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Bank Capital and Liquidity Creation: Granger Causality Evidence

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Contents

List of Tables

List of Figures

Abstract

This paper examines the relationship between capital and liquidity creation. This issue is of interest to determine the potential impact of tighter capital requirements such as those involved in Basel III reforms on liquidity creation. We perform Granger-causality tests in a dynamic GMM panel estimator framework on an exhaustive dataset of Czech banks from 2000 to 2010. We observe a strong expansion of liquidity creation during the full period, which was slowed by the financial crisis, and was mainly driven by large banks. We show that capital is found to negatively Granger-cause liquidity creation but also observe that liquidity creation Granger-causes capital reduction. These findings support the view that Basel III reforms can reduce liquidity creation, but also that greater liquidity creation can have a detrimental impact by reducing bank solvency. We thus show that there is a trade-off between the benefits of financial stability induced by stronger capital requirements and those of increased liquidity creation.

Keywords: bank capital, liquidity creation

JEL Classification: G21, G28

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1 Introduction

Recent financial turmoil has led the Basel Committee on Banking Supervision to propose new capital rules, commonly known as the Basel III reforms. They are based on the conclusion that the financial crisis was rooted in low solvency levels on bank balance sheets. As a consequence, these reforms introduce tighter capital requirements. In particular, the objective is to improve the resilience of the banking industry: "A strong and resilient banking system is the foundation for sustainable growth, as banks are at the center of the credit intermediation process between savers and investors. Moreover, banks provide critical services to consumers (…)." (Basel Committee on Banking Supervision 2010, p. 5).

Thus the Basel Committee emphasizes the importance of not only bank solvency, but liquidity creation as well, which is a key economic function of banks. Banks function as liquidity creators by financing relatively illiquid assets with relatively liquid liabilities. They thereby contribute to financing the economy and facilitating transactions between economic agents, or, to express it in Bank for International Settlements (BIS) terms, they contribute to credit intermediation and provide critical services to consumers.

This notion is extremely relevant, as the Basel Committee seems to neglect the possibility that bank solvency and liquidity creation may be antagonistic. Namely, by strengthening capital requirements, the Basel III Accords may have a detrimental impact on bank liquidity creation.

This view is supported by recent work by Berger and Bouwman (2009) that measures bank liquidity creation in the US. Analyzing the role of capital in bank liquidity creation, they conclude to the impact of opposing effects which can lead to a liquidity-destroying effect of capital. However, this study does not consider the potential for reverse causality that could influence the debate on capital requirements and modify their interpretation.

Our aim in this paper is to examine the relationship between capital and liquidity creation by testing their causal relationship. We, to our knowledge for the first time in the literature, propose a broad perspective on the interactions between capital and li-

quidity creation in the banking industry. In so doing, we are able to provide evidence on the potentially detrimental impact of capital requirements on liquidity creation. This would suggest a conflict between bank solvency and liquidity creation, which is not considered by the regulatory authorities.

A negative impact of capital on liquidity creation would suggest that greater capital requirements may hamper liquidity creation. In other words, there would be a trade-off between the benefits of financial stability induced by greater capital requirements and the costs of lower liquidity creation in the economy. This trade-off would be strengthened if liquidity creation was observed to have a negative effect on capital, as this would suggest that greater liquidity creation by banks may have detrimental effects on bank solvency. This reverse causality would also support the view that an optimal level of liquidity creation might exist.

Reciprocally, finding a positive impact of capital would provide support for the implementation of stronger bank capital requirements in the Basel III Accords, as they would result in greater safety and in higher liquidity creation. Furthermore finding that liquidity creation on capital has a positive effect on capital would mean that greater liquidity creation can also contribute to bank solvency and thus would show the existence of a virtuous circle in favor of tightening capital requirements.

Therefore, our research helps to assess the economic implications of the capital requirements in the Basel III reforms. The potential costs of these reforms have been assessed by international organizations. While Angelini et al. (2011) for BIS estimate that an increase of 1 percentage point leads to 0.09 percent decline in output, an OECD study by Slovik and Cournède (2011) concludes that increased financing costs from following the new capital requirements reduce GDP growth by 0.05 to 0.15 percentage point annually. However, neither study explicitly considers the potential costs of reduced liquidity creation, which might lead to a reappraisal of the strengthening bank capital requirements included in the Basel III accords.

The theoretical and empirical literature provides conflicting assumptions about the relationship between capital and liquidity creation, both in terms of sign and the type of causality. Berger and Bouwman (2009) proposed two contradictory hypotheses regard-

ing the impact of bank capital on liquidity creation. Furthermore, the literature suggests mechanisms for the potential influence of liquidity creation on bank capital that do not accord on the expected sign.

The concept of liquidity creation used in this paper is a rather comprehensive measure of a bank's overall ability to transform maturity in the economy, accounting for both the on- and off-balance sheet activities of banks (Berger and Bouwman, 2009). Including off-balance sheet activities in the liquidity creation indicator is relevant, as studies have highlighted the importance of banks' off-balance sheet activities (e.g., Boot, Greenbaum, and Thakor 1993, Holmstrom and Tirole 1997, Kashyap, Rajan, and Stein 2002). Therefore, the liquidity creation measure is used instead of some other indicators that only capture a bank's lending activity (e.g., credit-to-total asset ratio).

We perform some Granger-causality tests to check the sign and the type of causal relationship between bank capital and liquidity creation. We embed Granger causality estimations in GMM dynamic panel estimators to address the econometric complications induced by the use of lagged dependent variables. We then follow recent empirical studies on banking that similarly investigate causality in various banking issues such as the relationship between non-performing loans and efficiency (e.g., Podpiera and Weill, 2008, for Czech banks; Fiordelisi, Marques-Ibanez and Molyneux, 2011, for European banks) or the link between competition and efficiency (e.g., Pruteanu-Podpiera, Weill and Schobert, 2008, for Czech banks; Casu and Girardone, 2009, for European banks).

We explore the relationship between bank capital and liquidity creation using an exhaustive dataset of Czech banks from the Czech National Bank from 2000 to 2010. Our study is limited to a single country as it requires very detailed data. This requirement explains why all of the recent papers implementing Berger and Bouwman (2009)'s methodology are single-country studies. Measuring liquidity creation requires very detailed data because balance sheet items need to be classified to compute liquidity creation measures. As a consequence, cross-country databases such as Bankscope can-

not be used because the information provided is not sufficiently disaggregated to allow for the use of such measures.[1]

The Czech banking industry is an interesting case for our investigation. While it does not contain very large banks, it contains banks of various sizes. Therefore, an investigation of this banking industry does not suffer from selection bias, as could be the case for any study focusing on large banks or listed banks. Furthermore, the detrimental effects of new bank capital requirements might be of particular importance for small banks, which face greater difficulties in increasing their capital. Therefore, an analysis of the impact of bank capital on liquidity creation must include small banks.

The Czech Republic is a former transition country and is now an EU member. The vast majority of Czech banks are foreign-owned. Thus, results found for this country can be generalized to countries with high levels of foreign bank ownership of banks rather than to any other countries.[2] However, the results still provide interesting insights that may be of interest in the policy debate, particularly as the causal relationship between capital and liquidity creation has not been investigated previously. Moreover, as foreign bank entry is an important debate in many emerging countries, results obtained for a banking industry that is largely owned by foreign investors are of special interest to these countries.

The use of Czech data will also provide an opportunity to analyze the volume and evolution of liquidity creation in the Czech Republic over the last decade. We will then be able to examine whether the amount of liquidity created by Czech banks is similar to what Berger and Bouwman (2009) found for the US. It will also prove information on the evolution of aggregate liquidity creation over time. Importantly, we will investigate

[1] For instance, Bankscope does not provide the disaggregation of loans by category or by maturity for the vast majority of banks, which is of course needed for the computation of liquidity creation measures. Moreover, even within countries, the classifications of demand deposits, savings deposits, and time deposits are not consistent across banks.

[2] Note that a large share of foreign bank ownership is common in Central and Eastern European countries. In addition to the Czech Republic, in Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, FYR Macedonia, Georgia, Hungary, Lithuania, Montenegro, Romania and Slovakia foreign banks own greater than 80% of bank assets. These figures come from EBRD Structural Change Indicators.

whether the financial crisis reduced liquidity creation and thereby worsened economic difficulties via this transmission channel.

The remainder of this paper is structured as follows. In section 2, we present the hypotheses and related literature and then describe recent changes in the Czech banking industry. Section 3 presents the methodology. Section 4 develops the results. We conclude in section 5.

2 Background

2.1 Hypotheses

Contradictory assumptions can be advanced regarding the relationship between capital and liquidity creation. They diverge both in terms of the relationship's sign and the type of causality.

Berger and Bouwman (2009) posited two hypotheses framing the causal link that moves from bank capital to liquidity creation. The risk absorption hypothesis predicts that increased capital enhances the ability of banks to create liquidity. This hypothesis stems from two strands of the literature concerning the role of banks as risk transformers. Liquidity creation increases the bank's exposure to risk because banks that create more liquidity will face greater losses when they are forced to sell illiquid assets to satisfy the liquidity demands of customers (e.g., Allen and Santomero, 1998; Allen and Gale, 2004), while bank capital allows the bank to absorb greater risk (e.g., Bhattacharya and Thakor, 1993 Repullo, 2004).

In contrast, the financial fragility hypothesis predicts that increased capital hampers liquidity creation (Diamond and Rajan, 2001). Briefly, the financial fragility effect is an outcome of the following process. The bank collects funds from depositors and lends them to borrowers. Once a loan is issued, the bank has to monitor the borrower and collect loan payments. This helps the bank obtain private information on its borrowers that gives it an advantage in assessing their profitability. However, this informational advantage creates an agency problem, whereby the bank may be tempted to extract rents from its depositors by demanding a greater share of the loan income. If depositors refuse to pay the higher costs, the bank threatens to curtail its monitoring or loan collection efforts. As depositors know that the bank may abuse their trust, they become wary of depositing their money with the bank. The bank is thus forced to demonstrate its commitment to depositors by adopting a fragile financial structure with a large share of liquid deposits. The result of this fragile financial structure is that the bank runs the risk of losing funding if it attempts to withhold depositors. As such, the threat of bank runs mitigates the holdup problem that arises after depositors have put their funds in the bank. Consequently, by allowing the bank to receive more deposits and finance more loans, financial fragility favors liquidity

creation. As greater capital reduces financial fragility, it enhances the bargaining power of the bank and hampers the credibility of its commitment to the depositors. Thus, increased capital works to diminish liquidity creation.

However, we can also propose a mechanism through which the relationship moves from liquidity creation to capital. The illiquidity risk hypothesis contends that greater liquidity creation increases the risk of illiquidity for banks because illiquid assets occupy a larger share of their total balance sheets. This incentivizes banks to strengthen their solvency through increased capital, not only so that they can still have a relaxed access to external funding markets but also because capital acts as a buffer because creating liquidity is risky. Therefore, greater liquidity creation should lead to higher levels of bank capital. This hypothesis is related to empirical works examining the impact of risk on bank capital buffers (Lindqist, 2004; Jokippi and Milne, 2011).

2.2 Related literature

The literature on bank liquidity creation remains scarce because its expansion is a recent development in the wake of Berger and Bouwman (2009)'s pioneering article. This paper makes a major contribution by suggesting a new method for measuring the liquidity created by banks. They propose a classification of all balance sheet items as liquid, semi-liquid and illiquid. This applies to all items in a bank's assets, liabilities, equity, and off-balance sheet activities. They use different classifications for the items, leading to four different measures of liquidity creation. Two measures are based on category classification of balance sheet items, while two measures are based on maturity. For each type, one measure includes off-balance sheet activities, while the other does not. The authors then assign weights to all of the items and compute the amount of liquidity created by each bank.

Berger and Bouwman (2009) use this method to measure liquidity creation in the US banking industry between 1993 and 2003. They find that the US banking industry created $2.8 trillion in liquidity in 2003 and liquidity creation increased substantially between 1993 and 2003. They also show that that large banks, multibank holding company members, retail banks, and recently merged banks create the most liquidity.

Berger and Bouwman explore the relationship between bank capital and liquidity creation. They find that this relationship varies with size and depending on whether off-balance sheet items are included in the liquidity creation measure. With measures including off-balance sheet items, the relationship is positive for large banks, not significant for medium banks, and negative for small banks. With measures excluding off-balance sheet items, the relationship is not significant for large and medium banks, and negative for small banks.

A handful of recent papers have followed this study. Fungáčová, Weill and Zhou (2010) extend the debate on the relationship between bank capital and liquidity creation by analyzing how deposit insurance scheme affects this relationship. To do so, they study Russia, which provides a natural experiment to investigate this issue because a deposit insurance scheme was implemented there in 2004. Even if the deposit insurance scheme has effects, its implementation does not change the sign of the relationship. They find a negative relationship between bank capital and liquidity creation before and after the deposit insurance scheme. Moreover, they observe that the relationship varies with size and ownership. It is significantly negative for small and medium banks, and for private domestic banks, while it is not significant for large banks, foreign banks, and state-owned banks.

Berger and Bouwman (2010) analyze the impact of monetary policy on aggregate bank liquidity creation in the US. Analyzing the period from 1984 to 2008, they examine whether the impact differs between normal periods and financial crises, as well as with respect to bank size. They show that tightening monetary policy only reduces liquidity creation for small banks. This effect is weaker during financial crises. They also note that liquidity creation is somewhat higher prior to financial crises, which suggests that measures of aggregate liquidity creation have explanatory power in predicting crises.

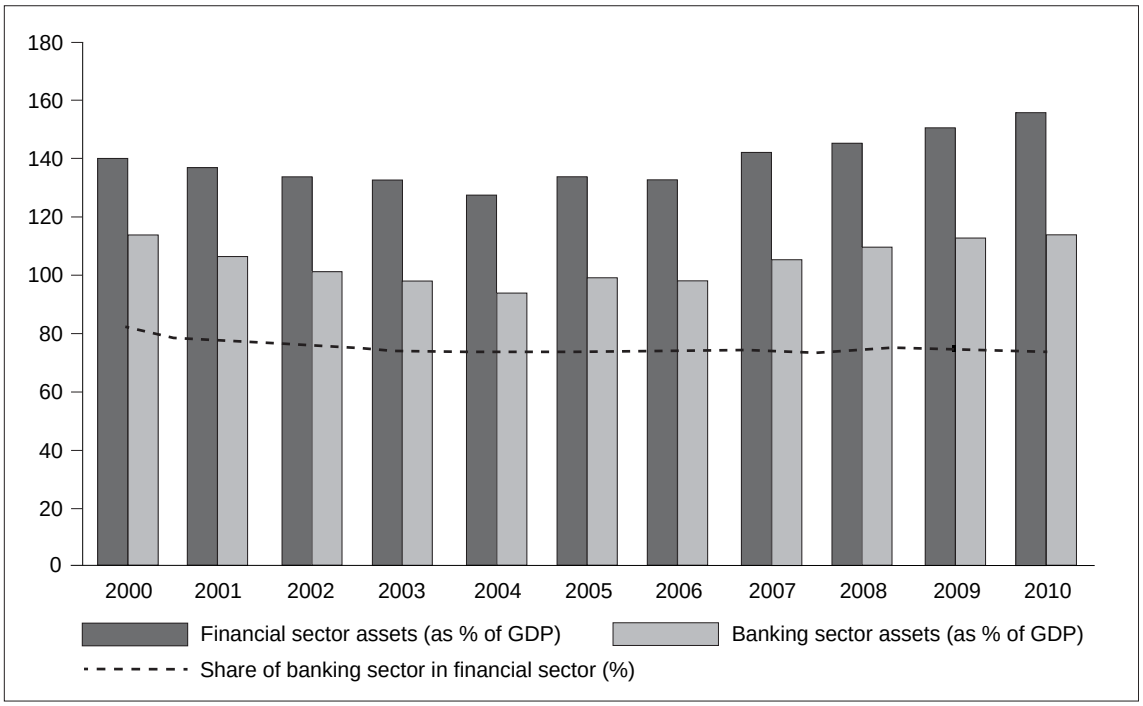
Berger et al. (2012) investigate how regulatory interventions and capital injections influence risk and liquidity creation using a sample of German universal banks. They find that these interventions reduce both risk and liquidity creation. Rauch et al. (2011) analyze potential determinants of liquidity creation for a sample of German savings banks. They compare the influence of macroeconomic factors, including monetary policy and unemployment, with the bank-specific factors such as size or financial perfor-

mance. They find some support for the impact of monetary policy, as monetary policy tightening reduces liquidity creation. However, bank-specific factors do not seem to have any influence on liquidity creation. Additionally, Pana, Park and Query (2010) examine the impact of bank mergers on liquidity creation for US banks. They report that mergers have a positive influence on bank liquidity creation.

2.3 The evolution of the Czech banking industry

The banking industry occupies a dominant position in the Czech financial system and represents the most relevant channel of financial intermediation. While the depth of financial intermediation (measured as total financial sector assets to GDP) reached 156% at the end of 2010, the ratio of banking sector assets to GDP was nearly 115% according to figures from the Czech National Bank. The banking sector's large share of the overall financial system has been relatively stable in recent years (see Chart 1). However, compared to Eurozone countries, the Czech financial sector remains relatively underdeveloped.

Chart 1: Financial and banking sector assets



Source: CNB

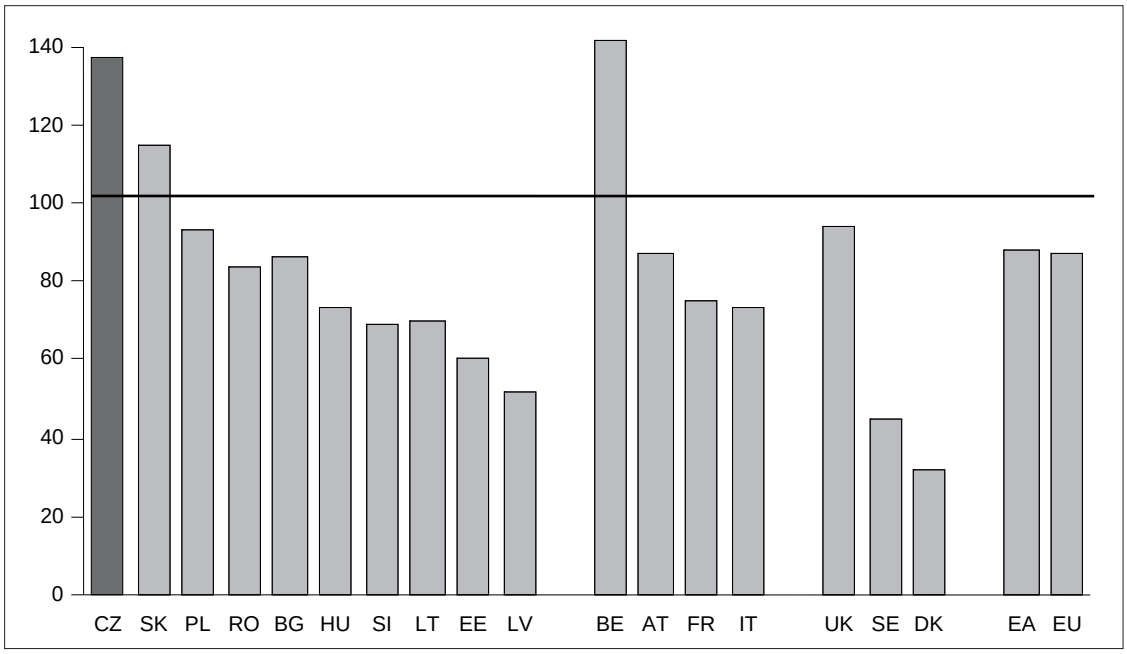
The 1990s was the first decade of a marked-based banking sector and was characterized by the deleveraging and cleaning of bank portfolios, which were primarily concentrated in the corporate sector. These loans were of dubious quality as a legacy of the centrally driven economy and poor asset management during this period. The banking sector underwent restructuring and privatization through 2001. As a result, approximately 97 percent of banking sector assets is currently owned by foreign capital, predominantly from other EU countries.

After the restructuring of the banking sector and in line with the solid performance of the Czech economy, bank credit to the private sector grew substantially during the 2003–2007 period. Nonetheless, this relatively rapid credit growth – especially to the household sector – was primarily financed through local currency deposits, and banks had no incentive to offer foreign currency loans. Thus, the Czech Republic is one of a small number of countries in the Central and Eastern European region that neither experienced a boom in foreign currency lending nor relied on external (foreign) funding. The increased lending to households was primarily conducted in the local currency, which mitigated potential future risk from exchange rate depreciation.

As a result, the performance of the Czech banking sector improved significantly after 2001, which is made apparent by high capital buffers (approximately 15% at the end of 2010) and relatively small non-performing loans ratio (6.2% in 2010). This also led to a relatively mild impact of the financial crisis in 2009, and no Czech bank needed government support.

The Czech banking sector is considered to be well funded because approximately 70% of liabilities are created by client deposits. This also illustrates that the ratio of deposits to loans in the Czech Republic is among the highest in the EU, as observed in Chart 2.

Chart 2: Ratio of deposits to loans granted in selected EU countries



Source: ECB

Note: EA = euro area; EU = average for all EU countries.

3 Methodology

3.1 Measures of bank liquidity creation

We use data for all Czech banks during the period 2000–2010 from the Czech National Bank.[3] The data come from the balance sheets of banks that are reported to CNB Banking Supervision of the central bank, and we have an unbalanced panel of 31 banks with 3,821 monthly observations.

We compute two measures of liquidity creation. We follow Berger and Bouwman (2009)'s procedure by classifying items on Czech banks' balance sheets as liquid, semi-liquid and illiquid. Once all of the balance sheet items are classified as liquid, semi-liquid or illiquid, we assign them weights and calculate the measures of liquidity creation by summing all weighed items.

Berger and Bouwman (2009) propose four different measures of liquidity creation, which differ with respect to the classification of balance sheet items. Their specifications use a classification based on the categories or maturities of items ("cat" or "mat" measures) and include or exclude off-balance sheet items ("fat" or "nonfat" measures). We only use the classification based on maturity of items, as our dataset provides detailed information that allows us to consider on- and off-balance sheet items by maturity, which is not the case for the classification by category. Our measures differ with respect to the inclusion of off-balance sheet items. Hence, in Berger and Bouwman's terminology, we consider the "mat fat" liquidity creation measure and the "mat nonfat" liquidity creation measure that we label, respectively, the broad and the narrow liquidity creation measures for the purposes of our analysis.

It is worth emphasizing that we do not use exactly the same definition that Berger and Bouwman employed for US banks. Our approach is "fully mat fat", i.e., all items are classified by the remaining maturity. Berger and Bouwman classify items on the asset side according to maturity; nevertheless, they classify loans entirely by either

[3] Czech banks in this analysis also include all foreign-owned subsidiaries but not foreign bank branches, which only represent 11.5% of the total assets in the Czech banking sector (as of the end-2011).

product category or by maturity and do not combine this information as they do for other bank activities. Concerning the liabilities and equity, they adopt the same classification based on category. Therefore, it has to be noted that our liquidity creation indicator represents a slightly different measure of liquidity creation, which is based solely on the detailed remaining maturity maturities of the balance sheet items not only on the asset side but also for liabilities and equity.[4]

Table 1: Liquidity classification of bank activities

Assets		
Illiquid assets (weight ½)	*Semi-liquid assets (weight 0)*	*Liquid assets (weight –½)*
Financial assets held for trading with maturity greater than 1 year	Financial assets held for trading with maturity between 3 months and 1 year	Financial assets held for trading with maturity lower than 3 months
Financial assets designated at fair value through profit or loss with maturity greater than 1 year	Financial assets designated at fair value through profit or loss with maturity between 3 months and 1 year	Financial assets designated at fair value through profit or loss with maturity lower than 3 months
Available-for-sale financial assets with maturity greater than 1 year	Available-for-sale financial assets with maturity between 3 months and 1 year	Available-for-sale financial assets with maturity lower than 3 months
Loans and receivables with maturity greater than 1 year	Loans and receivables with maturity between 3 months and 1 year	Loans and receivables with maturity lower than 3 months
Held to maturity investments with maturity greater than 1 year	Held to maturity investments with maturity between 3 months and 1 year	Held to maturity investments with maturity lower than 3 months
Derivatives hedge accounting (positive fair value) with maturity greater than 1 year	Derivatives hedge accounting (positive fair value) with maturity between 3 months and 1 year	Derivatives hedge accounting (positive fair value) with maturity lower than 3 months
Other assets with maturity greater than 1 year	Other assets with maturity between 3 months and 1 year	Other assets with maturity lower than 3 months
		Cash and cash balances with central banks

[4] Furthermore, when we calculate the maturity of corporate loans based on the categories of companies' various economic activities (e.g., agriculture, mining, manufacturing, etc.) using the data on all individual loans issued to corporations in the Czech Republic available in the Central Credit Register dataset, we find that the average maturity does not differ significantly for many economic sectors. For example, the average loan maturity for firms in mining is 3.8 years, for manufacturing is 4.3 years and for construction is 3.7 years. As a result, for the Czech data, it is less fruitful to classify some loan categories as liquid, while other categories as semi-liquid or illiquid.

Table 1 (continued)

Liabilities plus equity		
Illiquid liabilities plus equity (weight –½)	*Semi-liquid liabilities (weight 0)*	*Liquid liabilities (weight ½)*
Financial liabilities held for trading with maturity greater than 1 year	Financial liabilities held for trading with maturity between 3 months and 1 year	Financial liabilities held for trading with maturity lower than 3 months
Financial liabilities designated at fair value through profit or loss with maturity greater than 1 year	Financial liabilities designated at fair value through profit or loss with maturity between 3 months and 1 year	Financial liabilities designated at fair value through profit or loss with maturity lower than 3 months
Financial liabilities measured at amortized cost with maturity greater than 1 year	Financial liabilities measured at amortized cost with maturity between 3 months and 1 year	Financial liabilities measured at amortized cost with maturity lower than 3 months
Derivatives – hedge accounting (negative fair value) with maturity greater than 1 year	Derivatives – hedge accounting (negative fair value) with maturity between 3 months and 1 year	Derivatives – hedge accounting (negative fair value) with maturity lower than 3 months
Other liabilities with maturity greater than 1 year	Other liabilities with maturity between 3 months and 1 year	Other liabilities with maturity lower than 3 months
		Deposits, loans and other financial liabilities vis-à-vis central banks
Off-balance-sheet items		
Illiquid items (weight ½)	*Semi-liquid items (weight 0)*	*Liquid items (weight –½)*
Commitments and guarantees given with maturity greater than 1 year	Commitments and guarantees given with maturity between 3 months and 1 year	Commitments and guarantees given with maturity lower than 3 months
Commitments and guarantees received with maturity greater than 1 year	Commitments and guarantees received with maturity between 3 months and 1 year	Commitments and guarantees received with maturity lower than 3 months

This table presents the classification of the on- and off-balance sheet items and the weights used for the calculation of the liquidity creation measures.

The broad measure of liquidity creation is our preferred one because it accounts for off-balance sheet items that can also provide liquidity and is thus more comprehensive. Nevertheless, the narrow measure is relevant for our analysis, as it allows us to check the robustness of our conclusions. Table 1 gives a detailed description of the classification.

3.2 The Granger causality framework

To test the hypotheses on the relationship between bank capital and liquidity creation, we employ the Granger-causality framework. We thus estimate the following equations to examine the inter-temporal relationships between bank capital and liquidity creation:

$$LiquidityCreation_{i,t} = f(Capital_{i,lag}, LiquidityCreation_{i,lag}, Z_{i,t}) + e_{i,t} \quad (1)$$

$$Capital_{i,t} = f(LiquidityCreation_{i,lag}, Capital_{i,lag}, Z_{i,t}) + e_{i,t} \quad (2)$$

where the subscript t denotes the time dimension, i represents the cross-sectional dimension across banks, Z represents the control variables and $e_{i,t}$ is the error term. *LiquidityCreation* is the ratio of liquidity creation to assets. We will use the broad and narrow measures of bank liquidity creation to shed light on the robustness of our results even though, as mentioned above, the broad measure is preferred because it includes off-balance sheet items. *Capital* is the ratio of bank equity to total assets.

Equation (1) tests whether changes in capital temporally precede variations in liquidity creation, while equation (2) evaluates whether changes in liquidity creation temporally precede variations in capital. We use four lags, which appears reasonable given the monthly frequency of our data. In their analyses of the causal relationship between non-performing loans and bank efficiency, Podpiera and Weill (2008) use three lags and Fiordelisi, Marques-Ibanez and Molyneux (2011) choose two lags, but they have yearly data.

We estimate an AR(4) process in which Granger-causality is tested by a joint test that the sum of all of the lagged coefficients of the explained variable in question is significantly different from zero. The introduction of lagged dependent variables in the predicting variables creates econometric problems induced by unobserved bank-specific effects and joint endogeneity of the explanatory variables. To address these issues, we use the system GMM estimators developed for dynamic panel models by Arellano and Bover (1995) and Blundell and Bond (1998). Podpiera and Weill (2008) and Fiordelisi,

Marques-Ibanez and Molyneux (2011) used similar frameworks of a Granger-causality test embedded in GMM dynamic panel estimators.

We include a series of control variables. The selection of variables is partly driven by the work of Berger and Bouwman (2009) on US banks, as they also regress liquidity creation on capital by controlling for several factors. Nevertheless, we add additional control variables to account for the specific characteristics of the country under analysis and consider some potential determinants of capital to assets ratios, which was not a dependent variable for Berger and Bouwman.

We take various dimensions of risk into account using three variables: *Earnings Volatility*, defined as the standard deviation of the bank's monthly return on assets measured over the previous six months, *Credit Risk*, which is the ratio of risk-weighted assets and off-balance sheet activities divided by assets, and *Z-Score*, measured by the return on assets plus *Capital* divided by *Earnings Volatility*. We also control for *Non Performing Loans* with the ratio of non-performing loans to total loans for two reasons. On the one hand, many Czech banks had portfolios with a sizeable amount of non-performing loans because of the banking reforms implemented in the 1990s at the beginning of the period of our study. On the other hand, our study covers the recent financial crisis, in which the share of non-performing loans increased somewhat. The risk measures are not orthogonalized, as their correlation is low.

We consider *Size*, measured by the log of total assets, and *Market Share*, defined as the market share of total deposits for each bank. As we use monthly data at, we include *Inflation* and *Unemployment* to control for the macroeconomic environment. These macroeconomic data come from the Czech Statistical Office.

Unlike Berger and Bouwman (2009), we do not include a dummy variable for mergers and acquisitions, as there were very few during our sample period and the dummy would be largely correlated with the constant. Similarly, we do not include any variables that capture population density, as the Czech Republic is a rather small country and banks typically do not specialize geographically. Table 2 displays summary statistics for all of the variables used in the estimations.

Table 2: Description of variables and summary statistics

Variable	Description	N	Mean	Std. Dev.
Liquidity Creation: broad measure	Ratio of liquidity creation (including off-balance sheet items) to assets	4056	0.17	0.26
Liquidity Creation: narrow measure	Ratio of liquidity creation (excluding off-balance sheet items) to assets	4056	0.19	0.19
Capital	Equity to assets	4056	0.08	0.11
Earnings Volatility	Standard deviation of monthly return on assets measured over the previous six months	3876	0.35	0.89
Credit Risk	Basel II risk-weighted assets and off - balance sheet activities divided by assets	4056	0.41	0.41
Z-Score	Return on assets plus Capital divided by Earnings Volatility	3872	11.09	18.11
Non Performing Loans	Share of loans in default for 3 months and more to total loans	4039	5.94	8.37
Size	Log of assets	4056	17.37	1.59
Market Share	Share of deposits in total deposits in the country	4092	0.03	0.07
Unemployment	Unemployment rate	4092	7.17	1.27
Inflation	Year-on-year change in consumer prices	4092	2.67	1.87

Means and standard deviations for variables used in subsequent estimations.

4 Results

This section displays our results. We first provide evidence on the volume and evolution of liquidity creation by Czech banks. We then develop estimations of the relationship between capital and liquidity creation.

4.1 Analysis of liquidity creation

We study the volume and evolution of bank liquidity creation. To do so, we provide liquidity creation measures for all banks. We also separately consider four categories of Czech banks: large banks (with total assets of more than CZK 200 billion, approximately 11.3 billion USD), medium-sized banks (total assets between CZK 50 billion and 200 billion, approximately 2.8–11.3 billion USD), small banks (total assets less than CZK 50 billion), and building societies.[5] This decomposition allows us to draw conclusions about the roles that the different categories of banks play in liquidity creation. Table 3 provides the results for the liquidity creation measures over the period. They are also presented in Charts 3 and 4 for the broad and the narrow liquidity creation measures, respectively. Several conclusions are apparent.

Table 3: Summary statistics on bank liquidity creation

	Broad measure				Narrow measure			
	Mid-2000							
	N	LC (CZK)	LC (USD)	LC/ Assets	N	LC (CZK)	LC (USD)	LC/ Assets
All banks	31	357.1	20.2	0.15	31	378.1	21.4	0.16
Large banks	4	314.3	17.8	0.18	4	332.9	18.8	0.19
Medium banks	4	12.1	0.7	0.09	4	9.9	0.6	0.08
Small banks	18	8.7	0.5	0.1	18	12.6	0.7	0.15
Building societies	5	–11.3	–0.6	–0.09	5	–8.6	–0.5	–0.07

[5] A building society is a special type of bank that provides home loans to households under specific conditions given in Act No. 96/1993 Coll., on Building Savings Schemes and State Support for Building Savings Schemes and its later amendments. Based on the volume of total assets, 4 building societies would be classified as medium-sized banks and one as a small bank.

Table 3 (continued)

	Broad measure				Narrow measure			
				Mid-2006				
	N	LC (CZK)	LC (USD)	LC/ Assets	N	LC (CZK)	LC (USD)	LC/ Assets
All banks	31	897.4	50.7	0.28	31	911.8	51.5	0.29
Large banks	4	713.5	40.3	0.36	4	704.9	39.8	0.35
Medium banks	4	66.2	3.7	0.23	4	63.1	3.6	0.22
Small banks	18	0.3	0.017	0	18	18.4	1.0	0.15
Building societies	5	74.1	4.2	0.2	5	74.8	4.2	0.2
				Mid-2010				
	N	LC (CZK)	LC (USD)	LC/ Assets	N	LC (CZK)	LC (USD)	LC/ Assets
All banks	31	1,293.8	73.1	0.33	31	1,350.6	76.3	0.36
Large banks	4	890.0	50.3	0.39	4	875.9	49.5	0.40
Medium banks	4	89.1	5.0	0.18	4	140.0	7.9	0.27
Small banks	18	–2.9	–0.2	–0.01	18	38.9	2.2	0.17
Building societies	5	203.3	11.5	0.52	5	215.7	12.2	0.53

This table displays the means of bank liquidity creation measures. Liquidity creation measures are in millions of Czech crowns (CZK) and USD. LC/A is the ratio of liquidity creation to total assets. LC adjusted for inflation (Base 2005 = 100). N represents the number of banks. LC in USD is added for convenience; the 2011 average CZK/USD exchange rate of 17.7 is used.

First, we observe a strong expansion of liquidity creation during the full period. The aggregate volume of liquidity creation, when using the broad measure, increased in real terms from 357.1 million CZK in 2000 (approximately 20.2 million USD) to 1,293.8 million CZK in 2010 (approximately 73.1 million USD). The mean ratio of liquidity creation to assets more than doubled from 15% in 2000 to 33% in 2010. The same findings are observed when we use the narrow measure of liquidity creation.

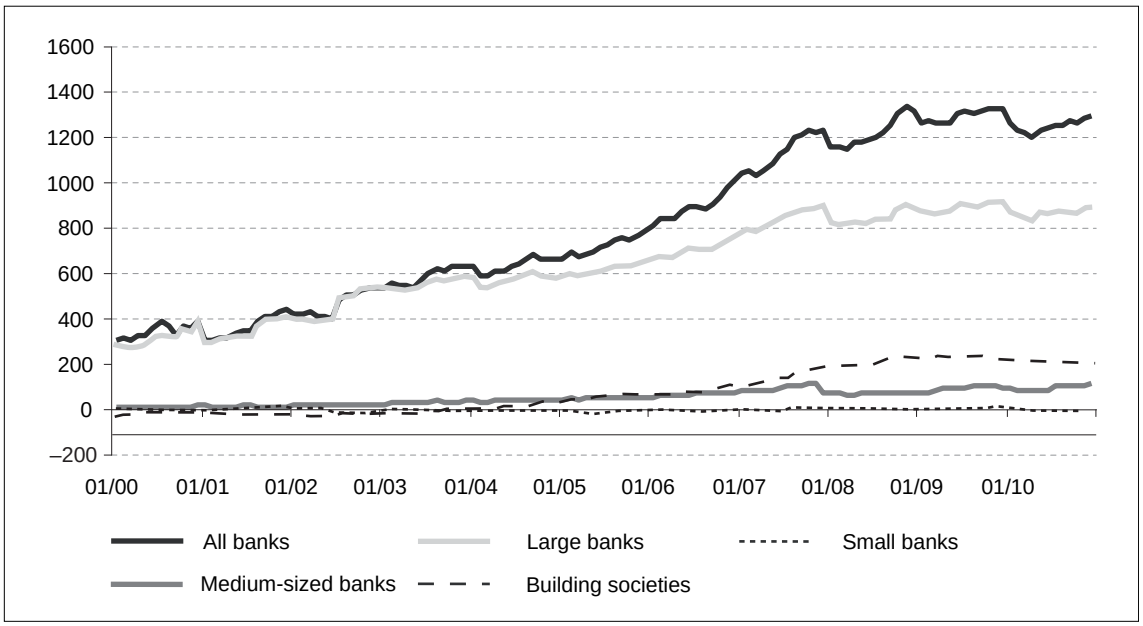
These changes are in line with developments in the Czech banking industry. The high growth in liquidity creation in 2001–2003 was stimulated by the decline in interest rates to levels similar to those in the Euro zone, following the successful disinflation. They were also driven by the consolidation of the banking industry, as larger banks are

associated with greater liquidity creation. The growth peaked again at the onset of the global financial crisis. This is likely linked to high economic growth associated with considerable credit growth. Bank prudence increased during the global financial crisis, which contributes to halting the growth of liquidity creation. However, the crisis was not associated with the decline in liquidity creation. This development likely reflects the good financial health of the Czech banking sector, as banks that are in better shape have less incentives to reduce their credit supply. The positive financial situation of Czech banks is supported by the observation that, unlike in most EU countries, these banks did not benefit from any governmental support during the crisis, and stress tests suggest that they are able to withstand considerable negative shocks (Czech National Bank, 2011).

Second, large banks contribute widely to liquidity creation. In 2000, large banks were responsible for 88% of total liquidity creation. Over the 2000s, their contribution to liquidity creation decreased somewhat but remained highly important: they represented 69% of total liquidity creation in 2010. This reduction is a consequence of the increasing role of medium-sized banks and building societies in liquidity creation over time. Small banks created very little liquidity during the full period. The key role of large banks in liquidity creation is in accordance with what Berger and Bouwman observe for the US banking industry. They show that large banks created 81% of total liquidity in 2003.

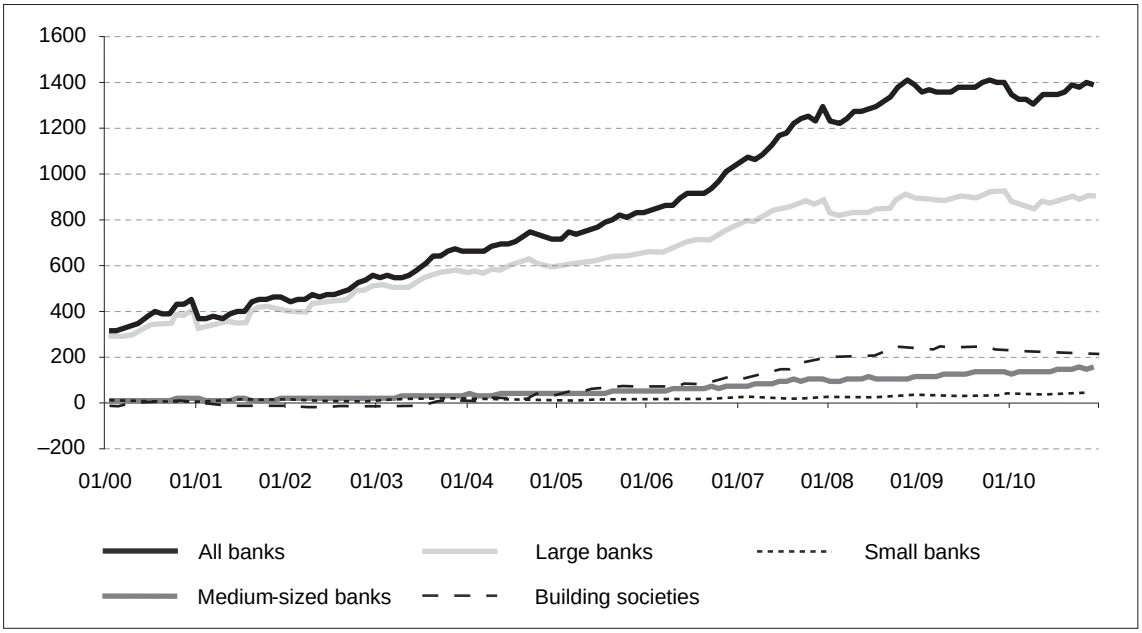
However, one may wonder whether large banks create more liquidity relative to their size. Namely, large banks can contribute more to liquidity creation in absolute terms, but might create less liquidity in relative terms when considering their total assets. The analysis of the ratios of liquidity creation to assets confirms the predominant role of large banks in liquidity creation in relative terms. The mean ratios for large banks are 18% in 2000 and 39% in 2010, compared with means for all banks of 15% in 2000 and 33% in 2010.

Chart 3: Bank liquidity creation (broad measure)



Source: CNB, authors' calculations
Note: The series are adjusted for inflation (Base 2005 = 100). In millions of Czech crowns.
X-axis = month/year

Chart 4: Bank liquidity creation (narrow measure)



Source: CNB, authors' calculations
Note: The series are adjusted for inflation (Base 2005 = 100). In millions of Czech crowns.
X-axis = month/year

Third, comparisons for both liquidity creation measures show that off-balance sheet items play a small role in liquidity creation. This differs from the US situation described in Berger and Bouwman: while off-balance sheet items contribute approximately 50% to the overall bank liquidity creation in the US, they only contribute approximately 10% in the Czech Republic. For example, building societies have almost no off-balance sheet items, which reflects regulatory issues. Interestingly, off-balance sheet items destroy rather than create liquidity in the Czech Republic. Nevertheless, it has to be acknowledged that the differences between our and Berger and Bouwman (2009)'s results may be driven by differences in the methods used to calculate liquidity creation. For example, our approach classifies loan commitments with short maturities as liquid with a weight of –1/2 thus destroying liquidity. In contrast, Berger and Bouwman (2009) classify loan commitments of any maturity as illiquid, arguing that it is equally hard to get rid of a short-term loan commitment.

4.2 Regressions

We now turn to the regressions we run to investigate the sign and sense of causality between capital and liquidity creation. We focus our estimations on the broad measure of liquidity creation. Table 4 contains the results. The dependent variable is *Capital* or *Liquidity Creation.* We test two alternative specifications of the set of control variables by including or excluding both macroeconomic variables, *Inflation* and *Unemployment*, to examine their potential influence on the results.

We show that capital is found to negatively Granger-cause liquidity creation, as the sum of the lagged variables for *Capital* is significantly negative for both models with *Liquidity Creation* as the dependent variable. This finding speaks in favor of the financial fragility hypothesis, according to which greater capital contributes to a deterioration of liquidity creation.

Table 4: Granger Causality Tests: Estimations with the broad measure of liquidity creation

	Explained variable: LiquidityCreation		Explained variable: Capital	
	(1)	(2)	(3)	(4)
$LiquidityCreation_{t-1}$	0.67***	1.03***	–0.01***	–0.01**
	(0.19)	(0.20)	(0.002)	(0.003)
$LiquidityCreation_{t-2}$	0.24	–0.585*	0.008***	0.01**
	(0.26)	(0.35)	(0.002)	(0.002)
$LiquidityCreation_{t-3}$	–0.02	0.725**	–0.007***	–0.01***
	(0.09)	(0.29)	(0.002)	(0.001)
$LiquidityCreation_{t-4}$	0.09	0.25	–0.003**	–0.0002)
	(0.18)	(0.32)	(0.001)	(0.001)
$LiquidityCreation_{total}$	0.98***	1.42***	–0.01***	–0.01***
	(0.00)	(0.00)	(0.00)	(–0.00)
$Capital_{t-1}$	0.06	–0.02	0.65***	0.72***
	(0.29)	(0.28)	(0.03)	(0.04)
$Capital_{t-2}$	–1.22	1.10	0.12***	0.10**
	(1.58)	(1.46)	(0.03)	(0.04)
$Capital_{t-3}$	–2.94**	–5.31**	–0.02	–0.10***
	(1.33)	(2.25)	(0.02)	(0.04)
$Capital_{t-4}$	–2.84***	–2.71**	–0.04	–0.14**
	(0.92)	(1.12)	(0.06)	(0.06)
$Capital_{total}$	–6.94***	–6.94***	0.71***	0.58***
	(0.01)	(0.07)	(0.00)	(0.00)
NPL	–0.00167	–0.003**	–0.0002***	–1.2E-06
	(0.0016)	(0.001)	(6.4E-05)	(4.3E-05)
Credit risk	6.1E-05	1.1E-05	–3.2e-05***	–1.5E-05
	(0.0001)	(0.0001)	(7.5E-06)	(1.0E-05)
Z-score	8.03-05	–0.0002*	1.29e-05***	1.7e-05***
	(9.7E-05)	(0.0001)	(4.5E-06)	(4.7E-06)
Earnings Volatility	0.002	–0.0004	–0.001*	–0.001**
	(0.002)	(0.003)	(0.001)	(0.001)
Market share	0.30	–1.046	–0.03	–0.03
	(1.00)	(0.992)	(0.13)	(0.11)
Size	–0.10***	–0.14***	–0.05***	–0.03***
	(0.04)	(0.04)	(0.01)	(0.01)

Table 4: (continued)

	Explained variable: LiquidityCreation		Explained variable: Capital	
	(1)	(2)	(3)	(4)
Unemployment		–0.01**		–0.002***
		(0.01)		(0.001)
Inflation		–0.0005		0.0002
		(0.001)		(0.0002)
Constant	2.31***	3.08***	0.89***	0.47***
	(0.74)	(0.93)	(0.11)	(0.16)
Observations	3821	3821	3821	3821
Sargan test	11.76	10.30	20.86	13.61
AB test AR(1)	–1.39*	–2.17**	–2.18***	–2.29***
AB test AR(2)	–0.11	0.86	–0.79	–0.77

Berger and Bouwman (2009) also find a negative impact of capital on liquidity creation but only for small banks. Hence our results for Czech banks diverge from their findings for US banks. At first glance, one could imagine that Czech banks are not large enough to make the sign positive. However, comparing the sizes of US and Czech banks rejects this view. The mean balance sheet for Czech banks is 105 billion CZK, i.e., 6 billion USD, with a maximum size exceeding 770 billion CZK, i.e., 45 billion USD, which has to be compared with a mean size of 10 billion USD for US large banks in the abovementioned paper. In other words, Czech banks are not smaller than US banks on average. Thus, our results tend to show a more detrimental influence of capital on liquidity creation in the Czech case. Our findings are in accordance with the observation from Fungáčová, Weill and Zhou (2010) on Russian banks, which concludes that capital has a significantly negative impact on liquidity creation. Ultimately, this tends to suggest that the US findings on this impact cannot be generalized.

When we study the reverse causality, we observe that liquidity creation negatively Granger-causes capital reduction because the sum of the lagged variables for *Liquidity Creation* is significantly negative for both specifications with *Capital* as the dependent variable. In other words, greater liquidity creation leads to lower levels of bank capital.

We can interpret this finding through a crowding-out effect, according to which increased liquidity creation is associated with increased deposits that crowd out capital. More generally, improved access to the depositor base would reduce the incentives for bank managers to search for external funding, including capital.

This latter finding is of the utmost importance. First, it shows the importance of investigating the reverse causality between capital and liquidity creation that was previously ignored in the literature. Second, a bi-causal, negative relationship between capital and liquidity creation stresses the existence of a trade-off for authorities between bank solvency, with high capital levels, and liquidity creation.

To sum it up, our regressions show that there is a bi-directional link between capital and liquidity creation that is negative.

Turning to the analysis of the control variables, we observe that most control variables are not significant. One notable feature is the significantly negative coefficient for *Unemployment*, which means that greater unemployment deteriorates both capital and liquidity creation. This finding is in accord with the fact that banks suffer from a reduction in solvency and create lower liquidity in troubled economic times.

4.3 Robustness checks

We perform alternative estimations to determine whether our findings are robust to the chosen measure of liquidity creation, to the period of study, and to the frequency of data.

In a first robustness check, we rerun all estimations by using the narrow measure of liquidity creation. Thus far, we have focused on the broad measure of liquidity creation. However, the results might differ when off-balance sheet activities are excluded. The results are displayed in Table 5. Interestingly, they show a similar pattern in the relationship between capital and liquidity creation. The total effect of capital on liquidity creation is again significantly negative, while we find the same conclusion for the total effect of liquidity creation on capital. The sums of the lagged variables for *Capital* when explaining *Liquidity Creation* and for *Liquidity Creation* when explaining *Capital* are still significantly negative. In other words, we again find evidence of Granger-causation running in both directions between capital and liquidity creation, which is negative.

Table 5: Granger Causality Tests: Estimations with the narrow measure of liquidity creation

	Explained variable: LiquidityCreation		Explained variable: Capital	
	(1)	(2)	(3)	(4)
$LiquidityCreation_{t-1}$	0.66***	0.52***	–0.01***	–0.01***
	(0.18)	(0.18)	(0.003)	(0.003)
$LiquidityCreation_{t-2}$	0.38**	0.25	0.002	0.003
	(0.17)	(0.20)	(0.002)	(0.002)
$LiquidityCreation_{t-3}$	–0.09	–0.11	0.003	0.002
	(0.15)	(0.19)	(0.002)	(0.002)
$LiquidityCreation_{t-4}$	–0.10	0.01	–0.002	–0.0002
	(0.15)	(0.19)	(0.003)	(0.003)
$LiquidityCreation_{total}$	0.85***	0.67***	–0.01**	–0.01**
	(0.00)	(0.00)	(0.01)	(0.01)
$Capital_{t-1}$	–0.22	–0.22	0.61***	0.68***
	(0.19)	(0.19)	(0.02)	(0.05)
$Capital_{t-2}$	–1.18	–2.29	0.07***	0.05
	(1.22)	(1.84)	(0.02)	(0.03)
$Capital_{t-3}$	–0.44	–2.23**	–0.05*	–0.07**
	(1.25)	(1.14)	(0.03)	(0.03)
$Capital_{t-4}$	–3.04***	–3.36***	–0.07	–0.08
	(1.07)	(1.23)	(0.06)	(0.05)
$Capital_{total}$	–4.88*	–8.10**	0.56***	0.58***
	(0.02)	(0.02)	(0.00)	(0.00)
NPL	–5.2E-06	–0.001	–0.0003***	–8.1e-05**
	(0.0008)	(0.001)	(6.3E-05)	(3.4E-05)
Credit risk	7.3E-05	5.3E-05	–3.9e-05***	–1.4E-05
	(6.30E-05)	(8.18E-05)	(1.0E-05)	(1.1E-05)
Z-score	–8.8E-05**	–0.0002***	3.8E-06	1.6e-05***
	(3.9E-05)	(5.2E-05)	(4.5E-06)	(4.6E-06)
Earnings Volatility	–0.001	0.001	–0.002***	–0.001**
	(0.002)	(0.002)	(0.001)	(0.001)
Market share	0.74	0.37	–0.04	–0.12
	(0.98)	(0.96)	(0.11)	(0.17)
Size	–0.10***	–0.12***	–0.05***	–0.05***
	(0.03)	(0.04)	(0.004)	(0.01)

Table 5 (continued)

	Explained variable: LiquidityCreation		Explained variable: Capital	
	(1)	(2)	(3)	(4)
Unemployment		–0.01**		–0.002***
		(0.01)		(0.0005)
Inflation		0.003**		0.0003***
		(0.002)		(0.0001)
Constant	1.88***	1.99***	0.89***	0.89***
	(0.55)	(0.68)	(0.07)	(0.14)
Observations	3821	3821	3821	3821
Sargan test	20.34	6.99	20.16	17.75
AB test AR(1)	–1.26*	–1.20**	–2.29***	–2.51***
AB test AR(2)	–0.22	–0.34	–0.61	–0.01

We use the two-step system GMM estimator with Windmeijer (2005) corrected standard errors (reported in brackets). *** p<0.01, ** p<0.05, * p<0.1. The Sargan/Hansen test of over-identifying restrictions for the GMM estimators: the null hypothesis is that instruments used are not correlated with residuals, and hence the over-identifying restrictions are valid. The Arellano–Bond (AB) test for serial correlation is in the first differenced residuals. The null hypothesis is that errors in the first difference regression do not exhibit second order serial correlation. The variables $Capital_{total}$ and $LiquidityCreation_{total}$ are the estimated coefficients for the test that the sum of lagged terms (for bank capital and liquidity creation, respectively) is not different from zero (p-values are reported in brackets).

Thus, choosing to exclude off-balance sheet items in the liquidity creation measures does not influence the relationship between capital and liquidity creation. At first glance, this may not seem to be a surprising result, given the weakness of off-balance sheet items in the aggregate liquidity creation in the Czech banking industry, which was observed above. However, the low volume of off-balance sheet items at the aggregate level could obscure some strong differences across banks, where some have off-balance sheet items that make a significant contribution to their liquidity creation activity. Furthermore, this is an important result for emerging markets that commonly have a minor share of off-balance sheet items in banking activities.

In a second robustness check, we test whether our results are contingent on the period of study, which includes the financial crisis. Even if the impact of the economic downturn on the relationship between capital and liquidity creation is unclear, this ma-

jor economic event might have influenced the behavior of banks. In their analysis of the relationship between capital and bank performance, Berger and Bouwman (2012) have shown that capital can affect banks differently during financial crises and normal periods. To address this issue, we rerun all of our estimations but only include the period from 2000 to June 2007. Tables 6 and 7 display the results with the broad and the narrow liquidity creation measures, respectively.

Table 6: Granger Causality Tests: Estimations with the broad measure of liquidity creation before the crisis

	Explained variable: LiquidityCreation		Explained variable:	
	(1)	(2)	(3)	(4)
$LiquidityCreation_{t-1}$	0.76***	0.66***	–0.01***	–0.01**
	(0.19)	(0.18)	(0.002)	(0.003)
$LiquidityCreation_{t-2}$	0.24	0.07	0.002	0.01*
	(0.15)	(0.19)	(0.003)	(0.003)
$LiquidityCreation_{t-3}$	–0.009	0.05	0.0004	0.0002
	(0.09	(0.15)	(0.002)	(0.002)
$LiquidityCreation_{t-4}$	–0.005	0.10	–0.01***	–0.01***
	(0.12)	(0.16)	(0.002)	(0.002)
$LiquidityCreation_{total}$	0.99***	0.88***	–0.02***	–0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
$Capital_{t-1}$	–0.45	1.23	0.76***	0.72***
	(0.28)	(0.96)	(0.04)	(0.04)
$Capital_{t-2}$	–1.91	–2.46	0.12**	0.05
	(1.54)	(2.23)	(0.06)	(0.08)
$Capital_{t-3}$	–3.02**	–1.37	–0.03	–0.04
	(1.19)	(1.51)	(0.02)	(0.05)
$Capital_{t-4}$	–1.69***	–2.22**	–0.01***	–0.01
	(0.59)	(1.04)	(0.004)	(0.03)
$Capital_{total}$	–7.07***	–4.82	0.84***	0.72***
	(0.01)	(0.11)	(0.00)	(0.00)
NPL	–0.003***	–0.004***	0.0003**	4.2E-05
	(0.001)	(0.001)	(0.0001)	(0.0002)

Table 6 (continued)

	Explained variable: LiquidityCreation		Explained variable:	
	(1)	(2)	(3)	(4)
Credit risk	–8.9E-05	–4.8E-05	–8.1E-06	–9.6E-06
	(8.3E-05)	(0.0001)	(1.8E-05)	(5.9E-06)
Z-score	–0.0002**	–6.6E-05	1.3e-05***	1.9e-05***
	(7.8E-05)	(8.5E-05)	(2.3E-06)	(2.7E-06)
Earnings Volatility	0.02**	0.02**	0.0008	0.001
	(0.01)	(0.01)	(0.0006)	(0.001)
Market share	0.19	0.37	–0.16	–0.07
	(0.97)	(0.99)	(0.11)	(0.12)
Size	–0.14***	–0.11***	–0.019**	–0.03***
	(0.04)	(0.04)	(0.008)	(0.01)
Unemployment		–0.01*		–0.003***
		(0.007)		(0.0004)
Inflation		0.003		4.04E-05
		(0.002)		(0.0002)
Constant	3.00***	1.57**	0.36**	0.59***
	(0.79)	(0.68)	(0.15)	(0.14)
Observations	2526	2526	2526	2526
Sargan test	14.12	12.70	16.31	17.10
AB test AR(1)	–2.23**	–2.07**	–2.18***	–2.37**
AB test AR(2)	–0.01	0.60	–0.83	0.01

We use the two-step system GMM estimator with Windmeijer (2005) corrected standard errors (reported in brackets). *** p<0.01, ** p<0.05, * p<0.1. The Sargan/Hansen test of over-identifying restrictions for the GMM estimators: the null hypothesis is that instruments used are not correlated with residuals, and hence the over-identifying restrictions are valid. The Arellano–Bond (AB) test for serial correlation is in the first differenced residuals. The null hypothesis is that errors in the first difference regression do not exhibit second order serial correlation. The variables $Capital_{total}$ and $LiquidityCreation_{total}$ are the estimated coefficients for the test that the sum of lagged terms (for bank capital and liquidity creation, respectively) is not different from zero (p-values are reported in brackets).

Table 7: Granger Causality Tests: Estimations with the narrow measure of liquidity creation before the crisis

	Explained variable: LiquidityCreation		Explained variable: Capital	
	(1)	(2)	(3)	(4)
$LiquidityCreation_{t-1}$	0.71***	0.21	–0.02***	–0.01***
	(0.20)	(0.25)	(0.004)	(0.004)
$LiquidityCreation_{t-2}$	0.11	0.35*	–0.001	–0.003
	(0.22)	(0.19)	(0.006)	(0.003)
$LiquidityCreation_{t-3}$	–0.09	0.36	0.01***	0.02***
	(0.11)	(0.25)	(0.004)	(0.01)
$LiquidityCreation_{t-4}$	0.07	0.19	–0.02***	–0.02***
	(0.13)	(0.15)	(0.01)	(0.01)
$LiquidityCreation_{total}$	0.80***	1.11***	–0.03***	–0.01**
	(0.00)	(0.00)	(0.01)	(0.02)
$Capital_{t-1}$	–0.29	–1.48*	0.66***	0.67***
	(0.20)	(0.85)	(0.04)	(0.05)
$Capital_{t-2}$	–0.75	–1.01	0.03	0.06***
	(1.70)	(1.43)	(0.08)	(0.01)
$Capital_{t-3}$	–0.38	–3.28**	–0.03*	–0.09
	(1.44)	(1.31)	(0.01)	(0.06)
$Capital_{t-4}$	–1.22*	–3.50**	–0.007*	0.01
	(0.70)	(1.43)	(0.004)	(0.02)
$Capital_{total}$	–2.64*	–9.27***	0.65***	0.65***
	(0.09)	(0.01)	(0.00)	(0.00)
NPL	–0.002***	–0.002	0.0001	0.0001
	(0.001)	(0.001)	(9.5E-05)	(0.0001)
Credit risk	1.2E-05	1.8E-05	–2.2e-05*	–9.5E-06
	(5.7E-05)	(8.5E-05)	(1.2E-05)	(6.0E-06)
Z-score	–6.1E-05	–3.5E-05	1.4e-05***	1.5e-05***
	(3.7E-05)	(4.3E-05)	(1.9E-06)	(4.0E-06)
Earnings Volatility	0.004	0.02*	0.002***	5.8E-05
	(0.007)	(0.01)	(0.0004)	(0.001)
Market share	–0.27	–0.46	–0.14	–0.11
	(0.83)	(0.87)	(0.11	(0.16)

Table 7 (continued)

	Explained variable: LiquidityCreation		Explained variable: Capital	
	(1)	(2)	(3)	(4)
Size	–0.11***	–0.15***	–0.03***	–0.04***
	(0.03)	(0.03)	(0.01)	(0.01)
Unemployment		–0.007		–0.003***
		(0.004)		(0.001)
Inflation		–0.0004		5.69E-05
		(0.002)		(0.0003)
Constant	1.96***	2.98***	0.59***	0.75***
	(0.61)	(0.72)	(0.13)	(0.11)
Observations	2526	2526	2526	2526
Sargan test	17.14	10.44	18.26	19.11
AB test AR(1)	–2.22**	–6.16***	–2.13**	–2.05**
AB test AR(2)	–0.16	1.47	0.72	–0.86

We use the two-step system GMM estimator with Windmeijer (2005) corrected standard errors (reported in brackets). *** p<0.01, ** p<0.05, * p<0.1. The Sargan/Hansen test of over-identifying restrictions for the GMM estimators: the null hypothesis is that instruments used are not correlated with residuals, and hence the over-identifying restrictions are valid. The Arellano–Bond (AB) test for serial correlation is in the first differenced residuals. The null hypothesis is that errors in the first difference regression do not exhibit second order serial correlation. The variables $Capital_{total}$ and $LiquidityCreation_{total}$ are the estimated coefficients for the test that the sum of lagged terms (for bank capital and liquidity creation, respectively) is not different from zero (p-values are reported in brackets).

The results are very similar. With one exception, we again observe significantly negative coefficients for the sum of the lagged variables for capital when explaining liquidity creation and for liquidity creation when explaining capital. The exception concerns the specification with the broad measure of liquidity creation and the inclusion of macroeconomic control variables. In that case, the sum of the lagged variables for capital when explaining liquidity creation is negative but not significant (although with a p-value of 0.11). However, the three alternative specifications again show a significantly negative sum of lagged variables for capital. Thus, the finding of Granger-causation running in both directions between capital and liquidity creation is also observed when we omit the financial crisis period from our sample. Similarly, we do not see any clear

differences in terms of the size of the effect of capital on liquidity and vice versa. This may be because, unlike banks in many European countries, the Czech banks were not strongly adversely affected by the crisis and maintained high capital adequacy at the pre-crisis levels (Czech National Bank, 2011).

In a third robustness check, we test whether our results are similar when using quarterly data rather than monthly data. Even if we were able to obtain a dataset including monthly data, the use of quarterly data might provide different results due to the periodicity of reporting and the longer time required for the impact of capital or liquidity creation on one another. Table 8 reports the results with the broad and the narrow measures of liquidity creation for the full sample and for the sample before the crisis. For the sake of brevity, we only report the sums of the lagged variables for capital and liquidity creation.

Table 8: Granger Causality Tests: Robustness Check with the Quarterly Data

	Explained variable: LiquidityCreation		Explained variable: Capital	
	(1)	(2)	(3)	(4)
	Estimations with the broad measure of liquidity creation, full sample			
$LiquidityCreation_{total}$	0.42***	0.38***	–0.01	–0.01
	(0.00)	(0.00)	(0.37)	(0.15)
$Capital_{total}$	–0.08***	–0.05***	0.95***	0.90***
	(0.00)	(0.00)	(0.00)	(0.00)
Bank controls	YES	YES	YES	YES
Macro controls	NO	YES	NO	YES
	Estimations with the narrow measure of liquidity creation, full sample			
$LiquidityCreation_{total}$	0.20***	0.13***	0.00	–0.01
	(0.00)	(0.00)	(0.46)	(0.92)
$Capital_{total}$	–0.06***	–0.04***	0.92***	0.92***
	(0.00)	(0.00)	(0.00)	(0.00)
Bank controls	YES	YES	YES	YES
Macro controls	NO	YES	NO	YES

Table 8 (continued)

	Explained variable: LiquidityCreation		Explained variable: Capital	
	(1)	(2)	(3)	(4)
	Estimations with the broad measure of liquidity creation before the crisis			
$LiquidityCreation_{total}$	0.27***	0.08***	–0.01***	0.01
	(0.00)	(0.00)	(0.00)	(0.42)
$Capital_{total}$	–0.06***	–0.02***	0.97***	0.98***
	(0.00)	(0.00)	(0.00)	(0.00)
Bank controls	YES	YES	YES	YES
Macro controls	NO	YES	NO	YES
	Estimations with the narrow measure of liquidity creation before the crisis			
$LiquidityCreation_{total}$	0.20***	0.01***	–0.01***	–0.01
	(0.00)	(0.00)	(0.00)	(0.20)
$Capital_{total}$	–0.05***	–0.01***	0.98***	0.95***
	(0.00)	(0.05)	(0.00)	(0.00)
Bank controls	YES	YES	YES	YES
Macro controls	NO	YES	NO	YES

We use the two-step system GMM estimator with Windmeijer (2005) corrected standard errors (reported in brackets). *** p<0.01, ** p<0.05, * p<0.1. The variables $Capital_{total}$ and $LiquidityCreation_{total}$ are the estimated coefficients for the test that the sum of lagged terms (for bank capital and liquidity creation, respectively) is not different from zero (p-values are reported in brackets).

In a fourth robustness check, we use 12 lags of capital and liquidity creation because our baseline regressions use monthly data. This is to check whether the 4 lags that are used in Table 4 are too restrictive. We report the results in Table 9. The results are largely unchanged, as higher lags are typically not statistically significant.

Table 9: Granger Causality Tests: Robustness Check with 12 Lags for Monthly Data

	Explained variable: LiquidityCreation		Explained variable: Capital	
	(1)	(2)	(3)	(4)
	Estimations with the broad measure of liquidity creation, full sample			
$LiquidityCreation_{total}$	0.89***	0.90***	–0.01***	–0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
$Capital_{total}$	–0.11*	–0.10*	0.94***	0.94***
	(0.06)	(0.07)	(0.00)	(0.00)
Bank controls	YES	YES	YES	YES
Macro controls	NO	YES	NO	YES
	Estimations with the narrow measure of liquidity creation, full sample			
$LiquidityCreation_{total}$	0.94***	0.93***	–0.01**	–0.01*
	(0.00)	(0.00)	(0.04)	(0.08)
$Capital_{total}$	–0.12***	–0.10***	0.91***	0.91***
	(0.00)	(0.00)	(0.00)	(0.00)
Bank controls	YES	YES	YES	YES
Macro controls	NO	YES	NO	YES
	Estimations with the broad measure of liquidity creation before the crisis			
$LiquidityCreation_{total}$	0.89***	0.89***	–0.01*	–0.01
	(0.00)	(0.00)	(0.09)	(0.11)
$Capital_{total}$	–0.14***	–0.12***	0.91***	0.91***
	(0.00)	(0.00)	(0.00)	(0.00)
Bank controls	YES	YES	YES	YES
Macro controls	NO	YES	NO	YES
	Estimations with the narrow measure of liquidity creation before the crisis			
$LiquidityCreation_{total}$	0.95***	0.96***	–0.01*	–0.01*
	(0.00)	(0.00)	(0.07)	(0.08)
$Capital_{total}$	–0.21***	–0.18***	0.96***	0.95***
	(0.00)	(0.00)	(0.00)	(0.00)
Bank controls	YES	YES	YES	YES
Macro controls	NO	YES	NO	YES

We use the two-step system GMM estimator with Windmeijer (2005) corrected standard errors (reported in brackets). *** p<0.01, ** p<0.05, * p<0.1. The variables $Capital_{total}$ and $LiquidityCreation_{total}$ are the estimated coefficients for the test that the sum of lagged terms (for bank capital and liquidity creation, respectively) is not different from zero (p-values are reported in brackets).

Finally, in our fifth robustness check, we lag all control variables by one period, as they may affect capital and liquidity creation with a lag. The results are presented in Table 10. Again, they largely support our baseline findings.

We also analyze the sub-sample issues and examine whether the effect of capital on liquidity creation differs between small and large banks. Berger and Bouwman (2009) find that the negative effect from capital on liquidity creation is present only for small banks, and the effect is in fact positive for large banks (for medium banks it is insignificant). We divided our sample into two categories: the 8 largest banks (4 large and 4 medium banks according to the Czech National Bank classification) and small banks (18 small banks and 5 building societies). The correlation coefficients between liquidity and capital (as well as its lags) for both categories are negative but not significantly different from zero for the large banks category. The corresponding correlation coefficient for small banks is approximately –0.15, which is statistically significant at the 1% level. However, this coefficient is only –0.04 for large banks. The regression results (not reported) suggest that there is no effect of the capital on liquidity creation for large banks, but the results have to be taken with caution because the Arrelano-Bond estimator is designed for the case of "small T, large N" and we have only 8 banks in our large banks category (and T = 132). The results for small banks support our baseline findings. Ultimately, it seems that our sub-sample exercise results corroborate the findings of Berger and Bouwman (2009).

Overall, we find similar results even if the significance of the results is lower in some cases. The sum of the lagged variables for *Capital* when explaining *Liquidity Creation* is significantly negative in all estimations, which confirms our first finding. The sum of lagged variables for *Liquidity Creation* when explaining *Capital* is negative in all estimations, but it is not significant for the full sample. So the use of quarterly data rather than monthly data has a limited impact on our findings. It does not change our empirical support for the negative role of capital on liquidity creation, but it moderates our result on the negative role of liquidity creation on capital without contradicting it.

Table 10: Granger Causality Tests: Robustness Check with the Lagged Control Variables

	Explained variable: LiquidityCreation		Explained variable: Capital	
	(1)	(2)	(3)	(4)
	Estimations with the broad measure of liquidity creation, full sample			
$LiquidityCreation_{total}$	0.67***	1.30***	–0.02***	–0.02***
	(0.00)	(0.00)	(0.00)	(0.00)
$Capital_{total}$	–4.77**	–6.89**	0.94***	0.93***
	(0.02)	(0.03)	(0.00)	(0.00)
Bank controls	YES	YES	YES	YES
Macro controls	NO	YES	NO	YES
	Estimations with the narrow measure of liquidity creation, full sample			
$LiquidityCreation_{total}$	0.84***	0.80***	–0.01***	–0.02***
	(0.00)	(0.00)	(0.00)	(0.00)
$Capital_{total}$	–5.51**	–5.61**	0.94***	0.93***
	(0.02)	(0.02)	(0.00)	(0.00)
Bank controls	YES	YES	YES	YES
Macro controls	NO	YES	NO	YES
	Estimations with the broad measure of liquidity creation before the crisis			
$LiquidityCreation_{total}$	0.71***	0.46***	–0.04***	–0.04***
	(0.00)	(0.00)	(0.00)	(0.00)
$Capital_{total}$	–7.99**	–2.83**	0.96***	0.96***
	(0.01)	(0.02)	(0.00)	(0.00)
Bank controls	YES	YES	YES	YES
Macro controls	NO	YES	NO	YES
	Estimations with the narrow measure of liquidity creation before the crisis			
$LiquidityCreation_{total}$	0.50***	0.37***	–0.04***	–0.04***
	(0.00)	(0.00)	(0.00)	(0.00)
$Capital_{total}$	–3.14**	–1.15	0.96***	0.95***
	(0.03)	(0.24)	(0.00)	(0.00)
Bank controls	YES	YES	YES	YES
Macro controls	NO	YES	NO	YES

We use the two-step system GMM estimator with Windmeijer (2005) corrected standard errors (reported in brackets). *** p<0.01, ** p<0.05, * p<0.1. The variables $Capital_{total}$ and $LiquidityCreation_{total}$ are the estimated coefficients for the test that the sum of lagged terms (for bank capital and liquidity creation, respectively) is not different from zero (p-values are reported in brackets). The control variables are lagged by one period.

5 Conclusion

In this study, we investigate the relationship between bank capital and liquidity creation by examining the causality of this link. A handful of recent papers have analyzed the impact of capital on liquidity creation, but they do so without considering the potential for reverse causality. We do so by performing Granger-causality tests on an exhaustive dataset of Czech banks, which makes a detailed computation of liquidity creation measures possible. This also allows us to provide evidence on the volume and evolution of liquidity creation in an emerging market in recent years. The analysis of liquidity creation by Czech banks shows a strong expansion in liquidity creation during the full period, which was slowed but not halted by the financial crisis. Large banks are the primary contributors to liquidity creation, which is in accord with observations of US banks.

We show that capital is found to negatively Granger-cause liquidity creation, which confirms the financial fragility hypothesis according to which greater capital hampers liquidity creation. However, we also observe that liquidity creation Granger-causes capital reduction. We thus support the view that there is a negative, bi-causal relationship between capital and liquidity creation, which corroborates the importance of examining this causality.

Our findings have two policy implications. First, they suggest that the Basel III Accords may lead to reduced bank liquidity creation by introducing tighter capital requirements. This may represent a weakness of these new rules, as they were implemented to preserve the financial system from future troubles similar to those observed during the financial crisis. However, by doing so, they may contribute to the creation of alternative economic troubles by reducing liquidity creation, which can slow growth through reducing the amount of available financing. Second, our findings support the view that symmetrically greater liquidity creation may hamper bank solvency. In other words, enhanced liquidity creation can have some detrimental consequences.

Overall, our primary conclusion is that there is a trade-off between the benefits of financial stability induced by stronger capital requirements and those of greater liquidity creation. Therefore, any action in favor of one objective would deteriorate the other. The derived lesson is that regulatory authorities should take this antagonistic relationship into account when proposing banking regulations.

We are fully aware that our findings may be dependent on our sample and may not be easily generalizable. However, the Basel III rules are planned to be implemented for a vast array of countries, including that examined here and others that are similar. Hence our conclusions are of interest to bank regulatory authorities. In any case, to deepen our understanding of the relationship between capital requirements and liquidity creation should occupy a high position on the bank regulation research agenda.

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