.8
LT	15	100.0	9	97.8	2	69.1	4	97.8
LU	119	100.0	21	34.7	0	0.0	1	0.0
LV	28	100.0	7	22.0	1	15.2	3	17.0
MT	9	100.0	2	69.3	1	63.9	1	63.9
NL	80	30.6	43	10.8	8	3.5	11	3.6
PL	62	100.0	40	73.5	0	0.0	0	0.0
PT	55	100.0	31	96.2	4	84.6	5	84.6
RO	29	100.0	15	52.6	0	0.0	1	44.1
SE	129	83.0	102	82.4	9	77.9	14	78.1
SI	31	100.0	24	95.9	3	62.7	7	83.6

Member State	Full sample		Sample of banks with a ratio of lending to total assets ≥40%		Cointegration test sample		Baseline estimation sample	
	Number of banks	*% of total assets*	*Number of banks*	*% of total assets*	*Number of banks*	*% of total assets*	*Number of banks*	*% of total assets*
SK	23	100.0	14	49.2	0	0.0	0	0.0
UK	355	38.6	152	32.5	16	28.8	25	29.6
EU	6,102	70.0	4,458	48.6	258	33.6	571	36.9

Source: Bankscope and LE Europe calculations

Table 29 shows the average ratio of bank lending stocks to total assets and the Total Capital Ratio by country for the wider sample of banks and the baseline estimation sample.

In the baseline estimation sample, the average Total Capital ratio ranges from 11 percent (Portugal) to 20 percent (Luxembourg) across countries. This is above the regulatory requirement of 8 percent.

Table 29: Average bank features by country – Wider sample

	Ratio of lending to total assets ≥40%			Baseline estimation sample		
Member State	*Number of banks*	*Ratio of lending stocks to total assets†*	*Total Capital Ratio*	*Number of banks*	*Ratio of lending stocks to total assets†*	*Total Capital Ratio*
AT	253	62.0	15.0	4	55.5	13.4
BE	40	56.4	14.6	2	46.8	13.2
BG	17	55.3	18.7	1	54.9	14.0
CY	19	56.7	17.1	3	58.7	17.0
CZ	17	55.2	16.0	4	50.2	17.5
DE	2,273	63.0	16.4	9	60.0	13.9
DK	102	63.1	16.3	66	63.9	15.7
EE	11	59.2	20.1	0		
EL	25	53.7	14.9	3	49.7	12.5
ES	187	64.0	12.9	27	61.4	12.4
FI	14	66.9	15.5	4	65.8	13.3
FR	241	69.9	13.9	8	63.2	14.9
HR	46	59.6	19.0	1	59.9	17.7
HU	24	60.1	14.9	2	50.5	13.2
IE	25	64.2	14.2	4	66.3	13.1
IT	704	59.0	17.0	361	59.4	16.3
LT	9	60.6	16.3	4	58.5	15.4
LU	21	56.0	14.3	1	42.3	19.6
LV	7	60.9	18.2	3	62.8	12.8
MT	2	42.0	16.7	1	43.6	15.0
NL	43	64.4	14.1	11	66.2	14.4
PL	40	57.4	16.6	0		
PT	31	61.3	13.4	5	60.6	11.3
RO	15	48.1	25.4	1	52.6	14.3

	Ratio of lending to total assets ≥40%			Baseline estimation sample		
Member State	*Number of banks*	*Ratio of lending stocks to total assets†*	*Total Capital Ratio*	*Number of banks*	*Ratio of lending stocks to total assets†*	*Total Capital Ratio*
SE	102	75.9	18.7	14	79.2	13.5
SI	24	60.2	15.3	7	58.1	15.6
SK	14	53.0	15.2	0		
UK	152	72.0	14.2	25	70.5	14.3
EU Average	-	62.9	16.2	-	61.2	15.6

Note: †Average over period from 1988 to 2007. Banks with an average ratio of bank lending stocks to total assets greater than 100% or no data on bank lending stocks and total assets are excluded from the analysis. Summary statistics for the cointegration test sample are provided in Annex 8.
Source: Bankscope and LE Europe calculations

Estimation issues

Measuring the impact of increased capital requirements

Quantifying the impacts of increased capital requirements on lending is challenging because they cannot be observed directly. All that can be observed are changes in the actual regulatory capital ratios that are presumably under the influence of changes in formal regulatory requirements, and at times, informal pressure from regulatory authorities, and their impacts on lending.

For the analysis undertaken, the assumption made is that actual regulatory capital ratios respond to capital requirements. However, it is also recognised that they respond to non-regulatory factors as well. For instance, bank managers may deem it prudent to operate at capital levels in excess of the regulatory minimum.[80]

Distinguishing short- and long-run effects

Buch and Prieto (2014) specify a reduced-form error correction model, relating lending for a group of banks *i* in Member State *j* (which is Germany only in Buch and Prieto, 2014) at time *t* to short-run fluctuations and long-run deviations from the equilibrium relationship of regressors[81]:

$$\Delta Y_{ijt} = \mu_i + \alpha_{0ij}(Y_{ijt-1} - \beta \cdot CAP_{ijt-1}) + \sum_{s=1}^{M_{ij}-1} \alpha_{1ijs} \Delta X_{ijt-s} + \varepsilon_{ijt} \qquad \text{.............................. (13)}$$

- Y_{ijt} is the natural logarithm of bank lending stocks for group of banks *i*, in Member State *j*, at time *t-s* (s=0 for the dependent variable)
- CAP_{ijt-s} is a vector containing Total Capital in levels and quotient of Total Capital and Risk Weighted Assets for group of banks *i*, in Member State *j*, at time *t-1*
- X_{ijt-s} is a vector containing Y_{ijt-s} (average bank lending stocks for group of banks *i*, in Member State j, at time *t-s*) and CAP_{ijt-s} (Total Capital in levels and quotient of Total Capital and Risk Weighted Assets for group of banks *i*, in Member State *j*, at time *t-s*)

[80] See discussion in chapter ‘On the relationship between requirements for and actual regulatory capital ratio’ for further details

[81] Buch and Prieto (2014) investigate the long-run relationship between bank lending stocks, total capital in levels and ratio and deposits. For simplicity, deposits are not considered in the equation

- μ_i are group of bank-specific effects
- ε_{ijt} is an error term for group of banks *i,* in Member State *j,* at time *t*
- α_0, α_1 and β are coefficient vectors
- M_{ij} is the lag structure for group of banks *i* in country *j*, determined by the Akaike Information Criterion (AIC)

The error correction framework captures the long-run relationship between the regulatory capital ratio and bank lending stocks (if such a relationship exists), since a shock to the bank capital ratio will have two effects on bank lending stocks.

First, there is an immediate (short-run) impact on the lending stocks due to a change in the regulatory capital in the previous period. This impact is measured through the corresponding coefficient in vector α_1.

Second, a change in the regulatory capital will disturb the equilibrium relationship between the regulatory capital ratio and bank lending stocks, such that bank lending stocks move towards a new long-run steady state given the new value of the regulatory capital ratio. This is measured by the corresponding coefficient in the cointegrating vector β. Hence, β measures the structural effect of changes in bank capital on bank lending stocks.

The two-step estimator proposed by Breitung (2005) is used by Buch and Prieto (2014) to estimate the equation above. In the first stage all individual specific short-run coefficients are estimated, and in the second stage the long-run parameters are estimated from a pooled OLS regression.[82]

The abovementioned estimator corrects for heteroskedasticity and contemporaneous correlation of the errors (which are common in cross-country studies), as well as unobserved heterogeneity that may arise due to short-run shifts in supply and demand factors, which are controlled for through the time-invariant (bank-specific effects) and time-varying factors (bank-specific trends) that allow for a parsimonious specification.

However, for the present study, the error-correction framework as specified above must be modified for the following reasons.

Unit of observation

While the unit of observation in the Buch and Prieto (2014) analysis is a group of banks, an unbalanced panel raises the issue with undertaking an analysis at a higher level than at the bank level, as unreported values may distort the data. This may yield biased results and incorrect inference.

For example, if lending stock values for a *Bank A* with above average lending stocks are not reported in a given year, undertaking the analysis at a group-of-banks level would suggest a fall in the bank lending stocks in that year for the group of banks in which *Bank A* is allocated. Therefore, fitting a model specification at a higher level may capture (or fail to capture) a statistically significant relationship between the variables of interest, which in fact is driven by the construction of the sample dataset and not economic theory.

[82] Breitung's (2005) approach is preferred over the fully-modified OLS (FM-OLS) estimator (Pedroni, 2000) and the dynamic OLS (DOLS) estimator (Kao and Chiang, 2000) as it is more effective in reducing small sample bias

Hence, in the present study, the unit of observation for the analysis of the structural effects is the bank.

Controlling for size

As abovementioned, banks of different sizes can maintain various asset structures for a given capital ratio. Therefore a long-run relationship between the Total Capital Ratio and bank lending stocks may be difficult to identify. Hence, the presence of a long-run relationship between the Total Capital Ratio and bank lending stocks is estimated by also controlling for bank size in the long-run equation.

Homogenous cointegrating vector

In the present multi-country setting, a major assumption in the equation above is that cointegrating vector β is restricted to be the same for all banks in the panel, and any individual heterogeneity is captured through disparate short-run dynamics.

However, there is no reason to believe this is true as the long-run trend between regulatory capital ratios and bank lending stocks (measured by β) may be different for each bank in the analysis.

Therefore, heterogeneity in the long- and short-run relationship across banks is captured by using the Mean Group (proposed by Pesaran and Smith, 1995) and Common Correlated Effects Mean Group (CCEMG) estimator (developed by Pesaran, 2006). The underlying principle of these approaches estimates N country-specific Ordinary Least Squares (OLS) regressions and then provides an average of the estimated coefficients across the cross sectional unit. In the case of the CCEMG estimator, the assumption of cross-sectional independence is also relaxed.

Cross-sectional dependence

The assumption of cross-sectional independence is also an issue, as the long-run relationship between bank lending stocks, regulatory capital ratios and bank size may be influenced by cross-country factors. The first generation of unit root tests (Breitung, 2002 and Hadri, 2000) assumes that the units of the panel exhibit cross-sectional independence (except for common time effects); however, with common shocks to macroeconomic variables, this assumption is restrictive (Bai and Kao, 2006). Moreover, failing to control for cross-sectional dependency yields biased and inconsistent estimators (Andrew, 2003).

Cross-sectional dependence can arise for many reasons, such as omitted observed common factors, dynamic feedback effects, unobserved common factors, or residual correlation that may remain even when all the observed and unobserved common effects are accounted for (Breitung and Pesaran, 2008).

Common factor models are a suitable means to address the issue of cross-sectional dependency, especially when the dependence is pervasive. A common factor approach assumes that each variable can be represented as a linear combination of common factors and an idiosyncratic component. Under such an assumption, it is possible to adjust for cross-sectional dependence by subtracting the estimated factor effects from the observations of the variable of interest, yielding a 'defactored' series (Bai and Ng, 2004).

Alternatively, Pesaran (2006) shows that employing cross-sectional averages of the dependent and independent variables in the model accounts for the unobservable factors that influence the cointegration relationship. Furthermore, Chudik and Pesaran (2015) find that Pesaran's (2006) approach may be subject to small sample bias (especially when the time dimension is not large) and suggest that the use of lagged cross-section averages of all variables improves the estimation, even in the presence of weakly exogenous regressors.

In the present study, the panel unit root test undertaken by Pesaran (2007) is used to control for cross-sectional dependency in the variables of interest. The cross-sectional dependence is directly tested using Pesaran's (2004) CD test.

Additionally, cointegration tests proposed by Westerlund (2007), which require no assumption on cross-sectional dependence, are used to determine the existence of a long-run relationship between bank lending stocks, the Total Capital Ratio and bank size.

Further details of the panel unit root, cross-sectional dependence and cointegration tests used are provided in Annex 8. The preferred choice of estimation given the abovementioned issues is discussed below.

Baseline econometric model

The baseline econometric model is specified in light of the discussions in the previous section on the potential estimation issues and relates changes in lending stocks for bank *i* at time *t* to short-run fluctuations and long-run deviations from the equilibrium relationship of bank lending stocks, the Total Capital Ratio and bank size.

The baseline econometric model is specified as follows:

$$\Delta Y_{it} = \mu_i + \alpha_{0i}(Y_{it-1} - \sum_{a}^{A} \beta_{1,a} CAP_{it-a} - \sum_{b}^{B} \beta_{2,b} SIZE_{it-b})$$
$$+ \sum_{c}^{C} \alpha_{1,c} \Delta Y_{it-c} + \sum_{d}^{D} \alpha_{2,d} \Delta CAP_{it-d} + \sum_{e}^{E} \alpha_{3,e} \Delta SIZE_{it-e} + \varepsilon_{it} \qquad \text{.............................. (14)}$$

- Y_{it} is the natural logarithm of lending stocks for bank *i* at time *t*
- CAP_{it-s} is the quotient of Total Capital and Risk Weighted Assets for *bank i* at time *t-s*
- $SIZE_{it-s}$ is the natural logarithm of total assets for bank *i* at time *t-s*
- μ_i are country-specific effects
- ε_{it} is an error term for bank *i* at time *t*
- α_0, α_1, α_2, α_3, β_1 and β_2 are coefficient vectors
- A, B, C, D and E are lag structures determined by the AIC criterion, where a>1, b>1 and c>1

Changes in bank lending stocks due to deviations from the long run equilibrium relationship between the Total Capital Ratio and bank lending stocks are measured by the cointegrating vector β_1. This is estimated for each bank *i* and averaged across the sample.

The coefficient α_{0i} determines the speed of adjustment to the new long-run equilibrium given an exogenous shock and varies for each bank *i*.

Short-run deviations due to changes in the past values of bank lending stocks, the Total Capital Ratio and bank size are measured by α_1, α_2, and α_3, respectively and are heterogeneous.

Choice of estimation method

As a starting point, the baseline econometric model is estimated using the standard Mean Group (MG) estimator, developed by Pesaran and Smith (1995). However, this estimator does not control for cross-sectional dependence.

To account for cross-sectional dependence, the Common Correlated Effects Mean Group (CCEMG) estimation, proposed by Pesaran (2006), is used.[83]

The CCEMG estimator employs contemporaneous cross-sectional averages of both dependent and independent variables to mitigate the impact of common factors across banks. Ordinary Least Squares (OLS) is used to perform the estimation for each panel member (that is, each bank) separately and reported coefficients are averaged across the banks using equal weights.

Pesaran's (2006) CCEMG estimation captures the important features of the model specification. In particular, along with controlling for cross section dependence, it allows for nonstationarity of variables and heterogeneity in both the long- and short-run coefficients.

Moreover, under a set of general assumptions, Kapetanios et al. (2011) show that the CCEMG estimator can be extended to cases where the unobserved common factors are nonstationary. That is, the estimator is consistent regardless of whether the cross-sectionally correlated error term is stationary or nonstationary.

The estimator also has better small sample properties when compared to alternative estimators, such as the continuously-updated and bias-corrected estimator developed by Bai et al (2009).

Following recent work by Chudik and Pesaran (2015), the baseline econometric model is extended with the inclusion of lagged cross-section averages of the dependent and independent variables to provide a dynamic CCEMG estimator, which allows for weakly exogenous regressors and corrects for potential small sample bias arising in Pesaran's (2006) approach.[84] A technical discussion of the estimation approaches is provided in Annex 8.

Robustness tests

The stability and sensitivity of parameter estimates from the baseline econometric model are checked by performing a number of robustness checks, which are discussed below.[85]

Additional controls

The baseline estimation is extended by introducing additional short-run bank-specific controls, as well as macroeconomic variables. These additional set of controls capture other exogenous short-run shocks to bank lending stocks.

[83] The two-step estimator proposed by Breitung (2005) implemented by Buch and Prieto (2014) is not used to estimate the baseline econometric model, as Professor Breitung was unable to provide the working GAUSS code to run the estimator robust to cross-sectional dependence

[84] The *xtmg* and *xtcce* commands are used in Stata to perform the Pesaran (2006) estimation with contemporaneous cross-section averages for all variables in the model, and the Chudik and Pesaran (2015) estimation with contemporaneous and lagged cross-section averages, respectively

[85] The analysis of the impact of the size of the capital ratio cushion that banks maintain on bank lending stocks is not explored in the analysis of structural effects, as the authors of this report are not aware of any studies that use interaction terms in a panel cointegration setting and the statistical properties of the dynamic CCEMG estimator under such a setting

To ensure relevant variables are included, groups of variables (that is, bank characteristics or macroeconomic variables, etc.) are added to the baseline model and the F-test is used to determine the significance of the group of variables, where significant regressors are kept.

Given the length of the panel (that is, the number of years of data), the number of variables that can be included in the baseline model is restricted. Therefore, the inclusion of various groups of variables is considered.

Estimation of heterogeneous panels with structural breaks

The baseline econometric model does not account for structural breaks that may arise due to policy changes or major shocks to the world economy that affect all banks. Failing to account for structural breaks in the current setting may lead to inconsistent estimates and incorrect inference.

Baltagi et al. (2016) apply the least squares method developed by Bai (1997) to estimate common change points in a heterogeneous panel setting. They find that Pesaran's (2006) CCEMG estimator has the same asymptotic properties regardless of whether the change point is known or not.

The least squares method estimates a break date for all cross-sectional units (i.e. for all banks) by calculating the minimum residual sum of squares, SSR(k), among all k such that $1 \leq k \leq T-1$.

As an extension to the baseline model in the present analysis, a structural break in the long-run equation is modelled following the work by Baltagi et al. (2016).

Sample changes

In the cointegration test sample, Italian banks represent 54.3% of all banks in that sample; whereas, in the sample focussing on banks with a ratio of lending stocks to total assets over 40%, they form 15.8% of all banks. Therefore, as an additional robustness check, estimations excluding Italian banks in both samples are performed.

Alternative measures of lending stocks and capital ratios

The long-run relationship and adjustment to equilibrium of bank lending stocks to changes in the Total Capital Ratio may vary given the type of bank lending (i.e. lending to households, lending to businesses, etc.) and the measure of regulatory capital. However, due to a lack of data on alternative lending variables and measures of capital, this robustness test cannot be performed.

Results

Before proceeding to the estimation results, the unit root properties of bank lending stocks (in logs), the Total Capital Ratio and bank size (in logs) are determined and the existence of a cointegrating relationship between the three variables is empirically tested using Westerlund's (2007) panel cointegration test. Moreover, the cross-section correlation properties of the data are investigated using Pesaran's (2004) CD test.

These empirical tests are based on the cointegration test sample described in the Sample data section, which consists of 258 banks covering 22 countries from 1988 to 2014. Further details on this sample are provided in Annex 8.

Panel unit root tests

Given an unbalanced heterogeneous panel, the Z[t-bar] statistic from the Pesaran (2007) panel unit root test for the variables in levels are presented in Table 67, and first-differenced series in Table 68 in Annex 8. The tests are implemented with individual specific constants, as well as with or without a time trend. The Z[t-bar] statistic for lag lengths ranging from 0 to 4 in each individual augmented Dickey Fuller regression are considered.

Bank lending stocks and size (in logs) can be considered non-stationary (that is, the null hypothesis of a unit root cannot be rejected) when tested with more than one lag in a test with or without a trend. Panel unit root tests on the first-differenced series for both variables suggest that they are integrated of order one, i.e. stationary after first-differencing.

The Total Capital Ratio is also integrated of order one. The panel unit root test for the series fails to reject the null hypothesis of non-stationarity with more than one lag and the differenced series suggests it may be integrated of order one. A similar finding was reported by Buch and Prieto (2014), who argue that it is *'economically reasonable'* for capital ratio to be non-stationary.

Cross-sectional dependence tests

The cross section correlation properties and the Pesaran (2004) CD test statistic for each variable in levels and first-difference are provided in Table 69 and Table 70 (respectively) in Annex 8.

The null hypothesis of cross sectional independence for the CD test can be rejected for all variables in levels. Therefore, there is considerable cross-sectional dependency across banks. Similarly, for the variables in first-difference, year-to-year changes exhibit cross-country dependency, as the CD test statistic is statistically significant and hence, the null hypothesis of cross section independence can be rejected.

Panel cointegration tests

As the variables of interest are non-stationary, Westerlund's (2007) four cointegration tests are used to determine the presence of a long-run relationship between bank lending stocks, the Total Capital Ratio and bank size. These tests are based on the statistical significance of the error-correction term, e.g. α_{0i} in equation 15. If the null hypothesis that the error-correction term is equal to zero can be rejected, the variables considered are cointegrated, that is, there is an underlying long-run relationship between bank lending stocks, the Total Capital Ratio and bank size. These tests are performed using bank-specific constants, as well as with and without bank-specific linear time trends. The lag length in each estimation is set according to the AIC.

Table 71 in Annex 8 presents results of Westerlund's (2007) cointegration tests for the sample of banks with a ratio of lending stocks to total assets greater or equal to 40%.

The two panel statistics (P_t and P_a) and group-mean t-statistic (G_t) from the cointegration tests with a bank-specific constant suggest that the null of no cointegration can be rejected at the 1% significance level. Hence, there is strong statistical evidence of a cointegrating relationship between lending stocks, the Total Capital Ratio and bank size for banks who are more involved in lending activities (that is, banks with a ratio of lending stocks to total assets greater or equal to 40%).

The inclusion of bank-specific time trends does not affect the statistical significance of a cointegrating relationship between the variables; although this test is based on a slightly smaller number of banks.

The selection of banks with a ratio of lending stocks to total assets more than or equal to 40% is supported by the cointegration test results in Table 72, which are based on the sample of banks that have a ratio under 40%. For the latter group of banks, all four tests fail to reject the null hypothesis of cointegration for the variables of interest.

Therefore, given a statistically significant cointegrating relationship between bank lending stocks, the Total Capital Ratio and bank size, the baseline estimation considers the long- and short-run relationship between these variables, as well as the speed of adjustment to a new equilibrium. The baseline model is then improved by adding additional short-run bank specific and macroeconomic controls. Furthermore, robustness checks are performed to test the stability and sensitivity of the parameter estimates.

Baseline estimation results

Cointegration test sample

Table 30 below provides the estimation results for the baseline error correction model based on the cointegration test sample of banks. The dependent variable is the change in bank lending stocks (*Y*), which is cointegrated with the Total Capital Ratio (*CAP*) and bank size (*SIZE*) and short-run dynamics in all three variables capture movements away from the equilibrium relationship. The lag structure is determined by the AIC.

Column [1A] reports estimates for the Mean Group estimator (Pesaran and Smith, 1995). It shows that bank lending stocks depend on the Total Capital Ratio in the long term and the impact of a one percentage point increase in the Total Capital Ratio is a 2.3% reduction in bank lending stocks, which is statistically significant at the 1% level. To put this estimate in perspective, it should be noted that the estimation sample average of the Total Capital Ratio is 15% (see Table 66 in Annex 8).

There is also a statistically significant long-run relationship between bank lending stocks and size, which is positive suggesting that larger banks have a higher lending stock.

The impact of short-run changes in the Total Capital Ratio and bank size are also statistically significant at the 1% significance level, with 59% of any disequilibrium corrected within one year.

Thus, a priori, one could conclude that increases in capital result in slightly lower lending stock in the long-run relative to a baseline scenario with no increases in capital. However, it would be misleading to attach great value to such estimation results as the Mean Group estimator does not control for any cross-sectional effects (which are present as the CD test on the residuals rejects the null of cross-sectional independence).

Hence, the Pesaran (2006) estimator, which corrects for cross-sectional dependence across banks, is used and the results from this estimation are presented in column [2A] in Table 30. The estimated long-run coefficient of the Total Capital Ratio, while still negative, is marginally statistically insignificant at conventional significance levels and the estimated impact of this ratio on bank lending stocks (i.e. the size of the coefficient) is also reduced (1.3% compared to 2.3%).

However, during the transition to a new equilibrium, the negative impact of an increase in the Total Capital Ratio on the change in bank lending stocks remains statistically significant and consistent with results obtained in the analysis of transitional effects.

Interestingly, the adjustment to the new equilibrium is faster once contemporaneous cross-sectional effects are taken into account with 71% of any disequilibrium corrected within one year (compared to 59% under the Mean Group estimation).

The CD test on the residuals from the estimation fails to reject the null of cross-sectional independence which suggests that cross-sectional effects have been controlled for.

Given the recent work by Chudik and Pesaran (2015), the assumption of strict exogeneity can be relaxed by introducing further lags of the cross-sectional averages. Moreover, the estimator performs better in small samples, especially with a short time dimension which is relevant in this context.

Column [3A] in Table 30 provides the coefficient estimates of the baseline model under the Chudik and Pesaran (2015) estimation. The long-run coefficient on the Total Capital Ratio is statistically significant at the 10% significance level and relatively unchanged to the estimate under the Pesaran and Smith (1995) approach.

Past changes in bank lending stocks have a negative and statistically significant impact on the future change in stocks in the short-run. That is, a one percent increase in the change in lending stocks at time *t-1* results in a 0.17% decrease in the change in lending stocks at time *t*. This parameter estimate has changed direction when compared to the Pesaran and Smith (1995) estimations.

Table 30: Baseline estimation results – Cointegration test sample – 1988-2014

Dependent variable: Change in bank lending stocks (ΔY_t)	[1A] Mean Group estimation	[2A] Common Correlated Effects Mean Group estimation	[3A] Dynamic Common Correlated Effects Mean Group estimation
Long-run coefficients			
CAP_{t-1}	-0.023*** (0.00)	-0.013 (0.11)	-0.022* (0.09)
$SIZE_{t-1}$	0.962*** (0.00)	0.818*** (0.00)	0.631*** (0.00)
Short-run coefficients			
ECT_{t-1}	-0.589*** (0.00)	-0.705*** (0.00)	-0.462*** (0.00)
ΔY_{t-1}	0.149*** (0.00)	-0.091 (0.18)	-0.174*** (0.00)
ΔCAP_t	-0.011*** (0.00)	-0.007** (0.03)	-0.011*** (0.00)
ΔCAP_{t-1}	0.004*** (0.00)	-0.001 (0.68)	-0.004* (0.30)
$\Delta SIZE_t$	0.550*** (0.00)	0.612*** (0.00)	0.486*** (0.00)
$\Delta SIZE_{t-1}$	-0.139*** (0.00)	-0.055 (0.40)	0.044 (0.32)
Constant	0.133 (0.35)	-0.016 (0.98)	1.508** (0.011)
Cross section averages	No	Yes	Yes
Additional lagged cross section averages	No	No	Yes, 1 lag
Number of observations	4,175	4,175	3,917
Number of banks	258	258	258
Root Mean Squared Error	0.0371	0.00868	0.00
CD test†	32.84***	0.55	-0.74

Note: p-values are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. †CD test reports the Pesaran (2004) test on the residuals, which under the null hypothesis of cross-section independence is distributed standard normal.
Source: Bankscope and LE Europe calculations

The long-run relationship between lending stocks and bank size remains positive and statistically significant; although correcting for cross-sectional dependence and allowing for weakly exogenous regressors has led to a decrease in magnitude from 0.96 to 0.63. The speed of adjustment is also much slower, suggesting that 46% of any movement to a new equilibrium occurs within one year.

The CD test on the residuals suggests that the null of cross-section independence cannot be rejected; and hence, the Chudik and Pesaran (2015) estimation results are preferred

Wider sample

Only 258 banks out of a sample of 4,458 feature in the cointegration test sample. Moreover, the EU banking sector is not well represented with 54.3% of the sample being Italian banks; whereas they make up only 15% of the full Bankscope dataset.[86]

Therefore, the baseline estimations are carried out on the wider sample of banks (those with a ratio of bank lending stocks to total assets being greater or equal to 40%) to check the robustness of the results obtained using the narrower sample of banks, which results from Westerlund's (2007) cointegration tests for each bank series requiring at least 16 continuous observations. Results for the wider sample of banks are presented in Table 31 below.[87]

Overall, the Mean Group estimates in column [1B] remain largely unchanged when the wider sample of banks are considered. However, as mentioned above, these estimates do not control for cross-sectional effects across banks.

The long-run effect of the Total Capital Ratio on bank lending stocks is marginally more negative under the Pesaran (2006) estimation and is statistically significant at the 5% level. That is, the impact of a one percentage point increase in the Total Capital Ratio is a 1.5% reduction in bank lending stocks (compared with 1.3% under the smaller sample of banks in estimation [1B]).

However, once the assumption of strict exogeneity is relaxed, the impact of a change in the Total Capital Ratio on bank lending stocks is positive but not statistically different from zero (see column [3B] in Table 31).

The negative impact of an increase in the Total Capital Ratio on the change in bank lending stocks in the adjustment to a new equilibrium remains statistically significant and consistent with results obtained in the analysis of transitional effects.

The speed of adjustment also becomes slower under the dynamic CCEMG estimation (Chudik and Pesaran, 2015), which is consistent with results obtained for the smaller sample of banks.

[86] The analysis presented in the main report focuses on banks that are more involved in traditional lending activities, that is, banks with a ratio of lending stocks to total assets greater or equal to 40%. The baseline model is re-estimated for all banks regardless of their asset structure and the results are provided in Table 73 and Table 74 in Annex 8 for the cointegration test and wider sample, respectively. Results are largely unaffected; however a cointegrating relationship can be rejected for banks with a ratio of lending stocks to total assets less than 40%

[87] It should be noted that the panel size for many banks is lower than the number of variables in the baseline estimation; therefore, only 571 are included in the analysis as opposed to 4,458. See Figure 11

Table 31: Baseline estimation results – Wider sample – 1988-2014

Dependent variable: Change in bank lending stocks (ΔY_t)	[1B] Mean Group estimation	[2B] Common Correlated Effects Mean Group estimation	[3B] Dynamic Common Correlated Effects Mean Group estimation
Long-run coefficients			
CAP_{t-1}	-0.026***	-0.015**	0.005
	(0.00)	(0.04)	(0.78)
$SIZE_{t-1}$	0.911***	0.818***	0.339***
	(0.00)	(0.00)	(0.00)
Short-run coefficients			
ECT_{t-1}	-0.673***	-0.667***	-0.241***
	(0.00)	(0.00)	(0.00)
ΔY_{t-1}	0.154***	0.024	-0.055***
	(0.00)	(0.59)	(0.00)
ΔCAP_t	-0.013***	-0.013***	-0.007**
	(0.00)	(0.00)	(0.02)
ΔCAP_{t-1}	0.005***	0.002	-0.004**
	(0.00)	(0.36)	(0.15)
$\Delta SIZE_t$	0.463***	0.416***	0.213***
	(0.00)	(0.00)	(0.00)
$\Delta SIZE_{t-1}$	-0.172***	-0.094**	-0.004
	(0.00)	(0.03)	(0.84)
Constant	0.400***	1.684**	1.870***
	(0.00)	(0.00)	(0.00)
Cross section averages	No	Yes	Yes
Additional lagged cross section averages	No	No	Yes, 1 lag
Number of observations	7,861	7,861	7,142
Number of banks	571	571	571
Root Mean Squared Error	0.0343	0.00678	0.00

Note: p-values are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The CD test does not run for the wider sample as the panel is highly unbalanced.
Source: Bankscope and LE Europe calculations

Hence, given the relative stability of parameter estimates using the wider sample, in the next section the baseline model for this sample of banks is extended to consider the inclusion of other bank characteristics and macroeconomic controls, the potential for a structural break in the long-run relationship and the exclusion of Italian banks from the sample.

Robustness tests

Using additional controls

The baseline estimation is extended by introducing additional short-run bank-specific controls and macroeconomic variables that may influence the relationship between bank lending stocks and the Total Capital Ratio and capture other exogenous short-run shocks to bank lending stocks.

The relevance of additional variables is determined by adding groups of similar variables (that is, bank characteristics or macroeconomic variables, etc.) to the baseline estimation. The F-test is then used to determine the significance of the group of variables and statistically significant regressors are retained.

Given the length of the panel (that is, the number of years of data), the number of variables that can be included in the baseline model is bounded. Therefore, different groups of variables are included one at a time. The list of variables considered includes:

- Bank characteristics; liquidity, profitability, leverage and reliance on wholesale funding
- Macroeconomic controls: Central bank rate, 3-month interbank rate, inflation rate, GDP and the output gap

Table 32 shows the estimation results for the dynamic CCEMG estimator (Chudik and Pesaran, 2015). A re-estimation of the baseline model is also provided to determine whether the change in coefficients is driven by either a change in the sample of banks used in the estimation or the inclusion of additional variables. Full set of all estimation results are presented in Table 76 and Table 77 in Annex 8.

Among all the additional variables considered, only bank liquidity is statistically significant as an additional short-run control in the dynamic CCEMG estimation. These results are shown in Table 32 below.[88]

The estimated impact of a change in the Total Capital Ratio on bank lending stocks in the long-run turns negative when compared to the baseline estimation; however it remains statistically insignificant (that is, it is statistically equal to zero).

The short-run impact of bank size on changes in bank lending stocks remains statistically significant when controlling for bank liquidity. More liquid banks are associated with negative changes in bank lending stocks in the short-run. However, the impact is negligible.

[88] Bank leverage controls in the short-run are also jointly statistically significant; however, separately the regressors are not statistically significant and the results are based on a very small number of banks (see Annex 8). Therefore, less emphasis is placed on these results

Table 32: Estimation results using additional controls – Wider sample – Dynamic CCEMG estimation – 1988-2014

Dependent variable: Change in bank lending stocks (ΔY_t)	[4] Baseline estimation	[5] Estimation with additional control(s)	[6] Re-estimation of baseline model on reduced sample
Long-run coefficients			
CAP_{t-1}	0.005 (0.78)	-0.012 (0.79)	-0.008 (0.83)
$SIZE_{t-1}$	0.339*** (0.00)	0.074 (0.54)	0.329** (0.02)
Short-run coefficients			
ECT_{t-1}	-0.241*** (0.00)	-0.174*** (0.00)	-0.208*** (0.00)
ΔY_{t-1}	-0.055*** (0.00)	-0.115*** (0.00)	-0.124*** (0.00)
ΔCAP_t	-0.007** (0.02)	-0.019*** (0.00)	-0.019*** (0.00)
ΔCAP_{t-1}	-0.004** (0.15)	-0.004 (0.46)	-0.004 (0.42)
$\Delta SIZE_t$	0.213*** (0.00)	0.218*** (0.00)	0.231*** (0.00)
$\Delta SIZE_{t-1}$	-0.004 (0.84)	0.006 (0.82)	0.015 (0.54)
ΔLIQ_t		-0.050* (0.051)	
Constant	1.870*** (0.00)	2.563*** (0.00)	2.101*** (0.00)
Number of observations	7,142	2,218	2,218
Number of banks	571	174	174
Root Mean Squared Error	0.00	0.00	0.00

Note: p-values are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dynamic CCEMG estimation uses one-period lagged values of the cross-sectional averages as well as the contemporaneous cross-sectional averages.
Source: Bankscope and LE Europe calculations

Re-estimation of the baseline model on the sample including the measure of bank liquidity shows little change in the coefficients when compared to the baseline estimation.

Hence, liquidity can be viewed as being orthogonal to the Total Capital Ratio and bank size. Therefore, given the small impact of liquidity and its statistical independence to other controls in the baseline estimation, the baseline estimation in column [4] is preferred.

Modelling a structural break

The least squares method developed by Bai (1997) is used to estimate an unknown common structural break in the long-run relationship between bank lending stocks, the Total Capital Ratio and bank size using the wider sample of banks.

A common structural break is identified in 2011 under the dynamic CCEMG estimation, which corresponds to the year in which the Basel III regulatory framework was announced by BIS. Table 33 below provides the results.

Prior to 2011, the impact of the Total Capital Ratio on bank lending stocks in the long-run is positive and statistically insignificant. There is no impact with the interaction term on the Total Capital Ratio being close to zero and statistically equal to zero.

The interaction term between the break in 2011 and bank size is also positive and statistically insignificant at conventional significance levels. Moreover, the joint hypothesis of the break interaction terms being equal to zero cannot be rejected, as the F-test statistic p-value is equal to 0.72.

Other potential structural breaks are also examined by considering the residual sum of squared values for different years which are close to the minimum in 2011 obtained from the least squares approach. Figure 34 in Annex 8 plots the residual sum of squared values by year for the dynamic CCEMG estimation (Chudik and Pesaran, 2015), where the year corresponds to the construction of the structural break dummy.

Structural breaks in 2008 and 2009 are modelled separately and results from the dynamic CCEMG estimation are provided in Table 77 in Annex 8. The structural break interaction terms in both estimations are statistically insignificant at the conventional significance levels. Therefore, the baseline model without a structural break (column [3B] in Table 31) is preferred.

Table 33: Estimation results modelling a structural break (2011) – Wider sample – 1988-2014

Dependent variable: Change in bank lending stocks (ΔY_t)	
	[7] Dynamic Common Correlated Effects Mean Group estimation
Long-run coefficients	
CAP_{t-1}	0.032 (0.40)
BreakCAP_{t-1}*	0.002 (0.97)
$SIZE_{t-1}$	0.433*** (0.00)
Break$SIZE_{t-1}$*	0.021 (0.42)
Short-run coefficients	
ECT_{t-1}	-0.194*** (0.00)

ΔY_{t-1}	-0.096*** (0.00)
ΔCAP_t	-0.006* (0.09)
ΔCAP_{t-1}	-0.008** (0.03)
$\Delta SIZE_t$	0.210*** (0.00)
$\Delta SIZE_{t-1}$	-0.032 (0.14)
Constant	1.155*** (0.00)
F-test statistic†	0.67 (0.72)
Number of observations	5,868
Number of banks	429
Root Mean Squared Error	0.00

Note: p-values are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. †Testing the joint significance of the structural break interaction terms
Source: Bankscope and LE Europe's analysis

Excluding Italian banks

Italian banks represent 15.8% of all banks with a ratio of lending stocks to total assets greater than or equal to 40% (see Table 28). However, in the cointegration test sample and baseline estimation sample, they represent over half of all banks.

Therefore, as a robustness test, the baseline model is re-estimated by excluding Italian banks from the cointegration test sample, as well as the wider estimation sample. Results are provided in Table 34 below for the wider estimation sample. The results for the cointegration test sample are presented in Table 78 in Annex 8.

As before, the estimated impact of the Total Capital Ratio on bank lending stocks is not statistically significant once cross-sectional dependence and the assumption of strict exogeneity across banks is taken into account.

However, the short-run impact of changes in the Total Capital Ratio, although still negative, is no longer statistically significant (at conventional significance levels) and smaller in magnitude when compared to results in Table 31 above.

Therefore, the exclusion of Italian banks has an impact on the preferred baseline estimation. However, the p-value for the short-run Total Capital Ratio coefficient suggests that the variable is statistically significant at the 20% significance level.

There exists a long history debating the importance of statistical significance to prove a scientific, commercial, medical, or legal claim. The misuse of statistical significance has been well reported; for example, see Ziliak and McCloskey (2008).

Ziliak (2016) argues that significance and importance are weakly correlated and using significance tests such as p-values, t-statistics, F-statistics and confidence intervals alone are not sufficient to establish the importance of an effect. Moreover, statistical insignificance is commonly, and incorrectly, associated with results being unimportant.

Hence, the coefficient on the short-run Total Capital Ratio in the preferred estimation, while statistically insignificant, does not imply that it is economically unimportant.

Table 34: Estimation results excluding Italian banks – Wider sample – 1988-2014

Dependent variable: Change in bank lending stocks (ΔY_t)

	[8] Mean Group estimation	[9] Common Correlated Effects Mean Group estimation	[10] Dynamic Common Correlated Effects Mean Group estimation
Long-run coefficients			
CAP_{t-1}	-0.012*** (0.00)	-0.005 (0.73)	-0.010 (0.81)
$SIZE_{t-1}$	0.945*** (0.00)	0.830*** (0.00)	0.794*** (0.00)
Short-run coefficients			
ECT_{t-1}	-0.803*** (0.00)	-0.638*** (0.00)	-0.219*** (0.00)
ΔY_{t-1}	0.245*** (0.00)	0.033 (0.76)	-0.121*** (0.00)
ΔCAP_t	-0.007*** (0.00)	-0.011*** (0.00)	-0.006 (0.20)
ΔCAP_{t-1}	0.005** (0.03)	-0.002 (0.63)	-0.0002 (0.97)
$\Delta SIZE_t$	0.691*** (0.00)	0.400** (0.03)	0.349*** (0.00)
$\Delta SIZE_{t-1}$	-0.162** (0.01)	-0.060 (0.71)	0.0377 (0.31)
Constant	0.144 (0.50)	2.494** (0.02)	-0.092 (0.83)
Cross section averages	No	Yes	Yes
Additional lagged cross section averages	No	No	Yes, 1 lag
Number of observations	3,065	3,065	2,814
Number of banks	210	210	210
Root Mean Squared Error	0.0415	0.00936	0.00

Note: p-values are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe calculations

Summary of findings

The impact of regulatory capital ratios on bank lending stocks in the long run is estimated empirically in an error correction framework. Bank lending stocks is the relevant measure for capturing lending developments in the long-run as it is has a balance sheet relationship with capital, as opposed to net lending in the short-run.

Empirically, a long-run relationship between regulatory capital ratios and bank lending stocks estimated using data on *a panel of banks* may be difficult to identify if the differences in bank size are not taken into account by the analysis, as the level of banking lending stocks is in large part related to bank size. In other words, banks with similar capital ratios may show very different levels of bank lending stocks because of differences in size.

It is also true that banks of the same size and with the same capital ratio may show different bank lending stocks if they pursue different business models.

By considering explicitly bank size as one of the determining factors of bank lending stocks in the long run, our approach allows one to take account implicitly of both differences in bank sizes and business models when testing for the existence of a long-run relationship between the capital ratio and bank lending stocks. This observation motivates our consideration of a possible long-run relationship between regulatory capital ratios, bank lending stocks *and bank size*.

The sample of banks focuses on those more involved traditional lending activities, that is, those with an average ratio of lending stocks to total assets greater or equal to 40%. The cut-off at 40% is justified by the tests for cointegration, which reject a cointegrating relationship between lending stocks, the Total Capital Ratio and bank size for those banks with a ratio of bank lending stocks to total assets less than 40%.

The choice of estimation method addresses key issues that may arise in the current setting. In particular, the model specification allows for heterogeneity in the equilibrium relationship between bank lending stocks, the Total Capital Ratio and bank size at the bank level and mitigates the impact of cross-sectional dependence across banks.

Model specification and sample changes are also made to the baseline model to test the robustness of the results. More specifically, the inclusion of additional bank characteristics and macroeconomic controls, the potential for a structural break in the long-run relationship between bank lending stocks, the Total Capital Ratio and bank size and the exclusion of Italian banks, which form a substantial proportion of banks in the estimation samples, are tested separately.

Overall, the following key findings emerge from the estimation of the various error correction models:

- The estimated impact of the Total Capital Ratio on bank lending stocks in long-run is negative in the baseline estimation; however the effect is not statistically different from zero once the assumption of strict exogeneity amongst the variables is relaxed.
- During the transition phase to a new equilibrium, an increase in the Total Capital Ratio has a statistically significant negative impact on the change in bank lending stocks, which is consistent with results obtained in the analysis of transitional effects.

- The baseline estimation is unaffected by the inclusion of other (statistically significant) bank characteristics and macroeconomic controls.
- A structural break in 2011 is modelled in the long-run relationship between bank lending stocks, the Total Capital Ratio and bank size. This corresponds to the announcement of Basel III. However, the statistical significance of a break is rejected at conventional significance levels.
- Italian banks represent a large proportion of banks in the estimation samples used. The estimated short-run impact of the Total Capital Ratio in the estimation excluding Italian banks is statistically insignificant and smaller in magnitude when compared to the baseline estimation including Italian banks. Therefore, Italian banks have an impact on the estimated coefficients. However, with a p-value of 20%, the economic significance of this effect is not unimportant given a lack of statistical significance.

The preferred estimation results are different to existing simulation studies, which find a negative relationship between lending stocks and regulatory capital ratios. For example, taking results for 38 models across 15 countries, the Macroeconomic Assessment Group (MAG) (2011) report a 1.4% decrease in lending volume given a one percentage point increase in the target capital ratio over 8 years. However, the estimation methods used in this report are not directly comparable to the results from simulation studies.

Conclusions

Simulation results and empirical results were presented in this section on the structural effects of increased capital requirements under the CRR.

The simulation results showed that that higher capital requirements can lead to an increase in banks' funding costs. This, in turn, translates into higher bank lending rates, so that in the theoretical model domestic credit demand and credit to output ratios tend to fall. That being said, considering related literature that attempts to quantify the magnitude of the impact on credit, one notes that the magnitude of impacts is relatively small.

Meanwhile, the empirical results suggests similarly that the impact of the Total Capital Ratio on bank lending stocks in long-run is negative; however the effect is not statistically different from zero once the assumption of strict exogeneity amongst the variables is relaxed.

Infrastructure financing effects

Overview and key results

The value and quantity of EU infrastructure projects funded wholly or in part by banks grew rapidly from 2000 to 2006 when it reaching a peak in terms of value. This was supported by economic growth in the EU, the willingness of banks to lend to infrastructure investors and the volume of PPPs in countries such as the UK and France.

However, thereafter, the value of projects fell from 2006 and crashed in 2009 as a result of the financial crisis and the reluctance of banks to offer infrastructure loans.

Since then and following the 2009 trough, both number of deals and total deal value have recovered markedly with the number of deals in 2014 being well above and the value of deals only slightly below their respective 2006 peaks.

These developments occurred in a context of a growing role and funding contribution of institutional investors in the EU infrastructure sector. As a result, the proportion of the total value of infrastructure deals financed through bank debt in the EU has declined in recent years from 82.7% in 2007 to 65.9% in 2014. This development reflects the growing role of non-bank infrastructure investors.

However, while the overall volume of infrastructure funding provided by banks and non-banks has more or less recovered from the financial crisis, the current state of affairs is characterised by the paradoxical situation of a combination on one side of very large infrastructure needs (estimated by some observers to total about €1 trillion over the period 2016-2019) and large pools of potential infrastructure funding, and on the other side an actual level of infrastructure financing that remain well below potential needs. According to market commentators and infrastructure finance specialists, this paradoxical situation reflects at the present time mainly a lack of a strong pipeline of high quality, investable infrastructure projects.

Obviously, this state of affairs raises the issue of whether the increased capital requirements and the capital charging methodologies that can be used for infrastructure projects have had a negative impact on the level of infrastructure funding provided by banks. A small consultation and a small survey of 13 banks (of which nine of the top 25 banks providing infrastructure finance) suggest that this is not generally the case.

Among the survey respondents, only one felt that the CRR had a negative impact while the other were of the opinion that it had no impact. However, the consultations also show that the CRR has led banks to focus on shorter tenor projects and often prefer less risky projects with capacity or availability payments. The consultation also highlights the fact that the CRR as it stands does not take into account the particular risk specificities of the various infrastructure projects, especially of those projects involving either availability or capacity payments with no or little demand risks or special risk mitigation measures such as guarantees or insurance. In particular, the slotting approach was viewed as not being sensitive and granular enough to take account of particular risk characteristics of infrastructure projects. This situation is viewed by the consultation participants as having a negative impact on banks' appetite for longer tenor projects.

As a complement to the more qualitative assessment of the impact of the CRR on bank infrastructure finance, an econometric analysis of the potential impact of the CRR was also undertaken.

In the empirical analysis, infrastructure financing transactions data at the bank-level are used, covering both PPP and non-PPP projects and infrastructure projects funded across the transport, telecommunications, power, renewables, environment and social sectors. An econometric model similar to the one used for estimating transitional effects of increased capital requirements was estimated. However, as transaction level data are available in the case of infrastructure, specific variables relating to particular infrastructure financing deals are included in the model.

The key result is that while a one percentage point increase in the Total Capital Ratio is estimated to have a negative impact on bank financing of infrastructure, the size of the impact is in a relatively wide range and the 95% confidence interval around the estimated impact is very close to zero or crosses zero at the upper end. Therefore, one can draw the conclusion that there is not clear evidence of a major negative impact of increased capital requirements under the CRR on bank financing of infrastructure, a result which is consistent with findings from the consultations and survey.

This chapter provides the evidence supporting the results described above. There are four strands of research that were undertaken: an analysis of CRR articles relevant to infrastructure, a market analysis involving a discussion of developments in bank financing of infrastructure, a consultation of banks and an empirical analysis. The remainder of this section details the various strands of research in more detail.

Legal analysis

Before reviewing which part(s) of the CRR may potentially impact bank funding of infrastructure, it is important to note that the CRR does not explicitly mention infrastructure in any of its articles or annexes.

This may be partially due to the fact that infrastructure is not a well-defined asset class in terms of the use of infrastructure funding (i.e. the type of project funded). Moreover, a range of different financial instruments can be used, alone or in combination, to finance infrastructure projects and the nature of the credit or counterparty risk for funders of infrastructure projects varies markedly depending on the legal status of the infrastructure sponsor (i.e. the party receiving funds from financial intermediaries and capital markets to finance an infrastructure project).

Therefore, before proceeding to a review of the potential impact of the CRR on bank funding of infrastructure, the present section sets out a definition of infrastructure and discusses the various ways infrastructure is funded.

A definition of infrastructure

A universally accepted definition of the term ‘infrastructure’ has remained elusive, and existing definitions are drawing on a variety of physical, regulatory, contractual, economic and financial characteristics.

In general, the literature distinguishes between economic infrastructure, understood as the physical structures from which goods and services are produced that enter directly as common inputs to many industries, and social infrastructure, producing services that enter indirectly as common inputs to many industries.

In terms of sectors and subsectors covered by national accounting statistics, the following are taken into account: economic infrastructure sectors: transport, energy, water, waste management; and social infrastructure sectors: health, education, security buildings, social services.

Some infrastructure studies take a broader perspective including as well, for example, energy production and extraction facilities.

In contrast, the 2015 EC Consultation on the impact of the CRR and the CRD IV takes a narrower perspective by noting that "infrastructure mainly involves joint projects and cooperation between the public sector and private sector. These generally take the form of a Private Public Partnership (PPP) with the aim of building public infrastructure."

For the purpose of the present study, the wider definition is adopted as a first step in examining developments in funding of infrastructure in recent years and the potential impact of the CRR. But, because most of the bank funding of infrastructure is in the form of lending to special purpose vehicles (SPV) set up for public-private partnership (PPP) initiatives, particular attention is paid to such infrastructure structures.

A general characteristic of infrastructure financed through PPPs is that, once the infrastructure projects are built, they are generally considered by infrastructure funders to be relatively low-risk as their cash-flow is relatively certain, especially if the infrastructure projects (or the funders of the projects) benefit from some form of guarantee. However, such infrastructure projects are still subject to operational, market, regulatory and political risks, among others. As a result, infrastructure projects are highly heterogeneous in terms of their precise risk profiles. Moreover, the risks (construction risk, etc.) are much higher during the pre-operational phase of the project during which no or only very little revenue is generated.

Another key characteristic of infrastructure projects is that their duration is typically relatively long.

Finally, it should be noted that, at the present time, the market price of infrastructure projects (especially mature ones) is high (and hence the yield is low) as a result of a large amount of infrastructure funding liquidity from non-bank sources chasing a limited set of opportunities (see for example, Ammerman, 2015; Linklaters, 2014; and PwC and Oxford Economics, 2015).

Financing of infrastructure

Essentially, infrastructure can be funded through two different channels, namely:

- Government funding – i.e. the government (central and sub-national governments) finances new public infrastructure out of general revenues and/or general debt issued in capital markets
- Project Finance which involves the creation of a SPV which is a stand-alone legal entity raising infrastructure finance in its own name. To enhance the credit worthiness of the SPV, the latter may benefit from a government guarantee in the case of PPPs and/or from the private project sponsors in the case of PPPs or purely private infrastructure projects

As will be shown below, the impact of the CRR on infrastructure financing will depend on the channel used to finance the infrastructure.

Financial instruments used for financing infrastructure projects

A large set of different instruments can be used to finance infrastructure with some instruments not being accessible by both channels presented above. The table below provides a quasi-exhaustive list of such instruments.

Figure 13: Financial instruments used for financing instructure projects

<table>
<tr><th>Modes</th><th colspan="3">Infrastructure Finance Instruments</th><th>Market Vehicles</th></tr>
<tr><th>Asset Category</th><th>Instrument</th><th>Infrastructure Project</th><th>Corporate Balance Sheet / Other Entities</th><th>Capital Pool</th></tr>
<tr><td rowspan="6">Fixed Income</td><td rowspan="3">Bonds</td><td>Project Bonds</td><td rowspan="2">Corporate Bonds, Green Bonds</td><td rowspan="3">Bond Indices, Bond Funds, ETFs</td></tr>
<tr><td>Municipal, Sub-sovereign bonds</td></tr>
<tr><td>Green Bonds, Sukuk</td><td>Subordinated Bonds</td></tr>
<tr><td rowspan="2">Loans</td><td rowspan="2">Direct/Co-Investment lending to Infrastructure project, Syndicated Project Loans</td><td>Direct/Co-Investment lending to Infrastructure corporate</td><td>Debt Funds (GPs)</td></tr>
<tr><td>Syndicated Loans, Securitized Loans (ABS), CLOs</td><td>Loans Indices, Loan Funds</td></tr>
<tr><td>Mixed</td><td>Hybrid</td><td>Subordinated Loans/Bonds, Mezzanine Finance</td><td>Subordinated Bonds, Convertible Bonds, Preferred Stock</td><td>Mezzanine Debt Funds (GPs), Hybrid Debt Funds</td></tr>
<tr><td rowspan="2">Equity</td><td>Listed</td><td>YieldCos</td><td>Listed infrastructure & utilities stocks, Closed-end Funds, REITs, IITs, MLPs</td><td>Listed Infrastructure Equity Funds, Indices, trusts, ETFs</td></tr>
<tr><td>Unlisted</td><td>Direct/Co-Investment in infrastructure project equity, PPP</td><td>Direct/Co-Investment in infrastructure corporate equity</td><td>Unlisted Infrastructure Funds</td></tr>
</table>

Source: OECD (2015)

The CRR and infrastructure financing

It is important to note that in terms of a potential impact of the CRR on bank infrastructure finance, one should distinguish between bank lending and market instruments (equity and debt instruments, and securitisations) held by banks.

The impact of the CRR on bank lending (used to finance new infrastructure projects or the acquisition of mature infrastructure) can be viewed as a direct effect while the impact of the CRR on infrastructure-related market instruments held by banks in their trading books can be considered as an indirect effect. The discussion below focuses on the direct effect.

The CRR and bank-loan financed infrastructure

With regards to infrastructure financed through general bank loans to government or corporate entities, the only potential impacts of the CRR are:

- Any change in bank lending resulting from the new risk weights attached to borrowing entities resulting from the application of the Standardised Approach (SA) or the Internal Ratings Based Approach (IRB) (Title II, Chapters 1, 2 and 3). As the risk weight attached to lending to governments (national and sub-national) is 0 in the case of such lending the CRR is likely to have no impact on the infrastructure fully funded by governments from general revenues and general debt issues. In the case of private infrastructure on the balance sheet of corporate, the CRR may result in a higher risk weight than previously but this can only be assessed on a case-by-case basis
- Any change in bank lending appetite resulting from the various measures aiming to increase and improve the quality of bank capital

With regards to bank lending to SPVs, the CRR takes a different approach under the SA and the IRB.

The articles specifying how the SA is to be implemented do not set out a specific approach for calculating the risk weights of SPVs. Thus, under the SA, by default exposures to SPVs are to be treated like corporate exposures. According to article 122:

1. Exposures for which a credit assessment by a nominated ECAI is available shall be assigned a risk weight according to Table 6 (Article 122 of the CRR) which corresponds to the credit assessment of the ECAI in accordance with article 136.

Table 6

Credit quality step	1	2	3	4	5	6
Risk weight	20 %	50 %	100 %	100 %	150 %	150 %

2. Exposures for which such a credit assessment is not available shall be assigned a 100% risk weight of exposures to the central government of the jurisdiction in which the corporate is incorporated, whichever is the higher.

In contrast, the CRR provides for a specific treatment of SPVs under the IRB approach. The key article in the CRR is article 147. Paragraph 8 of that article states that "within the corporate exposure class laid down in point (c) of paragraph 2, institutions shall separately identify as specialised lending exposures, exposures which possess the following characteristics:

a) the exposure is to an entity which was created specifically to finance or operate physical assets or is an economically comparable exposure;
b) the contractual arrangements give the lender a substantial degree of control over the assets and the income they generate;
c) the primary source of repayment of the obligation is the income generated by the assets being financed rather than the independent capacity of a broader commercial enterprise.

The method of calculation of the risk weight for such exposures to SPVs is set out in article 153.1 and 153.5 of the CRR. While article 153.1 sets out the general approach to be used for calculating risk weights, article 153.5 specifies that "for specialised lending exposures in respect of which an institution is not able to estimate PDs or the institution's PD do not meet the requirements set out in Section 6, the institution shall assign risk weights to those exposures according to Table 1 (Article 153 of the CRR) as follows:

Table 1

Remaining Maturity	Category 1	Category 2	Category 3	Category 4	Category 5
Less than 2,5 years	50 %	70 %	115 %	250 %	0 %
Equal or more than 2,5 years	70 %	90 %	115 %	250 %	0 %

In assigning risk weights to specialised lending exposures, institutions shall take into account the following factors: financial strength, political, and legal environment, transaction and/or asset characteristics, strengths of the sponsor and developer, including any public private partnership income stream, and security package."

To the extent that a SPV benefits from a government revenue guarantee (or something similar), the bank lending to the SPV can use article 214 Sovereign and other public sector counter-guarantees to mitigate the risk and reduce the risk weight.

In light of the heterogeneity of infrastructure projects, it is possible that, for a number of SPVs, the category allocation may be used by credit institutions instead of the general risk weight calculation approach set out in article 153.1.

It also appears that some low-risk SPVs may attract a lower risk weight under the SA than under the IRB. For example, under the SA, SPVs receiving the best credit ratings from an ECAI attract a risk weight of either 20% or 50% while the lowest risk weight in the table above is 70% if the loan maturity is equal to or longer than 2.5 years.

Overall, the impact of the CRR on infrastructure finance through SPVs will depend on whether the SPVs attract a different risk weight under the CRR than under the previous regime.

Looking ahead, the CRR may have a further impact of banks' appetite once the Net Stable Funding Requirement (NSFR) and the Liquidity Coverage Ratio (LCR) are fully implemented as banks themselves may have to raise more longer-term funding to match the longer-term nature of infrastructure funding, and the margins on matched maturity intermediation are generally lower than on intermediation involving maturity transformation.

Market analysis

Introduction

The present section reviews trends in infrastructure finance in the EU since the beginning of the century. The main data source is the InfraDeals Transactions database published by the inframation Group.

The database provides, among others, information on infrastructure deals which were closed in the following sectors: environment, power, renewables, social infrastructure, telecommunications and transport; and sub-sectors: accommodation, defence, education, health, leisure, prisons, social housing, street lighting, waste and water.

Information is provided for greenfield and brownfield projects and for refinancings.

Before reviewing recent trends in infrastructure financing in the EU, it is important to note that the actual number of projects which are financed in any given year depends on both:

- the demand for such projects as reflected by the availability of debt and equity funding from banks, institutional investors, specialised funds, capital markets, etc.
- the supply of projects which are ready to be funded or refinanced. Infrastructure projects typically have a long gestation period and the pipeline of investable projects depends on the actions taken by project sponsors many years before the project is actually brought to market.

At present, the general view from infrastructure market participants and observers is that the relatively low level of activity (relative to the pre financial crisis level) mainly reflects a low pipeline of high quality fundable infrastructure projects (see, for example, Ammerman, (2015), Ehlers (2014) and Linklaters (2014)).

In the immediate aftermath of the crisis, bond finance of infrastructure dried up, possibly as a result of the disappearance of monoline insurers (Wagenwoort et al. 2010). Banks may have also reduced their involvement in infrastructure in the immediate aftermath of the financial crisis. On their part, there is renewed interest in high quality infrastructure projects with a preference for projects with little or no demand risk, i.e. projects where there is provision for availability payments, guarantees or similar mechanisms.

The involvement of institutional investors and special funds in infrastructure has increased (see, for example, Crocce and Gatti (2014)), with some reports noting that such investors have an estimated €900 billion available for infrastructure investment over the period 2015-2025 (Linklaters 2014). However, such investment is hampered by the lack of solid pipeline of high quality projects, limited investment and risk management expertise, transparency issues, viability issues and a lack of relevant data and investment benchmarks for illiquid infrastructure assets (EPEC, 2010 and Della Croce and Yermo, 2013). Regulation is also a major factor in the case of some types of institutional investors such as pension funds (Croce, 2012).

Future needs

While the current levels of infrastructure investment and infrastructure project finance are relatively moderate in the EU, the needs for new infrastructure are huge (see European Commission, 2014).

- Firstly, in transport, the completion of the TEN-T network requires about €550 billion until 2020 and the total costs until 2030 are thought to be of the order of €1.5 trillion.
- Secondly, in energy, it is estimated that €200 billion is required up to 2020 to develop cross border interconnections. Moreover, it is estimated that investments of about €205 billion per year are needed up to 2020 to achieve

the 2020 climate and energy targets, and €209 billion per year over the period 2020-2030 to achieve the 2030 climate and energy targets.

The figures above do not take account of the ageing of the various domestic infrastructure systems (roads, rail social, etc.) which will need to be repaired or replaced and the growing needs in other areas. Overall infrastructure investment needs are estimated by some observers to be about € 1 trillion over the period 2016-2019 (Standard and Poor's, 2015).

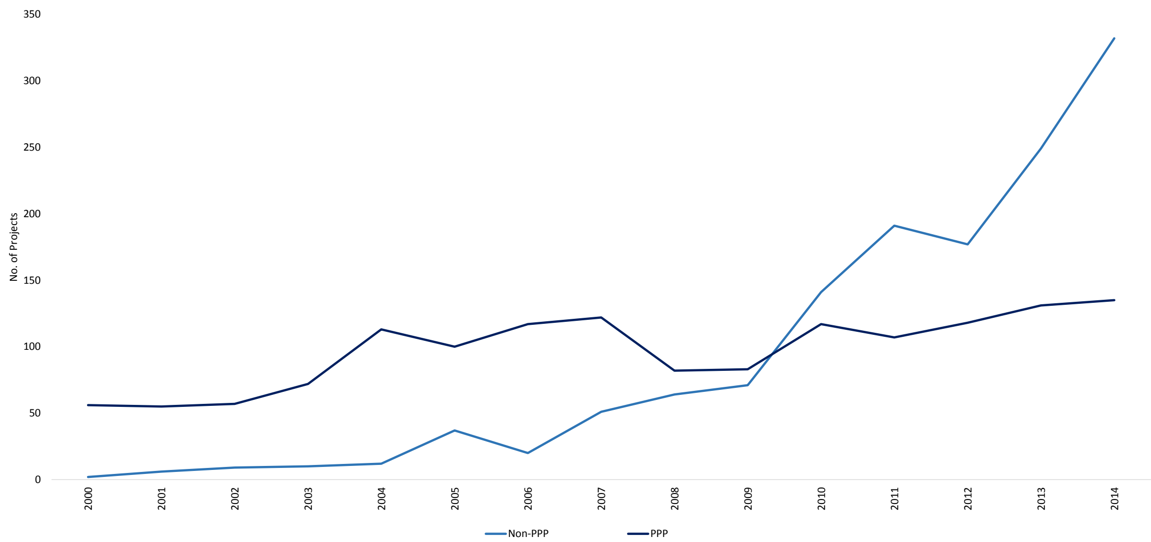
Trends in EU infrastructure financing trends: PPP deals vs. Non-PPP deals

Over 2006-9, the **volume of infrastructure funding** (in EUR at current market prices) of both PPPs and non-PPPs declined markedly and almost steadily from the pre-financial crisis peak of about EUR 45 billion in 2006. However, from 2010 onwards, Public-Private Partnerships (PPPs) and non-PPPs show a diverging trend with the volume of non-PPP funding more or less doubling from 2009 to 2014 while the volume of PPP funding increasing only moderately.

The **number of infrastructure deals** continued to grow at a very rapid pace from 2009 to 2014 in the case of non-PPP deals while the number of PPP deals shows more moderate growth. More recently, the number of non-PPP deals has increased by 24% from 2011 to 2014 while the number of non-PPP deals grew by 76%.

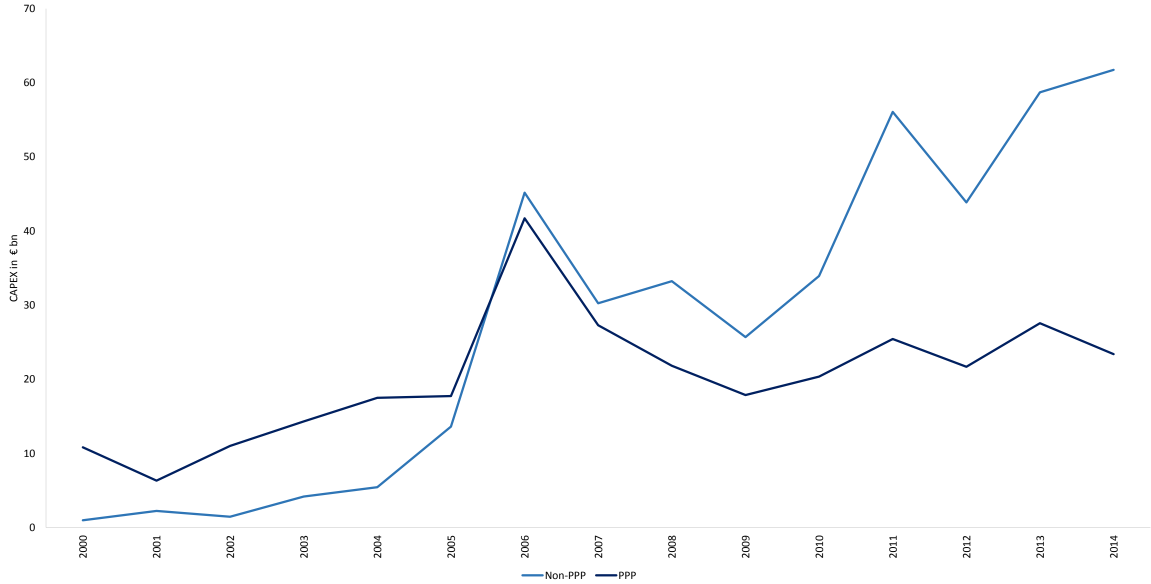
The sharp decrease in the relative importance of PPPs in the overall volume and number of infrastructure deals reflects the constrained fiscal situation faced by governments in the EU in the post financial crisis period.

Figure 14: Number of PPPs and non-PPP infrastructure deals – 2000-2014



Source: InfraDeals and Infrata calculations

Figure 15: Volume of PPPs and non-PPP infrastructure deals – 2000-2014



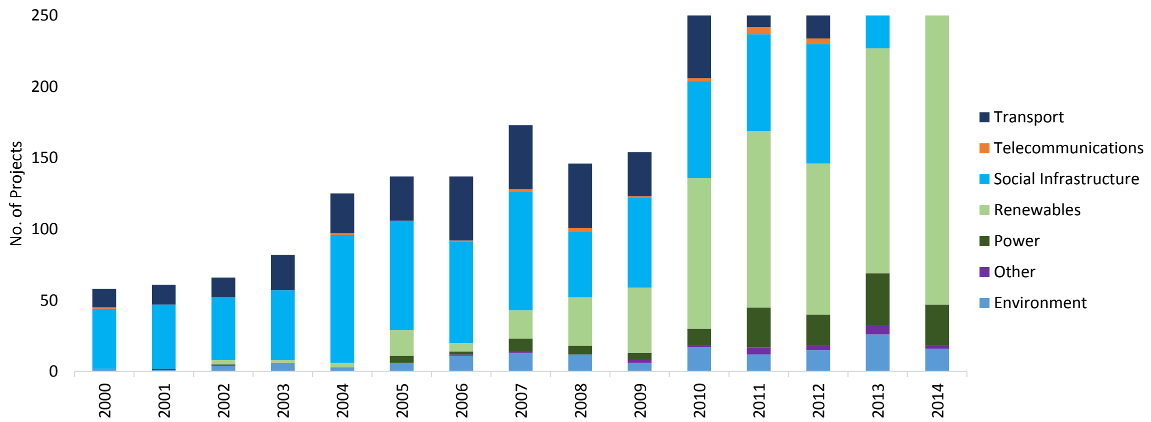
Source: InfraDeals and Infrata calculations

Overall infrastructure finance trends can mask different patterns across infrastructure sectors. Certain assets may be seen as a more robust investment, particularly if private investors benefit from the guarantee of government sponsorship within the PPP model.

For example, the sharp rise from 2010 onwards in infrastructure deals in the renewables sector can be attributed to EU government pledges to provide grants for solar farm and other 'green' asset developers.

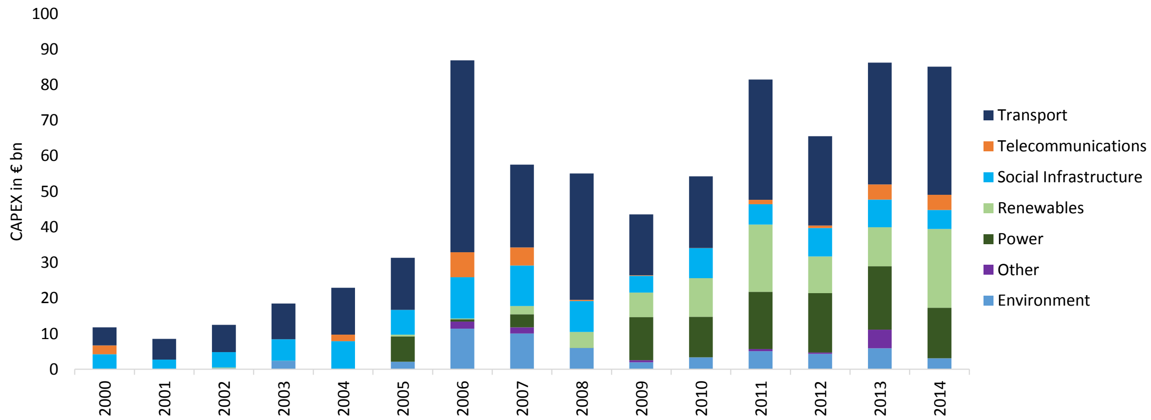
Transport infrastructure projects on the other hand, whilst showing annual increases ranging from 1.9% and 19.7% in the number of projects over the last four years, exhibit a much more erratic pattern in the case of the annual volume of such projects with a recent peak of EUR53.5bn in 2006 and a trough of EUR17.1bn in 2009.

Figure 16: Number of PPP and non-PPP infrastructure projects by sector – 2000-2014



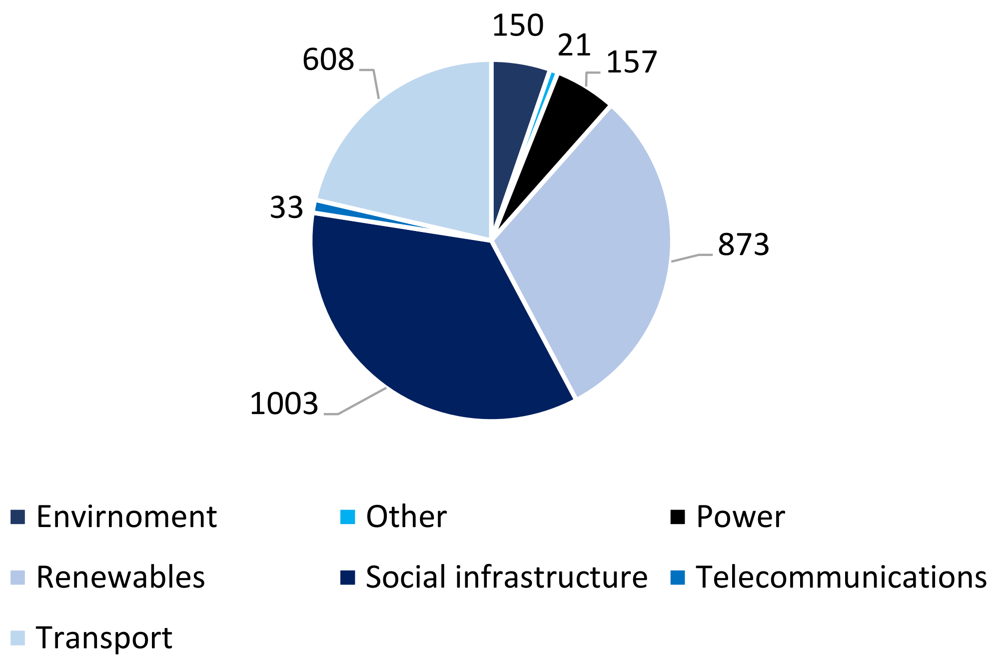
Source: InfraDeals and Infrata calculations

Figure 17: Volume of PPP and non-PPP infrastructure projects investment by sector – 2000-2014



Source: InfraDeals and Infrata calculations

Figure 18: Total number of infrastructure projects by sector – PPPs and non-PPPs 2000-2014

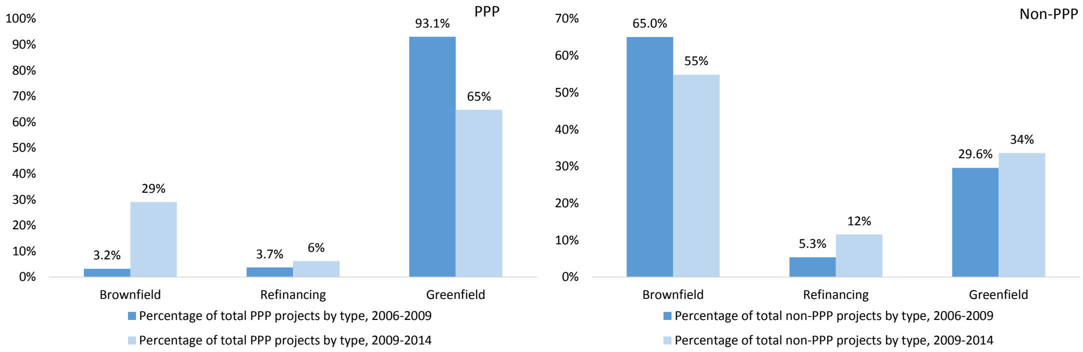


Source: InfraDeals and Infrata calculations

Between 2006-2009 and 2009-2014, the volume and number of project refinancings has grown as proportion of total projects for both PPP & non-PPP projects. This in part reflected the desire of many infrastructure project sponsors to avail themselves of the very low market interest rates and a certain preference of investors for more seasoned projects. Over the same period, the share of brownfield projects as a proportion of all projects has also fallen for both PPPs & Non-PPPs. However, the share of brownfield projects for non-PPP actually increased over this period. Thus, for non-PPPs there appears to have been a shift in brownfield towards a larger number of small scale projects.

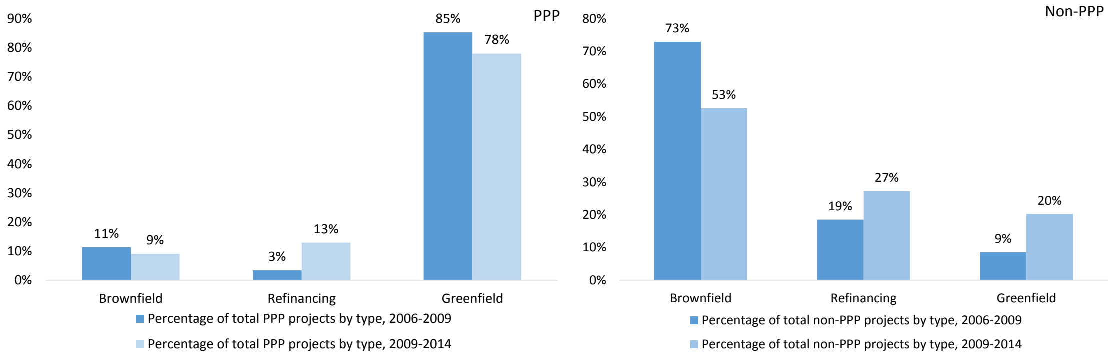
The trend in greenfield projects differs between PPPs and non-PPPs: while greenfield projects fell from 85% to 78% of the share of PPP projects, they rose from 9% to 20% of the share of non-PPP projects.

Figure 19: Change in the relative share of each type of project by number for PPP and non-PPP infrastructure projects for the periods 2006-2009 and 2009-2014



Note: Data covers all European infrastructure projects recorded in the InfraDeals database for the period from 1 January 2006 until 31 December 2014.
Greenfield infrastructure deal = new infrastructure built from scratch; brownfield infrastructure deal = acquisition of existing infrastructure
Source: LE Europe based on InfraDeals

Figure 20: Change in the relative proportion of each type of project by volume for PPP and non-PPP infrastructure projects for the periods 2006-2009 and 2009-2014



Note: Data covers all European infrastructure projects recorded in the InfraDeals database for the period from 1 January 2006 until 31 December 2014. Value refers to the project finance received (in million EUR).
Greenfield infrastructure deal = new infrastructure built from scratch; brownfield infrastructure deal = acquisition of existing infrastructure
Source: LE Europe based on InfraDeals

Overall, the recent trends for PPPs and even more so for non-PPPs show that infrastructure investment appears to be rising again. Along with greater bank lending, this development is due to growing equity investment in European infrastructure - particularly by investors from Canada, China/Hong Kong, the GCC region, Japan and South Korea.

A growing number of pension funds, insurers and sovereign wealth funds have been attracted to the long-term, stable returns on infrastructure projects. For example, pension funds, insurers and sovereign wealth funds together are estimated to have EUR 0.75 trillion (US$ 1 trillion) available for infrastructure investment in Europe over the next decade.

Furthermore, data from Preqin shows that fundraising by specialised infrastructure funds remains strong. The availability of capital for infrastructure is currently at an all-time high with 149 funds in the market seeking capital commitments of circa EUR 66 billion (US$ 90 billion).

The sharp growth in the availability of funds for equity infrastructure investments, combined with a lack of new infrastructure projects, has led to a rise in infrastructure asset values. This trend is particularly pronounced in Western Europe.

Overall, Western Europe continues to dominate infrastructure investment. By value, Western Europe accounted for 25.8% of the world's project finance deals in 2013.

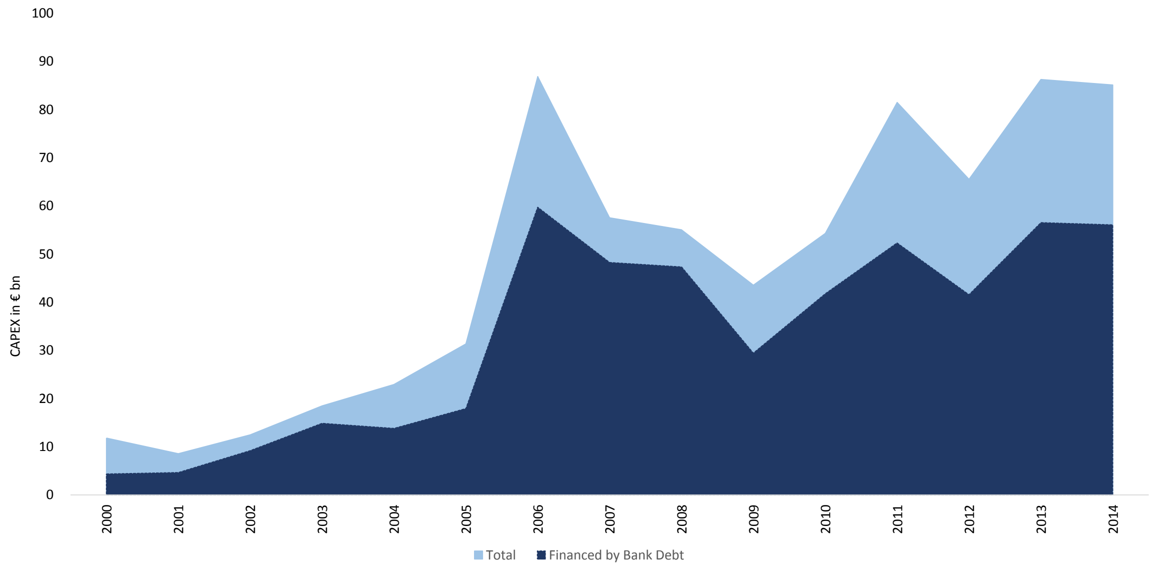
The analysis so far has focused on overall infrastructure financing. However, as the focus of the study is on bank lending the following section reviews in greater detail trends in bank-funded infrastructure projects.

Trends in bank financing of infrastructure

The proportion of the value of infrastructure financed through bank debt in the EU has declined in recent years from 82.7% of the total value of infrastructure deals in 2007 to 65.9% in 2014. This development reflects the growing role of non-bank infrastructure investors.

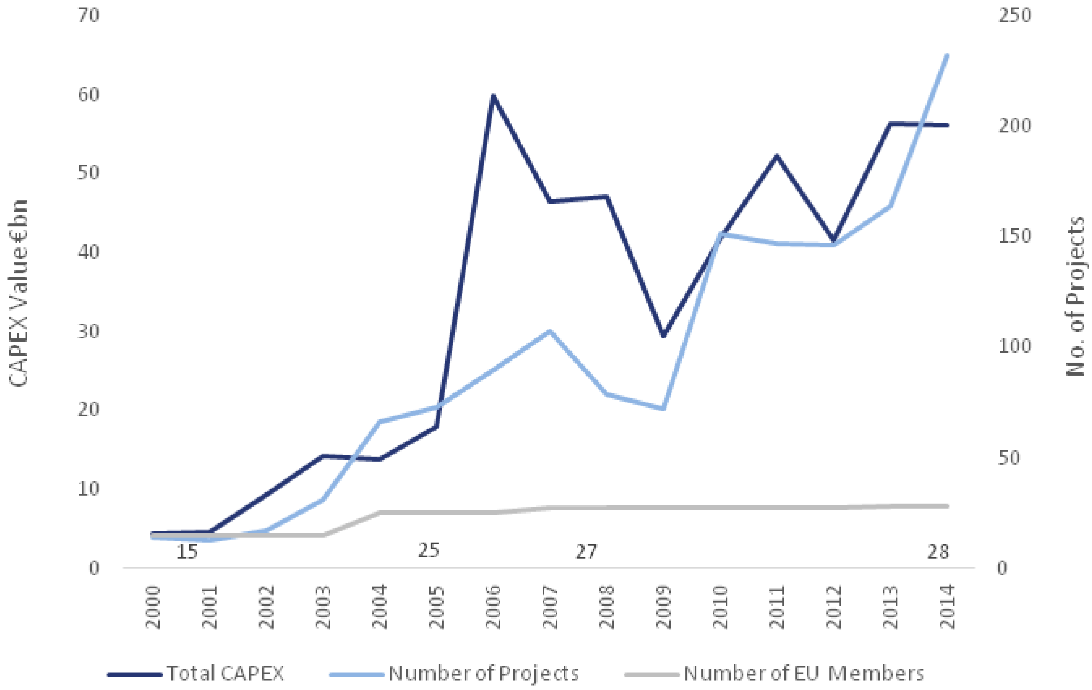
But in absolute terms, bank lending for infrastructure has grown markedly from 2009 (the most recent in bank infrastructure lending) to 2014, and was in that year only slightly below the 2006 peak.

Figure 21: Proportion of infrastructure finance lent by banks in total volume of infrastructure funding



Source: InfraDeals and Infrata calculations

Figure 22: Total value of EU Infrastructure projects for which banks provided financing – 2000-2014



Source: InfraDeals and Infrata calculations

As shown above, the value and quantity of EU infrastructure projects funded wholly or in part funded by banks grew rapidly up to 2006, reaching its peak in terms of value. This was supported by economic growth in the EU, the willingness of banks to lend to infrastructure investors and the volume of PPPs in countries such as the UK and France. However, the value of projects fell from 2006 and crashed in 2009 as a result of the financial crisis and the reluctance of banks to offer infrastructure loans. There was also a drop in infrastructure development in the private sector (AFME & Oliver Wyman, 2013). Following the 2009 trough, both number of deals and total deal value have recovered markedly with the number of deals in 2014 being well above and the value of deals only slightly below their respective 2006 peaks.

The value of infrastructure lending fell again temporarily in 2012. This fall may partly be attributed to a reduced loan supply (with banks preparing for Basel III capital requirements) (AFME & Oliver Wyman, 2013) and a lack of projects amidst deficit reduction plans in the EU. Due to their fiscal situation, governments sharply reduced their capital spending and the development of new infrastructure projects.

While the decrease in the relative importance of bank lending in total infrastructure funding reflects to a large extent the sharp increase in funding available from non-bank sources, other more bank-specific factors may also be at play such increases in bank capital requirements, other regulatory changes, the euro crisis, etc. (AFME & Oliver Wyman, 2013). The potential impact of these factors and others is further explored as part of the consultation exercise.

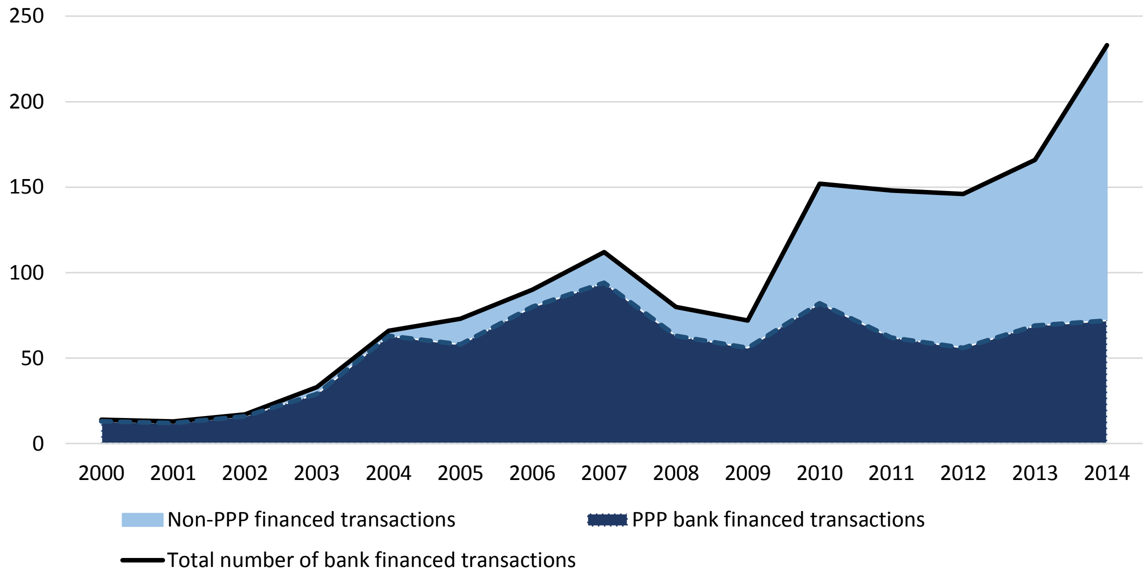
For example, the decline in project finance loans to €40 billion in 2012 from €60 billion in 2011 has been partly attributed to reduced lending appetite as required increases in bank capital and liquidity make it less attractive for banks to supply finance (AFME &

Oliver Wyman, 2013). The reduction in project finance loans has been observed particularly among long-term loans that require greater long-term funding.

There has been an increasing tendency towards 'Mini-Perm' financing structures (Linklaters 2011). These are short-term loans when long-term or permanent financing solutions are unavailable. The borrower is given incentives to refinance after several years. Furthermore, as a result of the future introduction of the NSFR, banks appear to be more hesitant to make longer-term investments and loan tenors have significantly shortened (Shearman and Sterling 2014). Lastly, some European banks have sold project loan books to Japanese and US banks in preparation for the implementation of CRD IV and the CRR.

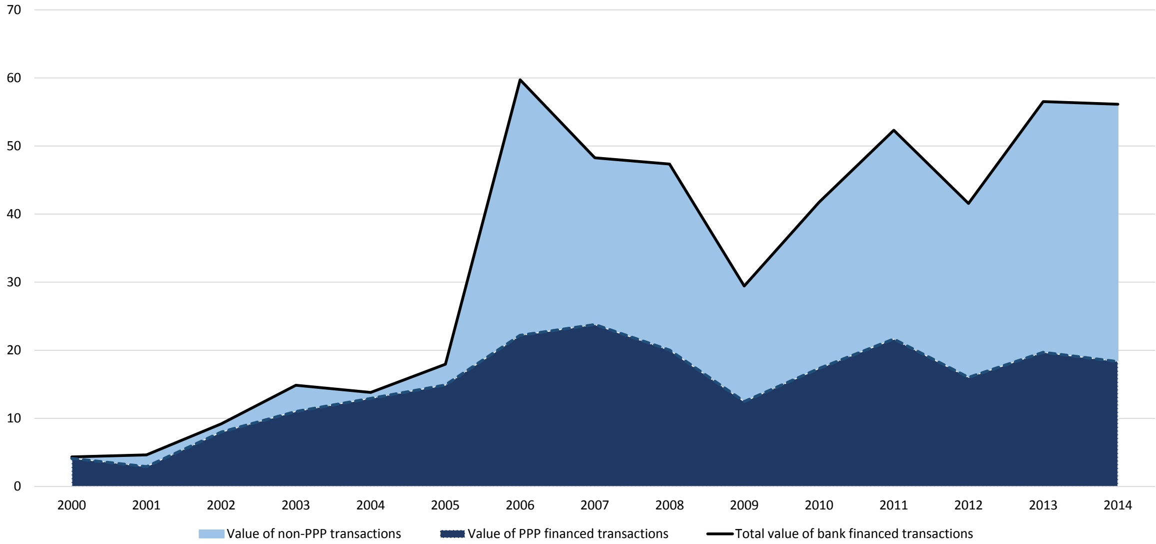
Within the bank-provided infrastructure finance, the importance of PPPs has declined since 2009 in terms of the number of PPP projects, continuing a trend that is observable since 2005 with regards to the value of bank-financed infrastructure projects.

Figure 23: Bank-financed infrastructure projects: number of PPP transactions relative to the number of all bank financed transactions from 2000 to 2014



Note: Data covers all bank financed European infrastructure projects recorded in the InfraDeals database for the period from 1 January 1999 until 31 December 2014.
Source: LE Europe based on InfraDeals

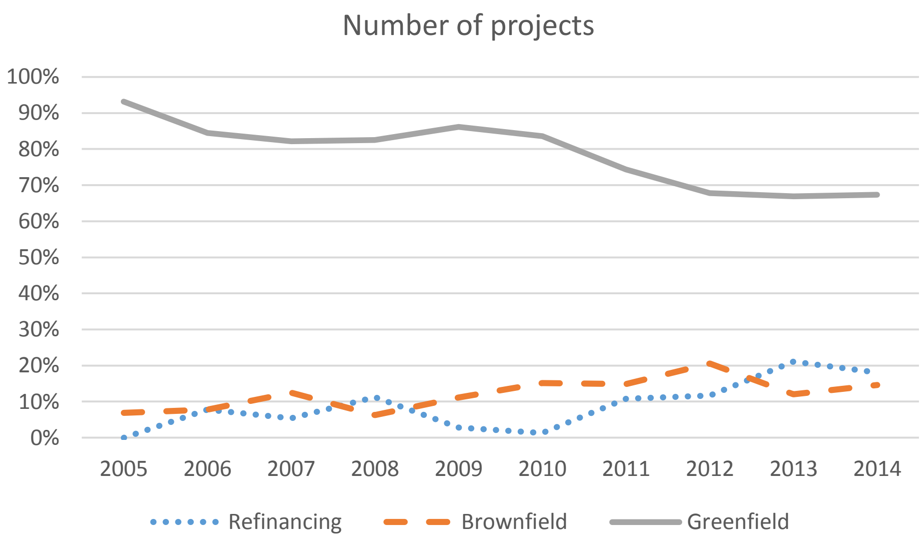
Figure 24: Bank-financed infrastructure projects: Value of PPP transactions relative to the value of all bank financed transactions from 2000 to 2014 (EUR million)

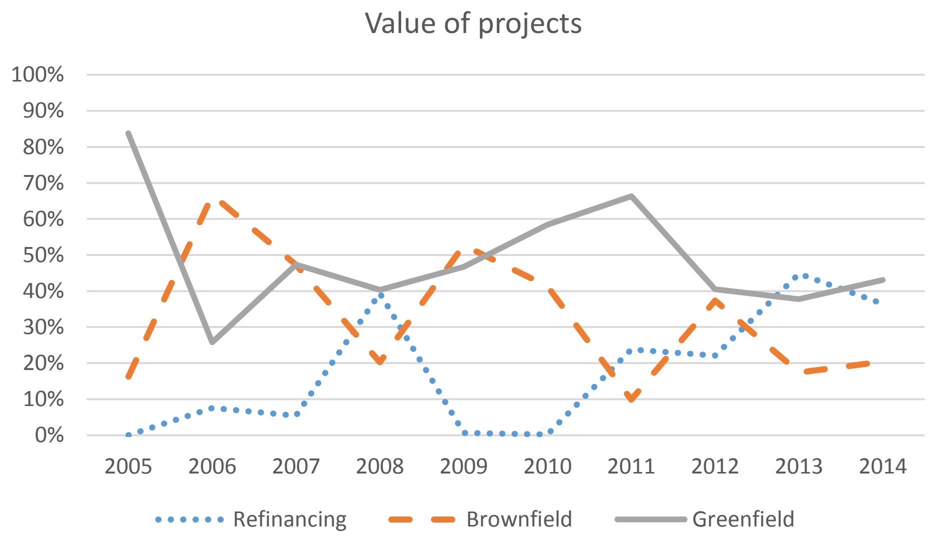


Note: Data covers all bank financed European infrastructure projects recorded in the InfraDeals database for the period from 1 January 1999 until 31 December 2014. Transaction value refers to the project finance received (in million EUR)
Source: LE Europe based on InfraDeals

In terms of the nature of infrastructure projects having received bank funding in recent years, the figure below shows that, over the last 10 years, greenfield infrastructure projects accounted for the bulk of the number of infrastructure bank-funded projects. However, the share of greenfield infrastructure projects in the total number of bank-financed infrastructure projects shows a mild trend decline while the shares of brownfield and refinancing deals exhibit a small trend increase.

Figure 25: Share of greenfield, brownfield and refinancing infrastructure projects in total bank-financed infrastructure projects: 2005-2014





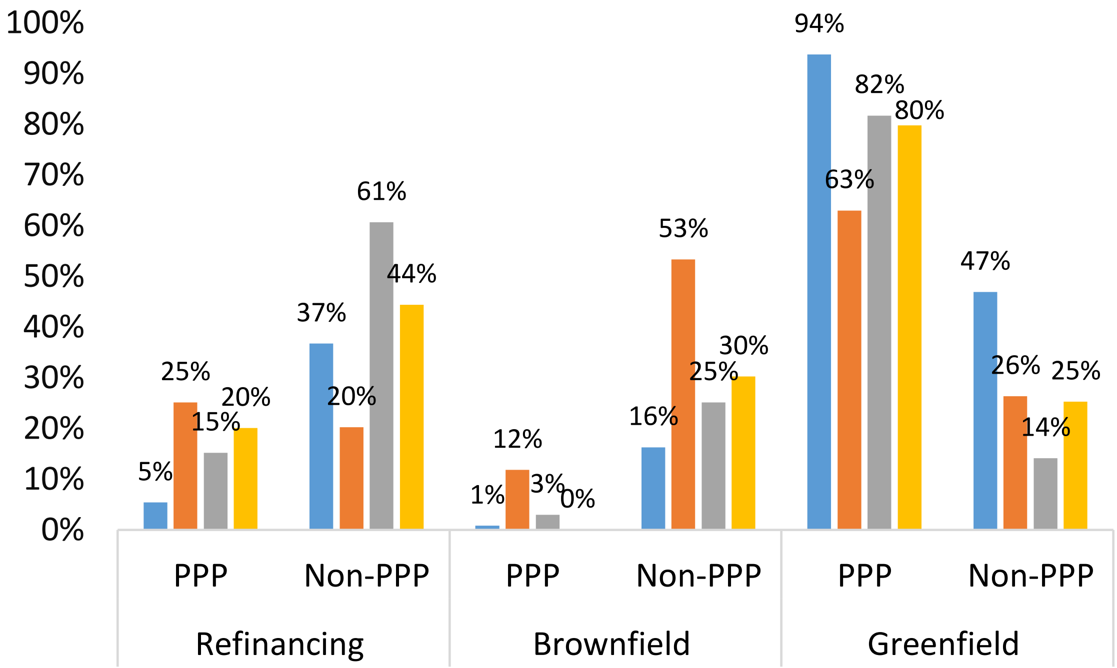
Note: Data covers all bank financed European infrastructure projects recorded in the InfraDeals database for the period from 1 January 2005 until 31 December 2014. Value refers to the project finance received (in million EUR).
Greenfield infrastructure deal = new infrastructure built from scratch; brownfield infrastructure deal = acquisition of existing infrastructure
Source: LE Europe based on InfraDeals

In contrast, the share of greenfield deals in the total value of bank-funded infrastructure deals is much lower. Indeed, in 2013 and 2014, the shares of greenfield and refinancing deals in the total value of bank-funded deals were broadly identical while the share of brownfield deals was broadly stable

Finally, in recent years, PPP bank financed deals were mostly greenfield deals (see figure below) while non-PPP bank deals involved a mix of the three types of infrastructure deals with an overall small predominance of refinancing and brownfield deals.

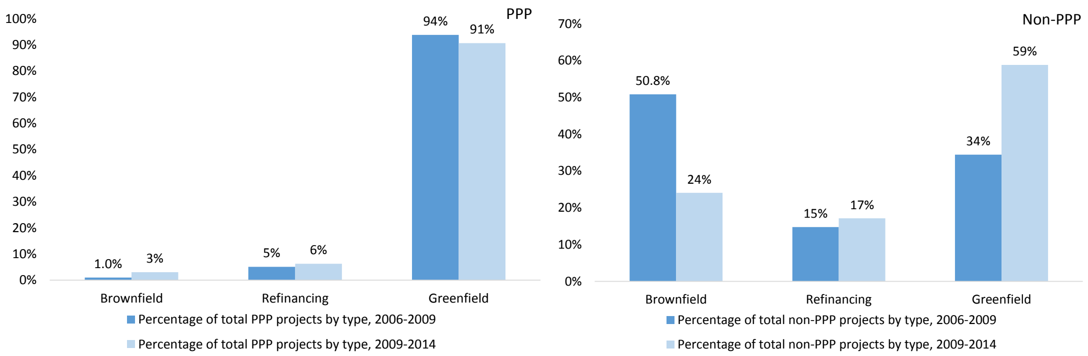
Comparing the relative shares of the volumes of different types of deals in 2006-2009 and 2009-2014, refinancing deals have increased and brownfield have decreased for both PPPs and non-PPPs. However, while the relative shares of greenfield have decreased for PPP bank financed deals, they have decreased for non-PPP bank financed deals.

Figure 26: Share of PPP and non-PPP greenfield, brownfield and refinancing infrastructure projects in total value of bank-financed infrastructure projects 2011-2014



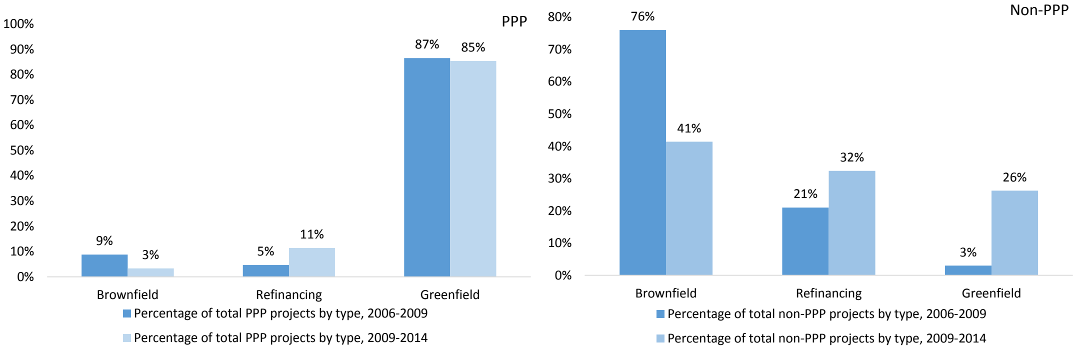
Note: Data covers all bank financed European infrastructure projects recorded in the InfraDeals database for the period from 1 January 2005 until 31 December 2014. Value refers to the project finance received (in million EUR).
Greenfield infrastructure deal = new infrastructure built from scratch; brownfield infrastructure deal = acquisition of existing infrastructure
Source: LE Europe based on InfraDeals

Figure 27: Share of greenfield, brownfield and refinancing infrastructure projects in total number of bank-financed infrastructure projects for PPP and non-PPP projects in 2006-2009 and 2009-2014.



InfraDeals database for the period from 1 January 2006 until 31 December 2014.
Greenfield infrastructure deal = new infrastructure built from scratch; brownfield infrastructure deal = acquisition of existing infrastructure
Source: LE Europe based on InfraDeals

Figure 28: Share of greenfield, brownfield and refinancing infrastructure projects in total volume of bank-financed infrastructure projects for PPP and non-PPP projects in 2006-2009 and 2009-2014.



InfraDeals database for the period from 1 January 2006 until 31 December 2014. Value refers to the project finance received (in million EUR).
Greenfield infrastructure deal = new infrastructure built from scratch; brownfield infrastructure deal = acquisition of existing infrastructure
Source: LE Europe based on InfraDeals

A more detailed look at bank-financed PPPs

Two economic sectors stand out as the destination of bank-financed PPPs, namely transport and social infrastructure. The latter accounts for 61% of the total value of the bank financed provided for PPPs from 2000 to 2014 and transport for another 31%. Within the social sector, education and health account for the bulk of bank PPP finance.

Almost all (93%) of bank-financed PPP projects over the period 2000-2014 were greenfield projects which, on average, had duration of 27 years.

Table 35: Sectoral-breakdown of bank finance provided for PPPs from 2000 to 2014

	Share in total value of projects	Share in total number of projects
Sectors		
Environment	6.06%	5.39%
Other	0.00%	0.00%
Power	1.21%	1.03%
Renewables	0.00%	0.00%
Social infrastructure	61.21%	27.79%
Telecommunications	0.73%	2.27%
Transport	30.79%	63.52%
Selected sub-sectors of sectors listed above		
Accommodation	8.36%	3.15%

	Share in total value of projects	Share in total number of projects
Defence	1.45%	3.31%
Education	22.55%	7.70%
Health	18.30%	9.97%
Leisure	2.91%	0.90%
Prison	2.42%	1.13%
Social Housing	2.42%	0.70%
Street Lighting	2.42%	0.64%
Waste	4.24%	3.87%
Water	1.70%	1.27%
Project type		
Brownfield		1.82%
Greenfield		93.09%
Refinancing		5.09%
Average duration (in years)	27.7	

Note: Data covers all bank financed European infrastructure projects recorded in the InfraDeals database for the period from 1 January 1999 until 31 December 2014. *Duration is given by length in project in years as reported by Infradeals. For a small subset the years were reported as a range and for these observations the average value of this range was used as the point estimate of duration.
Source: LE Europe based on InfraDeals

Three countries (GB, ES and FR) account for 73% of all bank financed PPP projects and almost 70% of all the bank funding received by PPPs.

Among the PPPs having received bank finance, practically all received only bank finance - 90% across all countries for which data are available for the period 2000-2014. A similar situation is observed at the country level.

Table 36: Breakdown of PPPs having received bank financing by country and financing mix -2000 to 2014

Country	Number of transactions	Capital Market & Bank finance - Number of Transaction	Government and Bank finance - Number of transactions	Bank finance only - Number of Transactions	Bank lending (Total amount)	Total Transaction Size	Mean transaction value	Median Transaction Value
AT	6	1	0	5	723	1440	240	66
BE	19	1	3	15	4297	4292	226	90
CY	1	0	0	1	130	250	250	250
CZ	**1**	**0**	0	1	40	30	30	30
DE	30	1	3	26	3640	5845	195	110
DK	2	0	0	2	162	229	115	115

Country	Number of transactions	Capital Market & Bank finance - Number of Transaction	Government and Bank finance - Number of transactions	Bank finance only - Number of Transactions	Bank lending (Total amount)	Total Transaction Size	Mean transaction value	Median Transaction Value
ES	104	2	7	95	22145	29366	288	140
FI	2	0	0	2	526	647	324	324
FR	106	1	16	88	31416	40644	391	100
GB	393	18	9	365	64299	81847	212	76
GR	16	0	6	10	6166	9435	590	391
HR	6	1	0	5	1686	2053	342	343
HU	6	1	0	5	3090	2923	585	520
IE	21	1	2	18	3825	4786	228	215
IT	52	0	9	42	9988	18123	378	208
LT	1	0	0	1	10	10	10	10
NL	25	2	0	23	6046	7645	306	185
PL	10	0	0	10	2783	3150	350	175
PT	21	1	0	20	7723	9200	460	396
SE	1	0	1	0	986	1400	1400	1400
SK	1	0	0	1	984	900	900	900

Note: Value in million euros. Data covers all bank financed European infrastructure projects recorded in the InfraDeals database for the period from 1 January 1999 until 31 December 2014. Transaction value refers to the project finance received (in million EUR)
Source: LE Europe based on InfraDeals

In terms of number of deals, in almost all sectors PPP and non-PPP deals for which banks provided funding rely almost exclusively (more than 90%) on bank finance (alongside the equity and other funding provided by the project sponsors).

The only exceptions are telecommunications and transport PPP deals where banks provide about 85% of the external funding and social and telecommunications non-PPP deals where banks provide about 75% of the external financing.

Table 37: Breakdown of number of PPP (and non-PPP) deals having received bank financing by infrastructure sector and financing mix -2000 to 2014

	PPP deals – share in total number of deals			Non-PPP deals – share in total number of deals		
	Capital markets + bank finance	Government + bank finance	Bank finance only	Capital markets + bank finance	Government + bank finance	Bank finance only
Sectors						
Environment	0.00%	4.00%	96.00%	15.00%	5.00%	80.00%
Other				40.00%	0.00%	60.00%
Power	0.00%	0.00%	100.00%	13.21%	0.00%	86.79%
Renewables				0.24%	1.69%	98.07%
Social	2.58%	5.17%	92.25%	0.00%	25.00%	75.00%

	PPP deals – share in total number of deals			Non-PPP deals – share in total number of deals		
	Capital markets + bank finance	Government + bank finance	Bank finance only	Capital markets + bank finance	Government + bank finance	Bank finance only
infrastructure						
Telecommunications	0.00%	16.67%	83.33%	22.22%	0.00%	77.78%
Transport	6.72%	11.07%	82.21%	15.48%	1.19%	83.33%
Selected sub-sectors of sectors listed above						
Accommodation	1.45%	2.90%	95.65%			
Defence	0.00%	0.00%	100.00%			
Education	1.08%	3.76%	95.16%	0.00%	0.00%	100.00%
Health	5.37%	7.38%	87.25%			
Leisure	4.17%	20.83%	75.00%	0.00%	50.00%	50.00%
Prison	5.00%	0.00%	95.00%			
Social Housing	0.00%	0.00%	100.00%			
Street Lighting	0.00%	5.00%	95.00%			
Waste	0.00%	5.71%	94.29%	10.00%	10.00%	80.00%
Water	0.00%	0.00%	100.00%	22.22%	0.00%	77.78%

Note: Data covers all bank financed European infrastructure projects recorded in the InfraDeals database for the period from 1 January 1999 until 31 December 2014.
Source: LE Europe based on InfraDeals

A broadly similar picture prevails in the terms of the relative importance of bank infrastructure deals in the total value of PPP and non-PPP deals.

Table 38: Breakdown of value of PPP (and non-PPP) deals having received bank financing by infrastructure sector and financing mix -2000 to 2014

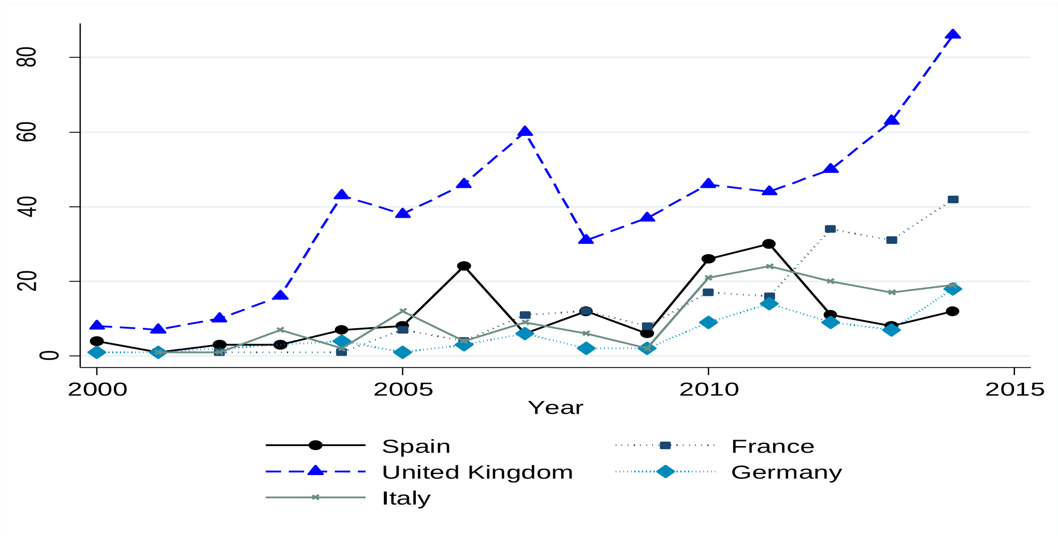
	PPP deals – share in total value of deals			Non-PPP deals – share in total value of deals		
	Capital markets + bank finance	Government + bank finance	Bank finance only	Capital markets + bank finance	Government + bank finance	Bank finance only
Sectors						
Environment	0.00%	8.44%	91.56%	6.93%	0.66%	92.41%
Other				67.38%	0.00%	32.62%
Power	0.00%	0.00%	100.00%	13.93%	0.00%	86.07%
Renewables				0.30%	0.77%	98.92%
Social infrastructure	10.42%	7.81%	81.76%	0.00%	40.13%	59.87%
Telecommunications	0.00%	1.96%	98.04%	37.86%	0.00%	62.14%
Transport	9.85%	17.53%	72.62%	25.60%	0.19%	74.21%
Selected sub-sectors of sectors listed above						
Accommodation	2.94%	2.95%	94.11%			

	PPP deals – share in total value of deals			Non-PPP deals – share in total value of deals		
	Capital markets + bank finance	Government + bank finance	Bank finance only	Capital markets + bank finance	Government + bank finance	Bank finance only
Defence	0.00%	0.00%	100.00%			
Education	2.62%	3.49%	93.89%	0.00%	0.00%	100.00%
Health	24.41%	12.76%	62.83%			
Leisure	8.15%	59.38%	32.47%	0.00%	73.31%	26.69%
Prison	11.79%	0.00%	88.21%			
Social Housing	0.00%	0.00%	100.00%			
Street Lighting	0.00%	2.78%	97.22%			
Waste	0.00%	11.75%	88.25%	7.13%	2.81%	90.06%
Water	0.00%	0.00%	100.00%	6.95%	0.00%	93.05%

Note: Data covers all bank financed European infrastructure projects recorded in the InfraDeals database for the period from 1 January 1999 until 31 December 2014.
Source: LE Europe based on InfraDeals

The number of bank-financed PPP projects has picked up very sharply in the UK in recent years and to a lesser extent in France.

Figure 29: Trends in the number of bank-financed PPP projects in countries with more then 30 PPP bank financed projects over the period 2000-2014

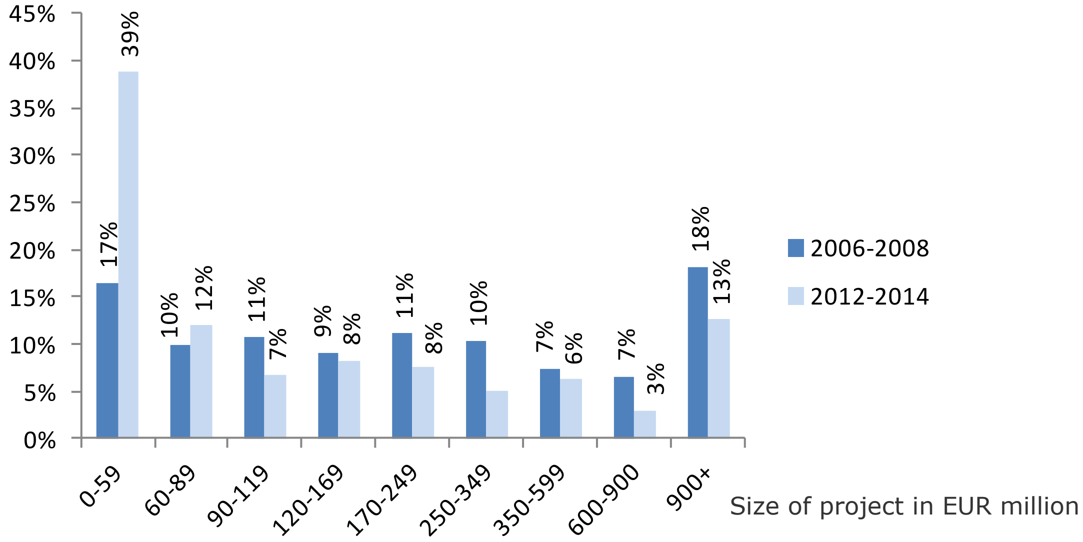


Note: Data covers all bank financed European infrastructure projects recorded in the InfraDeals database for the period from 1 January 1999 until 31 December 2014.
Source: LE Europe based on InfraDeals

Compared to the pre-crisis period of 2006-2008, 2012-2014 has seen a large increase in the share of small bank-financed PPPs in the total number of bank-financed PPPs.

The shift to smaller PPP projects has come at the expense of all other PPP size classes. Interestingly, very large PPPs of more EUR 900 million have not disappeared but have only become relatively less frequent.

Figure 30: Number of transactions in relation to size of transaction over the periods 2006-2008 and 2012-2014



Note: Data covers all bank financed European infrastructure projects recorded in the InfraDeals database for the period from 1 January 1999 until 31 December 2014.
Source: LE Europe based on InfraDeals

As noted earlier, 90% of all PPP projects having received bank finance relied only on bank finance. While this figure has fluctuated between 82% and 100% over the period 2000-2014. In 2014, it had rebounded to 89% after a temporary decline to 82% in 2011.

Table 39: Breakdown of PPPs having received bank finance by year and financing mix - 2000-2014

Year	Number of Transactions	Capital Market & Bank finance - Number of transactions	Government and Bank finance - Number of transactions	Bank finance only - Number of transactions	Bank lending - Total amount	Mean Transaction Value	Median Transaction Value
2000	13	1	1	11	4140	318	126
2001	12	1	1	10	1906	244	118
2002	16	0	0	16	5583	499	152
2003	29	3	2	24	6829	393	119
2004	63	3	3	57	6605	212	86
2005	58	2	2	54	10484	257	117
2006	80	7	1	72	16200	296	104
2007	94	4	7	83	18563	264	139
2008	63	1	3	59	17097	323	190
2009	56	0	2	54	10895	227	98
2010	82	0	10	72	14589	211	72
2011	62	0	11	51	14355	349	90
2012	56	0	7	49	15014	302	104

Year	Number of Transactions	Capital Market & Bank finance - Number of transactions	Government and Bank finance - Number of transactions	Bank finance only - Number of transactions	Bank lending - Total amount	Mean Transaction Value	Median Transaction Value
2013	69	2	3	61	15251	285	141
2014	72	6	4	62	13685	258	70
Total	825	30	57	735			

Note: Value in million euros. Data covers all bank-financed European infrastructure projects recorded in the InfraDeals database for the period from 1 January 1999 until 31 December 2014. Transaction value refers to the project finance received (in million EUR)
Source: LE Europe based on InfraDeals

Recent years have also seen a small decline in the duration of PPP projects having received bank finance relative to the pre-crisis period, although the average decline in duration is not very pronounced.

Table 40: Change in length of project over time

Year	Number of transactions	Bank lending - Total amount	Mean project length	Median project length	Lower quartile - project duration	Upper quartile - project duration
2000	14	4192	30	28.5	25	31
2001	11	1906	34	30	25	31
2002	15	2569	32	30	25	30
2003	26	7142	25	25.5	20	30
2004	59	4793	28	26	25	30
2005	62	10325	27	27	25	30
2006	67	8802	28	30	25	30
2007	85	16623	29	30	25	30
2008	54	13172	29	27.5	25	30
2009	53	11225	27	27	25	30
2010	85	15112	24	25	20	30
2011	57	13238	26	25	23	30
2012	50	10464	26	25	22	28
2013	69	11899	25	25	20	30
2014	79	14259	24	25	20	28

Note: Value in million euros. Data covers all bank financed European infrastructure projects recorded in the InfraDeals database for the period from 1 January 1999 until 31 December 2014. Transaction value refers to the project finance received (in million EUR). Duration is given by length in project in years as reported by InfraDeals. For a small subset the years were reported as a range and for these observations the average value of this range was used
Source: LE Europe based on InfraDeals

Bank consultation findings

In order to further assess the potential implications of capital requirements, a limited number of banks involved in infrastructure were interviewed or surveyed. The present section provides, first, information on the approach adopted for gathering the views of the banks and, second, presents a synthesis of the key findings.

Information gathering approach

The approach adopted early on in the project was to undertake interviews of 15 banks having a notable presence in the European infrastructure market over the period October 2015 – January 2016.

To that end, 37 banks were approached through a number of channels (both corporate HQs and project finance departments). Banks were targeted to cover a wide range of market share, industry sectors, and geographies in the EU infrastructure finance market. These banks are typically leading lenders in the project finance market.

However, in most cases, banks were extremely reluctant to be interviewed whether in a face-to face setting or by phone. Banks declining to participate in this interview process gave several reasons. Foremost among these were concerns about confidentiality (despite having provided assurances by the project team). Many had blanket policies not to hold interviews on the matter. Others noted that they already had established communication channels with the EC and other regulators and banks staff who had been contacted by the project team were told that internal policy was to use only those channels to avoid any inconsistency when they sought permission to participate in the exercise. More generally, many indicated that they had limited interest in the subject matter and that this was not a major priority for them at present.

As a result of these various factors, only 8 banks were interviewed. They are HSH Nordbank, NIBC, KfW, HSBC, SMBC, Natixis, Santander, and RBS. Five of these banks are among the top 25 banks having provided infrastructure finance in the EU over the period 2011-15 (see table below).

Table 41: Top 25 banks providing infrastructure financing in the EU, 2011-15*

Rank	Bank	Market share	Total value of lending ($m)	Number of transactions
1	Mitsubishi UFJ Financial Group (MUFG & BTMU)	7.88%	4,285	31
2	Sumitomo Mitsui Banking Corporation (SMBC)	7.04%	3,827	43
3	BNP Paribas	4.72%	2,568	16
4	Societé Générale (SocGen)	4.31%	2,341	30
5	Aviva	3.77%	2,048	31
6	Norddeutsche Landesbank Girozentrale (NORD/LB)	3.35%	1,824	30
7	Mizuho Bank	3.35%	1,823	17
8	Crédit Agricole CIB	3.32%	1,807	26
9	Banco Bilbao Vizcaya	3.12%	1,695	23

Table 41: Top 25 banks providing infrastructure financing in the EU, 2011-15*

	Argentaria (BBVA)			
10	KfW IPEX-Bank GmbH	3.01%	1,634	18
11	Cassa Depositi e Prestiti (CDP)	2.84%	1,544	5
12	Lloyds Banking Group	2.45%	1,333	15
13	UniCredit Group	2.33%	1,265	17
14	Santander	2.16%	1,176	23
15	Bayern LB	1.83%	994	14
16	Natixis	1.82%	990	12
17	ING Group	1.80%	979	12
18	Intesa Sanpaolo	1.74%	946	10
19	HSBC	1.40%	760	8
20	Caisse des Dépôts	1.15%	625	1
21	Deutsche Zentral-Genossenschaftbank (DZ Bank)	1.09%	591	10
22	KBC Bank NV	1.07%	580	9
23	Barclays	1.07%	580	13
24	Piraeus Bank	0.87%	471	4
25	Caixabank	0.86%	465	12

Note: *The table above has been created based on InfraDeals league tables (download date 22/09/15) for EU infrastructure deals financed by bank debt in the period 1st July 2011- 1st July 2015.
The ranks are arranged on the basis of value of lending. In this metric, RBS ranked 40 with a 0.48% market share, NIBC ranked 53 with a 0.36% market share and HSH Nordbank ranked 96 with a 0.10% market share.
Source: InfraDeals

While HSH Nordbank is a much smaller player in the infrastructure market, it has been included to represent the importance of smaller German banks in the project finance market. In the period 1st July 2014 – 1st July 2015 the bank was involved in 9 transactions in UK, France, Germany, Luxembourg, Hungary and Finland. NIBC is included to represent smaller Benelux players.

Table 42 below covers details of the 8 interviewed banks providing infrastructure financing in the EU.

Table 42: Geographic scope of interviewed banks providing infrastructure financing (only infrastructure deals in the EU)

Bank	Countries covered Jul 2014 – Jul 2015
KfW IPEX-Bank GmbH	UK (8), Germany (5), Netherlands, Ireland, Finland, France, Lithuania, Czech Republic (1)
HSBC	UK (1), Sweden (1)
HSH Nordbank	France (5), UK (2), Luxembourg (1), Hungary (1), Germany (1), Finland (1)
Natixis	France (12), Germany, Italy (3), Netherlands, Hungary (1)
NIBC	UK (3), Netherlands (1), Germany (1)
Sumitomo Mitsui Banking Corporation (SMBC)	UK (7), Germany, Netherlands (2), France, Finland, Hungary (1)
Royal Bank of Scotland (RBS)	UK (15), Ireland (2), Netherlands, Sweden, France (1)
Santander	Spain (14), UK (11), Portugal (4), Italy, France, Germany (2), Ireland, Netherlands (1)

Note: Figures in parentheses indicate number of transactions
In the UK, KfW provided financing for: 3i Portfolio Refinancing (£314m), Crook Hill 37.4MW Windfarm (£77.5m), Gayton le Marsh 16.4MW Windfarm (£47.8m), Mid Hill And Rothes II 117.4MW Wind Farms Repricing (£136.1m), North Yorkshire and York City Joint Waste PFI (£361.0m), Papworth Hospital NHS PFI (£165.0m), Scotrail (£370.0m), Thameslink Rolling Stock Refinancing (£1,600.0m).
Source: InfraDeals

The headquarters of the banks covered thus far include a wide variety of countries. These include France (Natixis), the UK (HSBC, RBS), Germany (KfW, HSH), Spain (Santander), Netherlands (NIBC) and an EU outsider (SMBC) headquartered in Japan but with regional headquarters in the UK.

The interviewed banks have, between 1st July 2014 and 1st July 2015, by and large lent across the EU. As a rule, larger and more complicated deals (EUR150m+) almost always require a bank club involving foreign lenders. Typically, this implies involvement of the more developed Project Finance teams in London or Paris. London itself is the centre of gravity for EU Project Finance deals, with the majority of funds, advisors, and lending desks concentrated there. The consultations have been a mix of in-person interviews in London and conference calls with foreign desks.

The maps below show the coverage of EU countries by the interviewed banks for the period of 1st July 2014 – 1st July 2015.

Figure 31: Geographic scope of interviewed banks' lending

Source: InfraDeals

The table below shows the interviewed banks have covered a wide variety of infrastructure sectors, including all main sectors of Transport, Power, Renewables, Environment, Telecommunications and Social Infrastructure.

Table 43: Sectoral scope of top lenders

Bank	Sectors
Royal Bank of Scotland (RBS)	Transport (8), Renewables (6), Environment, Power (3), Telecommunications
Santander	Renewables (18), Transport (9), Power (4), Environment (3), Social Infrastructure (2), Telecommunications
KfW IPEX-Bank GmbH	Renewables (9), Social Infrastructure (4), Power (3) Transport (2), Environment (1)
Sumitomo Mitsui Banking Corporation (SMBC)	Transport (5), Environment, Social Infrastructure (3), Power (2), Renewables
Natixis	Renewables (10), Transport (5), Social Infrastructure, Telecommunications (2), Environment
HSBC	Environment (1), Power (1)
HSH Nordbank	Renewables (6), Power (1), Transport (4)
NIBC	Renewables (2), Environment (1), Power (1), Transport (1)

Notes: Figures in parentheses indicate number of transactions.
Source: InfraDeals

In order to increase the feedback from the banking sector involved in infrastructure funding, an additional survey of banks involved in infrastructure was undertaken with the help of the trade associations AFME and BBA and personal contacts of the team members. While shorter in scope, this survey aimed to address the key points which were to be covered by the interviews.

In total, six banks responded to this additional survey (Caixabank, Cassa Depositi e Prestiti, Crédit Agricole, ING, and two banks which wished remain anonymous).

Thus, in total 14 banks provided information (8 banks participated in the interviews and 6 banks participated in the survey), of which 9 banks are among the top 25 banks involved in infrastructure finance.

Results of bank interviews

The consultations consisted of hour-long discussions with bank staff involved in project finance or capital allocation decisions and the section below presents a summary of the consultation responses. Various themes emerged from the consultations.

The primary effect of stricter capital requirements has been a declared preference among the banks consulted for issuing fewer long-term loans (over 20 years in duration) that have been commonly used for certain types of infrastructure projects such as greenfield PPPs.

Banks stressed the need for infrastructure to be considered in view of its specific characteristics rather than against regulations that apply uniformly to all asset classes.

All consultees noted that institutional capital (investments made by insurance companies and pension funds) has been providing some of the infrastructure financing that is no longer being provided by the banks.

1. *How do Capital Reserve Requirements affect your general risk appetite?*

By way of background, the European infrastructure PPP market usually involves concession projects that require large lump-sum investments upfront during 3-5 year construction periods followed by 25-30 years of cash flow during operations.

Construction periods are generally riskier. For example, the operation of a road is relatively straightforward (simply ensuring the roadway is open for cars to use). However, construction can be very complex. Among other factors, it involves relocating live utilities and interaction with active roads and rail lines. An unexpected setback during the construction phase can lead to costly delays on many dependent construction works phases. Thus, project risk profiles dramatically reduce with the end of construction, at which point they tend to be refinanced at accordingly lower rates.

Though infrastructure provides relatively low margins, it is generally viewed as being an attractive investment sector for providing stable long-term risk-adjusted returns.

One respondent noted that because of higher capital charges the respondent’s bank finances projects with higher risk-return profiles at the margin.

Other respondents made the point that stricter capital regulation has led to banks pursuing higher risk-return profiles, among loans facing similar capital charges.

In addition, it was noted by one bank that it preferred shorter loan tenors in the infrastructure sector in order to reduce risk and hence reduce capital charges relative to investments in long tenors.

2. How are the required capital charges determined for infrastructure lending?

Typically, banks used the IRB approach for quantifying the required capital charges for infrastructure loans, with a number of banks reporting using the slotting approach foreseen by the CRR for specialised lending exposures when the probability of default cannot be estimated (article 153.5 of the CRR).

3. *How does the approach to capital charges impact the bank's infrastructure portfolio relative to other sectors?*

Certain banks' project finance departments reported facing internal competition for capital against other sectors and asset classes. In these situations, a credit allocation committee must approve loans in light of the banks' total capital allocation needs.

In the banks that do provide for such internal competition, respondents commented that infrastructure does not fare well relative to other sectors whose more secure collateral can be used as part of meeting capital requirements. Real estate loans compete keenly with infrastructure loans for capital, as a real estate loans have more tangible collateral.

In several cases, infrastructure remained a priority investment area for certain banks. This usually had to do with the bank's mission to focus on infrastructure, particularly for banks with some form of state ownership.

One bank also pointed out that infrastructure provided diversity in its loan portfolio, which benefits its aggregate ratings assessments.

4. *Have the new regulations focused your lending more towards any particular sector within the infrastructure market?*

The latest capital requirements have generally not given rise to a preference for particular sectors within infrastructure according to the banks responding to this question.

However, it has been observed that increased capital requirements have led to a preference for certain risk profiles and financial structures. Some banks expressed the view that they are less interested in new-build infrastructure and all expressed an aversion to full market risk projects, meaning projects which are dependent on user/traffic volume, due to associated capital charges.

In light of increased capital requirements, lenders preferred projects that guarantee payments by government regardless of usage levels (known as availability-based projects). This preference is most pronounced in the toll road sector, where demand risk is more volatile than other transportation sectors (while many cities have only one airport or port, there are generally alternatives to toll roads even if they are less convenient).

One bank also did note a slight preference towards renewable energy projects due to shorter tenors.

5. *Are there any differences between greenfield and brownfield infrastructure lending with the present regime of capital reserve requirements?*

Most surveyed banks have so far preferred greenfield infrastructure over brownfield. Some noted that this is only tangentially due to capital requirements, while others felt that capital requirements play an important role in financing greenfield projects.

Banks of most nationalities reported better risk adjusted returns with greenfield projects, but this was not due to any capital requirement drivers.

One respondent cited partnerships with institutional investors (that is, pension funds and insurance companies) leading to greenfield investment preferences due to the combination of this traditional bank lender's construction expertise and the institutional long-term lending preference, for liability matching purposes.

Some banks, however, expressed wanting to avoid long-term loans to greenfield projects because of uncertainty with how capital requirements might change over time. Another respondent noted concern over shoring up capital reserves for the large long-tenor portfolio already on its books.

Other banks, with less construction expertise, further noted that the risk-adjusted returns of greenfield projects (that is, projects which must go through the risk-heavy construction phase) have been dragged down by the new capital requirements.

6. *Has the recent shift away from peripheral EU economies been in any amount driven by capital regulations?*

Within the EU, geographical shifts in infrastructure lending have primarily been driven by sovereign risk and not increased capital requirements.

All of the surveyed banks reported that the shift away from extending credit to peripheral EU economies has been the result of sovereign risk inputs into credit models. Sovereign risk considerations have almost entirely been the result of the onset of the financial crisis.

However, it was also observed that, at the margin, increased capital requirements do inhibit the financing of infrastructure projects in peripheral EU economies.

7. *What are some sector specific incentives which you feel could counteract the negative effects of capital reserve regulations?*

The surveyed banks offered a variety of suggestions for adjustments to capital requirements for infrastructure.

The common theme was for regulators to acknowledge explicitly in the calculation of the risk-weighted capital the differences between infrastructure and other asset classes.

One of the primary issues identified was the proposal from the Basel Committee (2014) to adopt as an integral component of the capital framework a common floor for capital charges across all asset classes. Often the common floor overrides the proprietary models the individual banks had developed to calculate the capital charges for each loan. This erodes the asset-specific distinctions banks can use to charge lower interest rates for infrastructure projects. For instance, banks were uncertain whether the common floor truly takes account of the fact that infrastructure assets usually constitute a natural monopoly or can be highly leveraged due to low-risk long-term returns.

Some specific recommendations made were:

i) for capital requirements to better account for guarantees from State institutions and other risk mitigation techniques (insurance, etc.)

ii) for capital requirements to decrease over time for long-term assets that perform well

iii) for regulators to derive capital reserve formulas which take account of risk differences within the infrastructure sector, such as the difference between availability-based and demand-based toll roads

iv) for risk mitigation techniques (such as insurance, guarantees, etc.) to be taken into account when determining capital charges

It was recommended that all of these factors should also be considered in adjusting the Slotting Criteria. One bank suggested creating a new category within the Slotting Criteria approach for infrastructure projects separate from loans to corporate borrowers.

8. *Do capital reserve regulation changes cause you to refocus your appetite for infrastructure within Europe or lead you to refocus that capital towards infrastructure projects outside Europe?*

Some banks have refocused on Northern and Western Europe, but not necessarily as a result of the CRR.

Regardless of European regulations, most nationalities suggested that they were unlikely to shift European capital outwards. Some banks reported that the cost of lending outside of their base currencies was prohibitive.

9. *What have been the effects of higher capital requirements for lenders insuring their project finance debt?*

Only one interviewed bank insures its infrastructure debt. The respondent from this bank reported that it uses a variety of insurance products. The use of different insurance products means that increased capital requirements have not had any particularly material impact on its activities.

However, banks did report uncertainty regarding the derivatives that lenders use to hedge interest rate risk on their loans. Banks felt that structuring institutions will continue to be more conservative issuing such products until they have a clearer understanding of what the new regulations do to these derivatives. This may further raise the price of long-term risk.

10. *Are there other sectors you might exit in response to more favourable conditions in the project finance market? If so, what kind of timeline would you be looking at?*

Most respondents reported that there is no definitive answer at this point. It is not immediately clear how expensive it would be to liquidate positions in other sectors.

Some respondents felt that the latest regulations give undue advantage to real estate however, as already mentioned. Specifically, if the banks’ risk models could be adjusted to properly take account of the specificities of infrastructure’s risk profile (less disadvantage for lack of intangible collateral and more advantage for lower likelihood of default), infrastructure would probably perform better relative to real estate.

11. *Have the effects of Basel III fully set in or do you anticipate further adjustment in response to the present capital regulations?*

All but one of the banks agreed that the full impact of the regulations has not yet set in. Banks still feel uncertainty over the final effects on lending. While most were of the view two years would be required to understand the regulatory impacts, some noted that the full effects would take 5 to 7 years to materialise.

12. *What are some otherwise attractive-return infrastructure projects within the EU that the current financial sector regulatory climate discourages?*

The consensus was that longer tenor deals are less attractive in light of capital regulation under the CRR. The current regulations disadvantage them via long-term capital charges without also reflecting the fact that they provide stable returns over that period.

Toll roads appeared to be the most common answer as to which assets the current regulatory regime discourages. The capital regulation regime is also not sophisticated enough to recognise some de-risked features. As previously mentioned, toll roads with government-guaranteed revenue are treated the same as those with traffic volume risk. One respondent reported that 30 year projects in Eastern Europe have been most impacted due to the combination of term and sovereign risk.

13. *Have regulators generally been open and responsive to your concerns about the project finance market, specifically in relation to capital reserve regulations?*

The consulted lenders reported varying relations with their regulators but none were negative.

Some of the larger banks reported that they discuss capital regulation with regulators in general, but the impact of capital regulation on infrastructure features little in their interactions.

One bank reported that it does not maintain strong relationships with regulators due to a culture of following rules rather than attempting to influence them.
Most banks did express that, while regulators have generally been open to listening, they have generally been slow to respond or give feedback.

14. *What are your general sentiments towards the present Basel III capital regulations? Which elements have been favourable to the project finance industry and which have been unjustifiably restrictive?*

Most banks feel that the CRR has unnecessarily penalised the long-term risk at the core of infrastructure lending. Respondents reported that they are being required to place more capital towards projects in a sector which has not been prone to particularly risky lending or frequent default.

As a result, banks have had to adjust towards different practices which either focusing on projects offering higher returns or which allow them to take advantage of the capital requirements placed on less risky projects (for instance, some banks have shortened their loan tenors).

One bank reported that the current treatment of infrastructure projects does not reflect differences with loans to corporate borrowers. Unlike many corporate loans, infrastructure debt is accompanied by comprehensive documents with numerous financial and technical covenants (providing tighter control on the evolution of the loan). Infrastructure lenders have dedicated departments which internally monitor projects throughout their lives. Early detection of problems and/or deviations provide the opportunity to adapt the loan. This is a substantial difference from pure corporate lending and partially explains the low default associated with this asset class.

In addition, the Slotting Criteria Approach does not recognise the full impact of risk mitigation techniques like third party guarantees (ECAs or EFSI Fund).

15. *Do you think other funding sources will be capable (or willing) to cover project finance gaps in light of Basel III capital reserve regulations?*

As abovementioned, one of the most noticeable changes has been the introduction of institutional capital into the infrastructure market. It has contributed to filling the gap left by traditional lenders in the wake of tighter capital regulation. A major reason is that institutional capital is inherently longer term. For instance, pension funds have defined long periods of time where pension holders pays into pension funds before needing to drawdown. Insurance companies have defined durations over which they will receive payments with an easily calculable risk of policy payout. Thus pension funds and insurance companies have more capacity to absorb long-term risk.

The critical factor for institutional capital being able to participate in financing infrastructure is the difference in capital regulations, according to some respondent banks.

However, respondents report many institutions do not (yet) possess the same level of expertise as traditional infrastructure lenders. Thus while all the surveyed banks readily acknowledged the growing role of institutional capital, they agreed that the process will still require traditional lenders for the foreseeable future. The common pattern that has emerged is for traditional lenders to finance the construction stage, after which institutional capital is used for refinancing. Most banks expressed the importance of institutional capital in absorbing their post-construction portfolios.

In one country, it has become common over the last few years for banks to co-invest with institutional capital which is not subject to the same regulations. These institutional lenders include pension funds and insurance companies as opposed to commercial banks. Co-investment partnerships generally involve mid-sized insurance companies which are less familiar with the infrastructure due diligence process (many large insurance companies have active infrastructure investment professionals with an accompanying depth of experience). The bank maintains the capital reserves required from a bank for its portion of the loans while the remainder is posted at the lower institutional capital rate.

In the country where the abovementioned partnerships are common, many large banks use these co-investment structures on a case-by-case basis. However, some of the mid-sized lenders have found it advantageous to form long-term framework commitments with amounts of up to €2 billion. At present, the majority of these frameworks only involve infrastructure. However they could extend to other sectors in the future.

Survey results

Only two of the six the respondents to the survey felt that the implementation of the CRR had a negative impact on the level of the bank's infrastructure funding. The other four were of the view that it had no impact. One of the two banks with a negative view noted that the risk insensitive leverage ratio does not distinguish between safer project finance and structured export finance business and other lending. Moreover, the higher level of risk mitigation which is typically required for project finance but which is not recognised in the risk weighting makes project finance business less attractive than straight corporate lending.

All but one of the respondents were of the opinion that the CRR had no impact on:

- The bank's funding of brownfield investment. Five of the respondents held the same view with regards to greenfield investment while one thought that it had a negative impact.
- The preference for particular location in the EU (old Member States, new Member States) of the infrastructure projects funded by the bank
- The type of infrastructure funding provided by the banks.

Similarly, all but one of the respondents were of the view that tjere are no otherwise attractive-return infrastructure projects within the EU that the current financial sector regulatory climate discourages.

In contrast to the quasi unanimity of views on the impact of the CRR, respondents diverged somewhat in the relative importance of the factors explaining the current relatively low level of infrastructure investment with no clear dominant picture emerging (see table below).

Table 44: Relative importance of project pipeline and supply of funds factors in explaining relative low level of infrastructure funding at the present time

Factor	Number of respondents for each importance level				
	1 (not all important)	2	3	4	5 (very important)
Importance of limited pipeline	1		1	2	1
Importance of reduced availability of infrastructure funding	2	1	1	1	

Note: Not all respondents answered this question
Source: LE Europe survey

Empirical analysis

Overview and key results

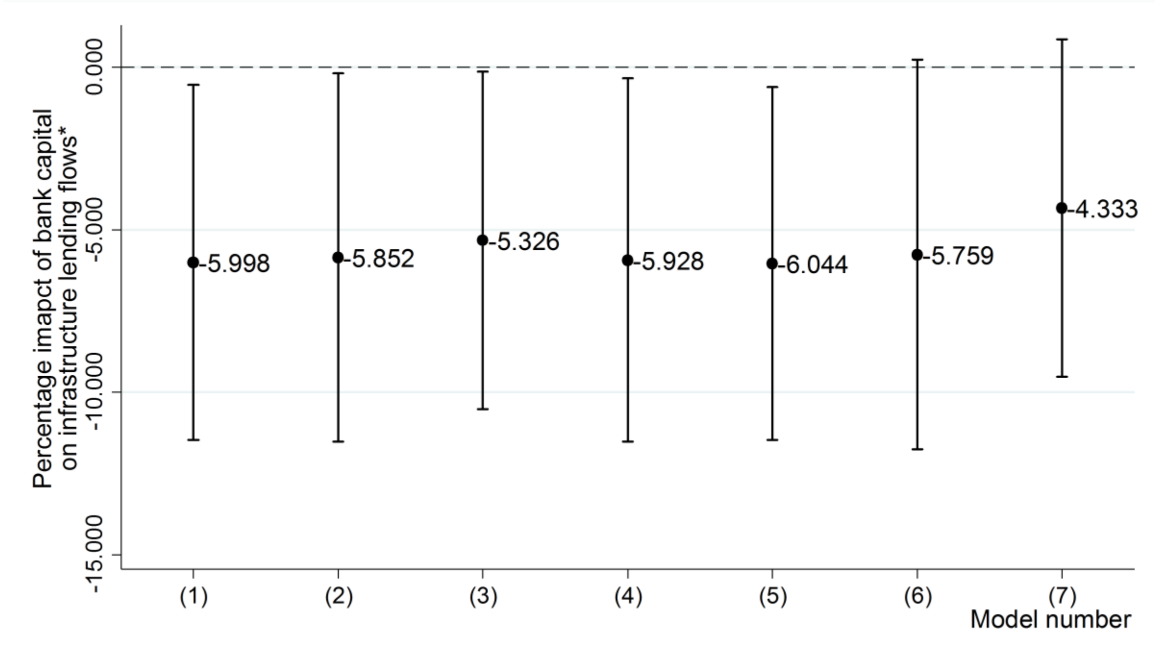
The economic importance of infrastructure motivates an empirical analysis of the impact of increased capital requirements under the CRR on bank financing of infrastructure.

Infrastructure financing transactions data at the bank-level are used, covering both PPP and non-PPP projects and infrastructure projects funded across the transport, telecommunications, power, renewables, environment and social sectors.

A similar econometric model is used to that applied to generating estimates of transitional effects of increased capital requirements. However, as transaction level data are available, control variables relating to particular infrastructure financing deals are included in the model. Such data were not available for the transitional effects or structural effects analysis because bank balance sheet data were used.

The key result is that while a one percentage point increase in the Total Capital Ratio is estimated to have a negative impact on bank financing of infrastructure, the size of the impact is in a relatively wide range. Across a range of the models tested, the 95% confidence interval for the impact is very close to zero or crosses zero at the upper end. Therefore, there is not clear evidence of an impact of increased capital requirements under the CRR on bank financing of infrastructure. In light of this finding, it is important to read the results in the context of the findings of the other strands of research presented in this chapter.

Figure 32: Box plots of the impact of the Total Capital Ratio on bank financing of infrastructure



Source: Bankscope, InfraDeals and LE Europe calculations

Data and methodology

Baseline econometric model

A dynamic panel model is used to relate changes in bank lending flows to changes in regulatory capital ratios and other factors as described by the equation below and estimated using a an unbalanced panel of banks.

$$\ln(GROSSLENDING)_{ijt} = \mu_i + \sum_{s=1}^{N} \alpha_s \cdot \ln(GROSSLENDING)_{ijt-s} + \beta \cdot CAP_{ijt} + \chi \ln(SIZE)_{ijt} + \delta LIQ_{ijt} + \phi WHOLE_{i\,jt} + \Gamma P_{kt} + \varepsilon_{ijt} \quad \text{..........} (16)$$

- $ln(GROSSLENDING)_{ijt-s}$ is the natural logarithm of gross lending in terms of bank financing to infrastructure for bank *i*, in Member State *j*, at time *t-s* (s=0 for the dependent variable)
- μ_i are bank-specific effects
- CAP_{ijt} is the quotient of Total Capital Ratio and Risk Weighted Assets for bank *i*, in Member State *j*, at time *t*

- $ln(SIZE)_{ijt}$ is the natural logarithm of total assets for bank *i*, in Member State *j*, at time *t*
- LIQ_{ijt} is the quotient of cash and trading securities and total assets for bank *i*, in Member State *j*, at time *t*
- $WHOLE_{ijt}$ is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets at *t* for bank *i,* in Member State *j* at time *t*
- P_{kt} is a vector of bank-specific infrastructure project funding characteristics, including the total value of transactions undertaken by a bank during period t and the average proportion of bank funding for the projects *k* at time *t*[89]
- ε_{ijt} is an error term for bank *i,* in Member State *j,* at time *t*
- α, β, χ, δ and ϕ are coefficients
- Γ is a vector of coefficients

There are two key differences between the infrastructure financing effects and transitional effects model of note.

Firstly, gross lending (measuring new lending) rather than net lending (measuring new lending and repayments) is the dependent variable because the data are drawn from an infrastructure transactions database rather than bank balance sheets. The focus on gross lending is an advantage in the present context because increased capital requirements are expected to affect bank lending flows through new lending (rather than repayments).

Secondly, variables related to infrastructure project funding are included in the model, the key benefit of which is that they are likely to be relevant in explaining the observed patterns of bank lending to infrastructure, and improve the identification of the impact of capital ratios on bank financing of infrastructure. By contrast, the analysis of transitional effects and structural effects cannot directly control for loan-level features because bank balance sheet data is being used.

Overview of infrastructure data

This section focuses on the data required for applying the empirical methodology for the analysis of bank financing of infrastructure.

The focus is the bank financing of infrastructure data, as bank capital and other explanatory variables have been described previously, in the section on the analysis of transitional effects.

InfraDeals is the key data source used for bank infrastructure financing. As noted earlier in this chapter, the database covers greenfield, brownfield and refinancing transactions in all of the following infrastructure sectors:

- Transport (Airports, Bridges and Tunnels, Car Parks, Light Rail, Ports, Rail, Roads, Rolling Stock, Other)

[89] Analysis of a correlation matrix of bank lending to infrastructure and project characteristics indicates that transaction size and total bank funding committed are the key drivers of any given bank's infrastructure financing activities in any given quarter, as shown in Annex 9

- Telecommunications (Fixed line, Wireless Transmission, Other)
- Power (Energy Generation, Energy Storage, Energy Transmission, Other)
- Renewables (Biomass, Hydro, Offshore Wind, Onshore Wind, Portfolio, Solar CSP, Solar PV, Other)
- Environment (Waste, Water, Other)
- Social infrastructure (Accommodation, Defence, Education, Healthcare, Leisure, Prisons, Social Housing, Street Lighting, Other)

While the sectoral scope of the InfraDeals database is comprehensive, it should be noted that the database does not cover all instruments used for bank financing of infrastructure. In particular, the database is limited to project finance, defined as financings based on single project assets.[90] Within project finance, the database focuses on the bank loans as opposed to equity funding.[91]

Data on bank-specific lending amounts was obtained from the InfraDeals League Tables, which report loan values on a by-project basis for the Top 200 bank lenders by country, sector and time.

The main dataset to be used for the analysis of the effects of the CRR on bank lending to infrastructure includes all projects financed by banks recorded in the league tables for either one or more of the Member States between 1 January 1999 and 30 June 2015. The frequency of the dataset is quarterly because bank characteristics and other explanatory variables are available at this frequency for banks providing infrastructure financing.

Note, a full list of variables used in the analysis, their definitions and data sources is provided at Annex 3.

Results

Baseline results

The results of the analysis are reported in Table 45 below. The baseline specification in column (1) includes lagged bank financing of infrastructure, project funding and bank characteristics as instruments. Second-order autocorrelation in the residuals is absent and the Hansen test for over-identifying restrictions is comfortably passed as well. Overall, the model properties are relatively good.

The coefficient on the Total Capital Ratio in the baseline specification in column (1) in Table 45 is -0.06, and is significant at the 5% level. This indicates that a one percentage point increase in the Total Capital Ratio leads to a reduction in bank lending to infrastructure of 6%, all else equal. However, considering the 95% confidence interval for the estimated impact (see Figure 32), the coefficient value is not very different from zero. The results highlight that the impact of changes in the

[90] While in practice regulated utility companies and other large corporate entities often issue equity or bonds to finance infrastructure, consistent data on bank holdings are not available due to issues in the construction of such data. For instance, bank investment in the equity of a vertically integrated utility may result in investment in infrastructure assets but it cannot be determined what proportion of bank financing is dedicated to said investment, as opposed to other financing needs of the regulated utility that it uses equity funding to fulfil

[91] Project bonds are not included due to data issues, including missing data

Total Capital Ratio on bank lending flows in general (as per the chapter on transitional effects) are economically more significant than on bank financing of infrastructure in particular.

Many other regressors are statistically significant and have plausible signs in the baseline regression in column (1) in Table 45, as described below.

Larger projects attract greater bank financing, which is consistent with a size effect: larger projects need greater funding from all sources. There may also be a mix effect: banks perhaps are also able to fund larger projects to a greater degree than other sources. In addition, the provision of bank funding being more economical for larger loans due to fixed due diligence and loan administration costs may also be a factor driving the positive relationship between larger projects and bank funding.

The funding of an infrastructure project by a particular bank is positively related to total funding provided by banks, although the effect is economically very small.

Regarding funding drivers of bank financing of infrastructure other than capital the following points are to be noted: Firstly, the greater share of wholesale funding in total funding, the more funding the bank is providing to infrastructure projects. As size is already taken into account in the model, this reflects the fact that bank financing of infrastructure projects are funded through wholesale liabilities to a greater extent than deposits. Secondly, the share of short-term liabilities in total bank funding is not significant, implying that the use of short-term financial instruments to a greater/lesser degree does not drive bank funding of infrastructure projects.

Robustness tests

The robustness of the key result on the relationship between the Total Capital Ratio and bank financing of infrastructure is tested in subsequent models.

The aim of the robustness tests is to check whether the key result is sensitive to the inclusion of macroeconomic variables, which may be important drivers of demand for infrastructure projects. For instance, user demand for a new toll road is likely to be closely related to economic performance - and therefore also the demand to fund and build the toll road.

Relatively few banks fund infrastructure projects and there are many important drivers of bank funding of infrastructure. Empirically, the presence of relatively few cross-sectional units (banks) to variables, constrains how many variables can be included in any one model, and therefore the robustness tests have to be carried out through the selective inclusion/exclusion of macroeconomic variables.

The strategy of the robustness tests is to add, one by one, the macroeconomic variables to the baseline specification, the results of which are presented in columns (2)–(6) in Table 45.

The main finding is that the coefficient on the Total Capital Ratio remains the same sign and approximately the same size, and is statistically significant. Across the specifications in columns (1) to (5) the effect size is in between -5.3% to -6.0%. In the model in which GDP growth is included the effect of -5.8% is only significant at the 10% level. However, as with the baseline model, considering the 95% confidence interval for the estimated impact, at the upper end, impact is very close to zero or crosses zero (see Figure 32).

Considering the impact of the macroeconomic variables on bank financing of infrastructure in columns (2) to (6): the size of central bank assets (in column (5)) is an economically and statistically significant driver of the funding banks provide to infrastructure projects, while the rate of inflation, interbank lending rate and GDP growth rate are not. The output gap is significant but only at the 10% level. It is of interest that the size of central bank assets is positively related to bank financing of infrastructure, as it may suggest that central bank asset purchases led to an increase in liquidity that allowed the banks to fund additional infrastructure projects.

A shortcoming of the strategy of including macroeconomic variables individually to the baseline specification in the models in columns (2) to (6) is the potential for omitted variables bias: statistically and economically significant macroeconomic variables could be capturing the effect of correlated macroeconomic variables that are not included. Therefore, as a final check, all variables that might plausibly explain some of the variation in bank financing of infrastructure projects[92] are included in the model in column (7) to address potential omitted variables bias. The model results show that the effect of the Total Capital Ratio on bank lending to infrastructure is in the same order of magnitude as previous results and is statistically significant, albeit at the 10% level. Further, the only macroeconomic variable that is significant is the size of central bank assets, which supports the findings of columns (2) to (6).

[92] The criterion of a p-value of 0.5 or less was used in the selection of variables

Table 45: Bank financing of infrastructure projects: baseline results and robustness tests – 1999Q1-2015Q2

Dependent variable: *ln(GROSSLENDING)*	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln(GROSSLENDING)$_{it-1}$	0.066	0.064	0.068	0.065	0.064	0.066	0.115***
TRANSACTION SIZE$_k$	0.471***	0.469***	0.480***	0.471***	0.469***	0.468***	0.525***
TOTAL BANK FUNDING$_k$	0.000**	0.000**	0.000**	0.000**	0.000*	0.000**	0.000
LIQ$_i$	-0.636	-0.627	-0.564	-0.678	-0.378	-0.631	
WHOLE$_i$	1.214**	1.184**	0.779	1.149**	1.101**	1.228**	0.952*
CAP$_i$	-0.060**	-0.059**	-0.053**	-0.059**	-0.060**	-0.058*	-0.057*
Π$_j$		0.010					-0.028
OUTPUT GAP$_j$			0.041*				0.037
ΔIB$_j$				0.098			0.122
Δln(CB)$_j$					1.362***		1.286**
Δln(GDP)$_j$						-3.628	
C	1.166**	1.161**	1.321**	1.208**	1.206**	1.146**	0.723
Number of observations	232	232	232	232	225	232	256
Cross-sectional units	94	94	94	94	92	94	100
AR(2) (p-value)	0.962	0.954	0.832	0.851	0.827	0.944	0.896
Hansen test (p-value)	0.997	0.996	0.996	0.996	0.998	0.996	0.984

Notes: The model is given by equation (16). *ln(GROSSLENDING)* is the natural logarithm of net lending; *TRANSACTION SIZE* is the transaction size; *TOTAL BANK FUNDING* is the total funding provided by banks in the transaction value; *LIQ* is the quotient of cash and trading securities; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital ratio; and total assets; *π* is the inflation rate, *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; *ΔIB* is the change in the 3-month interbank rate; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *Δln(GDP)* is the difference in the logarithm of real GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robustness standard errors, principal components for lags of bank-level variables are used as instruments. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope, InfraDeals and LE Europe calculations

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Annex 1 Construction of the sample databases

Bloomberg

Quarterly bank level data on loan volumes and bank-specific controls for the transitional and infrastructure analysis was drawn from Bloomberg. This annex describes the steps that were followed when constructing the quarterly bank sample.

Bank selection criteria applied before downloading data from the Bloomberg Terminal

Publicly quoted banks: Bloomberg only provides data for listed banks. The quarterly bank sample is therefore comprised of quoted banks only.

Regional subsample: Bloomberg data was obtained directly from the Bloomberg terminal using the equity screening function. Selected were all banks located in the EU-28.

Industry subsample: The equity screening function allows for a selection of specific industries only. Selected were all entities classified as 'banks' according to Bloomberg's Industry Classification Benchmark (ICB). In order to make sure no non-banks were selected, the Bloomberg data was later matched with Bankscope (see paragraph on specialisations below).

Quarterly observations: The Bloomberg Excel Add-in allows for a pre-specification of the frequency of the data. Quarterly data was obtained for all banks.

Matching of Bloomberg data with Bankscope

In order to control for the specialisation of the banks identified in Bloomberg as well as a potential double counting of banks resulting from parent-subsidiary relationships, the Bloomberg data was matched with Bankscope data using the name and location of the banks. After having obtained the Bankscope identification number *bvdidnum* for the banks in the Bloomberg sample[93], further adjustments could be made using the Bankscope variables.

Specialisation: The Bankscope variable *special* allowed for the exclusion of institutions such as central banks.

Subsidiaries: The Bankscope database about ownership structures of banks was used to exclude all banks from the sample that had a majority shareholder (total ownership of over 50%) that was itself represented in the sample[94].

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[93] 5 out of 191 banks could not be matched to the corresponding entity on Bankscope. For those five cases, specialisation and ownership structures were checked individually, using the annual reports provided by the institutions themselves

[94] Note that it was not necessary to additionally specify that subsidiaries should only be excluded when the parent bank provides consolidated statements (see Annex on data cleaning procedures for Bankscope), since Bloomberg exclusively provides data at the consolidated level.

Implausible values for standard balance sheet variables: Additional data cleaning procedures were used. Observations containing negative values for loan volumes, capital ratios, total assets, liquidity, capitalisation, and number of employees were excluded from the sample.

Bankscope

Annual bank level data on loan volumes and bank-specific controls for the transitional and Infrastructure analysis was drawn from Bureau van Dijk's Bankscope database, which provides comparable microdata on financial statements for more than 30,000 worldwide banks. This section provides an overview of the necessary data cleaning procedures that had to be undertaken in order to deal with issues of double counting, consolidation, mergers and acquisitions and data comparability. The following elaborations as well as the procedures followed during the data editing process closely follow the steps suggested by Thibaut and Mathias (2015).

Bank selection criteria

Regional subsample: The first step in the data selection process involved excluding all non-European banks from the sample based on the variable *region*.

Specialisation: Bankscope covers the financial statements of a wide range of financial institutions, not all of which are relevant for the current study. The variable *special* allowed for the exclusion of institutions such as central banks.

Availability of financial information: For some of the financial institutions listed on Bankscope no valuable balance sheet information is available. Using the variable *format*, which exhibits the type of statement that is available for each bank, banks and branches without statements as well as with statements under processing by Fitch ratings were excluded.

Minimum number of observations for loan variable: Given the ultimate purpose of the econometric analysis, only banks that had values for *gross loans* recorded within Bankscope for both 2013 and 2014, the first years under the CRR regulation, were included in the sample.

Duplicates

Bankscope identifies banks by means of two different numerical identifier variables: *bvdidnum* and *index*. The variable *bvdidnum* uniquely identifies a given bank, while the variable *index* identifies a bank-consolidation status and/or bank-accounting standard relation. Given that a bank might publish several statements with different consolidation status or different accounting rules per year, there are several index for a given bvdidnum within a year. However, in order to avoid double-counting the loan volumes of the same bank twice, the final bank sample should contain a given bvdidnum only once per year.

Pure duplicates: Pure duplicates, that is observations with the same bvdidnum, year, consolidation code, total assets and gross loans, were dropped first.

Consolidation code: Bankscope provides financial statements of banks at various consolidation levels, which is why there might be several records for the exact same bank in a given year. The variable *consol* provides the relevant consolidation codes required for the selection of the adequate statements. The different consolidations status captured within the variable *consol* are:

- C1: statement of a mother bank integrating the statements of its controlled subsidiaries or branches with no unconsolidated companion;
- C2: statement of a mother bank integrating the statements of its controlled subsidiaries or branches with an unconsolidated companion;
- C*: additional consolidated statement;
- U1: statement not integrating the statements of the possible controlled subsidiaries or branches of the concerned bank with no consolidated companion;
- U2: statement not integrating the statements of the possible controlled subsidiaries or branches of the concerned bank with a consolidated companion;
- U*: additional unconsolidated statement;
- A1: aggregated statement with no companion;
- A2: aggregated statement with one companion;
- NA: bank with no statement; only the name and address are available;

where the term 'companion' refers to an additional balance sheet statement for the exact same bank as identified by its *bvdidnum*. As highlighted in the main text, an analysis at the consolidated level is preferred for the study at hand because strategic lending decisions are expected to be taken at the group level. In order to obtain the longest possible time series, additional/mid-year (*) statements published between two main statements were considered as well. Following Thibaut and Mathias (2015), the following priority rule was applied: C1/C2 > C* > U1/U2 > U*. Thus, for banks for which several consolidation status were available, duplicates were iteratively dropped favouring consolidated statements over unconsolidated ones and type 1 or 2 statements over complementary statements (*).

Remaining duplicates: Statement status, quality, accounting standards and currency: The Bankscope dataset contains some bank observations that have the same *consolidation code* but different financial information (e.g. value of total assets/gross loans) for a given bank in a given year due to differences in reporting procedures and accounting standards. To remove those remaining duplicates, four other variables were considered: *statement status, status quality, accounting standards, reporting currency*. In essence, restated/revised statements were favoured over original statements, and original statements favoured over proforma statements (*statement status*); moreover, preference was given to unqualified reports, and qualified reports were preferred to not audited reports (*status quality*). Next, the observations using the accounting standard less frequently than used by the respective banks were dropped, and finally, statements published in US-Dollars were preferred to statements published in other currencies[95].

[95] The thinking behind this last step was that a single currency conversion from USD into EUR would be less prone to rounding errors than a conversion of data reported in the national currency into USD using the exchange rate provided by Bankscope, followed by a conversion from USD into EUR using Eurostat data (see section on data comparability below).

Subsidiaries

Even after dealing with the consolidation and reporting standard issues as described above, there remains an important double counting issue due to bank parent/subsidiary relations. In particular, sub-consolidated statements, that is the (consolidated or unconsolidated) statements of a bank subsidiary which are themselves included in the consolidated statements of the parent bank, are recorded in Bankscope as well, thus resulting in a double counting of the financial positions of the subsidiary. To address this issue, a separate Bankscope database about ownership structures of banks was used to exclude all banks from the sample that had a majority shareholder (direct ownership of over 50%) that was itself represented in the sample and that provided a consolidated statement.

A second approach to dealing with the issue of subsidiaries using the variable *entity type* was considered as well. The variable entity type would allow to only include banks at the highest level of ownership, that is Global ultimate owners (company which is the ultimate owner of a corporate group), independent companies (company which is not a GUO but could be a GUO; company that has BvD independence indicator A or B and that has neither shareholders nor subsidiaries) and single location companies (a company which has no ownership links). However, relying on the variable *entity type* would have resulted in the exclusion of partially dependent companies that are owned by banks outside the European Union which are not represented in the sample.

Data comparability

Yearly observations: While most banks publish their financial statements at the end of December, some banks follow a non-calendar fiscal year to report their statements. Moreover, in an attempt to provide the longest possible time series, mid-year statements (consolidation status C* or U*, see above) were considered in the sample as well. Therefore, statements published at various closing dates had to be correctly allocated to the appropriate year. All statements published between January and May in year t were assumed to contain year t-1 information, while all statements published between July and December in year t were considered year t information. Statements published in June were dropped since it was unclear whether to attribute those observations to year t or t-1.

Currency: Financial statements recorded within Bankscope are reported in different currencies. All variables were converted into Euros using a 2-step process: first, all statements not reported in either Euros or US-Dollars were converted into US-Dollars using the Bankscope variable *exchrate*, which provides the exchange rate in USD of a given observation with respect to the date and currency unit of the values expressed in currency unit. Secondly, monthly Eurostat data was used to convert values reported in US-Dollars into euros[96].

Units: The variable *unit* was used to convert all numerical values (excluding ratios and growth rates) reported by different banks into millions.

[96] The end of month exchange rate was used since the vast majority of statements available on Bankscope are published at the end of a month. For those banks that reported their financial statements at the beginning of the month, the exchange rate conversion is thus not perfectly accurate.

Annex 2 Listed bank sample features

Table 46 below shows the number of banks and banking sector asset coverage at the Member State level for the list bank sample sourced from Bloomberg – 208 banks are covered and 37.5% of EU banking sector assets, on average. A relatively large proportion of EU banking sector assets is represented because listed banks tend to be large but, as the number of banks covered in some Member States is particularly small, the Bankscope sample is preferred for its representativeness of the EU.

Table 47 shows how the requirement for bank-level data to be present for all variables in at least one period in the transitional effects analysis reduces the number of banks entering the estimation sample substantially.

Table 46: Number of banks and asset coverage, by Member State

	Number of banks	Asset coverage
AT	13	57.0%
BE	2	75.0%
BG	4	53.9%
CY	4	47.6%
CZ	0	0.0%
DE	11	21.0%
DK	32	90.5%
EE	0	0.0%
EL	11	99.2%
ES	11	30.8%
FI	5	47.5%
FR	9	31.3%
HR	11	38.4%
HU	2	65.2%
IE	3	18.5%
IT	35	76.8%
LT	4	93.2%
LU	4	47.5%
LV	1	15.2%
MT	1	63.9%
NL	6	10.7%
PL	13	90.8%
PT	5	52.3%
RO	1	44.1%
SE	4	84.7%
SI	4	30.8%
SK	3	21.7%
UK	9	29.7%
EU	208	37.5%

Notes: The table reports the number of banks and asset shares at the Member State level covered in the sample used in estimating the baseline econometric model. The percentage of assets covered is based on reported 2013 assets
Source: Bloomberg and LE Europe calculations

Table 47: Number of banks by variable

	$ln(NETLENDING)_{it}$	$ln(NETLENDING)_{it-1}$	CAP_{it}	$ln(SIZE)_{it}$	LIQ_{it}	$WHOLE_{it}$	$PROFIT._{it}$	LEV_{it}	*FINAL MODEL*
AT	14	14	14	14	13	13	13	13	13
BE	3	3	2	2	2	2	2	2	2
BG	5	5	4	4	4	4	4	4	4
CY	5	5	5	5	4	4	4	4	4
CZ	1	1	1	1	1	1	1	1	
DE	26	22	16	16	12	12	11	11	11
DK	48	45	45	45	34	33	33	33	32
EE	2	2	2	2	2	2	2	2	
EL	12	12	11	11	11	11	11	11	11
ES	22	17	16	16	11	11	11	11	11
FI	7	7	7	7	5	5	5	5	5
FR	27	26	12	12	10	9	9	9	9
HR	18	18	14	14	12	12	12	12	11
HU	3	3	3	3	3	3	3	3	2
IE	4	3	3	3	3	3	3	3	3
IT	45	42	39	39	37	37	36	36	35
LT	4	4	4	4	4	4	4	4	4
LU	4	4	4	4	4	4	4	4	4
LV	2	1	1	1	1	1	1	1	1
MT	2	2	1	1	1	1	1	1	1
NL	7	6	6	6	6	6	6	6	6
PL	17	17	15	15	13	13	13	13	13
PT	10	10	7	7	5	5	5	5	5
RO	2	1	1	1	1	1	1	1	1
SE	8	8	8	8	5	5	5	5	4
SI	4	4	4	4	4	4	4	4	4
SK	4	4	3	3	3	3	3	3	3
UK	21	20	16	15	10	10	10	10	9
EU	327	306	264	263	221	219	217	217	208

Note: Each column reports the number of banks in the sample by Member State, for which data is available: i) for the variable the column relates to; and ii) *all the variables the previous columns (to the left) relate to.* The last column reports the number of banks in the sample for the final model specification, which includes the country-level variables $\Delta lnCB_{it}$, ΔIB_{it}, $\Delta lnGDP_{it}$, Π_{jt} and $OUTPUT\ GAP_{it}$ Source: Bloomberg and LE calculations

Annex 3 Detailed list of variables used in econometric analyses

Variable	Definition	Source	Data series
Lending variables			
ln(NETLENDING)[97]	Natural logarithm of the flow of total loans	Bankscope	data2001
ln(CONS)[98]	Natural logarithm of the flow of loans and leases to individuals (except for loans secured by residential property)	Bankscope	data11050
ln(MORTGAGES)[99]	Natural logarithm of the flow of loans secured by residential property	Bankscope	data11040
ln(CORP)[100]	Natural logarithm of the flow of loans and leases to corporate and commercial enterprises	Bankscope	data11060
Ln(GROSS LOANS)	Natural logarithm of outstanding loans, excluding reserves for impaired loans/non-performing loans	Bankscope	data2001
ln(GROSS LENDING) (infrastructure)	Natural logarithm of gross lending in terms of bank financing to infrastructure	InfraDeals	
Regulatory capital ratios and regimes			
CAP	Quotient of Total Capital and Risk Weighted Assets at *t-1*	Bankscope	data2125
T1	Quotient of Tier One (T1) and Risk Weighted Assets at *t-1*	Bankscope	data2130
CAPCUSHION	Quotient of Total Capital and Risk Weighted Assets at t-1 minus 8 percent	Bankscope	data2125
Bank characteristics			
ln(SIZE)	Natural logarithm of total assets at *t-1*	Bankscope	data2025
LIQ	Quotient of Cash and trading securities, and total assets at *t-1*	Bankscope	data11270, data11150, data2025

[97] The difference in gross loans can be negative, and the natural logarithm of a negative value is undefined. To ensure both positive and negative values for the difference in gross loans are included, a constant of 1,342 for the Bankscope dataset (14,263.56 for the Bloomberg dataset) is added to all values for the difference in gross loans such that the minimum value of the difference in gross loans is just positive, as is common in the literature

98 To ensure both positive and negative values for the difference in consumer loans are included, a constant of 9,996 is added to all values for the difference in gross loans such that the minimum value of the difference in loans is just positive

99 To ensure both positive and negative values for the difference in mortgage loans are included, a constant of 790 is added to all values for the difference in gross loans such that the minimum value of the difference in gross loans is just positive

100 To ensure both positive and negative values for the difference in corporate loans are included, a constant of 1,681 is added to all values for the difference in gross loans such that the minimum value of the difference in gross loans is just positive

Variable	Definition	Source	Data series
WHOLE	Quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets at *t-1*	Bankscope	data11750, data11550, data2025
PROFITABILITY	Quotient of net income and total assets at t-1 (expressed as percentage)	Bankscope	data18115
LEV	1 – quotient of equity and total assets at t-1 (expressed as percentage)	Bankscope	data4009
Monetary, macroeconomic, etc. characteristics			
Δln(CB)	Difference in the natural logarithm of central bank assets	ECB and national central banks	
ΔIB	Change in the local currency 3-month interbank rate	Bloomberg	EUR003M (euro area countries), CIBO03M (DK), WIBR3M (PL), STBB3M (SE), SOBR3M (BG), ZIBOR3M (HR), BUBR3M (RO), BUBOR03M (HU), PRIB03M (CZ), BP0003M (UK)
Δln(GDP)	Difference in logarithm of real GDP	Eurostat	nama_10_gdp
Π	Inflation rate	Eurostat	prc_hicp_aind
Output gap	Difference between actual and potential GDP as a percentage of potential GDP	AMECO	AVGDGP[101]
CRISIS	Indicator variable equal to 1 from 2008 onwards	n/a	
RECAP AND ASSET REL	Value of recapitalisations and asset relief provided to the financial sector by Member State	EC State Aid Scoreboard	
GUAR AND LIQ SUPP	Value of state guarantees and liquidity support provided to the financial sector by Member State	EC State Aid Scoreboard	
CROSSBORDER	Natural logarithm of the flow of cross-border claims (from domestic banks abroad)	BIS Locational Banking Statistics	Table 5A
FINANCING NEEDS	Underlying reasons for credit demand	ECB and national central banks: Bank Lending Survey	
USE OF ALT FINANCE	Borrowers use of other sources of funding than that provided by banks	ECB and national central banks: Bank Lending	

[101] Autumn 2015 forecasts (last updated on 22.10.2015) were used for the analysis. These forecasts can be found here: http://ec.europa.eu/economy_finance/eu/forecasts/2015_autumn/statistical_en.pdf

Variable	**Definition**	**Source**	**Data series**
		Survey	
ΔSOV YIELD	Difference in the sovereign yield at Member State level	Bloomberg	GT[COUNTRY CODE]M10Y Govt
MKT VOL	Market volatility	Bloomberg	
COST OF FUNDS	Banks' perceptions of funding costs	ECB and national central banks: Bank Lending Survey	
COMPETITION	Banks' perceptions of competition to supply credit	ECB and national central banks: Bank Lending Survey	
RISK PERCEPTIONS	Banks' perceptions of risks	ECB and national central banks: Bank Lending Survey	
Infrastructure project financing characteristics			
TRANSACTION SIZE	Total value of transactions undertaken by a bank during period	InfraDeals	
TOTAL BANK FUNDUNG	Average proportion of bank funding for the projects k at time t	InfraDeals	

Annex 4 Choice of estimation method for analysis of transitional effects

The baseline econometric model is estimated using the system GMM estimator proposed by Blundell and Bond (1998) for the following reasons.

Rationale for the choice of the system GMM framework: The baseline econometric model includes bank-specific effects (θi) and includes the past values of the dependent variable ($ln(NETLENDING)_{ijt-s}$, where s>0) as predictors for its value in the current period. The presence of bank-specific effects and lagged dependent variables present problems in the estimation of the dynamic panel data model using OLS and fixed effects estimation.

Firstly, past values of bank lending for bank *i* are a function of the bank-specific effects that are time invariant, therefore OLS estimation of equation (1) yields biased and inconsistent estimates as the model suffers from endogeneity (Nickell, 1981).

Secondly, while fixed effects estimation removes the bank-specific effects (θ_i), the estimates remain biased and inconsistent if T is small[102] as lags of the dependent variable are correlated with the average value of the error term, even if it is not serially correlated (Baltagi, 2005). In the present context, bank-specific effects are removed by measuring deviations of individual observations from group means using the fixed effects estimator. However, the group mean for the error term contains past values, such as $\varepsilon_{i,t-1}$, which are correlated with $ln(NETLENDING)_{ijt-1}$.

Given the above issues, a system GMM framework will be used to estimate the baseline econometric model in equation (1). Conventional estimators, such as OLS and two-stage least squares (2SLS), can be derived from GMM estimation. However, when standard assumptions such as homoskedasticity fail to hold, GMM estimation provides more efficient estimates (Wooldridge, 2001). Heteroskedasticity may be present in the current data as the variance of errors may change as regulatory capital ratios grow.

System GMM description: Developed by Blundell and Bond (1998), a system GMM specifies a system of equations in levels and first-difference, using (respectively, lagged levels and difference) instruments for the (respectively, first-difference and level) endogenous variables. The system GMM approach is designed to address particular assumptions made about the data generating process. More specifically, it allows for the dynamic nature of the dependent variable, where past realisations determine the current one, the potential for endogenous regressors and bank-specific effects.

Rationale for the choice of system over difference GMM estimation: System GMM estimation builds on the difference GMM approach proposed by Arellano and Bond (1991) as it introduces a transformed equation (alongside the original equation of interest), which uses first-difference instruments that are assumed to be exogenous to the bank-specific effects.[103][104]

[102] Simulation results have shown that the bias can be significant even with as many as 30 time periods (see Judson and Owen, 1999)
[103] The difference GMM estimation is carried out by first-differencing the data in order to eliminate the bank-specific effects
[104] In order to perform system GMM estimation, a quasi-stationarity assumption is made, which requires deviations from the long-run mean of the dependent variable to be uncorrelated with the stationary bank-specific long-run mean

In the current setting, system GMM estimation is preferred to the difference GMM procedure for the following reasons.

System GMM estimation addresses the problem of weak instruments that may arise in the difference GMM approach due to a lack of correlation between the instrumental variables and the regressors in the first-difference model.

The problem of weak instruments arises using the difference GMM approach if the dependent variable shows a high level of persistence over time. The difference GMM approach regresses the differenced dependent variable on lagged levels of variables that serve as instruments. However, if the dependent variable is highly persistent in levels, the instruments in levels contain little information about the future values of the differenced dependent variable.

Blundell and Bond (1998) illustrate the impact of weak instruments, which leads to erratic behaviour and bias in the difference GMM estimator. Moreover, they use Monte-Carlo simulations to demonstrate dramatic efficiency gains on parameter estimates using the system GMM approach instead of difference GMM. Hence, resulting estimates of the parameters of interest from system GMM are both consistent and unbiased, as well as being more efficient and robust.

Use of system GMM estimation in banking studies: A number of studies have reported a high level of persistence in bank lending and capital structures data. For example, Carlson et al. (2013) examine the impact of capital ratios on bank lending in the US and find persistence in bank lending flows, that is, banks with high bank lending flows tend to continue to have high bank lending flows. Findings from Lemmon et al. (2005), Huang and Ritter (2009) and Meeks (2012) show a high level of persistence in capital ratios. Moreover, Flannery and Hankins (2012) recommend the use of system GMM in areas of corporate finance when the level of persistence of the dependent variable is unknown.

Given the above, the use of system GMM estimation has become widely used in the literature on the bank lending channel of monetary policy transmission, which also takes into account capital ratios. For example, Brei, Gambacorta and von Peter (2013) use a system GMM methodology to examine the impact of rescue measures adopted by 14 major advanced economies during the global financial crisis on the supply of bank lending. Gambacorta and Marques-Ibanez (2011) adopt a similar methodology to investigate the impact on bank loan supply in 15 countries due to shocks to monetary policy during the financial crisis. Hence, under the current setting, the use of system GMM is justified.

Preference for two-step GMM estimation over standard 2SLS: It is common practice to report both one-step and two-step GMM estimations. One-step GMM estimation is equivalent to 2SLS when the error term is homoskedastic; however one-step GMM estimates are more efficient and perform better in the presence of unknown heteroskedasticity and serial correlation in the error term. Two-step GMM estimation uses the consistent variance-covariance estimate from the first-step estimation to update the weighting matrix in the second-step, which produces an asymptotically more efficient estimator (Cameron and Trivedi, 2005).

Other issues: The validity of GMM estimation relies on the exogeneity of the instruments, that is, the values of the instruments are independently distributed of the error process. This can be checked using the Sargan-Hansen test, which tests the null hypothesis that the joint validity of the moment conditions is equal to zero.

It is also important to note the potential issues that arise from the use of GMM estimation. In particular, Roodman (2009) reports the issues faced when too many instruments are used in a GMM framework. Specifically, 'instrument proliferation' can lead to over-fitting instrumented variables and imprecise estimates of the optimal weighting matrix, which leads to biased standard errors and weakens the Hansen specification test. These issues will be overcome by using principle components analysis to limit the instrument set. Additionally, the Windmeijer (2005) finite-sample correction in the two-step estimation is used to correct the downward biased standard errors due to the use of too many instruments.

Annex 5 Additional transitional effects analysis

Baseline econometric model

The table below reports regression results for the baseline econometric model presented in the main report.

Table 48: Baseline results

Dependent variable: *ln(NETLENDING)*	(1)	(2)	(3)	Baseline (4)
$ln(NETLENDING)_{it-1}$	0.375***	0.353***	0.347***	0.339***
	(0.000)	(0.000)	(0.000)	(0.000)
$ln(NETLENDING)_{it-2}$	0.134*	0.140**	0.135**	0.131**
	(0.055)	(0.036)	(0.034)	(0.042)
$ln(SIZE)_{it}$	0.031**	0.039***	0.036***	0.038***
	(0.010)	(0.000)	(0.000)	(0.000)
CAP_{it}	-0.011***	-0.010***	-0.008***	-0.008***
	(0.000)	(0.000)	(0.001)	(0.001)
LIQ_{it}	0.111*	0.032	0.014	-0.018
	(0.051)	(0.608)	(0.817)	(0.767)
$WHOLE_{it}$	-0.020	-0.050	-0.037	-0.033
	(0.800)	(0.518)	(0.630)	(0.668)
$\Delta ln(CB)_{jt}$	-0.089***	-0.055**	-0.053**	-0.067**
	(0.001)	(0.049)	(0.043)	(0.014)
ΔIB_{jt}	-0.006	-0.005	-0.003	-0.009
	(0.244)	(0.362)	(0.525)	(0.133)
$\Delta ln(GDP)_{jt}$	0.903***	0.698***	0.688***	0.559***
	(0.000)	(0.000)	(0.000)	(0.000)
Π_{jt}	0.027***	0.020***	0.018***	0.012*
	(0.000)	(0.002)	(0.002)	(0.060)
$PROFITABILITY_{it}$		0.049***	0.047***	0.043***
		(0.000)	(0.000)	(0.000)
LEV_{it}			0.000	0.000
			(0.892)	(0.908)
$OUTPUT\ GAP_{jt}$				-0.958***
				(0.003)
C	3.489***	3.534***	3.639***	3.683***
Number of observations	11,068	10,720	10,719	10,719
Cross-sectional units	2,371	2,364	2,364	2,364
AR(2) (p-value)	0.793	0.685	0.698	0.710
Diff-in-Hansen test (p-value)	0.477	0.154	0.301	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets; *CAP* is the Total Capital Ratio*; LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; п is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe calculations

Robustness tests

A number of checks have been carried out to test the robustness of the final baseline results presented in column (4) in the table above. The tables below report coefficients and p-values for the results discussed in the main report.

Alternative regulatory capital ratio

The table below presents in column (1) the baseline model with the Tier 1 ratio in place of the Total Capital Ratio; and in column (2), the baseline results are reproduced for comparison.

Table 49: Robustness checks: Alternative regulatory capital ratio

Dependent variable: *ln(NETLENDING)*	(1)	Baseline (2)
ln(NETLENDING)$_{it-1}$	0.323***	0.339***
	(0.000)	(0.000)
ln(NETLENDING)$_{it-2}$	0.132**	0.131**
	(0.041)	(0.042)
ln(SIZE)$_{it}$	0.038***	0.038***
	(0.001)	(0.000)
CAP$_{it}$		-0.008***
		(0.001)
T1$_{it}$	-0.005*	
	(0.080)	
LIQ$_{it}$	-0.052	-0.018
	(0.490)	(0.767)
WHOLE$_{it}$	-0.025	-0.033
	(0.749)	(0.668)
Δln(CB)$_{jt}$	-0.109***	-0.067**
	(0.001)	(0.014)
ΔIB$_{jt}$	-0.015**	-0.009
	(0.017)	(0.133)
Δln(GDP)$_{jt}$	1.283***	0.559***
	(0.000)	(0.000)
Π$_{jt}$	0.032***	0.012*
	(0.000)	(0.060)
PROFITABILITY$_{it}$	0.043***	0.043***
	(0.000)	(0.000)
LEV$_{it}$	0.001	0.000
	(0.595)	(0.908)
OUTPUT GAP$_{jt}$	-1.200***	-0.958***
	(0.004)	(0.003)
C	3.574***	3.683***
Number of observations	7,665	10,719
Cross-sectional units	2,065	2,364
AR(2) (p-value)	0.600	0.710
Diff-in-Hansen test (p-value)	0.000	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *CAP* is the Total Capital ratio; *T1* is the Tier One Capital ratio; *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe calculations

Impact of the crisis and crisis interventions

Robustness tests regarding the impact of the crisis discussed in the main text are presented in the table below.

Table 50: Robustness checks: Impact of the crisis and crisis interventions

Dependent variable: *ln(NETLENDING)*	(1)	(2)	(3)	(4)	Baseline (5)
ln(NETLENDING)$_{it-1}$	0.281***	0.338***	0.337***	0.334***	0.339***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(NETLENDING)$_{it-2}$	0.130**	0.131**	0.130**	0.130**	0.131**
	(0.028)	(0.042)	(0.043)	(0.043)	(0.042)
ln(SIZE)$_{it}$	0.113***	0.039***	0.037***	0.040***	0.038***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
*ln(SIZE)$_{it}$*CRISIS*	-0.112***				
	(0.000)				
CAP$_{it}$	-0.001	-0.008***	-0.007***	-0.006***	-0.008***
	(0.468)	(0.002)	(0.003)	(0.008)	(0.001)
*CAP$_{it}$*CRISIS*	-0.003**				
	(0.025)				
LIQ$_{it}$	-0.046	-0.012	-0.071	-0.091	-0.018
	(0.554)	(0.838)	(0.250)	(0.140)	(0.767)
*LIQ$_{it}$*CRISIS*	-0.074				
	(0.560)				
WHOLE$_{it}$	-0.177**	-0.029	-0.064	-0.074	-0.033
	(0.038)	(0.706)	(0.405)	(0.334)	(0.668)
*WHOLE$_{it}$*CRISIS*	0.086				
	(0.400)				
Δln(CB)$_{jt}$	-0.029	-0.075**	-0.037	-0.046	-0.067**
	(0.232)	(0.010)	(0.215)	(0.122)	(0.014)
ΔIB$_{jt}$	-0.007	-0.008	-0.009	-0.005	-0.009
	(0.199)	(0.186)	(0.110)	(0.384)	(0.133)
Δln(GDP)$_{jt}$	0.407**	0.530***	0.654***	0.611***	0.559***
	(0.011)	(0.001)	(0.000)	(0.000)	(0.000)
Π$_{jt}$	0.019***	0.013**	0.010	0.014**	0.012*
	(0.001)	(0.041)	(0.103)	(0.027)	(0.060)
PROFITABILITY$_{it}$	-0.006	0.042***	0.043***	0.043***	0.043***
	(0.458)	(0.000)	(0.000)	(0.000)	(0.000)
*PROFITABILITY$_{it}$*CRISIS*	0.052***				
	(0.000)				
LEV$_{it}$	-0.007**	0.000	0.002	0.002	0.000
	(0.018)	(0.911)	(0.367)	(0.495)	(0.908)
*LEV$_{it}$*CRISIS*	0.007***				
	(0.000)				
OUTPUT GAP$_{jt}$	0.013	-1.011***	-0.549	-0.437	-0.958***
	(0.968)	(0.004)	(0.170)	(0.274)	(0.003)
C	4.279***	3.719***	3.550***	3.591***	3.683***
RECAP AND ASSET REL$_{j}$	N	Y	N	Y	N
GUAR AND LIQ SUPP$_{j}$	N	N	Y	Y	N
STRUCTURAL SHIFTS$_{i}$	Y	N	N	N	N
Number of observations	10,719	10,719	10,719	10,719	10,719
Cross-sectional units	2,364	2,364	2,364	2,364	2,364
AR(2) (p-value)	0.604	0.712	0.724	0.744	0.710
Diff-in-Hansen test (p-value)	0.476	0.126	0.270	0.208	0.110

Notes: see overleaf.

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *CAP* is the Total Capital ratio; *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; *RECAP AND ASSET REL* is the value of recapitalisations and asset relief provided to the financial sector by Member State; *GUAR AND LIQ SUPP* is the value of state guarantees and liquidity support provided to the financial sector by Member State; and *STRUCTURAL SHIFTS* are interactive terms between bank characteristics and an indicator variable equal to 1 from 2008 onwards (crisis); and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** $p<0.01$, ** $p<0.05$, * $p<0.1$
Source: Bankscope and LE Europe calculations

Impact of cross-border lending

The coefficients and p-values for the regression investigating the impact of cross-border lending are presented in the table below.

Table 51: Robustness checks: Impact of cross border lending

Dependent variable: *ln(NETLENDING)*	(1)	Baseline (2)
ln(NETLENDING)$_{it-1}$	0.350***	0.339***
	(0.000)	(0.000)
ln(NETLENDING)$_{it-2}$	0.109	0.131**
	(0.116)	(0.042)
ln(SIZE)$_i$	0.046***	0.038***
	(0.000)	(0.000)
CAP$_i$	-0.007***	-0.008***
	(0.006)	(0.001)
LIQ$_i$	0.042	-0.018
	(0.515)	(0.767)
WHOLE$_i$	-0.037	-0.033
	(0.614)	(0.668)
Δln(CB)$_i$	-0.091***	-0.067**
	(0.001)	(0.014)
ΔIB$_i$	-0.004	-0.009
	(0.588)	(0.133)
Δln(GDP)$_i$	0.067	0.559***
	(0.857)	(0.000)
Π$_i$	0.026***	0.012*
	(0.004)	(0.060)
PROFITABILITY$_i$	0.040***	0.043***
	(0.000)	(0.000)
LEV$_i$	0.000	0.000
	(0.963)	(0.908)
OUTPUT GAP$_i$	-1.070***	-0.958***
	(0.002)	(0.00331)
CROSS-BORDER$_i$	-0.002	
	(0.129)	
C	3.727***	-3.683***
Number of observations	10,203	10,719
Cross-sectional units	2,233	2,364
AR(2) (p-value)	0.631	0.710
Diff-in-Hansen test (p-value)	0.278	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *CAP* is the Total Capital ratio; *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; *CROSS-BORDER* is the share of cross-border claims to total claims outstanding (in the host country); and C is a constant. The model is estimated using the two-step system GMM estimator and robustness standard errors, bank-level variables are instrumented for by using their lags. . Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe calculations

Non-linear responses to capital shocks

The results for the model version including a second-order term for the regulatory capital ratio, CAP^2_{ijt} are presented in the table below.

Table 52: Robustness checks: Non-linear responses to capital shocks

Dependent variable: *ln(NETLENDING)*	(1)	Baseline (2)
$ln(NETLENDING)_{it-1}$	0.328***	0.339***
	(0.000)	(0.000)
$ln(NETLENDING)_{it-2}$	0.121*	0.131**
	(0.059)	(0.042)
$ln(SIZE)_{it}$	0.034***	0.038***
	(0.001)	(0.000)
CAP_{it}	-0.034***	-0.008***
	(0.000)	(0.001)
CAP^2_{it}	0.001***	
	(0.000)	
LIQ_{it}	-0.055	-0.018
	(0.376)	(0.767)
$WHOLE_{it}$	-0.088	-0.033
	(0.296)	(0.668)
$\Delta ln(CB)_{jt}$	-0.086***	-0.067**
	(0.002)	(0.014)
ΔIB_{jt}	-0.009	-0.009
	(0.112)	(0.133)
$\Delta ln(GDP)_{jt}$	0.631***	0.559***
	(0.000)	(0.000)
Π_{jt}	0.013**	0.012*
	(0.046)	(0.060)
$PROFITABILITY_{it}$	0.044***	0.043***
	(0.000)	(0.000)
LEV_{it}	0.001	0.000
	(0.476)	(0.908)
$OUTPUT\ GAP_{jt}$	-0.998***	-0.958***
	(0.002)	(0.003)
C	4.016***	3.683***
Number of observations	10,719	10,719
Cross-sectional units	2,364	2,364
AR(2) (p-value)	0.732	0.710
Diff-in-Hansen test (p-value)	0.055	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital ratio; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; CAP^2 is a second-order term for the Total Capital Ratio; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe calculations

Demand for bank credit

The table below presents the results of the robustness checks on capturing the demand for bank credit.

Table 53: Robustness tests: Demand for bank credit

Dependent variable: *ln(NETLENDING)*	(1)	(2)	(3)	Baseline (5)
$ln(NETLENDING)_{it-1}$	0.303***	0.298***	0.298***	0.339***
	(0.000)	(0.000)	(0.000)	(0.000)
$ln(NETLENDING)_{it-2}$	0.179***	0.158**	0.159**	0.131**
	(0.008)	(0.025)	(0.025)	(0.042)
$ln(SIZE)_{it}$	0.038***	0.049***	0.049***	0.038***
	(0.001)	(0.000)	(0.000)	(0.000)
CAP_{it}	-0.007**	-0.006*	-0.006*	-0.008***
	(0.022)	(0.091)	(0.089)	(0.001)
LIQ_{it}	-0.139	-0.474***	-0.463***	-0.018
	(0.134)	(0.000)	(0.000)	(0.767)
$WHOLE_{it}$	-0.045	-0.239**	-0.222***	-0.033
	(0.601)	(0.011)	(0.008)	(0.668)
$\Delta ln(CB)_{jt}$	-0.067**	-0.190***	-0.183***	-0.067**
	(0.013)	(0.000)	(0.000)	(0.014)
ΔIB_{jt}	-0.020**	0.013	0.011	-0.009
	(0.017)	(0.182)	(0.305)	(0.133)
$\Delta ln(GDP)_{jt}$	0.297	0.730***	0.669***	0.559***
	(0.129)	(0.000)	(0.000)	(0.000)
Π_{jt}	0.046***	0.046***	0.048***	0.012*
	(0.000)	(0.000)	(0.000)	(0.060)
$PROFITABILITY_{it}$	0.046***	0.038***	0.038***	0.043***
	(0.001)	(0.001)	(0.001)	(0.000)
LEV_{it}	0.000	0.003	0.003	0.000
	(0.900)	(0.413)	(0.452)	(0.908)
$OUTPUT\ GAP_{jt}$	-0.106	-0.447	-0.350	-0.958***
	(0.855)	(0.404)	(0.573)	(0.003)
$FINANCING\ NEEDS_{jt}$	0.002***		0.000	
	(0.000)		(0.481)	
$USE\ OF\ ALT\ FINANCE_{jt}$		0.017***	0.016***	
		(0.000)	(0.000)	
C	3.574***	3.481***	3.465***	3.683***
Number of observations	8,460	8,451	8,451	10,719
Cross-sectional units	1,975	1,971	1,971	2,364
AR(2) (p-value)	0.387	0.326	0.326	0.710
Diff-in-Hansen test (p-value)	0.008	0.006	0.033	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital Ratio; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; п is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; *FINANCING NEEDS* relates to the underlying reasons for credit demand; *USE OF ALT FINANCE* relates to borrowers use of other sources of funding than that provided by banks; and C is a constant. The model is estimated using the two-step system GMM estimator and robustness standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe calculations

Supply of bank credit

The table below presents the results of the robustness checks on capturing different supply drivers of bank credit.

Table 54: Robustness checks: Supply of bank credit

Dependent variable: *ln(NETLENDING)*	(1)	(2)	(3)	(4)	(5)	(6)	Baseline (7)
ln(NETLENDING)$_{it-1}$	0.312***	0.296***	0.313***	0.301***	0.343***	0.339***	0.339***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(NETLENDING)$_{it-2}$	0.158**	0.152**	0.164**	0.165**	0.165***	0.131**	0.131**
	(0.022)	(0.020)	(0.017)	(0.010)	(0.010)	(0.041)	(0.042)
ln(SIZE)$_{it}$	0.039***	0.039***	0.035***	0.037***	0.044***	0.037***	0.038***
	(0.000)	(0.000)	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)
CAP$_{it}$	-0.009***	-0.007***	-0.010***	-0.007***	-0.006***	-0.008***	-0.008***
	(0.006)	(0.010)	(0.004)	(0.007)	(0.010)	(0.002)	(0.001)
LIQ$_{it}$	-0.041	-0.182*	0.058	-0.082	0.017	-0.016	-0.018
	(0.611)	(0.089)	(0.501)	(0.449)	(0.793)	(0.796)	(0.767)
WHOLE$_{it}$	-0.071	-0.226*	-0.032	-0.167	-0.023	-0.033	-0.033
	(0.422)	(0.060)	(0.731)	(0.169)	(0.740)	(0.670)	(0.668)
Δln(CB)$_{jt}$	-0.010	-0.041	-0.061**	-0.061**	-0.085***	-0.052**	-0.067**
	(0.718)	(0.109)	(0.021)	(0.033)	(0.001)	(0.043)	(0.014)
ΔIB$_{jt}$	-0.012	-0.034***	-0.031***	-0.053***	-0.012*	-0.010*	-0.009
	(0.148)	(0.000)	(0.001)	(0.000)	(0.076)	(0.094)	(0.133)
Δln(GDP)$_{jt}$	0.130	1.048***	0.593***	1.221***	0.575***	0.513***	0.559***
	(0.571)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Π$_{jt}$	0.043***	0.050***	0.045***	0.064***	0.028***	0.013**	0.012*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.039)	(0.060)
PROFITABILITY$_{it}$	0.043***	0.036***	0.043***	0.035***	0.041***	0.042***	0.043***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.000)	(0.000)	(0.000)
LEV$_{it}$	-0.001	0.001	-0.002	0.000	-0.001	0.001	0.000
	(0.770)	(0.769)	(0.494)	(0.956)	(0.801)	(0.740)	(0.908)
OUTPUT GAP$_{jt}$	-0.002	0.787	-0.444	0.834	-0.622*	-1.027***	-0.958***

	(0.997)	(0.336)	(0.407)	(0.305)	(0.061)	(0.002)	(0.003)
ΔSOV YIELD					0.006		
					(0.148)		
MKT VOL						-0.001**	
						(0.021)	
COST OF FUNDS	-0.004***			0.001			
	(0.005)			(0.284)			
COMPETITION		-0.015***		-0.016***			
		(0.004)		(0.004)			
RISK PERCEPTIONS			-0.002***	-0.002***			
			(0.001)	(0.000)			
C	3.752***	3.674***	3.844***	3.623***	3.372***	3.648***	3.683***
Number of observations	8,467	8,467	8,467	8,467	10,230	10,719	10,719
Cross-sectional units	1,974	1,974	1,974	1,974	2,250	2,364	2,364
AR(2) (p-value)	0.323	0.248	0.319	0.217	0.673	0.714	0.710
Diff-in-Hansen test (p-value)	0.013	0.206	0.079	0.055	0.189	0.181	0.110

ln(NETLENDING) is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; *ΔSOV YIELD* is the difference in the sovereign yield at Member State level; *MKT VOL* measures market volatility; *COST OF FUNDS* measures banks' perceptions of funding costs; *COMPETITION* measures banks' perceptions of competition to supply credit; *RISK PERCEPTIONS* measures banks' perceptions of risks; and C is a constant. The model is estimated using the two-step system GMM estimator and robustness standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1.
Source: Bankscope and LE Europe calculations

Country and year fixed effects

The table below presents results for re-estimations of the baseline model that include country and year fixed effects.

Table 55: Country and year fixed effects

Dependent variable: *ln(NETLENDING)*	(1)	(2)	Baseline (3)
$ln(NETLENDING)_{it-1}$	0.241***	0.320***	0.339***
	(0.000)	(0.000)	(0.000)
$ln(NETLENDING)_{it-2}$	0.047	0.122*	0.131**
	(0.409)	(0.058)	(0.042)
$ln(SIZE)_{it}$	0.032	0.046***	0.038***
	(0.111)	(0.000)	(0.000)
CAP_{it}	-0.010***	-0.005**	-0.008***
	(0.000)	(0.045)	(0.001)
LIQ_{it}	-0.243**	-0.318***	-0.018
	(0.013)	(0.000)	(0.767)
$WHOLE_{it}$	-0.242**	-0.219**	-0.033
	(0.023)	(0.014)	(0.668)
$\Delta ln(CB)_{jt}$	-0.107***	-0.391***	-0.067**
	(0.001)	(0.004)	(0.014)
ΔIB_{jt}	-0.020***	0.000	-0.009
	(0.002)	(0.965)	(0.133)
$\Delta ln(GDP)_{jt}$	0.863***	-0.986	0.559***
	(0.000)	(0.182)	(0.000)
Π_{jt}	0.018**	0.018**	0.012*
	(0.015)	(0.042)	(0.060)
$PROFITABILITY_{it}$	0.040***	0.037***	0.043***
	(0.000)	(0.000)	(0.000)
LEV_{it}	0.006*	0.003	0.000
	(0.067)	(0.196)	(0.908)
$OUTPUT\ GAP_{jt}$	-1.441***	-0.918	-0.958***
	(0.000)	(0.101)	(0.003)
C	4.379***	3.508***	3.683***
COUNTRY FIXED EFFECTS	Y	N	N
YEAR FIXED EFFECTS	N	Y	N
Number of observations	10,719	10,719	10,719
Cross-sectional units	2,364	2,364	2,364
AR(2) (p-value)	0.988	0.617	0.710
Diff-in-Hansen test (p-value)	0.986	0.178	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital ratio; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1

Source: Bankscope and LE Europe calculations

Capital cushion

Table 56: Capital cushion

Dependent variable: *ln(NETLENDING)*	(1)	(2)	Baseline (3)
$ln(NETLENDING)_{it-1}$	0.296***	0.294***	0.339***
	(0.000)	(0.000)	(0.000)
$ln(NETLENDING)_{it-2}$	0.166**	0.165**	0.131**
	(0.011)	(0.011)	(0.042)
$ln(NETLENDING)_{it-3}$	0.007	0.005	
	(0.905)	(0.933)	
$ln(SIZE)_{it}$	0.033***	0.034***	0.038***
	(0.002)	(0.002)	(0.000)
CAP_{it}	-0.022***	-0.032*	-0.008***
	(0.005)	(0.080)	(0.001)
LIQ_{it}	-0.069	-0.070	-0.018
	(0.273)	(0.249)	(0.767)
$WHOLE_{it}$	-0.062	-0.061	-0.033
	(0.428)	(0.412)	(0.668)
$\Delta ln(CB)_{jt}$	-0.055**	-0.049**	-0.067**
	(0.029)	(0.043)	(0.014)
ΔIB_{jt}	-0.011**	-0.011**	-0.009
	(0.028)	(0.029)	(0.133)
$\Delta ln(GDP)_{jt}$	0.516***	0.505***	0.559***
	(0.001)	(0.001)	(0.000)
Π_{jt}	0.012**	0.010*	0.012*
	(0.036)	(0.070)	(0.060)
$PROFITABILITY_{it}$	0.040***	0.042**	0.043***
	(0.000)	(0.042)	(0.000)
LEV_{it}	0.001	0.001	0.000
	(0.651)	(0.734)	(0.908)
$OUTPUT\ GAP_{jt}$	-0.935***	-0.952***	-0.958***
	(0.002)	(0.003)	(0.003)
*CAPCUSHION*CAP*	0.000***	0.001	
	(0.004)	(0.158)	
$CAPCUSHION^2*CAP$		0.000	
		(0.263)	
C	3.799***	3.951***	3.683***
Number of observations	9,936	9,936	10,719
Cross-sectional units	2,254	2,254	2,364
AR(2) (p-value)	0.821	0.826	0.710
Diff-in-Hansen test (p-value)	0.351	0.211	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital ratio *; Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; п is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; *CAPCUSHION* is the Total Capital ratio – 8%; $CAPCUSHION^2$ *is* a second-order term for *CAPCUSHION*; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe calculations

Net charge-offs

As an additional check of the results, a model is estimated with net charge-offs as a control. The table below presents the results.

Table 57: Net charge-offs

Dependent variable: *ln(NETLENDING)*	(1)	Baseline (3)
ln(NETLENDING)$_{it-1}$	0.342***	0.339***
	(0.000)	(0.000)
ln(NETLENDING)$_{it-2}$	-0.052	0.131**
	(0.485)	(0.042)
ln(SIZE)$_{it}$	0.027*	0.038***
	(0.054)	(0.000)
CAP$_{it}$	-0.007**	-0.008***
	(0.011)	(0.001)
LIQ$_{it}$	-0.270**	-0.018
	(0.011)	(0.767)
WHOLE$_{it}$	0.013	-0.033
	(0.897)	(0.668)
Δln(CB)$_{jt}$	-0.079	-0.067**
	(0.170)	(0.014)
ΔIB$_{jt}$	1.718***	-0.009
	(0.000)	(0.133)
Δln(GDP)$_{jt}$	0.015**	0.559***
	(0.029)	(0.000)
Π$_{jt}$	-0.079	0.012*
	(0.170)	(0.060)
PROFITABILITY$_{it}$	0.052***	0.043***
	(0.001)	(0.000)
LEV$_{it}$	-0.003	0.000
	(0.471)	(0.908)
OUTPUT GAP$_{jt}$	-1.136**	-0.958***
	(0.033)	(0.003)
NCO$_{jt}$	0.001***	
	(0.000)	
C	5.354***	3.683***
Number of observations	3,755	10,719
Cross-sectional units	1,142	2,364
AR(2) (p-value)	0.915	0.710
Diff-in-Hansen test (p-value)	0.000	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital ratio *; Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; п is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; *NCO* is net-charge-offs; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe calculations

Monetary variables expressed in levels

Monetary controls enter the main econometric specification as differences. The table below presents the results for when the baseline model is re-estimated using the level of central bank assets (1), the interbank lending rate (2) and sovereign bond yields (3) instead.

Table 58: Monetary controls in levels

Dependent variable: *ln(NETLENDING)*	(1)	(2)	(3)	Baseline (4)
ln(NETLENDING)$_{it-1}$	0.339***	0.343***	0.337***	0.339***
	(0.000)	(0.000)	(0.000)	(0.000)
ln(NETLENDING)$_{it-2}$	0.137**	0.144**	0.154**	0.131**
	(0.029)	(0.025)	(0.017)	(0.042)
ln(SIZE)$_{it}$	0.034***	0.041***	0.049***	0.038***
	(0.000)	(0.000)	(0.000)	(0.000)
CAP_{it}	-0.007***	-0.007***	-0.006**	-0.008***
	(0.004)	(0.003)	(0.010)	(0.001)
LIQ_{it}	-0.222***	-0.013	-0.062	-0.018
	(0.003)	(0.815)	(0.387)	(0.767)
$WHOLE_{it}$	-0.097	-0.063	-0.109	-0.033
	(0.238)	(0.396)	(0.218)	(0.668)
$\Delta ln(CB)_{jt}$		-0.047*	-0.108***	-0.067**
		(0.075)	(0.000)	(0.014)
ΔIB_{it}	-0.004		-0.018**	-0.009
	(0.506)		(0.016)	(0.133)
$\Delta ln(GDP)_{jt}$	0.281*	0.452***	0.710***	0.559***
	(0.071)	(0.000)	(0.000)	(0.000)
Π_{jt}	0.007	0.005	0.028***	0.012*
	(0.200)	(0.375)	(0.001)	(0.060)
$PROFITABILITY_{it}$	0.038***	0.045***	0.043***	0.043***
	(0.000)	(0.000)	(0.000)	(0.000)
LEV_{it}	0.001	0.000	0.000	0.000
	(0.772)	(0.955)	(0.889)	(0.908)
$OUTPUT\ GAP_{jt}$	-0.839***	-0.474	-1.008***	-0.958***
	(0.007)	(0.158)	(0.003)	(0.003)
$ln(CB)_{jt}$	-0.054***			
	(0.000)			
IB_{it}		0.007**		
		(0.017)		
SOV YIELD			0.015***	
			(0.004)	
C	4.420***	3.566***	3.362***	3.683***
Number of observations	10,729	10,748	10,248	10,719
Cross-sectional units	2,364	2,369	2,254	2,364
AR(2) (p-value)	0.676	0.853	0.704	0.710
Diff-in-Hansen test (p-value)	0.333	0.532	0.226	0.110

Notes: see overleaf.

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital ratio *; Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; *ln(CB) is* the natural logarithm of central bank assets; *IB* is the change in the 3-month interbank rate; *SOV YIELD* is the sovereign yield at Member State level; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe calculations

Alternative sample

Each of the models presented in the "baseline results" and "robustness checks" sections in the main text was re-estimated using a sample of listed banks for which data at a half-yearly frequency is available.

The table below presents the results of re-estimating the models presented in these sections.

Table 59: Robustness checks: Alternative sample

Dependent variable: *ln(NETLENDING)*	Baseline (1)	Profitability (2)	Leverage (3)	Output gap (4)	Baseline (5)
$ln(NETLENDING)_{it-1}$	-0.028	0.044	0.009	-0.068	0.339***
	(0.863)	(0.749)	(0.946)	(0.561)	(0.000)
$ln(NETLENDING)_{it-2}$					0.131**
					(0.042)
$ln(SIZE)_{it}$	0.000	0.008	0.022	0.021	0.038***
	(0.991)	(0.621)	(0.406)	(0.270)	(0.000)
CAP_{it}	-0.014*	-0.008	-0.017**	-0.014**	-0.008***
	(0.056)	(0.128)	(0.027)	(0.038)	(0.001)
LIQ_{it}	0.620*	0.272	0.266	0.191	-0.018
	(0.090)	(0.351)	(0.481)	(0.436)	(0.767)
$WHOLE_{it}$	-0.176	-0.271	-0.271	-0.324*	-0.033
	(0.219)	(0.108)	(0.184)	(0.053)	(0.668)
$\Delta ln(CB)_{jt}$	0.147	0.122	0.046	-0.088	-0.067**
	(0.155)	(0.234)	(0.679)	(0.484)	(0.014)
ΔIB_{jt}	0.004	-0.012	-0.020	-0.037	-0.009
	(0.919)	(0.644)	(0.541)	(0.234)	(0.133)
$\Delta ln(GDP)_{jt}$	2.590	0.623	0.444	0.336	0.559***
	(0.153)	(0.547)	(0.803)	(0.788)	(0.000)
Π_{jt}	0.015*	0.008	0.010	-0.002	0.012*
	(0.062)	(0.157)	(0.199)	(0.733)	(0.060)
$PROFITABILITY_{it}$		0.010**	0.005	-0.002	0.043***
		(0.031)	(0.538)	(0.764)	(0.000)
LEV_{it}			0.015**	0.011**	0.000
			(0.013)	(0.043)	(0.908)
$OUTPUT\ GAP_{jt}$				0.021***	-0.958***
				(0.002)	(0.003)
C	9.991***	9.249***	9.441***	10.270***	3.683***
	(0.000)	(0.000)	(0.000)	(0.000)	
Number of observations	1,380	1,364	1,364	1,364	10,719
Cross-sectional units	293	287	287	287	2,364
AR(2) (p-value)	0.343	0.300	0.305	0.333	0.710

Notes: The model is estimated over the listed sample of banks in columns (1)-(4) and the wider sample of banks in column (5). *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital ratio; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; п is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1
Source: Bloomberg and LE Europe calculations

Additional analysis

Sources of bank lending adjustments

The impact of increases in capital ratios on three different types of lending (corporate loans, mortgages and other consumer loans) are presented in the table below.

Table 60: Sources of bank lending adjustments

Dependent variable:	Consumer loans (1)	Mortgages (2)	Corporate loans (3)	All loans - Baseline (4)
ln(Dependent var)$_{it-1}$	0.116**	0.218**	0.435***	0.339***
	(0.021)	(0.012)	(0.004)	(0.000)
ln(Dependent var)$_{it-2}$				0.131**
				(0.042)
ln(SIZE)$_{it}$	-0.016	0.024	0.063**	0.038***
	(0.172)	(0.282)	(0.021)	(0.000)
CAP$_{it}$	-0.003**	0.001	-0.004†	-0.008***
	(0.023)	(0.667)	(0.124)	(0.001)
LIQ$_{it}$	-0.142	0.129	-0.038	-0.018
	(0.518)	(0.234)	(0.876)	(0.767)
WHOLE$_{it}$	0.043	0.186	-0.128	-0.033
	(0.469)	(0.171)	(0.305)	(0.668)
Δln(CB)$_{jt}$	-0.037	-0.011	-0.037	-0.067**
	(0.722)	(0.761)	(0.174)	(0.014)
ΔIB$_{jt}$	0.003	0.003	0.008	-0.009
	(0.532)	(0.810)	(0.322)	(0.133)
Δln(GDP)$_{jt}$	-0.053	-0.495	0.376	0.559***
	(0.854)	(0.392)	(0.117)	(0.000)
Π$_{jt}$	-0.005	-0.008	-0.019**	0.012*
	(0.367)	(0.493)	(0.011)	(0.060)
PROFITABILITY$_{it}$	0.009***	0.048**	0.048***	0.043***
	(0.007)	(0.029)	(0.000)	(0.000)
LEV$_{it}$	-0.001	0.017*	0.000	0.000
	(0.487)	(0.089)	(0.967)	(0.908)
OUTPUT GAP$_{jt}$	-0.313	-1.441**	-1.655***	-0.958***
	(0.388)	(0.034)	(0.005)	(0.003)
C	8.473***	3.455***	3.920***	3.683***
Number of observations	443	4,752	3,957	10,719
Cross-sectional units	141	1,671	1,375	2,364
AR(2) (p-value)	0.194	0.340	0.913	0.710
Diff-in-Hansen test (p-value)	0.997	0.138	0.429	0.110

Notes: Each dependent variable is the natural logarithm of net lending of the loan category specified; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital ratio*; Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robustness standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1, †p-value=0.124
Source: Bankscope and LE Europe calculations

Bank business models

Results for the re-estimation of the baseline econometric model for a subsample of banks that maintain greater than 40% lending stocks-to-total assets are presented below.

Table 61: Estimates for banks for which lending represents at least 40% of total assets

Dependent variable: *ln(NETLENDING)*	(1)	Baseline (2)
ln(NETLENDING)$_{it-1}$	0.338***	0.339***
	(0.000)	(0.000)
ln(NETLENDING)$_{it-2}$	0.169***	0.131**
	(0.000)	(0.042)
ln(SIZE)$_{it}$	0.031***	0.038***
	(0.001)	(0.000)
CAP_{it}	-0.007**	-0.008***
	(0.015)	(0.001)
LIQ_{it}	-0.002	-0.018
	(0.980)	(0.767)
$WHOLE_{it}$	-0.009	-0.033
	(0.920)	(0.668)
$\Delta ln(CB)_{jt}$	-0.082***	-0.067**
	(0.006)	(0.014)
ΔIB_{jt}	-0.011*	-0.009
	(0.051)	(0.133)
$\Delta ln(GDP)_{jt}$	0.630***	0.559***
	(0.000)	(0.000)
Π_{jt}	0.011	0.012*
	(0.118)	(0.060)
$PROFITABILITY_{it}$	0.055***	0.043***
	(0.000)	(0.000)
LEV_{it}	0.002	0.000
	(0.545)	(0.908)
$OUTPUT\ GAP_{jt}$	-1.114***	-0.958***
	(0.001)	(0.003)
C	3.285***	3.683***
Number of observations	9,525	10,719
Cross-sectional units	2,086	2,364
AR(2) (p-value)	0.439	0.710
Diff-in-Hansen test (p-value)	0.392	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *CAP* is the Total Capital ratio; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; п is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1

Source: Bankscope and LE Europe calculations

The baseline econometric model is re-estimated for subsamples of banks split by the median values for different measures of risk of bank business models, with results being reported in the table below.

Table 62: Bank business models

Dependent variable: *ln(NETLENDING)*	Size (Low) (1)	Size (High) (2)	Cap (Low) (3)	Cap (High) (4)	Whole (Low) (5)	Whole (High) (6)	Baseline (7)
$ln(NETLENDING)_{it-1}$	1.352**	0.287***	0.300***	0.303**	0.274**	0.327***	0.339***
	(0.031)	(0.000)	(0.000)	(0.017)	(0.015)	(0.000)	(0.000)
$ln(NETLENDING)_{it-2}$	0.490**	0.085	0.135**	-0.109	0.145	0.106	0.131**
	(0.040)	(0.170)	(0.021)	(0.185)	(0.168)	(0.121)	(0.042)
$ln(SIZE)_{it}$	-0.006	0.081***	0.057***	0.027	0.028*	0.043***	0.038***
	(0.716)	(0.000)	(0.000)	(0.169)	(0.074)	(0.000)	(0.000)
LIQ_{it}	0.003	-0.231*	-0.181	-0.035	0.007	-0.159	-0.018
	(0.901)	(0.073)	(0.200)	(0.776)	(0.915)	(0.139)	(0.767)
$WHOLE_{it}$	-0.069*	-0.129	-0.256*	-0.069	-0.054	-0.034	-0.033
	(0.065)	(0.202)	(0.065)	(0.646)	(0.448)	(0.749)	(0.668)
CAP_{it}	-0.001**	-0.011**	-0.011**	-0.005	-0.002*	-0.010***	-0.008***
	(0.0226)	(0.010)	(0.048)	(0.263)	(0.0553)	(0.006)	(0.001)
$\Delta ln(CB)_{jt}$	0.018	-0.101**	-0.192***	0.013	0.034	-0.157***	-0.067**
	(0.114)	(0.016)	(0.001)	(0.732)	(0.267)	(0.000)	(0.014)
ΔIB_{jt}	-0.005***	-0.015	0.000	-0.005	-0.013**	-0.012	-0.009
	(0.003)	(0.120)	(0.996)	(0.283)	(0.0110)	(0.122)	(0.133)
$\Delta ln(GDP)_{jt}$	0.172***	0.866***	0.580**	0.283	0.292**	0.912***	0.559***
	(0.000)	(0.004)	(0.037)	(0.193)	(0.021)	(0.001)	(0.000)
Π_{jt}	0.000	0.018*	0.018*	0.001	-0.001	0.022***	0.012*
	(0.980)	(0.081)	(0.062)	(0.850)	(0.722)	(0.010)	(0.060)
$PROFITABILITY_{it}$	0.002	0.061***	0.082***	0.014**	0.037**	0.039***	0.043***
	(0.288)	(0.001)	(0.001)	(0.039)	(0.023)	(0.001)	(0.000)
LEV_{it}	-0.001**	-0.002	0.007	-0.004	-0.001	-0.002	0.000
	(0.015)	(0.553)	(0.114)	(0.331)	(0.787)	(0.446)	(0.908)
$OUTPUT\ GAP_{jt}$	-0.011	-2.070***	-1.749***	-0.547	-0.595	-1.922***	-0.958***
	(0.925)	(0.000)	(0.001)	(0.207)	(0.117)	(0.000)	(0.003)
C	-5.905	4.301***	3.252***	6.114***	4.140***	4.150***	3.683***
Number of observations	5,546	5,114	3,765	4,487	4,808	5,852	10,669
Cross-sectional units	1,155	1,177	801	812	1,132	1,201	2,337
AR(2) (p-value)	0.095	0.832	0.525	0.299	0.278	0.477	0.911
Diff-in-Hansen test (p-value)	0.904	0.773	0.924	0.999	0.850	0.610	0.053

Notes: See overleaf.

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *CAP* is the Total Capital ratio; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** $p<0.01$, ** $p<0.05$, * $p<0.1$
Source: Bankscope and LE Europe calculations

Regional variation

The following groupings of EU Member States are used for the regional analysis:

EU15

- Market-based EU: The Netherlands, United Kingdom, Belgium, France, Finland and Sweden
- Bank-based EU: Austria, Denmark, Germany
- Bank-based EU crisis countries: Greece, Italy, Portugal, and Spain

New Member States

- Bulgaria , Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia

The results are presented in the table below.

Table 63: Regional variation in transitional effects

Dependent variable: *ln(NETLENDING)*	Market-based EU (1)	Bank-based EU (2)	Bank-based EU crisis countries (3)	NMS (4)	Baseline (5)
ln(NETLENDING)$_{it-1}$	0.245***	0.347***	0.446***	0.217***	0.339***
	(0.000)	(0.000)	(0.003)	(0.000)	(0.000)
ln(NETLENDING)$_{it-2}$	0.255***	0.044	-0.057	0.406***	0.131**
	(0.003)	(0.636)	(0.510)	(0.000)	(0.042)
ln(SIZE)$_{it}$	0.145***	0.024**	0.049***	0.005	0.038***
	(0.000)	(0.026)	(0.004)	(0.793)	(0.000)
LIQ$_{it}$	-0.355	-0.154	-0.204***	-0.103	-0.018
	(0.371)	(0.213)	(0.006)	(0.444)	(0.767)
WHOLE$_{it}$	-0.129	0.166**	-0.166***	-0.123	-0.033
	(0.595)	(0.0426)	(0.006)	(0.198)	(0.668)
CAP$_{it}$	-0.005	-0.003**	0.000	-0.004*	-0.008***
	(0.286)	(0.014)	(0.925)	(0.078)	(0.001)
$\Delta ln(CB)_{jt}$	-0.161	0.063**	-0.101***	-0.068	-0.067**
	(0.301)	(0.018)	(0.009)	(0.665)	(0.014)
ΔIB_{jt}	-0.002	0.025**	-0.025***	0.000	-0.009
	(0.963)	(0.032)	(0.000)	(0.934)	(0.133)
$\Delta ln(GDP)_{jt}$	3.427	-0.523*	1.579***	0.798**	0.559***
	(0.251)	(0.052)	(0.000)	(0.012)	(0.000)
Π_{jt}	0.075***	-0.053***	0.042***	-0.003	0.012*
	(0.001)	(0.003)	(0.000)	(0.333)	(0.060)
PROFITABILITY$_{it}$	0.087**	0.016*	0.016***	0.055**	0.043***
	(0.015)	(0.056)	(0.002)	(0.015)	(0.000)
LEV$_{it}$	-0.012	-0.003	0.002	0.002	0.000
	(0.217)	(0.205)	(0.460)	(0.709)	(0.908)
OUTPUT GAP$_{jt}$	3.426	-1.168	-1.308***	-0.284	-0.958***
	(0.110)	(0.240)	(0.000)	(0.562)	(0.003)
C	3.494***	4.620***	3.924***	2.608***	3.683***
Number of observations	300	5,182	4,620	396	10,719
Cross-sectional units	103	1,348	758	102	2,364
AR(2) (p-value)	0.353	0.359	0.042	0.395	0.710
Diff-in-Hansen test (p-value)	1.000	1.000	1.000	1.000	0.110

Notes: The model is estimated over subsamples of countries in columns (1) to (4). *ln(NETLENDING)* is the natural logarithm of net lending; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *CAP* is the Total Capital ratio; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; п is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors, bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe calculations

The baseline model was re-estimated on a subsample excluding Germany (1) and Italy (2), to determine whether the main result is driven by the fact that these Member States have a large number of banks. These results are presented in the table below.

Table 64: Excluding countries with a large number of banks

Dependent variable: *ln(NETLENDING)*	(1)	(2)	Baseline (3)
ln(NETLENDING)$_{it-1}$	0.331***	0.317***	0.339***
	(0.000)	(0.000)	(0.000)
ln(NETLENDING)$_{it-2}$	0.155***	0.104	0.131**
	(0.009)	(0.130)	(0.042)
ln(SIZE)$_{it}$	0.037***	0.057***	0.038***
	(0.000)	(0.000)	(0.000)
CAP_{it}	-0.004	-0.009***	-0.008***
	(0.170)	(0.004)	(0.001)
LIQ_{it}	-0.272***	-0.167	-0.018
	(0.003)	(0.179)	(0.767)
$WHOLE_{it}$	-0.261**	-0.200*	-0.033
	(0.035)	(0.088)	(0.668)
$\Delta ln(CB)_{jt}$	-0.085*	-0.055*	-0.067**
	(0.070)	(0.093)	(0.014)
ΔIB_{jt}	-0.010*	-0.005	-0.009
	(0.100)	(0.536)	(0.133)
$\Delta ln(GDP)_{jt}$	1.277***	0.469**	0.559***
	(0.000)	(0.013)	(0.000)
Π_{jt}	0.015**	0.008	0.012*
	(0.015)	(0.197)	(0.060)
$PROFITABILITY_{it}$	0.037***	0.051***	0.043***
	(0.000)	(0.000)	(0.000)
LEV_{it}	0.005**	0.002	0.000
	(0.045)	(0.519)	(0.908)
OUTPUT GAP_{jt}	-1.364***	-1.017**	-0.958***
	(0.000)	(0.010)	(0.003)
C	3.164***	3.788***	3.683***
Number of observations	5,996	6,401	10,719
Cross-sectional units	1,165	1,689	2,364
AR(2) (p-value)	0.894	0.769	0.710
Diff-in-Hansen test (p-value)	0.222	0.624	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *CAP* is the Total Capital ratio; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors for the full sample excluding Germany (1) and Italy (2), bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe calculations

The baseline model was also re-estimated on the sample of banks in Germany (1) and Italy (2), as they represent a large proportion of the overall sample. These results are presented in the table below.

Table 65: Baseline model estimated for a subsample of banks in Germany only (1) and Italy only (2)

Dependent variable: *ln(NETLENDING)*	(1)	(2)	Baseline (3)
ln(NETLENDING)$_{it-1}$	0.141	0.103	0.339***
	(0.154)	(0.437)	(0.000)
ln(NETLENDING)$_{it-2}$	-0.113	-0.024	0.131**
	(0.377)	(0.878)	(0.042)
ln(NETLENDING)$_{it-3}$	-0.139*	-0.126	
	(0.096)	(0.124)	
ln(SIZE)$_{it}$	0.007**	0.092**	0.038***
	(0.548)	(0.022)	(0.000)
CAP$_{it}$	-0.002**	-0.008***	-0.008***
	(0.056)	(0.005)	(0.001)
LIQ$_{it}$	-0.144	-0.030	-0.018
	(0.830)	(0.657)	(0.767)
WHOLE$_{it}$	-0.030	0.104	-0.033
	(0.863)	(0.252)	(0.668)
Δln(CB)$_{jt}$	0.006	-0.073**	-0.067**
	(0.953)	(0.022)	(0.014)
ΔIB$_{jt}$	-0.001	-0.034***	-0.009
	(0.973)	(0.003)	(0.133)
Δln(GDP)$_{jt}$	0.164	1.205***	0.559***
	(0.857)	(0.003)	(0.000)
Π$_{jt}$	0.024	0.011***	0.012*
	(0.841)	(0.004)	(0.060)
PROFITABILITY$_{it}$	0.014	0.002	0.043***
	(0.504)	(0.754)	(0.000)
LEV$_{it}$	-0.004	-0.011	0.000
	(0.396)	(0.152)	(0.908)
OUTPUT GAP$_{jt}$	1.076***	-2.014***	-0.958***
	(0.798)	(0.002)	(0.003)
C	6.323***	8.086***	3.683***
Number of observations	4,536	3,789	10,719
Cross-sectional units	1,182	625	2,364
AR(2) (p-value)	0.544	0.520	0.710
Diff-in-Hansen test (p-value)	0.192	0.211	0.110

Notes: *ln(NETLENDING)* is the natural logarithm of net lending; *CAP* is the Total Capital ratio; *ln(SIZE)* is the natural logarithm of total assets**;** *LIQ* is the quotient of cash and trading securities, and total assets; *WHOLE* is the quotient of assets funded by non-deposit liabilities (total liabilities (excluding equity) minus total deposits) and total assets; *Δln(CB)* is the difference in the natural logarithm of central bank assets; *ΔIB* is the change in the 3-month interbank rate; *Δln(GDP)* is the difference in the logarithm of real GDP; π is the inflation rate; *PROFITABILITY* is the quotient of profits before tax and total assets; *LEV* is one minus the quotient of equity and total assets; *OUTPUT GAP* is the difference between actual and potential GDP as a percentage of potential GDP; and C is a constant. The model is estimated using the two-step system GMM estimator and robust standard errors for Germany (1) and Italy (2), bank-level variables are instrumented for by using their lags. Asterisks indicate p-values: *** p<0.01, ** p<0.05, * p<0.1. Source: Bankscope and LE Europe calculations

Annex 6 A general equilibrium model with heterogeneous banks

The model features a representative private household, a representative non-financial firm that produces output using labour, and a large number of banks that differ in their productivity of extending credit to firms. Productivity differences translate into different bank sizes, so that a bank size distribution with a few very large and very efficient banks and many small banks emerges – as observed for many economies (Amiti and Weinstein 2013, Bremus et al. 2013, Ghossoub and Reed 2015). The role of banks in the model economy is to channel the consumer savings to firms.

As structural effects of increased capital requirements are of interest, the focus is on the long-term equilibrium of the model economy. In the steady state, firms cannot retain earnings to finance their working capital, but have to pay out any profits to their owners in the form of dividends. As a consequence, firms have to finance the wage bill through external funds. Thus, they pay workers by taking loans from the banks before sales revenues accrue.

In more detail, the three sectors – consumers, non-financial firms, and banks – are modelled as follows.

Consumers

A representative household consumes a final good q, supplies labour, h, to firms, and saves in the form of deposits, d, to banks. It maximises its lifetime utility function:

$$U(q_t, h_t) = \sum_{t=1}^{\infty} \beta^t \left[\frac{q_t^{1-\rho}}{1-\rho} - \frac{h_t^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}} \right]$$

which positively depends on consumption, while labour effort reduces utility. The parameter ρ denotes the coefficient of relative risk aversion, and γ is the elasticity of labour supply. The larger this elasticity, the stronger the household's labour supply reacts to changes in wages. The utility optimisation is subject to the household's budget restriction $d_{t+1} + q_t \leq (1 + r^d)d_t + w_t h_t + \Pi$, which states that the sum of consumption and savings today has to be no greater than the sum of deposits and interest payments received on last-period deposits, labour income, and dividends paid by banks. Given that the focus of our analysis is on competition in the credit market here, we assume perfect competition in the market for deposits and deposit insurance. Thus, all banks pay the same, risk-free deposit rate, r^d, and consumers are indifferent of where to place their deposits.

The consumer optimisation problem yields the risk-free interest rate on deposits, $r^d = \frac{1-\beta}{\beta}$, where β is the subjective discount factor.[105] It mirrors the consumer's willingness to forgo consumption today for consumption tomorrow. The more impatient the household is to consume, the lower is the discount factor and hence the higher the deposit rate r^d that banks have to offer in order to receive savings.

[105] All equations characterizing the steady state of the model can be found in the appendix of Bremus (2015)

Firms

A representative manufacturing firm produces final output y, using labour h as the only input factor, with production technology $y = Ah^{1-\alpha}$.
The firm demands a bundle of loans from banks to finance the wage payments to workers before receiving sales revenues. The economy's loan portfolio contains loans from J different banks and is denoted by $\left[\sum_{j=1}^{J} l(j)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}} = \ell^d$. The firm maximises its profit function $\Omega = Ah^{1-\alpha} - wh - r\ell^d$, where w is the wage, r is the lending rate, and $\ell^d = wh$ is the wage bill and hence the amount of credit demanded by the firm. Profit maximisation yields the optimal demand for labour as well as the optimal demand for different bank loans,

$$l(j) = \left[\frac{r(j)}{r}\right]^{-\epsilon} \ell^d. \qquad \text{(a)}$$

The higher the elasticity of substitution between different loans, ϵ, the more does loan demand change in response to a change in the loan rate $r(j)$.

Banks

The banking sector consists of a large number of banks, $j = 1, \ldots, J$, that supply credit $l(j)$ under imperfect competition. Banks differ in their productivity of lending. This productivity is captured in terms of their non-interest cost of lending, $c(j) \geq 1$, and can be interpreted as their efficiency of monitoring or screening borrowers. The lower the cost of monitoring or screening is, the higher the bank's efficiency of lending. Thus, banks can be ranked according to their non-interest cost of transforming deposits into loans, $c_1(j) < c_2(j) < \cdots < c_n(j)$, with $c_1(j)$ reflecting the cost parameter of the best bank. Following the literature, to close the model, the bank efficiency parameters are drawn from a Pareto distribution with shape parameter θ.

In line with the empirical evidence, the credit market is segmented, and each bank serves a certain market segment j. Market segments can be thought of, for example, as locally fragmented credit markets. In each credit market segment, banks compete for loan demand by setting their loan rate $r(j)$. They fund their credit supply by deposits, $d(j)$, and equity, $e(j)$.

Each bank maximises profits by optimally setting its lending rate $r(j)\colon \max_{r(j)} \Pi = r(j)l(j) - [r^d d(j) - r^e e(j)]c(j)$, where $l(j)$ is credit supplied by bank j, and $e(j) = e \cdot l(j)$ is bank equity. Each bank has to fulfill a capital requirement, e, which is expressed as equity relative to total loans. As shown by the loan demand function, equation (a), the higher the lending rate $r(j)$ relative to the aggregate lending rate r, the lower is the demand for bank j's loans. Given that loans are the only asset on the bank balance sheet in this simplified setup, the equity ratio e mirrors the equity-to-total assets ratio. It can thus be interpreted as the leverage ratio of bank j.[106]

Following the literature (e.g. Langedijk et al. 2015, Bremus et al. 2013), we assume that the interest rate that banks have to pay on equity, r^e, exceeds the interest rate on deposits, r^d, because of a corporate tax on profits $\tau \geq 0$, so that $r^e = r^d(1+\tau)$. Even if funding loans via equity is more expensive than via deposits, banks hold equity because of a regulatory capital requirement. Their equity holdings exactly match the

[106] Given that all bank assets (i.e. loans) have the same risk in the model, total assets are equal to risk-weighted assets here

regulatory requirement. Note that the cost of bank capital is exogenous here. That is, the equity share that a bank holds does not influence the interest rate it has to pay on its equity.

The profit maximisation problem yields the optimal lending rate for each bank, $r(j)$. In a using the balance sheet condition which requires that $d(j) = (1-e)l(j)$, the bank profit function can be rewritten as

$$\Pi = r(j)l(j) - [r^d(1-e)l(j) - r^d(1+\tau)e \cdot l(j)]c(j) = r(j)l(j) - r^d(1+e\tau)c(j)l(j)$$

Maximising the bank profit function Π with respect to the lending rate $r(j)$ and using the fact that $\frac{\partial l(j)}{\partial r(j)} = -\epsilon \frac{l(j)}{r(j)}$ from equation (a) yields the optimal Dixit-Stiglitz interest $r(j) = \frac{\epsilon}{\epsilon-1} r^d(1+e\tau)c_1(j)$. It is determined by the product of a constant markup, $\bar{m} = \frac{\epsilon}{\epsilon-1}$, and the marginal cost of lending. The marginal cost of lending consists of the banks funding cost, $r^d(1+e\tau)$, multiplied by its non-interest cost of lending, $c_1(j)$. The higher the bank capital requirement, and hence the higher banks' equity share e, the higher its funding cost.

So far, we have determined each bank's optimal markup and lending rate by considering competition *across* different market segments. *Within* each credit market segment j, banks compete for clients by undercutting their rivals' lending rate until the lowest-cost (i.e. the most efficient) bank absorbs the entire loan demand in its market. Even if the most efficient bank has some market power, the optimal lending rate it wants to set, $r(j) = \bar{m}\, c_1(j) r^d(1+e\tau)$, is further limited by the cost of lending of the second best bank in its market, $c_2(j)$. In order to supply credit in market segment j, the most efficient bank cannot set its markup higher than $c_2(j)$. Otherwise, the second best bank will just break even by setting its lending rate at $r(j) = c_2(j)r^d(1+e\tau)$ and lure all clients away. The maximum markup over marginal costs that the best bank can set has to fulfill $c_2(j) \geq m(j)c_1(j)$, so that the markup cannot be larger than the ratio of $c_2(j)/c_1(j)$. Hence, the optimal lending rate in credit segment j will be given by

$$r(j) = \min\left\{\frac{c_2(j)}{c_1(j)}; \bar{m}\right\} r^d(1+e\tau)c_1(j). \quad \text{(b)}$$

Intuitively, the bank can only set the maximum markup $\bar{m}$ if the gap between its cost of lending and the lending cost of the second best bank in its market segment is large enough, i.e. if $\bar{m} \cdot c_1(j)$ is no larger than $c_2(j)$. The more efficient the next best bank is, and hence the lower its cost $c_2(j)$, the lower is the markup that the best bank can charge. Thus, credit markups vary across banks and are endogenously determined by the degree of competitive pressure in the credit market (for a more detailed discussion, see De Blas and Russ 2013).

Knowing lending rates and solving for the equilibrium wage and output, one can compute each bank's credit volume using equation (a). Banks' credit volumes are equivalent to their total assets in this simple setup. Total loans are taken as a measure of bank size. In order to measure credit market structures, we compute the 3-bank concentration ratio and the Herfindahl index of concentration. The 3-bank concentration ratio is defined as the market share of the largest three banks in the economy in terms of assets, $3BC = \sum_{j=1}^{3} \frac{l(j)}{\xi d}$, whereas the Herfindahl index is the sum of squared credit market shares of all banks, $HHI = \sum_{j=1}^{J} \left[\frac{l(j)}{\xi d}\right]^2$.

The number of banks in the economy is fixed at J here. How many banks enter the economy in equilibrium depends on the fixed cost of entry and the expected profits of each bank. An entrepreneur will enter the banking market as long as its expected profits are at least as large as the fixed cost of entering the market, i.e. $E[\Pi(\mathrm{j}) = r(j)l(j) - r^{\mathrm{d}}(1 + e\tau)c_1(j)l(j)] \geq f$, where $E[\cdot]$ denotes the expectation across all possible realisations of the efficiency parameters drawn from a Pareto distribution, and f is the fixed cost of entering the banking business which can be interpreted as the cost related to applying for a banking license and setting up the business. Bank profits $\Pi(j)$ decline the higher the number of banks J. Consequently, there is a fixed number of banks in the model economy that possess an efficiency of lending which is high enough to generate sufficient profits to cover the fixed cost of entry f.

Annex 7 Simulation results for an increase in the capital-to-asset ratio

(a) Calibration as in Table 25

Capital-to-asset ratio	**0**	**0.09**	**0.10**	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**	**1**
Herfindahl index	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174
Average lending rate	0.0261	0.0307	0.0313	0.0365	0.0417	0.0469	0.0521	0.0573	0.0625	0.0677	0.0730	0.0782
Average markup	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18
Total credit/output	0.6238	0.6209	0.6206	0.6175	0.6144	0.6113	0.6083	0.6053	0.6023	0.5994	0.5965	0.5936

(b) Calibration as in Table 25, apart from labour share $(1-\alpha) = 0.5$

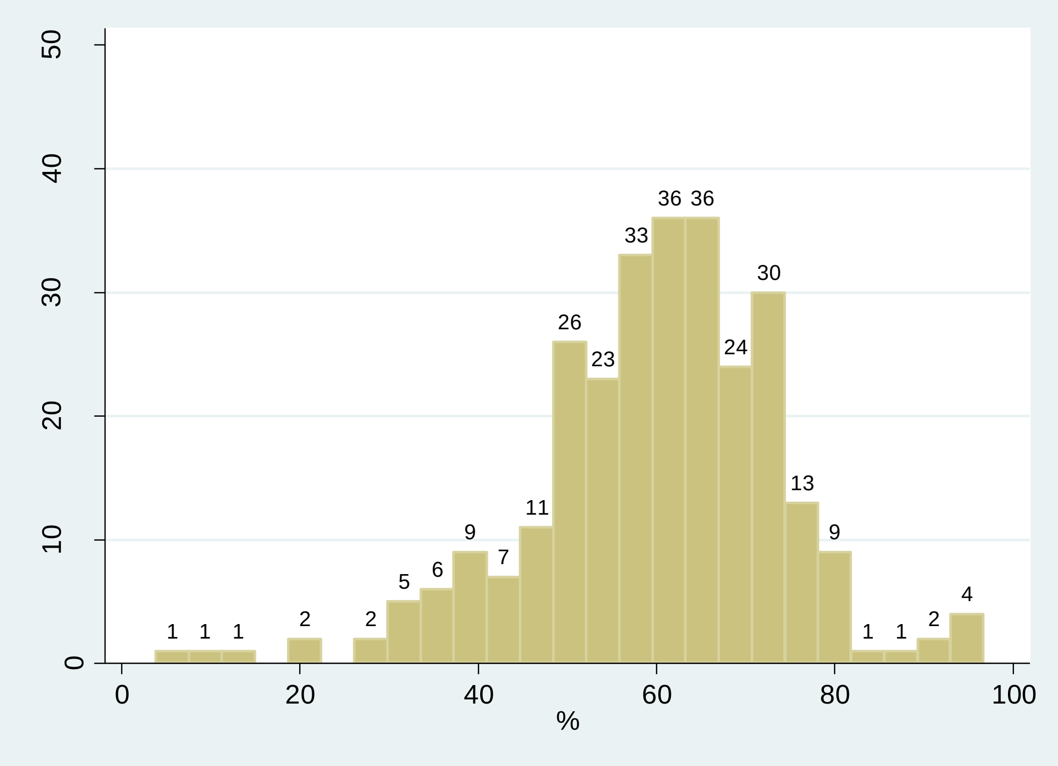
Capital-to-asset ratio	**0**	**0.09**	**0.10**	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**	**1**
Herfindahl index	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174
Average lending rate	0.0261	0.0307	0.0313	0.0365	0.0417	0.0469	0.0521	0.0573	0.0625	0.0677	0.0730	0.0782
Average markup	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18
Total credit/output	0.4873	0.4851	0.4848	0.4824	0.4800	0.4776	0.4752	0.4729	0.4706	0.4683	0.4660	0.4638

Source: DIW Berlin calculations

Annex 8 Additional structural effects analysis

Summary statistics for cointegration test sample

Figure 33: Distribution of banks by the average ratio of bank lending stocks to total assets – Cointegration test sample



Note: This figure is based on banks with a reported value for bank lending stocks and total assets over the period from 1988 to 2007, which is less than or equal to 100% and 16 continuous values (283 banks).
Source: LE Europe analysis of Bankscope data

Table 66: Average bank features by country – Cointegration test sample

Member State	*Number of banks*	*Ratio of lending stocks to total assets†*	*Total Capital Ratio*
AT	2	55.8	11.9
BE	2	46.4	13.2
BG	0		
CY	1	58.4	13.9
CZ	2	54.1	17.7
DE	4	62.9	11.4
DK	42	63.7	16.0
EE	0		
EL	1	50.3	12.3
ES	12	62.4	12.8
FI	2	67.9	13.9
FR	2	41.1	11.0

Member State	*Number of banks*	*Ratio of lending stocks to total assets†*	*Total Capital Ratio*
HR	1	59.9	17.9
HU	1	65.1	11.7
IE	3	65.3	12.4
IT	140	60.4	16.4
LT	2	59.3	17.3
LU	0		
LV	1	65.9	12.6
MT	1	43.6	15.2
NL	8	70.7	13.9
PL	0		
PT	4	64.9	11.3
RO	0		
SE	9	79.8	11.7
SI	3	57.4	18.3
SK	0		
UK	16	70.7	13.8
EU Average	-	62.6	15.4

Note: †Average over period from 1988 to 2007. Banks with an average ratio of bank lending stocks to total assets greater than 100% or no data on bank lending stocks and total assets are excluded from the analysis.
Source: Bankscope and LE Europe's calculations

Choice of estimation method

The baseline econometric model will be estimated using the Mean Group (MG) estimator, proposed by Pesaran and Smith (1995). Following Eberhardt and Presbitero (2015), the baseline error correction model (assuming a lag length of one) can be re-parameterised and represented as follows:

$$\Delta Y_{it} = \mu_i + \alpha_{0i}(Y_{it-1} - \beta_{1i} CAP_{it-1} - \beta_{2i} SIZE_{it-1}) + \alpha_{1i}\Delta Y_{it-1} + \alpha_{2i}\Delta CAP_{it} + \alpha_{3i}\Delta SIZE_{it} + \varepsilon_{it}$$

.... (17)

$$\Leftrightarrow \Delta Y_{it} = \pi_{0i} + \pi_{1i} Y_{it-1} + \pi_{2i} CAP_{it-1} + \pi_{3i} SIZE_{it-1} + \pi_{4i}\Delta Y_{it-1} + \pi_{5i}\Delta CAP_{it} + \pi_{6i}\Delta SIZE_{it} + \varepsilon_{it}$$

.... (18)

As such, the long-run coefficient for the Total Capital Ratio can be derived as: $\beta_{1j}=-\pi_{2j}/\pi_{1j}$.

To control for cross-sectional dependence, the Common Correlated Effects Mean Group (CCEMG) estimator, proposed by Pesaran (2006), is used. This introduces cross-sectional averages of all variables in the model to provide the following estimation equation:

$$\Delta Y_{it} = \pi_{0i} + \pi_{1i} Y_{it-1} + \pi_{2i} CAP_{it-1} + \pi_{3i} SIZE_{it-1} + \pi_{4i}\Delta Y_{it-1} + \pi_{5i}\Delta CAP_{it} + \pi_{6i}\Delta SIZE_{it} +$$
$$\pi_{7i}^{CS}\overline{\Delta Y_{it}} + \pi_{8i}^{CS}\overline{Y_{it-1}} + \pi_{9i}^{CS}\overline{CAP_{it-1}} + \pi_{10i}^{CS}\overline{SIZE_{it-1}} + \pi_{11i}^{CS}\overline{\Delta Y_{it-1}} + \pi_{12i}^{CS}\overline{\Delta CAP_{it}} + \pi_{13i}\overline{\Delta SIZE_{it}} + \varepsilon_{it}$$

.... (19)

This equation can then be estimated by OLS for each bank *i* separately and averaged across banks to provide the CCEMG estimates for both the long-run and short-run relationships.

Chudik and Pesaran (2015) allow for feedback between the variables in the model by including further lags of the cross-section averages in addition to the contemporaneous cross-section averaged included by Pesaran (2006). This dynamic CCEMG estimator performs well in the presence of weakly exogenous variables.

The model specification under Chudik and Pesaran (2015) for a maximum lag length A can be represented as follows:

$$\Delta Y_{it} = \pi_{0i} + \pi_{1i} Y_{it-1} + \pi_{2i} CAP_{it-1} + \pi_{3i} SIZE_{it-1} + \pi_{4i} \Delta Y_{it-1} + \pi_{5i} \Delta CAP_{it} + \pi_{6i} \Delta SIZE_{it} +$$
$$\pi_{7i}^{CS} \overline{\Delta Y_{it}} + \pi_{8i}^{CS} \overline{Y_{it-1}} + \pi_{9i}^{CS} \overline{CAP_{it-1}} + \pi_{10i}^{CS} \overline{SIZE_{it-1}} + \pi_{11i}^{CS} \overline{\Delta Y_{it-1}} + \pi_{12i}^{CS} \overline{\Delta CAP_{it}} + \pi_{13i} \overline{\Delta SIZE_{it}}$$
$$\sum_a^A \theta_{1ai}^{CS} \overline{\Delta Y_{it}} + \sum_a^A \theta_{2ai}^{CS} \overline{Y_{it-1}} + \sum_a^A \theta_{3ai}^{CS} \overline{CAP_{it-1}} + \sum_a^A \theta_{4ai}^{CS} \overline{SIZE_{it-1}} + \sum_a^A \theta_{5ai}^{CS} \overline{\Delta Y_{it-1}} + \sum_a^A \theta_{6ai}^{CS} \overline{\Delta CAP_{it}} + \sum_a^A \theta_{7ai}^{CS} \overline{\Delta SIZE_{it}} + \varepsilon_{it}$$

.... (20)

Panel unit root tests

As a starting point, it is important to determine the unit root properties of the series of interest (bank lending stocks, the Total Capital Ratio and bank size). While panel unit root tests increase the power of short span unit root tests by pooling across individual units, in the presence of cross section dependence, these tests are not valid (Persyn and Westerlund, 2008).

As such, Pesaran's (2007) panel unit root test, which addresses the issues raised by Persyn and Westerlund (2008), can be used to test for non-stationarity of the variables of interest in the presence of cross-sectional dependence.[107] The test estimates the augmented Dickey-Fuller (ADF) regression model in a panel setting. This can be represented for a series, Y_{it} as follows:

$$\Delta Y_{it} = \beta_{0i} + \beta_{1i} Y_{it-1} + \beta_{2i} \overline{Y}_{t-1} + \beta_{3i} \Delta \overline{Y}_{t-1} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

(21)

- Y_{it-1} is a one-period lag
- $\overline{Y}_{t-1}$ is the cross-section average of the one-period lagged levels
- $\Delta \overline{Y}_{t-1}$ is the first difference of the cross-section average of the one-period lagged levels
- ε_{it} is an error term

Hence, the augmented ADF statistic ($CADF_i$) is computed over each individual unit and then averaged to obtain the CIPS-statistic (Im at el, 2003), where the null hypothesis tests the presence of a unit root. In the case of an unbalanced panel, the Z[t-bar] statistic is reported, which is distributed standard normal under the null hypothesis of non-stationarity.

[107] Pesaran's panel unit root tests are employed using the module, *pescadf*, in Stata

As an extension to the Pesaran (2007) unit root test, Pesaran et al. (2013) introduced an augmented panel unit root test to account for multiple common factors that may be shared by the variable under consideration and other time series. However, the Stata code for this test is still under development and only Pesaran's (2007) unit root test results are presented.

Table 67: Pesaran's (2007) panel unit root test for variables in levels – *1988-2014*

Variables in levels	*Z[t-bar] statistic*							
Deterministic	*Constant only*				*Constant and trend*			
Lags	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*
Y	-8.10 ***	-0.92	-4.24 ***	44.14	-2.05 **	5.97	5.14	48.89
CAP	-4.45 ***	-0.11	3.07	48.05	-2.09 **	3.49	4.69	47.82
SIZE	3.92	5.43	9.33	48.09	-0.28	3.28	6.73	49.24

Note: *Significance at 10% level, **Significance at 5% level, ***Significance at 1% level
Source: Bankscope and LE Europe's analysis

Table 68: Pesaran's (2007) panel unit root test for variables in first-difference – *1988-2014*

Variables in first-difference	*Z[t-bar] statistic*							
Deterministic	*Constant only*				*Constant and trend*			
Lags	*0*	*1*	*2*	*3*	*0*	*1*	*2*	*3*
Y	-26.22 ***	-16.67 ***	-3.75 ***	0.18	-23.65 ***	-17.48 ***	-4.83 ***	11.91
CAP	-36.35 ***	-17.74 ***	-6.69 ***	-2.57 **	-29.12 ***	-10.78 ***	-0.76	13.02
SIZE	-27.17 ***	-14.61 ***	-4.73 ***	-3.94 ***	-20.28 ***	-10.64 ***	-0.81	12.32

Note: *Significance at 10% level, **Significance at 5% level, ***Significance at 1% level
Source: Bankscope and LE Europe's analysis

Cross section dependence tests

There has been a growing amount of literature over the last decade covering the issue of cross-sectional dependence in macro panels. For example, Eberhardt and Teal (2011) provide a detail discussion of the issue.

Formally, Pesaran's (2004) CD-test uses the correlation coefficients between the time-series for each panel (in this case, for each bank) to test for variable cross-sectional dependence.[108] The CD statistic can be represented as follows:

$$\sqrt{\frac{2}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{i,j}$$

- N is the unit of observation

[108] The *xtcd* command in Stata runs the Pesaran (2004) CD test for any specified variable

- $\hat{\rho}_{i,j}$ is the correlation coefficient between unit *i* and *j*

Under the null hypothesis of no cross sectional dependence, the CD statistic is normally distributed as N approaches ∞ and T is sufficiently large.

Table 69: Pesaran's (2004) CD test for variables in levels – *1988-2014*

Variables in levels	*Pesaran's (2004) CD test*			
	$\hat{\rho}$	$\lvert\hat{\rho}\rvert$	*CD statistic*	*p-value*
Y	0.87	0.90	628.56	0.00
CAP	0.10	0.41	75.41	0.00
SIZE	0.87	0.89	629.95	0.00

Note: $\hat{\rho}$ and $\lvert\hat{\rho}\rvert$ are average and absolute average correlation coefficients (respectively) across the 66,306 (N(N-1)) sets of correlations for each variable. The CD statistic is distributed under the standard normal, where the null hypothesis tests the presence of cross-sectional independence.
Source: Bankscope and LE Europe's analysis

Table 70: Pesaran's (2004) CD test for variables in first-difference – *1988-2014*

Variables in first difference	*Pesaran's (2004) CD test*			
	$\hat{\rho}$	$\lvert\hat{\rho}\rvert$	*CD statistic*	*p-value*
Y	0.27	0.35	196.00	0.00
CAP	0.06	0.24	43.51	0.00
SIZE	0.13	0.27	95.02	0.00

Note: $\hat{\rho}$ and $\lvert\hat{\rho}\rvert$ are average and absolute average correlation coefficients (respectively) across the 66,306 (N(N-1)) sets of correlations for each variable. The CD statistic is distributed under the standard normal, where the null hypothesis tests the presence of cross-sectional independence.
Source: Bankscope and LE Europe's analysis

Panel cointegration tests

In general, there exist two approaches to determine the presence of a long-run relationship between two non-stationary variables in a panel setting.

In particular, one group of tests uses the null hypothesis of cointegration (McCoskey and Kao, 1998 and Westerlund, 2005), while the others test the null of no cointegration (Kao, 1999 and Pedroni, 1999; 2004). The latter tests examine the existence of a unit root in the residuals of a static spurious regression (based on the approach developed by Engle and Granger, 1987). However, in the presence of cross sectional dependence, there is a significant loss of power for residual-based cointegration tests. Banerjee et al (1998) and Kremers et al (1992) refer to this as a 'common-factors restriction'.

Given the loss of power in the residual-based cointegration tests, Westerlund (2007) developed four panel cointegration tests that are based on testing the significance of

the error-correction parameter (for example, α_{0i} in equation (22)) rather than residual dynamics. Therefore, there is no need to impose any common-factor restriction.[109]
The null hypothesis under this test is then given by H_0: α_{0i} =0; that is, there is no cointegration since the error correction term is equal to zero. This can be tested against two alternatives: (i) H_1: α_0 <0, i.e. there is cointegration for the panel as a whole; or (ii) H_1: α_{0h} <0 for some subset $h<N$ and/or $h<T$, i.e. at least one unit if cointegrated.

These tests are normally distributed and also accommodate for heterogeneous short-run effects as well as unit-specific trend and slope parameters.

Table 71: Westerlund's (2007) panel cointegration test – Bank lending stocks, Total Capital Ratio and bank size – Sample of banks with ratio of lending stocks to total assets greater or equal to 40%

Dependent variable: Y *Independent variables: CAP and SIZE*		
Statistic	*With constant only*	*With constant and trend†*
G_t	-6.12***	-2.69***
G_a	-4.29	-2.34
P_t	-39.74***	-52.85***
P_a	-10.11***	-11.89***

Note: The G_t and G_a test statistics test the null hypothesis of no cointegration against the alternative of cointegration of at least one of the cross-sectional units. The P_t and P_a test statistics test the null hypothesis of no cointegration against the alternative of cointegration for the panel as a whole. †Westerlund's (2007) cointegration test with a constant and trend requires each bank time series to have at least 17 continuous values; therefore, this test is based on a smaller sample of 204 banks. *Significance at 10% level, **Significance at 5% level, ***Significance at 1% level.
Source: Bankscope and LE Europe's analysis

Table 72: Westerlund's (2007) panel cointegration test – Bank lending stocks, Total Capital Ratio and bank size – Sample of banks with ratio of lending stocks to total assets less than 40%

Dependent variable: Y *Independent variables: CAP and SIZE*		
Statistic	*With constant only†*	*With constant and trend‡*
G_t	-1.33	-2.25
G_a	-2.02	-2.47
P_t	-6.94	-9.56
P_a	-4.63	-5.02

Note: See Table 71 for details on Westerlund's (2007) test statistics. †This test is based on a sample of 25 banks with a ratio of lending stocks to total assets less than 40%. ‡This test is based on a sample of 22 banks with a ratio of lending stocks to total assets less than 40%. *Significance at 10% level, **Significance at 5% level, ***Significance at 1% level.
Source: Bankscope and LE Europe's analysis

[109] The *xtwest* command in Stata implements the four panel cointegration tests developed by Westerlund (2007) and requires continuous time series to run successfully

Other estimation results

Table 73: Estimation results for all banks – Cointegration test sample – 1988-2014

Dependent variable: Change in bank lending stocks (ΔY_t)	[11] Mean Group estimation	[12] Common Correlated Effects Mean Group estimation	[13] Dynamic Common Correlated Effects Mean Group estimation
Long-run coefficients			
CAP_{t-1}	-0.024*** (0.00)	-0.017* (0.08)	-0.008 (0.50)
$SIZE_{t-1}$	0.948*** (0.00)	0.678*** (0.00)	0.649*** (0.00)
Short-run coefficients			
ECT_{t-1}	-0.569*** (0.00)	-0.682*** (0.00)	-0.484*** (0.00)
ΔY_{t-1}	0.132*** (0.00)	-0.114 (0.45)	-0.124** (0.02)
ΔCAP_t	-0.011*** (0.00)	-0.004 (0.33)	-0.013*** (0.00)
ΔCAP_{t-1}	0.003*** (0.00)	0.001 (0.81)	-0.0093** (0.02)
$\Delta SIZE_t$	0.524*** (0.00)	0.618*** (0.00)	0.376*** (0.00)
$\Delta SIZE_{t-1}$	-0.130*** (0.00)	0.103 (0.47)	0.006 (0.90)
Constant	0.162 (0.24)	0.985 (0.26)	1.069 (0.12)
Cross section averages	No	Yes	Yes
Additional lagged cross section averages	No	No	Yes, 1 lag
Number of observations	4,585	4,585	4,302
Number of banks	283	283	283
Root Mean Squared Error	0.0565	0.0136	0.00

Note: p-values are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe's analysis

Table 74: Estimation results for all banks – Wider sample – 1988-2014

Dependent variable: Change in bank lending stocks (ΔY_t)			
	[14] Mean Group estimation	[15] Common Correlated Effects Mean Group estimation	[16] Dynamic Common Correlated Effects Mean Group estimation
Long-run coefficients			
CAP_{t-1}	-0.024*** (0.00)	-0.020** (0.02)	0.006 (0.66)
$SIZE_{t-1}$	0.925*** (0.00)	0.785*** (0.00)	0.363*** (0.00)
Short-run coefficients			
ECT_{t-1}	-0.638*** (0.00)	-0.543*** (0.00)	-0.302*** (0.00)
ΔY_{t-1}	0.135*** (0.00)	-0.024 (0.55)	-0.030* (0.07)
ΔCAP_t	-0.012*** (0.00)	-0.010*** (0.00)	-0.008*** (0.00)
ΔCAP_{t-1}	0.005*** (0.00)	0.002 (0.40)	-0.002 (0.31)
$\Delta SIZE_t$	0.463*** (0.00)	0.391*** (0.00)	0.188*** (0.00)
$\Delta SIZE_{t-1}$	-0.151*** (0.00)	-0.081 (0.12)	-0.011 (0.60)
Constant	0.213 (0.35)	2.172*** (0.00)	2.084*** (0.00)
Cross section averages	No	Yes	Yes
Additional lagged cross section averages	No	No	Yes, 1 lag
Number of observations	8,759	8,759	7,954
Number of banks	638	638	638
Root Mean Squared Error	0.0489	0.0112	0.00

Note: p-values are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe's analysis

Table 75: Estimation results using additional bank controls – Wider sample – Dynamic CCEMG estimation – 1988-2014

Dependent variable: Change in bank lending stocks (ΔY_t)	Baseline	[17] Profitability (first-difference)	[18] Profitability (lagged first-difference)	[19] Liquidity (first-difference)	[20] Liquidity (lagged first-difference)	[21] Wholesale funding (first-difference)	[22] Wholesale funding (lagged first-difference)	[23] Leverage (first-difference)	[24] Leverage (lagged first-difference)
Long-run coefficients									
CAP_{t-1}	0.005 (0.78)	-0.016 (0.74)	0.197 (0.11)	-0.012 (0.79)	-0.018 (0.53)	0.019 (0.62)	-0.024 (0.77)	0.019 (0.71)	-0.173* (0.08)
$SIZE_{t-1}$	0.339*** (0.00)	0.293** (0.04)	0.167 (0.44)	0.074 (0.54)	0.291** (0.0101)	0.183 (0.16)	0.269 (0.13)	0.343** (0.011)	0.175 (0.14)
ECT_{t-1}	-0.241*** (0.00)	-0.090*** (0.00)	-0.047*** (0.00)	-0.174*** (0.00)	-0.194*** (0.00)	-0.193*** (0.00)	-0.172*** (0.00)	-0.131*** (0.00)	-0.084*** (0.00)
ΔY_{t-1}	-0.055*** (0.00)	0.00002 (1.00)	-0.014 (0.10)	-0.115*** (0.00)	-0.114*** (0.00)	-0.090*** (0.00)	-0.155*** (0.00)	-0.027 (0.14)	-0.052*** (0.00)
ΔCAP_t	-0.006*** (0.00)	-0.016*** (0.00)	-0.011*** (0.00)	-0.019*** (0.00)	-0.015*** (0.00)	-0.019*** (0.00)	-0.018*** (0.00)	-0.018*** (0.00)	-0.013*** (0.00)
ΔCAP_{t-1}	-0.004 (0.15)	-0.005* (0.0504)	-0.001** (0.0102)	-0.004 (0.46)	-0.003 (0.43)	-0.011** (0.02)	-0.005 (0.55)	-0.009** (0.04)	-0.004 (0.48)
$\Delta SIZE_t$	0.213*** (0.00)	0.101*** (0.00)	0.088*** (0.00)	0.218*** (0.00)	0.269*** (0.00)	0.206*** (0.00)	0.283*** (0.00)	0.073*** (0.00)	0.047** (0.013)
$\Delta SIZE_{t-1}$	-0.004 (0.84)	-0.022 (0.26)	-0.004 (0.50)	0.006 (0.82)	0.033 (0.30)	0.085** (0.02)	0.040 (0.40)	-0.011 (0.66)	-0.007 (0.76)
$\Delta PROFIT_t$		0.009 (0.18)	0.017* (0.09)						
$\Delta PROFIT_{t-1}$			0.009 (0.36)						
ΔLIQ_t				-0.050* (0.051)	-0.026 (0.37)	-0.035 (0.27)	0.005 (0.94)	-0.021* (0.07)	-0.016 (0.31)
ΔLIQ_{t-1}					0.033 (0.14)				
$\Delta WHOLE_t$						-0.029 (0.41)	-0.034 (0.25)		
$\Delta WHOLE_{t-1}$							-0.041 (0.15)		
ΔLEV_t								-0.006 (0.42)	-0.011 (0.15)
ΔLEV_{t-1}									0.019 (0.11)
Constant	1.870*** (0.00)	0.723*** (0.00)	0.539** (0.02)	2.563*** (0.00)	2.061*** (0.00)	2.543*** (0.00)	1.197** (0.01)	1.431*** (0.00)	1.073** (0.02)
F-test/t-test statistic of additional variables	-	1.34 (0.18)	2.99 (0.22)	-1.96* (0.051)	3.28 (0.19)	0.67 (0.41)	2.59 (0.27)	0.64 (0.42)	7.09** (0.03)

Dependent variable: Change in bank lending stocks (ΔY_t)									
	Baseline	[17] Profitability (first-difference)	[18] Profitability (lagged first-difference)	[19] Liquidity (first-difference)	[20] Liquidity (lagged first-difference)	[21] Wholesale funding (first-difference)	[22] Wholesale funding (lagged first-difference)	[23] Leverage (first-difference)	[24] Leverage (lagged first-difference)
Number of observations	7,142	4,895	3,333	2,218	1,861	1,662	1,319	1,904	1,598
Number of banks	571	413	266	174	138	125	93	141	112
Root Mean Squared Error	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: p-values are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe’s analysis

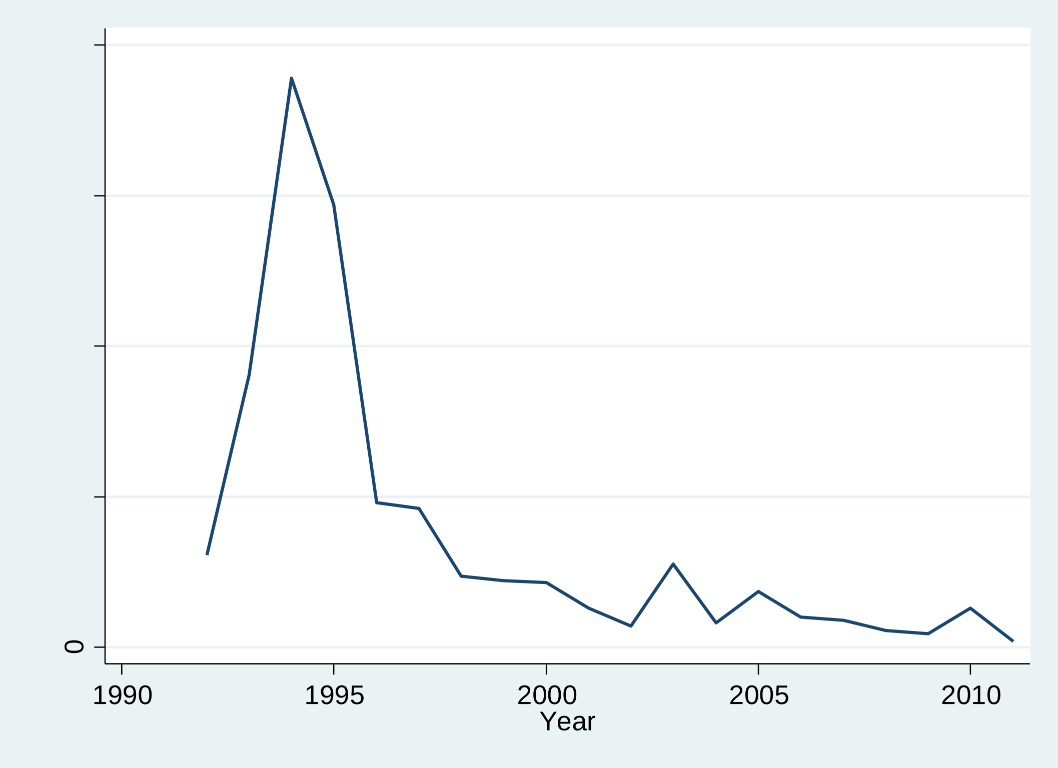
Table 76: Estimation results using combination of macroeconomic controls – Wider sample – Dynamic CCEMG estimation – 1988-2014

Dependent variable: Change in bank lending stocks (ΔY_t)

	Baseline	[25] Combination 1	[26] Combination 2	[27] Combination 3	[28] Combination 4	[29] Combination 5
Long-run coefficients						
CAP_{t-1}	0.005 (0.78)	0.015 (0.60)	0.055 (0.40)	0.001 (0.94)	0.026 (0.45)	-0.016 (0.58)
$SIZE_{t-1}$	0.339*** (0.00)	0.056 (0.60)	-0.226*** (0.00)	0.173** (0.02)	-0.131 (0.19)	-0.150* (0.051)
Short-run coefficients						
ECT_{t-1}	-0.241*** (0.00)	-0.184*** (0.00)	-0.099*** (0.00)	-0.313*** (0.00)	-0.150*** (0.00)	-0.170*** (0.00)
ΔY_{t-1}	-0.055*** (0.00)	-0.126*** (0.00)	-0.024*** (0.00)	-0.106*** (0.00)	-0.072*** (0.00)	-0.073*** (0.00)
ΔCAP_t	-0.007*** (0.00)	-0.008*** (0.00)	-0.011*** (0.00)	-0.007*** (0.00)	-0.012*** (0.00)	-0.011*** (0.00)
ΔCAP_{t-1}	-0.004 (0.15)	-0.005* (0.09)	-0.003 (0.40)	-0.004* (0.099)	-0.006* (0.053)	0.004 (0.18)
$\Delta SIZE_t$	0.213*** (0.00)	0.157*** (0.00)	0.044*** (0.00)	0.277*** (0.00)	0.130*** (0.00)	0.139*** (0.00)
$\Delta SIZE_{t-1}$	-0.004 (0.84)	-0.029 (0.20)	-0.012 (0.12)	0.013 (0.59)	0.007 (0.68)	0.006 (0.75)
$\Delta lnCB_t$		0.021 (0.16)				
ΔIB_t			0.006 (0.47)			0.006 (0.54)
$\Delta lnGDP_t$		0.001 (0.32)		0.024 (0.15)		
$\Delta Inflation_t$			0.0005 (0.96)		0.025* (0.07)	
$\Delta outputgap_t$				-0.003 (0.32)		
Constant	1.870*** (0.00)	2.028*** (0.00)	1.934*** (0.00)	2.036*** (0.00)	2.171*** (0.00)	1.807*** (0.00)
F-test statistic of additional variable(s)	-	2.95 (0.23)	0.52 (0.77)	3.08 (0.21)	3.21 (0.07)	0.37 (0.54)
Number of observations	7,142	4,676	3,868	5,651	4,512	4,816
Number of banks	571	368	312	420	348	382
Root Mean Squared Error	0.00	0.00	0.00	0.00	0.00	0.00

Note: p-values are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. ΔlnGDP drops out of estimation [33] and outputgap drops out of estimation [34].
Source: Bankscope and LE Europe's analysis

Figure 34: Distribution of sum of squared residuals by year – Dynamic CCEMG estimation



Note: Years 1988-1992, 2012 and 2013 are excluded as the interaction terms drop out from the estimation.
Source: Bankscope and LE Europe's analysis

Table 77: Estimation results modelling other potential structural breaks – Wider sample – 1988-2014

Dependent variable: Change in bank lending stocks (ΔY_t)		
	Dynamic CCEMG estimation	
	[30] Break in 2009	[31] Break in 2008
Long-run coefficients		
CAP_{t-1}	0.058 (0.22)	0.026 (0.60)
$Break*CAP_{t-1}$	0.036 (0.59)	0.059 (0.50)
$SIZE_{t-1}$	0.486*** (0.00)	0.296*** (0.00)
$Break*SIZE_{t-1}$	0.044 (0.42)	0.070 (0.18)
Short-run coefficients		
ECT_{t-1}	-0.158*** (0.00)	-0.137*** (0.00)
ΔY_{t-1}	-0.046** (0.02)	-0.039** (0.01)
ΔCAP_t	-0.006** (0.048)	-0.006* (0.06)
ΔCAP_{t-1}	-0.006* (0.085)	-0.004 (0.91)

Dependent variable: Change in bank lending stocks (ΔY_t)		
	Dynamic CCEMG estimation	
	[30] Break in 2009	[31] Break in 2008
$\Delta SIZE_t$	0.201*** (0.00)	0.180*** (0.00)
$\Delta SIZE_{t-1}$	-0.023 (0.16)	-0.027 (0.14)
Constant	0.863** (0.03)	1.312*** (0.00)
F-test statistic†	0.91 (0.63)	2.19 (0.33)
Number of observations	5,868	5,868
Number of banks	429	429
Root Mean Squared Error	0.00	0.00

Note: p-values are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. †Testing the joint significance of the structural break interaction terms
Source: Bankscope and LE Europe's analysis

Table 78: Estimation results excluding Italian banks – Cointegration test sample – 1988-2014

Dependent variable: Change in bank lending stocks (ΔY_t)			
	[32] Mean Group estimation	[33] Common Correlated Effects Mean Group estimation	[34] Dynamic Common Correlated Effects Mean Group estimation
Long-run coefficients			
CAP_{t-1}	-0.015*** (0.00)	0.026 (0.20)	0.011 (0.62)
$SIZE_{t-1}$	0.972*** (0.00)	0.941*** (0.00)	0.830*** (0.00)
Short-run coefficients			
ECT_{t-1}	-0.751*** (0.00)	-0.873*** (0.00)	-0.467*** (0.00)
ΔY_{t-1}	0.221*** (0.00)	-0.031 (0.74)	-0.012 (0.87)
ΔCAP_t	-0.006*** (0.00)	-0.005 (0.36)	-0.004 (0.42)
ΔCAP_{t-1}	0.004* (0.08)	-0.021** (0.03)	-0.006 (0.21)
$\Delta SIZE_t$	0.740*** (0.00)	0.597*** (0.00)	0.605*** (0.00)
$\Delta SIZE_{t-1}$	-0.182*** (0.00)	-0.213* (0.06)	0.001 (0.99)
Constant	0.023 (0.90)	1.168 (0.11)	0.010 (0.99)
Cross section averages	No	Yes	Yes
Additional lagged cross section averages	No	No	Yes, 1 lag
Number of observations	1,977	1,977	1,859
Number of banks	118	118	118
Root Mean Squared Error	0.0416	0.0120	0.00

Note: p-values are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Source: Bankscope and LE Europe's analysis

Annex 9 Correlation matrix of bank lending to infrastructure and infrastructure project / project financing characteristics

The correlation matrix below relates bank lending to infrastructure and project funding characteristics, and indicates that transaction size and total bank funding committed are the key drivers of any given bank's infrastructure financing activities in any given quarter.

Table 79: Correlation matrix of bank lending to infrastructure and infrastructure project / project financing characteristics

	Bank lending to infrastructure	Transaction size	Total bank financing of infrastructure	Total capital market financing of infrastructure	Total government financing of infrastructure	Bank lending / Total bank lending of infrastructure	Weighted average of project duration
Bank lending to infrastructure	1						
Transaction size	**0.69**	1					
Total bank financing of infrastructure	**0.72**	0.94	1				
Total capital market financing of infrastructure	**0.1**	0.28	0.22	1			
Total government financing of infrastructure	**0.18**	0.3	0.3	-0.01	1		
Bank lending to infrastructure / Total bank lending of infrastructure	**0.03**	-0.24	-0.27	-0.14	-0.06	1	
Weighted average of project duration	**-0.4**	-0.36	-0.39	-0.14	0.04	-0.06	1

Source: InfraDeals and LE Europe's analysis

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