5 ANALYSES SPÉCIFIQUES

1 FUNDAMENTAL LIQUIDITY [1]

By
Jean-Pierre Zigrand*

1 INTRODUCTION

In this paper I would like to encourage a discussion about a basic issue that in the midst of a crisis by necessity tends to be brushed under the carpet for the simple reason that financial decision makers spend much of their time on putting out fires. The topic is the one of true asset market liquidity. It is perhaps only a bit of an exaggeration to say that liquidity is an intellectual blind spot in our understanding of markets.

Indeed, what is a *fundamentally liquid* market? The phenomenon of liquidity has been largely absent from the formal discourses in financial economics until quite recently, and a history of not understanding the factors and differences in liquidity across multiple securities, markets and times has probably had deleterious effects on finance theory as well as on the practice and policy making of finance. Given that not even a clear definition exists, this would seem a hopeless endeavour. But the worry I have is that if we do not know what liquidity is, then we cannot know whether liquidity is good or bad or how we can arrange markets to improve upon their current liquidity. But even if we knew how to make a certain market a bit more liquid, what do we know about why the market has the liquidity it currently has in the first place? How can we know liquidity is resilient? A simple idea would be to say that liquidity is fundamental, or resilient, if the security serves a useful purpose, and that the liquidity would therefore survive if some of the economic or regulatory parameters were to change a bit, say though the imposition of a small tax or the closing of a regulatory arbitrage loophole.

For instance, the empirical finance literature has shown in a series of impressive papers the extent and the dynamics of statistics such as bid-ask spreads, depth of the limit order book, volume, as well as a multitude of named, amalgamated, metrics that combine a few of these statistics.[2] We would argue that bid-ask spreads, volume, depth and the like are some of the *symptoms* of liquidity. If an investment company is going to arrange its trading, including minimising market impact, such metrics are very useful. They also have the advantage of being quick and easy to compute (which has the potential drawback that observers will focus solely on these measures for the simple reason that they are easy to compute). Still, they are not liquidity itself, at least not the liquidity that matters from an overall social welfare point of view. They are a short-cut to liquidity. They are a *reflection* of liquidity but they do not imply fundamental liquidity.

Does it follow from the observation about a symptom, say that a market's bid-ask spreads tightened, that this asset is *fundamentally liquid* or that the evolution has been welfare improving? Or more to the point, how confident are you to predict future liquidity on the basis of current symptoms, without also thinking about why this security is being traded in the first place and by whom? The literature has very largely shown for example that Mifid and RegNMS have reduced bid-ask spreads, and have concluded that therefore those markets have become more liquid, which in turn must mean they have improved social welfare. The last two implications might well be true, but I have yet to see any systematic analysis of the reasons why this ought to be expected, probably because the implication almost seems tautological. Does the fact that bid-ask spreads remained tight during the flash-crash make us rethink liquidity? And what if, as is commonplace these days, the exact same security is trading on many different exchanges and alternative trading venues? Which bid-ask spreads does one consider? What is more, since a large fraction of trades occurs off the lit exchanges in dark pools and on crossing networks, those trades do not even involve any notion of spread. One would like to find a measure for the overall market liquidity of the cross-listed security.

* London School of Economics

1 I thank Andy Haldane, Oliver Linton and Rohit Rahi for helpful discussions.

2 See for instance the paper by Goyenko et al. (2006) for a survey of some of those measures and how they compare to each other.

All of these observations lead me to explore the idea that the *fundamental reasons* why a security can exhibit some of the liquidity symptoms ought to be referred to as the "true liquidity" of a security or a basket of securities in a given market as well as across all markets. Or put differently, there is *proximate liquidity* ("a low bid-ask spread") and *ultimate*, or *fundamental liquidity* ("a deep welfare-based desire to trade this security"). While both may coincide in many instances, confusing or confounding them would be dangerous.

The starting point of my thinking is to move away from a narrow finance-centric focus and to go back to Economics 100 and to say that the fundamental job of the financial markets is to allocate resources to their best use while allowing investors to diversify their risky holdings doing so. In that sense one would expect a market to be more liquid the better it delivers on this promise, both in the sense of being better tailored to the required reallocation and in the sense of allowing this transfer to occur on a larger scale. In other words, a truly liquid security ought to have both a useful payoff profile and the scale. The standardised observable symptoms would then be expected to reflect the same. Or viewed from the opposite end, if a given market has tight bid-ask spreads or the like but delivers no useful role to market participants, any small transaction cost, tax or other impediment to trade would mean that the market effectively closes, and this lack of resilience is incompatible with the notion of true liquidity. Or consider a market with a large number of identical, wealthy and not very risk-averse investors. There is no trade in that economy, but if an outsider came in and wanted to trade a certain number of units of some security, the market impact of that trade is close to zero, and yet there is no liquidity in that market since apart from the small newcomer no-one has an interest in trading the security. Similarly, the bid-ask spreads remained very tight compared to historical norms during the flash crash episode of May 6th, 2010 as well as during the many other mini flash crashes, and yet few would argue that the markets were very liquid. We see that true liquidity is not simply a question of atemporal spreads but a deeper question of the role played by the market. This is the first question regulators need to ask themselves when they consider setting the rules of the game:

> "What is the aim of the game? What is the purpose of financial markets in the first place? Should the objective be finance-centric, and therefore focus on inward-looking liquidity metrics, or should the objective be broader and involve the economy as a whole, in which case the liquidity metric needs to be fundamental?"

For instance, let us assume that a regulator needs to form a prediction as to the future liquidity of the sovereign CDS market after the banning of naked shorts, or to form an estimate of the resulting liquidity losses. It would be difficult, even slightly odd, to do so through extrapolation of past proximate liquidity measures, but it would make a lot of sense to do so by asking the question as to the amount of true benefit that end-users get by being able to hedge their exposures, direct as well as indirect, to sovereign risk factors.

True liquidity also has the connotation of a certain stability, or permanence over the cycle. For instance, a market can be very "liquid" in a boom, when a certain lucky constellation of ephemeral coincidences obtains, but dry up quickly once this balance disappears. Governor Mersch (Mersch (2009)) makes the observation that the onset of the crisis has refocused the discussion from the topic of liquidity abundance to severe liquidity penury in just a few months. Since the holders of a security might have counted on the ability to offload the security in times of stress or thereafter, this security would fail the test of "over-the-cycle-liquidity." Some observers point out that our horizons and patience shrink as the time scales of market events speed up, see for instance Haldane (2010). Some might conjecture that by relying on the current real-time instantaneous measures of liquidity market participants may be subtly induced to ignore the bigger picture of fundamental liquidity over multiple, including longer, horizons. They become more high-frequency trader rather than more Warren Buffett.

Finally, regulations are not neutral in terms of liquidity. It is true, for instance, that government debt plays a crucial role in allowing reasonably safe intertemporal transfers of resources from today to later periods. Pension funds for instance come to mind. Still, the liquidity of some such bond benefits directly from regulations. A number of regulated investors for instance cannot invest is sub-investment grade bonds. This creates additional liquidity for government debt and removes some liquidity from corporates and the like. Or consider the kinds of securities that are accepted by central banks as collateral. The fact of being acceptable to a central bank by itself creates liquidity, at least as long as future acceptance is credible. The idea is that regulations can affect one side of a trade, either the natural demand or the natural supply of a given security by providing incentives to carry this natural demand or supply over to a similar security, but one that benefits from a regulatory advantage. The security that now suffers from an imbalance between demand and supply will suffer from a liquidity point of view because the depth is no longer there, even though its theoretical profile of cash flow reallocations is equally attractive.

2 HOW SHOULD WE THINK ABOUT FUNDAMENTAL LIQUIDITY?

A full formal treatment can be found in Rahi and Zigrand (2010). In a nutshell, we propose a metric that is not model-dependent, but its properties of course will be. Roughly, we define liquidity as the gains from trade achieved in equilibrium through the trading of securities. Financial markets are liquid if they allow investors to execute large amounts of welfare-enhancing security trades. One would expect that the proximate measures of liquidity offer a picture that is consistent with the fundamental measures of liquidity in normal circumstances. The gains from trade are determined by the magnitude of the change in both prices and quantities, i.e. by the extent to which the marginal valuations of investors change relative to autarky, and by the scale of the accompanying trades.

The notion that liquidity manifests itself in the interaction of the scale of trades and the alignment of marginal valuations is commonsensical to market practitioners. For instance, for a new derivative contract to establish itself successfully on an exchange it needs to attract trades that benefit from this new security because of a hedging need between natural counterparties with a need for sizable trades. Purely speculative contracts attract less liquidity in part due to the no-trade theorems. Most new derivatives contracts listed fail because they fail to attract sizable demand and supply exhibiting mutual benefits.

Heuristically, our fundamental liquidity metric, which can be applied to a single security as well as to an exchange or to the overall market, can be written as follows:

Fundamental liquidity
=gains from trade mediated through securities markets
=(scale of trades)× (measure of change in marginal valuations)

This measure of liquidity is intuitive. The first component, the scale of trades, is related to the market impact of trades, or depth. If markets are deep, an agent can trade a large amount without adversely affecting the terms of trade. By itself, however, this is not a sufficient measure of liquidity. A market could be very shallow at the margin and yet already at equilibrium have realised large amounts of welfare improving gains. The second component of our liquidity metric, i.e. the change in marginal valuations induced by trading, measures the usefulness of security markets in terms of the gain in efficiency that trading secures for investors.[3] This efficiency gain is reflected in the degree to which marginal valuations are aligned

3 Formally, the measure of change in marginal valuations is given by the mean-square difference between the marginal valuation (the so-called state-price deflator p satisfying: $price = E[p*payoff]$) in equilibrium after trading the given securities on one hand and the marginal pre-trade valuation on the other hand, $E[(p_{post\text{-}trade}-p_{pre\text{-}trade})^2]$. The paper by Chen and Knez (1995) exhibits a wealth of useful properties of this metric, as well as empirical methods to implement it. The scale or depth of the market is measured by a first-order approximation to the market impact function, essentially equal to the harmonic sum of all of the market participants' risk tolerances (and therefore a larger addressable market or individually more risk tolerant end-users, or both, will naturally exhibit a larger scale).

relative to autarky as agents trade their way from the endowment point towards the contract curve. This will naturally depend upon the potential gains from trade, the degree of competition in intermediation, and the payoff characteristics of the securities available for trade. By itself, alignment of marginal valuations is not a sufficient characteristic of liquid markets either, for it could be that there is a large adjustment in marginal valuations, and yet the amount traded and its welfare impact are small.

The advantages of this metric are manifold. First, our liquidity metric is expressed not in terms of an abstract unit but directly in terms of real resources saved, a proof of which can be found in Rahi and Zigrand (2010). While the metric appears abstract, it can be shown that it is exactly equal to the additional real resources that can be consumed as a result of being able to reallocate resources using this security.

Second, being in terms of real resources saved implies that liquidity can be aggregated and disaggregated easily, including across multiple trading venues, a feature that few other liquidity metrics have been designed to do since they focus on one given security at a time. In other words, regulators may not be mainly interested in whether an option with strike price 35 and time-to-maturity of 18 months is liquid, but whether the options market in general is liquid. The metric proposed here works out-of-the-box on one security, on one family of securities, or indeed on all securities, and the liquidity of a portfolio of securities is equal to the sum of liquidities of its constituent elements, i.e. the sum of all real additional resources available because of the trades mediated through the given assets.

3 WELFARE EFFECTS OF LIQUIDITY

When thinking about the longer term organisation of the financial architecture, as opposed to putting out the fires of the current crisis, measures need to go back to the basics and make sure they think about overall welfare as opposed to incremental tinkering with welfare. It is tempting for example to observe the effects or the proximate causes of a crisis and to act and legislate with an overly strong emphasis on these, and with insufficient perspective about the larger picture. We give a few illustrations.

- Liquidity played a crucial role in the development of the current credit crisis, and again in the flash crash. In the credit crisis it was the disappearance of the overnight and ABCP markets that contributed to the downfall of SIV and conduit type structures. The symptoms were suggestive of an illiquid market, and the fundamental measure of liquidity was in agreement since a non-negligible part of the interest in the pre-crisis CP, SIV, CDO etc. markets did not arise because of the fundamentally useful allocational services rendered by these securities but rather relied on narrow regulatory arbitrage margins. Some of these markets have yet to recover accordingly given the absence of compelling economics. On the other hand, we would venture to suggest that CDOs in general can contribute to social welfare if set up properly to address those potential welfare improving gains from trade, rather than as a mere vehicle to exploit low-margin regulatory arbitrages.

- In the flash crash, it was the absence of any buy-and-hold buyers (especially at the NYSE due to the slight delays) that led to the disappearance of liquidity and to the extreme prices at stub quotes as market orders wiped out the limit-order book. This raises interesting questions about the fundamental liquidity of markets that operate at such micro-second scales: is it really necessary and socially useful to trade that quickly and to quote stuff and to submit thousands and thousands of quotes for the same stock, far removed from the best bid and the best offer, per second? Or can the continuous auction be replaced by a repeated batch auction, and what would the unintended consequences of that be? The answer to these questions are not known, but they are the object of much scrutiny. If liquidity was not grounded in welfare (the fundamental liquidity metric we propose is solidly welfare based) then the structure of trading did not really matter.

- Similarly, during the unravelling of the sovereign credit crisis in Europe, CDS spreads that reflected the markets concerns about a sovereign's creditworthiness were attacked by the officials of the respective countries and institutions as being the unrepresentative quotes determined in an illiquid and one-sided market, and therefore that any interpretations of these spreads in terms of informed creditworthiness would be unwarranted. Serious studies ought to be conducted that show the welfare benefits arising from sovereign CDSs, including the informational benefits that both markets and central banks need to monitor, as well as the indirect social costs that can arise if illiquid spreads can infect other markets through threshold effects and the resulting damage done through positive feedback loops.

These few examples illustrate two of the many facets of liquidity, proximate and fundamental.

4 LIQUIDITY AND DIVERSITY DYNAMICS

Liquidity for a given security is not constant and varies with the cycle. For instance, securities markets exhibit occasional bouts of insidious positive feedback effects that wipe out liquidities. Some securities are more prone to such amplifying feedback effects than others, and some classes of securities recover quickly while others never do. The securities that suffer less over the cycle from bouts of vanishing risk appetite are often those securities that serve a useful role to society and for which there is a natural demand and supply balance. Since the underlying services rendered are going to be in demand again, once risk aversion abates the market's liquidity is restored, and in anticipation of this, the downfalls during the downwards amplification episode are milder also. For instance, some structured vehicles existed solely to exploit small arbitrage or rates spreads, rather than serve the purpose of enabling investors to trade towards the contract curve. All it takes is a small change in regulations to eliminate any interest this given security could have held.

We construct now a more elaborate example in order to illustrate that healthy trades require a double coincidence of wants, and that the gains from trade are themselves endogenous. The formal model can be found in Danielsson and Zigrand (2008). Assume that there is a diverse population of intelligent forward-looking investors who trade with each other on the basis of unexploited gains from diversification, hedging or indeed differential risk-aversion. They are also facing risk-sensitive regulatory constraints, say of the VaR type, either because VaR-type rules are mandated by Basel II or because the debt and equity holders of the company would like to reign in moral hazard on behalf of traders who otherwise may engage in excessively risky trades. The securities that the investors can use to accomplish those gains from trade exhibit good liquidity given that the initial diversity of players and the availability of useful securities allow all investors to reap diversification, allocational and risk-transforming benefits. Now suppose that an initial negative shock hits a small class of securities. This shock will on one hand lead to capital losses to the holders of the securities, and on the other hand it will lead to an elevated level of risk as signalled by the VaR measures. Both effects lead investors to reduce their risky holdings so as to stay compliant with the VaR constraints, or otherwise they need to raise new capital, which is often difficult exactly in such circumstances and new issues also take time. Since many financial institutions now need to unload some of their risky portfolios, such prices fall. The renewed fall and the further heightened VaR levels mechanically force a further round of fire sales and so forth. This is the insidious positive feedback loop studied in Danielsson et al. (2010) and Zigrand (2010). Even though the original holdings were not necessarily speculative and levered positions, financial institutions (FIs) still felt compelled to sell them off, at least temporarily, appearing as if their risk appetite had vanished. What is more, though, is that in such a situation pretty much all FIs find themselves acting in a more risk-averse fashion, but the largest increase in risk aversion occurs in the behaviour of the intrinsically more risk-loving FIs who were holding the riskier and perhaps more levered portfolios in the first place. In other words, not only do most FIs suddenly act in unison, driven by a latent risk-appetite factor, their *diversity* has been reduced as well. Of course some FIs will appear to have mastered the onset of the

crisis better than some others, with a few having been so lucky to have profited opportunistically, the market as a whole will act more alike because the distribution of the effective risk-aversions has become more uniform, as well as higher.[4]

Diversity often has a positive effect on stability, refer for instance to the colourful introductory text by Page (2011). It also has such a positive effect on liquidity. In contrast, in a world that has become less diverse there are bound to be fewer gains from trade, and market liquidity dries up. This is one aspect that current regulations do not seem to have taken on board. Regulators explicitly refer to their determination to apply uniformity to all players. We appreciate their reasoning, but we feel it overly simplistic and short sighted. A crisis driven by positive feedback loops can be dampened if investors step in as the markets fall and forward looking benefit-risk ratios improve. This requires the existence of investors able to step in, unhampered by regulatory VaR and other constraints. Some investors subjected to such rules may happen to be sitting on dry powder and are able to buy, but what is required is a large enough measure of investors free to buy. The few who did step in during the last crisis and stabilise markets were the sovereign wealth funds, the Buffetts, some hedge funds, as well as the central banks. The stabilising effects on markets and on liquidity of regulatory diversity cannot be overstated. Similarly, imposing bans on naked short selling of CDS may (and we presume this is part of the original intention) remove one of the two sides of a trade and imposes uniformity. If all FIs desire to hedge a risk, it requires a speculator to step in, for a fee. If speculators cannot step in, then a more uniform market will support little trade and little hedging can be done.[5]

While the uncertainty unfolds, risk appetite and diversity vanish, and liquidity vanishes as a result since only few of the ultimately desirable trades get done. But in this dismal episode the seeds of recovery are sown because the forward looking risk premia and Sharpe ratios on fundamentally useful securities are very high. Asset prices are so low that new demand, through slow-moving new capital raised to explore the favourable investment opportunities, pushes prices up. Together with the natural upward drift that must exist so as to rationalise the high risk premia in the first place, those markets that do exist for a reason gradually recover and FI capital replenishes. Those securities, especially those in zero net supply, that turn out not to have played any welfare improving roles do not exhibit high forward looking Sharpe ratios, and therefore they do not recover and simply vanish. As capital is replenished, the endogenous risk recedes, allowing both a more natural level of risk appetite and a more diverse risk appetite to return. The stranglehold of the risk-appetite factor that drives much of the movements during a crisis recedes, and securities prices and returns disperse again more, driven by a larger set of factors that includes their own more idiosyncratic ones.

5 PATH DEPENDENCY AND LIQUIDITY

With the main ideas and concepts of liquidity defined and illustrated, I would like to explore some fascinating implications.

If fundamental liquidity is equal to scale times pricing improvement towards more efficient markets, *scale* is the variable that directly depends on institutional details. Consider for instance the treasury futures. The pricing benefits are easy enough to figure out, and even if the overall scale of trades that can be supported by this market was known beforehand, it still is not necessarily known beforehand how the scale will be distributed across fragmented and competing market places. The CBOT, now part of the CME Group, has always had the lion's share of this market despite the fact that competitors, such as Eurex US, have offered

4 In the original paper it is shown that as the feedback loops become more violent, the ultimate distribution of effective risk aversion coefficients is exactly uniform among those FIs who operate under the VaR-type rules.

5 The signalling value of the CDS would then also deteriorate as dissenting voices will find themselves heard less, over and above the knock-on effects of lower liquidity on the CDS markets to lower liquidity on those markets where one of the sides used to hedge their exposure through proxy sovereign CDS

this contract on possibly more attractive terms for final users. But on June 16th, 2005 Eurex US admitted they were unable to wrestle volume from CBOT and exited the market. The market for Treasury futures in general when defined by its payoffs is very liquid in our sense, although this does not necessarily mean that any precise such form will be exhibiting great proximate liquidity statistics. Or seen the other way around, one cannot deduce from the fact that the Eurex US treasury futures appears to be illiquid that the treasury futures market is illiquid. The relevant market for welfare purposes is the overall market for treasury futures.

As a further example, consider the decisions of a central bank that between two payoff-equivalent securities accepts one security as collateral but not another. The security deemed eligible by the central bank would be more liquid, even for identical payoff profiles, since the scale is magnified through the additional acceptance and useful properties the security inherits as a result. Similarly, assume that one security is admissible in satisfying the Basel III Liquidity Coverage Ratio but another very payoff-similar one is not. Given the charges suffered by the non-admissible one, market liquidity will be reduced.

Liquidity exhibits interesting path-dependencies and positive feedback rules of its own. Ever since the research by Becker (1974), Schelling (1978), Arthur (1990) and others has the economics profession focused more of its attention on the interaction between increasing returns, path-dependency, social, network and positive feedback effects. Just as the story of VHS vs Betamax illustrates these links, liquidity does as well. Strategic complementarities exist that imply that the larger the number of people with a coincidence of wants who trade a certain contract on a certain exchange, the more likely I am to join them, everything else equal. Ideally all would like to coordinate on the same market (everything else equal, meaning that the chosen market does not charge monopoly rents etc.). If initially two exchanges have started to offer roughly the same contract, a small difference or sheer luck could have led one of the two to become dominant. Once one of the exchanges is dominant, trying to steal liquidity away from this dominant exchange requires therefore a very clear advantage, such as more efficient, cheaper, faster or subsidised (e.g. the so-called "maker-taker" model) trade executions. But it can be done, as Eurex proved to LIFFE, and as alternative trading venues in conjunction with high-frequency traders have shown when competing with the main incumbent exchanges.

The crucial question that academics, politicians, regulators and market participants are trying to come to grips with at this very moment is whether *overall* fundamental (i.e. welfare based) liquidity in today's fragmented markets is larger than it would have been had markets remained monopolised.

6 LIQUIDITY, NETWORK EFFECTS AND CONTAGION

Securities markets are interconnected in a sophisticated web of relationships. For instance, a bank that sells a derivatives product to a customer hedges its exposure either in the underlying market (the so-called "delta-hedging") or using yet other derivatives products. A large trade in one option leads to the repricing of hundreds of contracts, including all other options with different strikes and maturities as well as all products with embedded options. In the modern fragmented world of alternative trading venues, such as the exchanges and the MTFs in Europe, any trade on a given trading venue may lead to a counteracting trade on another trading venue to align prices.

It follows that liquidity for one product on one given trading venue depends through this web of links on the liquidity of other securities on possibly other trading venues. The question arises how the liquidities of different products on different venues depend on each other. For instance, suppose a bank sold an OTC put option to a client. The liquidity of that OTC put market depends on the ease by which the bank can hedge its exposure, which is reflected in the liquidity of the hedging market, and the liquidity of the hedging market in turn may depend on yet other market liquidities. Now assume there is a shock to liquidity on the hedging market, say short selling of the underlying stock is restricted. If the market

for puts and the market for stocks are complementary, then the market for put options will be hit by a detrimental liquidity shock as well. On the other hand, assume that there are two alternative trading venues that list the underlying security that serves as hedge. Assume also that due to a computer outage one of the two trading venues needs to shut down. One can then imagine that liquidity can move from the shut to the second, open, underlying market. Liquidity is badly affected on the shut market, but it reappears to some extent on the second open market, with a small but not catastrophic effect on liquidity in the options market. Here the two trading venues for the underlying security are substitutes while the overall any one of them is complementary to the options market.

This thought experiment is not just an intellectual exercise. It ought to be of great importance for financial stability to know the map of links across trading venues and markets and to know the circumstances under which a given link in this network is complementary or substitutable. In fact, the network must also consider balance-sheet links between various financial institutions. As highlighted by Governor Mersch (Mersch (2009)), the usefulness of the assets held by banks on their balance sheets as liquidity buffers depended on not having to honour the liquidity backstops they provided to various SPVs that refinanced themselves by short-maturity ABCP (in what used to be a very liquid ABCP market) so as to hold less liquid MBSs and tranches of collateralised debt obligations and the like. The initial subprime losses ripped through the network like an e-coli contagion and did not only expose the various liquidities to be highly complementary, but led also to a dearth of liquid instruments[6] that would have breached further thresholds with the potential to create further nefarious feedback loops had the central banks not implemented the various liquidity replenishment programmes. As it was, endogenous risk in this network led to the simultaneous drying up of many liquidities that in normal times were thought of as neither complementary nor as substitutable, but as the overall risk appetite generated by endogenous risk vanished, it led to a forceful and simultaneous scaling back of many different liquidities. It appears that in periods of stress, liquidities tend to become more complementary and less diverse.

For an equity-specific pure market example (more fully argued in Rahi and Zigrand (2010)), consider the extraordinary events of Thursday 26th of November 2009. The UK stock markets basically consist of the London Stock Exchange as the main venue with around 60% of trading volume for FTSE-100 stocks, with Chi-X, BATS and Turquoise as the main MTFs. Since these exchanges list a large common set of securities, one could not unreasonably view them as being competing exchanges, or substitutes. On that day due to a server error, the LSE halted trading at 10:33, placing all order books into auction mode until trading resumed at 14:00. If these venues were strong substitutes, then one would have thought that the negative liquidity shock on the LSE would lead to a positive liquidity shock on the MTFs. But the opposite happened. Our model suggests that these markets ought to be understood as liquidity complements.

We come back once more to the CDS market and to the proposal to ban naked shorts on sovereign CDS. The liquidity into which small and medium Portuguese infrastructure companies can tap in order to issue bonds or stocks does not exist in a vacuum. For instance, the liquidity for these securities is related to the extent by which a non-Euro area sovereign wealth fund can arrange this investment. The liquidity of the infrastructure bonds in euros is complementary to the liquidity of the dollar/euro forex market and to the liquidity of the Portuguese sovereign CDS market. A negative liquidity shock to the CDS market will transmit the shock contagiously to all markets that are complementary and linked. The welfare losses accumulate through positive feedback effects. Those feedback effects are worsened further by the fact that liquidity restrictions tend to reduce the number of market intermediaries willing or able to make markets.

6 When analysing bank balance sheets, central banks and regulators worry about both the liquidity of any given security held by credit institutes and with the *amount* of such liquid instruments held, as illustrated by the paper by Giordana and Schumacher (2011) in this issue of the Revue de Stabilité Financière. The crisis affected *both*. Our paper deals mainly with the intrinsic fundamental liquidity of a given instrument and less with whether any one financial institution holds enough such instruments.

7 CONCLUSION

We outlined our thinking on the sort of liquidity that is explicitly welfare based as opposed to ad-hoc. We argued that assets that are fundamentally liquid in this sense possess natural properties in terms of real resources saved. Being in terms of gains from trade, fundamental liquidity looks through the symptoms of liquidity and links liquidity to the reasons why market participants choose certain markets in the first place. This allows a deeper understanding as to why certain markets are more liquid than others, links liquidity to the bio-diversity in the market, and in particular it offers a window to the future by allowing informed predictions as to the effects of institutional or business-cycle changes on future liquidities. The fundamental liquidity measure allows comparisons of liquidity over various horizons and across various markets, and allows for an intuitive understanding of liquidity dynamics and liquidity path dependencies. In particular, it lends itself easily to the analysis of network effects and cross-market contagion.

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2 THE IMPACT OF THE BASEL III LIQUIDITY REGULATIONS ON THE BANK LENDING CHANNEL IN LUXEMBOURG [1]

By
Gaston Giordana*
Ingmar Schumacher*

1 INTRODUCTION

The recent financial crisis uncovered the importance of liquidity positions and maturity mismatches in banks' portfolios. This led to a widespread agreement that there is a need for closer monitoring of the financial sector and for an improvement in the standards and regulatory practices. The Basel Committee on Banking Supervision (BCBS) recognizes the need for further regulatory action and suggests the introduction of the Liquidity Coverage Ratio (LCR) and the Net Stable Funding ratio (NSFR) (Basel Committee BIS (2010)). These ratios address the resilience of the liquidity risk profile of banks by building upon the main lessons of the financial crisis 2007-2010.

As the liquidity risk regulations are likely to induce behavioral changes that will be reflected in the composition of banks' balance sheets, one can expect an effect on monetary policy transmission. Thus, in this article we study how the new Basel III liquidity regulations are likely to alter the bank lending channel of monetary policy transmission [2] in Luxembourg.

The innovations presented in this paper are as follows. Firstly, this study is the first that assesses the bank lending channel using Luxembourg bank level data. Secondly, we estimate and analyze the LCR and NSFR using individual bank data for a representative sample of the Luxembourgish banking sector. Thirdly, this study is the first one, to the authors' knowledge, that quantitatively analyzes the impact of the new liquidity standards on the monetary policy transmission mechanism.

We start off by estimating the effect of the Basel III liquidity regulations on monetary policy transmission using historical individual bank data for a sample of banks covering between 82% and 100% of total assets of the banking sector in Luxembourg from 2003q1 to 2010q4. Under the assumption of imperfect information the bank lending channel operates when, after a policy-driven increase in short-term interest rates, banks are not able to compensate the reduction of core deposits with alternative sources of funding inducing then a reduction in the assets. This is likely to be the case for banks that hold neither sufficient liquidity nor capital buffers, or for small banks with a worse prospect to access wholesale funding markets [3]. Therefore, we study the role of the bank characteristics that have been identified in the literature as being important for monetary policy transmission and add new ones which we derive based on the LCR and NSFR.

Our analysis based on the historical data remains valid in the case that the introduction of the regulations does not induce significant changes to the balance sheet of banks. However, the objective of the regulations is exactly the opposite. The historical balance sheets might, thus, only provide limited information on the way that the LCR and NSFR would change monetary policy transmission, and the information is bound to be less correct the larger the impact of the regulations on banks' balance sheets. In order to get an idea of how large the impact of the regulations on banks is likely to be, we simulate banks' balance sheets by maximizing banks' profits subject to the balance sheet constraints and the requirements of the new regulations. We then use this simulated data to study how the monetary policy transmission would have

* Financial Stability Department

1 This contribution is a non-technical summary of a forthcoming BCL working paper.

2 The economic literature provides an extensive analysis of the mechanism underlying the transmission of monetary policy to the real economy. Surveys are available in Bernanke and Getler (1995), Ceccheti (1995).

3 See, among others, Angeloni et al. (2003), Kashyap and Stein (1995), Ehrmann et al. (2002), Kishan and Opiela (2000) and Chatelain et al. (2003), Peek and Rosengren (1995).

been if the regulations had already been put in place prior to the crisis. This exercise is different from the regressions and predictions based on the historical data since we take into account the optimal balance sheet adjustments induced by the regulations.

Our results are as follows. We find a significant role for the bank lending channel in Luxembourg, which mainly works through small banks with a large shortfall in the NSFR. Thus, small banks that are suffering from relatively large maturity mismatches and that are relatively under-capitalized, as measured by the NSFR shortfall, are those that are most affected by a contractionary monetary policy shocks. We also show that big banks are able to increase their lending following a policy-driven increase in the short-term interest rate. This result confirms that Luxembourgish banks are liquidity providers to the market[4]. Additionally, we provide a more detailed description of the underlying mechanism of the bank lending channel in Luxembourg by disaggregating the shortfalls into their components (i.e. the stock of high quality liquid assets, the net outflows, the required stable funding and the available stable funding). The results suggest that indicators of the width of the funding bases (i.e. net outflows, available stable funding) are more relevant bank characteristics for the identification of the bank lending channel in Luxembourg than qualifiers on the assets (e.g. liquidity).

These results, firstly, qualify further on previous findings in studies for other European countries that do not find that the size of a bank is a relevant characteristic for explaining distributional effects of monetary policy shocks[5]. We show that a bank's size is a significant driver of monetary policy distributional effects but only if one also takes into account the current liquidity and maturity mismatch structure of a bank itself.

Our findings regarding the impact of the new liquidity regulations lead us to the conclusion that the relevance of the bank lending channel is likely to be abridged as banks make their way to compliance. Adhering to the NSFR may reduce the reaction of the loan supply to monetary policy shocks more strongly than complying with the LCR. This was to be expected as any reduction in the maturity mismatch of banks strengthens the bank's position to cope with funding run-offs. In any case we find that, once banks adhere to both ratios, the bank lending channel will no longer be effective in Luxembourg.

The article is organized as follows. In section 2 we discuss the LCR and NSFR more deeply in order to understand how they relate to monetary policy transmission. Section 3 describes the data and the empirical specification of the econometric model. The estimation results are presented in Section 4, while Section 5 concludes.

2 BASEL III LIQUIDITY REGULATION AND MONETARY POLICY TRANSMISSION MECHANISM

Here we discuss the potential roles that the LCR and NSFR would have in altering the impact of monetary policy on bank lending.

The LCR requires that banks hold high quality liquid assets to meet liquidity needs over a 30-day time horizon under an acute liquidity stress scenario (BIS (2010), p.1). The Basel committee's regulation then demands that banks have an LCR that exceeds one, suggesting that the stock of high-quality liquid assets

4 In case of Luxembourg, interbank lending mainly refers to intra-group lending activities as Luxembourg's banks are not strongly active in the international interbank market. All along the paper we will interchangeably use interbank and intra-group activities.

5 A series of studies has been devoted to measuring the relevance of the bank lending channel in the Euro Area (Angeloni, Kashyap and Mojon, 2003). Although a common finding to each country-level study is that a bank's size is not a relevant characteristic for identifying the bank lending channel, there are also country-wide differences underlying this result (see Ehrmann et al.; Worms; Hernando and Martinez-Pagés; Loupins, Sauvignac and Sevestre; Gambacorta in Angeloni, Kashyap and Mojon, 2003). More recent studies have analyzed the implications of new practices, namely securitisation, market funding and financial innovation, on the bank lending channel (Altunbas et al. (2009), Loutskina and Strahan (2009), Hirtle (2008)). Their findings show that these practices have helped banks to isolate their asset portfolio from monetary policy shocks.

(HQLA) covers the net outflows (NO). Thus, the LCR shortfall is given by: LCR $shortfall_{it} = NO_{it} - HQLA_{it}$. The HQLA encompasses cash, high-quality securities and government debt. One would expect that banks with more HQLA are, *ceteris paribus*, more liquid banks and, therefore, be able to more easily offset monetary policy shocks through selling their liquid assets. The NO encompasses the entire expected outflow minus the expected inflow of money during one month. The main focus of the Basel Committee's definition of Outflows is on stable versus unstable deposit financing and off-balance sheet activities. Funding from unstable sources receives a higher run-off factor in the definition of NO than stable funding. Similarly, the Inflows compound different sources of revenues within the 30-day horizon. In order to encourage banks to hold higher HQLA, the Inflows are bounded at 75% of the Outflows. On the one hand, one would expect that a bank with higher NO faces a higher external finance premium because of the presumed lower resiliency of the bank's short-term liquidity risk profile. On the other hand, since bigger Outflows imply a bigger funding base due to a wider access to wholesale funding, one would expect that, during non stress periods, NO might be positively related to the ability of the bank to compensate for a reduction of core deposits[6].

The NSFR requires a minimum of stable funding over a one-year horizon (BIS (2010), p.1). Thus, one could say that the NSFR focus is on a bank's maturity mismatch. As the NSFR ratio should exceed one, the shortfall is given by: $NSFR\ shortfall_{it}$ = $Required\ Stable\ Funding_{it}$ - $Available\ Stable\ Funding_{it}$. The Available Stable Funding (ASF) consists of capital, liabilities with maturity greater than a year or those that are expected to be stable during a crisis. The amount of Required Stable Funding (RSF) places more weight on those assets that are less liquid during stress periods and therefore require a more stable source of funding. One would expect that the loan supply of those banks with a higher NSFR will be less responsive to monetary policy. Firstly, given that a bank's capital is one of the components of the available stable funding, a higher NSFR might be associated with less reliance on outside funding and a lower external finance premium. Secondly, the bigger the ASF the larger a bank's stable funding base which increases the resiliency of a bank to liquidity shocks. Additionally, banks that have a higher amount of ASF are, *ceteris paribus*, less subject to maturity mismatch. Finally, the amount of RSF consists mainly of long-term assets (i.e. exceeding one year) and loans to retail clients or non-financial corporate clients of maturity less than one year. It also includes off-balance sheet exposures. A bank with assets that have a maturity structure that tends to be longer is more likely to face significant maturity mismatch risk and might face a higher external finance premium.

3 THE MODEL SPECIFICATION AND THE DATA

The empirical specification, based on the standard literature for identifying the bank lending channel, is designed to test whether banks that show different balance sheet structures react differently to monetary policy shocks. This approach is in line with the works conducted by the ECB on monetary policy transmission (see Angeloni et al. 2003). Our contribution is to use, as additional bank characteristics, the shortfalls in the LCR and NSFR.

$$\Delta \log(L_{it}) = \alpha_i + \beta_1 \Delta \log(L_{i,t-1}) + \beta_2 \Delta r_t + \beta_3 \Delta \log(GDP_{t-1}) + \sum_{h=1}^{z} \beta_{4h} x_{ih,t-1} + \sum_{h=1}^{z} \beta_{5h} x_{ih,t-1} \Delta r_t +$$

$$+ \beta_6 \prod_{h=1}^{z} x_{ih,t-1} \Delta r_t + c_t + \varepsilon_{it} \qquad (1)$$

where $i=1,...,N$ and $t=1,...,T$ and where N denote the number of banks and T the number of quarters in the sample. L_{it} are the total loans of bank i in quarter t. Δr_t is the first difference of a nominal short-term

6 Given the cap on inflows, the relationship between the Outflows and the NO is expected to be monotonic.

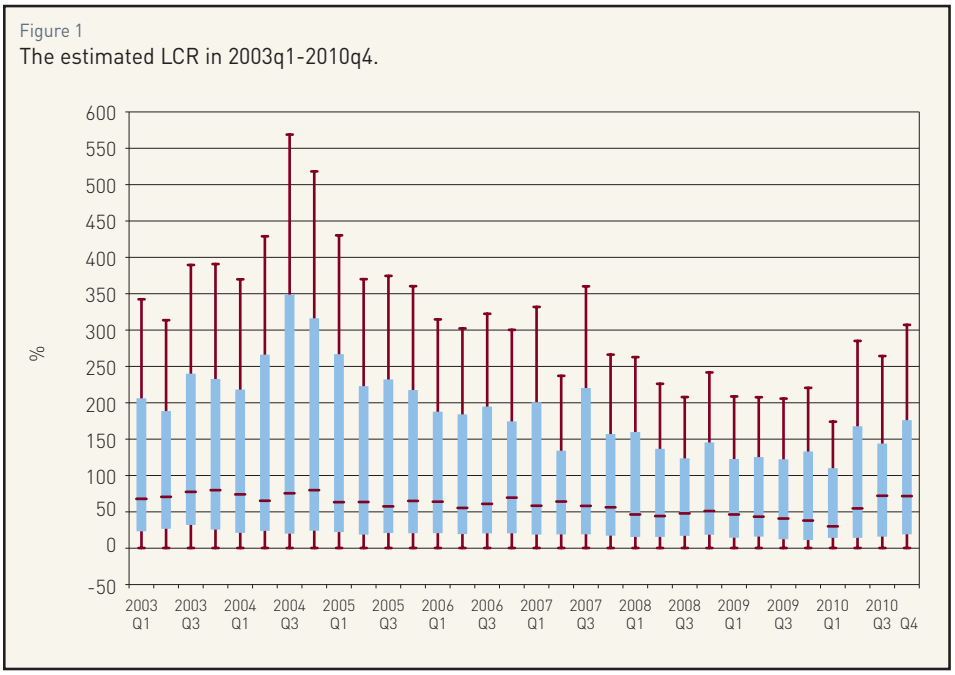
interest rate, and represents a proxy for the change in monetary policy. $\Delta\log(GDP_{t-1})$ is the growth rate of the Luxembourgish real GDP, which allows us to control for the evolution of loan demand. The dummy variable c_t equals one for those quarter within the last liquidity crisis period[7] and zero otherwise. The lagged bank-specific characteristic h are given by $x_{ih,\ t-1}$. We include an interaction term between bank characteristics and the change in the level of monetary policy indicator aiming at testing for non-linear reactions of banks to monetary policy shocks. All bank characteristics are calculated as shares of total assets. Finally, the model allows for individual fixed effects in the error term ε_{it}.

We consider as bank characteristics the ratios of the LCR and NSFR estimated shortfalls over total assets and their components (i.e. the stock of HQLA, NO, ASF and RSF). Additionally, we follow the literature by considering indicators of size (i.e. the logarithm of total assets), capitalization (i.e. the ratio of capital over total assets) and liquidity (i.e. the ratio of HQLA over total assets[8]).

In this study we make use of data from the statistical reporting of banks to the Banque Centrale du Luxembourg. We build an unbalanced panel for the period spanning 2003q1 to 2010q4 and have quarterly observations on balance sheet characteristics for a maximum of 157 banks per quarter (and a minimum of 68 banks)[9]. Our monetary policy indicator comes from the ECB Statistical Warehouse and is the Euribor 3 month interest rate.

In order to identify the bank lending channel of monetary policy transmission, standard practice considers the loans to non-financial corporates and retail customers in the econometric analysis. We deviate from that by using total loans. Since NFC and retail loans of Luxembourgish banks only add-up to less than 14% of total assets and less than 18% of total loans, the standard practice would give a constrained picture of the ECB monetary policy transmission through Luxembourg's banking sector. In the case of Luxembourg, combining loans granted to different sectors is likely to be neutral for the analysis of monetary policy transmission as they tend to react similarly to a monetary policy shock.

Figure 1
The estimated LCR in 2003q1-2010q4.



Source: BCL, authors' calculations

In the following paragraphs we take a closer look at the evolution of the Luxembourgish banks' positions regarding the LCR and NSFR in the period spanning 2003q1 to 2010q4. Figures 1 and 2 show, respectively, the evolution of the quartiles of LCR and NSFR. A distinction should be made for the last three periods of the series because of the changes in the sample that followed the modifications in the reporting rules (see footnote 9). The median of the LCR declined from a maximum

7 We consider 2007q3 as the starting quarter which corresponds to the beginning of the financial turbulence (ECB Monthly Bulletin, 2010).

8 We consider a more restrictive definition of liquid assets than in the mainstream literature in other to fit to the definition of liquid assets required in the LCR. It is worth to note that underlying the LCR components there is the BCBS's acute stress scenario.

9 In the last three quarters we make use of a sample of banks representing between 82% and 95% of the sector's total assets. This is due to a change in the reporting rules of the Eurosystem of Central Banks which made the statistical reporting non-mandatory for small banks.

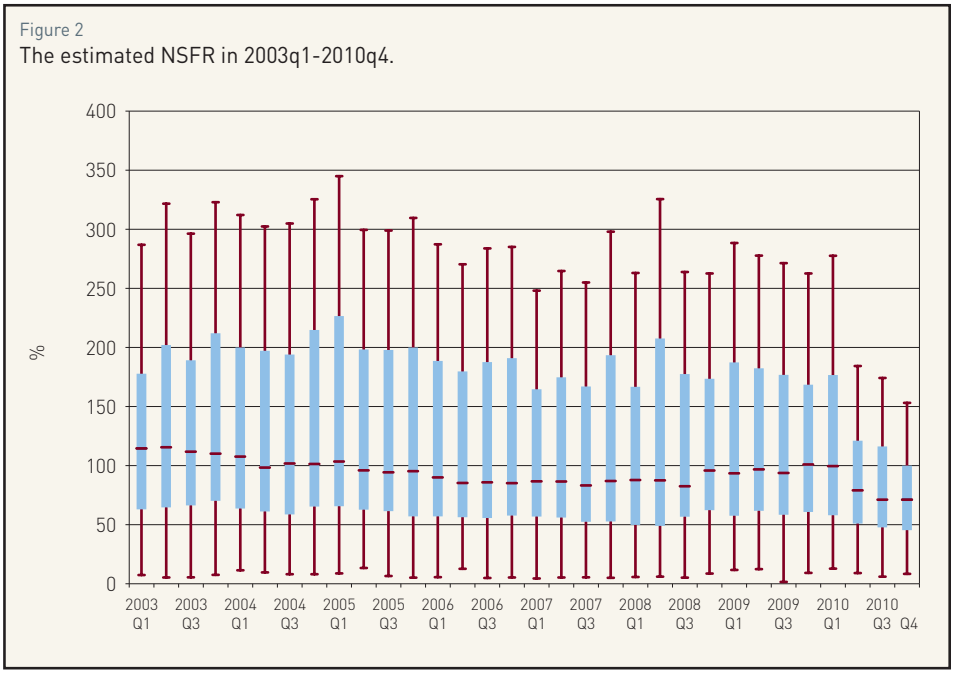
of 80% in 2003q4 to a minimum of 30% in 2010. Currently it stands at 71%, but potentially due to the reduced sample. In the aftermath of the crisis the LCR started to recover essentially due to big banks. The median of the NSFR was initially above 100% before 2005, but declined continuously until the start of the crisis to a level of 80%. It then recovered mainly due to small banks.

It is worth noting the significant differences in the median of the LCR and NSFR between big and small banks. Big banks fare better in terms of the LCR but worse in terms of the NSFR. This can be attributed to several crucial differences in terms of balance sheet characteristics (see Table 1 below). Big banks' average growth rate of loans is higher than the one of small banks. Small banks[10] have a higher ratio of LCR shortfall over total assets than big banks, mainly because of the differences in the ratio of HQLA over total assets rather than in the NO ratio. Conversely, the NSFR shortfall is lower for the smaller banks because of the differences in both the RSF and ASF. Small banks are also better capitalized than big banks.

We perform a simulation exercise in order to assess the optimal balance sheet adjustments that compliance with the LCR and NSFR would require. The simulated model[11] assumes that, in each period and given a vector of prices and adjustment costs, the banks maximize profits by selecting the amount of total loans, Level 1 and Level 2 securities (i.e. securities to be included in the stock of high quality liquid assets of the LCR[12]), capital (i.e. Tier 1 capital), and different categories of deposits, under the constraint of complying with the LCR, NSFR and leverage requirements[13]. The categories of deposits fit the definition of the cash outflows by counterparties of the LCR[14].

The outcome is summarized in Table 1. It presents the average values, by quartiles of size, of the components of the standards, namely the ratios of HQLA, NO, ASF and RSF over total assets, as well as the share of the shortfalls in LCR and NSFR over total assets and the leverage ratio. On average, banks in the third and fourth quartiles of total assets mainly increase the ASF rather than reducing the RSF in order to adhere to the NSFR requirements. Regarding the LCR, moderate changes in the HQLA and the NO suffice for these important banks for complying. The most sizable changes are undertaken by medium-sized banks with increases in basically all components of the LCR and NSFR while small banks need to increase both their HQLA and their RSF.

Figure 2
The estimated NSFR in 2003q1-2010q4.



Source: BCL, authors' calculations

10 We consider as small (big) banks those in the first (fourth) quartile of the total assets distribution. Medium-sized banks are those in the second and third quartiles.

11 See Kopecky and VanHoose (2004) for applications of a similar approach.

12 See items 39 to 42 in BIS (2010).

13 The details of the optimization program and the simulation procedure are available under request.

14 See items 54 to 83 in BIS (2010).

Table 1:
Average of the components of the shortfalls over total assets, by quartiles of total assets. Historical and Simulated data.

	Quartiles of Size	Shortfall						
		LCR	NSFR	HQLA	NO	ASF	RSF	Capital
Historical Data	1	0.029	-0.156	0.042	0.071	0.456	0.300	0.088
	2	0.062	0.024	0.048	0.110	0.302	0.326	0.035
	3	0.054	0.067	0.036	0.090	0.296	0.363	0.030
	4	-0.025	0.146	0.082	0.056	0.267	0.412	0.021
	Total	0.030	0.020	0.052	0.082	0.330	0.350	0.043
Simulated Data	1	-0.087	-0.030	0.133	0.047	0.528	0.498	0.506
	2	-0.122	-0.100	0.163	0.041	0.549	0.449	0.396
	3	-0.041	-0.140	0.085	0.044	0.451	0.311	0.108
	4	-0.060	-0.040	0.098	0.037	0.367	0.327	0.076
	Total	-0.080	-0.075	0.122	0.042	0.477	0.402	0.284

Sources: BCL, authors' calculations

4 ESTIMATION RESULTS

In this section we present the results of the econometric estimation of alternative specifications of the model of equation 1 [15]. In our estimation we resort to GMM type estimators since we include the lag of the dependent variable and other potentially endogenous variables as regressors (Holtz et al., 1988; Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and Bond, 1998).

4.1 Monetary Policy Transmission

This section is based on the historical data series. We will present the estimated long-term marginal effects of a contractionary monetary policy shock on the growth rate of total loans and discuss the underlying economic intuition.

We firstly analyze the monetary policy effects using the specification that combines the shortfalls in both ratios. The bank lending channel in Luxembourg works through the smallest banks with a large shortfall in the NSFR. On average, banks in the first quartile of total assets and in the last quartile of the NSFR shortfall over total assets reduce total loans by 0.169% after an increase of one percentage point of the short-term interest rate. This result prevails since banks with a lack of stable funding are prone to lose funds following a contractionary monetary policy shock. Moreover, if these banks are small it would be harder for them to access alternative sources of funding.

Further, our estimation reveals that medium-to-small sized banks do not react to monetary policy shocks, while medium-to-big and big banks with a small NSFR-shortfall increase their loans by 0.119%. The explanation for the positive reaction of bigger banks' loan supply following a tightening in the monetary policy is that Luxembourg's banking sector plays the role of a liquidity provider within their group. A stricter monetary policy increases the demand for funds which is partly satisfied by an increase in loans from Luxembourg's banks. In addition, larger banks also tend to have a better access to short-term wholesale funding.

We turn now to the analysis of models disaggregating the shortfalls into their components. The analysis of the long-term marginal effects indicates that liquidity is not a relevant characteristic for the identification of the bank lending channel in Luxembourg. In contrast, the long-term marginal effects of a contractionary

15 The econometric results presented in the following sections are based on specifications that do not include the growth rate of Luxembourg's GDP or any other variable potentially related to the demand for loans because of their high correlation with the changes in the short-term interest rates. The correlation coefficient between a lag of the growth rate of Luxembourg's GDP and the change in the short-term interest rate equals 0.65.

monetary policy shock are significantly higher for big banks with a low ratio of HQLA (0.074%) than for big banks with high HQLA (0.004% and not significantly different from zero). This suggests that HQLA do not play the fundamental role of safeguarding the portfolios against liquidity problems. Clearly, banks with few HQLA are those that are more active on the market for loans and tend to function as liquidity providers. Conclusively, they are more likely to react positively to monetary policy shocks. However, small banks mainly funded by unstable sources (i.e. big net outflows) are better prepared to cushion monetary policy shocks than other small banks with more limited NOs. The average long-term marginal effect of a contractionary monetary policy shock is equal to -0.120% for the former banks but it is not significantly different from zero for the latter banks. Conversely, the ability of medium and big-sized banks to shelter monetary policy shocks is reduced the bigger are the NOs. Intuitively, larger funding bases prevent contractions of the loan supply more robustly than a bigger stock of HQLA may do. Furthermore, as big banks tend to have a higher leverage ratio compared to small ones, exceedingly unstable funding bases tend to overcompensate, for such banks, the positive effect of bank size.

Finally, we analyze a specification that includes the components of the NSFR shortfall (i.e. ASF and RSF) as regressors. The results are consistent with previous ones but, the exclusion of the LCR shortfall in this specification may have biased downwards the reaction of small banks toward a monetary policy tightening. The long-term marginal effects of a monetary policy contractionary shock estimated for small banks using this specification are significantly lower (the average long-term marginal effect for banks in the first quartile of total assets equals -0.243%). This highlights the fundamental role that short-term wholesale funding plays in helping small banks to cushion monetary policy shocks. As expected the availability of stable funding prevents total loans to diminish after a monetary policy shock and higher amounts of RSF enhance the transmission of contractionary monetary policy shocks. Nevertheless, the negative effect from RSF overcomes the positive effect from ASF for banks which are big enough or for those with an exceedingly high RSF ratio.

4.2 The impact of compliance with the new standards on the bank lending channel

In order to understand the potential impact of compliance with the Basel III regulations we perform three complementary analyses in this sub-section. As a benchmark we use the results from the specification that combines the shortfalls in both ratios to calculate the elasticities of the long-term marginal effects of a contractionary monetary policy shock. This allows us to argue, in a qualitative way, how the Basel III regulations might impact the bank lending channel. Then we predict the long-term marginal effects of a monetary policy shock (also calculated relying on the same specification) by extrapolating the previous results assuming that banks adhere to the regulations. In addition, we predict the long-term marginal effects of a monetary policy shock by making use of the model that combines the components of LCR and NSFR shortfalls and of the simulated balance sheet data. Finally, we use the simulated data to estimate the long-term marginal effects of a monetary policy shock directly.

4.2.1 Analysis based on historical data

Table 2 depicts the elasticities of the long-term marginal effects of a contractionary monetary policy shock with respect to changes in the shortfalls. The analysis of the elasticities allows us to conclude that complying with the NSFR would reduce the importance of the bank lending channel in Luxembourg (the elasticities are significantly negative and significant for all the quartiles but the fourth one). However, complying with the LCR is likely to enhance the relevance of the bank lending channel such as it currently operates in Luxembourg (the elasticities are negative for the first two quartiles but positive for the last two)[16]. The intuition of this result is straight-forward if we take into consideration the fact that a higher LCR

16 These effects are slightly statistically non-significant (p-value = 0.102), we will analyze them as if they were fully significant. The p-values are equal for every quartile because the calculation of the long-term marginal effect engages only two estimated coefficients.

shortfall is related to a larger funding base relative to the holdings of HQLA. Thus, complying with the LCR would tend to reduce the availability of funds to feed the growth of loans.

Table 2:
Average elasticities of the Long-term marginal effect of monetary policy contractionary shock with respect to the shortfall in each ratio.

	Quartiles of LCR shortfall				
	1	2	3	4	Total
Elasticities with respect to NSFR shortfall	-3.676	-7.556	-3.332	-0.736	-3.825
p-value	0.053	0.053	0.058	0.222	0.096
	Quartiles of NSFR shortfall				
	1	2	3	4	Total
LCR shortfall	-0.544	-0.738	0.379	0.796	-0.027
p-value	0.102	0.102	0.102	0.102	0.102

Sources: BCL, authors' calculations

We turn now to the quantitative analysis of the impact on the bank lending channel of the compliance strategy that banks would have to implement in order to adhere to the standards. Also relying on the same specification, we simulate the long-term marginal effect of a one point increase in the short-term interest rate assuming that banks comply, respectively, with the LCR but not with NSFR, and with the NSFR but not with the LCR. There is no particular assumption about the strategy a bank would implement to comply with the each standard, the positive shortfalls are simply, *ceteris paribus*, set to zero. We performed t-student test in order to compare the statistical significance of the differences observed between the estimated long-term marginal effects of a contractionary monetary policy shock and the simulated ones. The results of these tests confirm the conclusion of the analysis on the marginal effects' elasticities with respect to the NSFR shortfall. However, the predicted enhancement of the banks' reaction to a monetary policy shock after complying with the LCR standard, as measured by the simulated long-term marginal effects, is not as significant as the elasticities have suggested.

4.2.2 Prediction on simulated data

A potential limitation of the previous analysis lies in the neutrality assumption of the balance sheet ad-hoc modifications adopted to reach compliance with the standards, i.e. there is no substitution effect on other balance sheet components. In order to overcome this weakness, we predict the long-term marginal effect of a monetary policy shock by using the balance sheet figures resulting from the simulation exercise described above. The results indicate that the bank lending channel in Luxembourg would not be strongly affected after compliance with the liquidity standards. The marginal effects are smaller in absolute terms but continue to be statistically significantly different from zero. Moreover, the marginal effect for small banks with a lower NSFR shortfall remains almost constant but statistically significant after compliance (i.e. -0.073%). Conversely, big banks will tend to see their ability to shelter monetary policy shocks slightly improved (i.e. 0.085% after compliance versus 0.078% before). Two reasons, related to the optimal adjustments prescribed by the simulation exercise, are underlying this result. First, the LCR shortfall will be lower and even negative for most banks, pushing-up the marginal effects. Secondly, compliance with NSFR seems to be achieved by increasing the ASF rather than reducing the RSF, sustaining the negative impact of a contractionary monetary policy shock for small banks. However, it is likely that banks with extremely high NSFR shortfall are also constrained to reduce the RSF in order to adhere to the NSFR. As previously stated, in our sample such banks are mainly the big ones.

4.2.3 Counterfactual analysis

We finally argue that complying with the new liquidity regulations might modify the mechanism of monetary policy transmission. Then, we adopt an alternative approach in order to estimate to which extent complying with the liquidity standards would affect the bank lending channel. We perform a counterfactual exercise that consists in fitting alternative specifications of equation 1, similar to the previously described regression models, but using bank level simulated data. The estimated long-term marginal effects of a contractionary monetary policy shock are exposed in Table 3. A general conclusion from the following analysis would be that the bank lending channel effectiveness for cooling down the economy is likely to be strongly limited after compliance with the standards.

Table 3:
Average Long-term Marginal Effect of Monetary Policy shock: counterfactual exercise.

	Quartiles of Size				
Quartiles	1	2	3	4	Total
of HQLA					
1	0.108	0.112	0.024	-0.022	0.045
	(0.161)	(0.120)	(0.280)	(0.197)	(0.207)
2	0.150	0.122	0.096	-0.053	0.069
	(0.053)	(0.186)	(0.230)	(0.240)	(0.176)
3	0.154	0.069	0.123	-0.062	0.070
	(0.038)	(0.175)	(0.168)	(0.233)	(0.140)
4	0.114	0.048	0.016	-0.066	0.029
	(0.165)	(0.173)	(0.412)	(0.232)	(0.239)
of NO					
1	0.088	0.065	-0.014	-0.073	0.022
	(0.167)	(0.132)	(0.344)	(0.244)	(0.218)
2	0.117	0.077	0.057	-0.050	0.040
	(0.069)	(0.133)	(0.266)	(0.187)	(0.174)
3	0.144	0.087	0.095	-0.044	0.062
	(0.034)	(0.137)	(0.270)	(0.273)	(0.188)
4	0.173	0.062	0.086	-0.038	0.090
	(0.076)	(0.283)	(0.251)	(0.190)	(0.181)
of ASF					
1	0.259	0.220	0.180	0.005	0.122
	(0.014)	(0.012)	(0.094)	(0.304)	(0.163)
2	0.140	0.113	0.030	-0.095	0.032
	(0.052)	(0.073)	(0.365)	(0.159)	(0.162)
3	0.087	0.050	0.012	-0.112	0.036
	(0.111)	(0.164)	(0.393)	(0.109)	(0.197)
4	0.100	0.050	-0.041	-0.073	0.024
	(0.144)	(0.245)	(0.350)	(0.217)	(0.238)
of RSF					
1	0.267	0.174	0.127	0.044	0.126
	(0.078)	(0.055)	(0.144)	(0.346)	(0.183)
2	0.171	0.102	-0.003	-0.081	0.027
	(0.031)	(0.132)	(0.434)	(0.199)	(0.192)
3	0.090	0.057	0.008	-0.121	0.032
	(0.104)	(0.136)	(0.363)	(0.089)	(0.148)
4	0.092	0.048	-0.019	-0.077	0.029
	(0.128)	(0.245)	(0.388)	(0.206)	(0.238)
Total	0.138	0.072	0.054	-0.050	0.053
	(0.084)	(0.166)	(0.285)	(0.226)	(0.190)

Note: p-values in parenthesis
Sources: BCL, authors' calculations

A visual inspection is enough to see the differences in the effects compared to those currently at work. Firstly, big banks are no longer able to cushion monetary policy shocks, as can be seen in the last row of Table 3 the effects are even negative though not significant. Small banks are better prepared after compliance with the standards to shelter a monetary policy tightening; 100 basic points increase in the short-term interest rate triggers an increase of 0.138% of the loan supply of small banks. Secondly, while NO continues to play a similar role as before compliance, HQLA tend to help small banks to better cushion the impact of the contractionary shock in monetary policy. In contrast, for bigger banks the sheltering effect is not significant. Finally, the higher the RSF ratio the lower the marginal effect.

The results confirm the previous statements; the effectiveness of the bank lending channel in Luxembourg tends to disappear. The striking result concerning the ability of small banks to protect their loan portfolio from a monetary policy tightening stems from the increase in their stock of HQLA which is positively related to the marginal effects, and from the softer burden that adhering to the NSFR imposes on them compared to big banks.

5 CONCLUSION

The aim of this article is to study the potential impact of the Basel III liquidity standards on monetary policy transmission through the bank lending channel in Luxembourg using bank level data.

A first contribution of this paper is the assessment of the relevance of the bank lending channel in Luxembourg. One of the innovations of this study is that, in addition to those bank characteristics usually considered in the literature, we test the potential explanatory power of the new liquidity standards for identifying distributional effects of monetary policy shocks. Our results indicate that the LCR and NSFR are vehicles of relevant information for identifying the bank lending channel. More precisely, we find that the bank lending channel in Luxembourg mainly works through small banks with a large shortfall in the NSFR.

Moreover, in contrast to the findings of studies focusing on other European countries, we find a significant asymmetry between the lending responses to monetary policy shocks of small and big banks. The small banks are less able to shelter their loan portfolio from monetary policy shocks, although the ability of small banks to absorb monetary policy shocks is improved as they have a higher ratio of Available Stable Funding (essentially composed of liabilities with maturity greater than one year) or benefit from a better access to short-term funding (i.e. bigger Net Outflows over total assets). Conversely, liquidity does not play a highly significant role for small banks. On the other hand, big banks are able to increase their loans following a monetary policy tightening which supports our argument that they are liquidity providers. In comparison to the results for small banks, higher ratios of ASF, NO or HQLA tend to reduce the ability of big banks to cushion contractionary monetary policy shocks. This arises since big banks with high ASF ratio are those that also have high ratios of RSF over total assets. The negative effect of the latter overcompensates for the positive effect of the former. Also, big banks tend to have higher leverage ratios than small banks and thus, for those banks, exceedingly high NO ratios are likely to overcompensate for the positive effect of the bank size. Finally, if banks hold HQLA for the purpose of long-term investment or as collateral then a higher share of HQLA is likely to reduce the effect of bank size.

The second contribution in the paper is the estimation and the analysis of LCR and NSFR time series. We show that the liquidity of Luxembourg's banks, as measured by the LCR, declined during the build-up to the crisis in 2008 from a maximum of 80% in 2003q4 to a minimum of 30% in 2010, and has just started to recover. Regarding the evolution of the NSFR we show that its median was above 100% before 2005, but declined steadily until 2008 to a level of 80%. This description suggests that further balance sheet restructuring is likely to take place in the medium term. Then, we estimate the optimal balance sheet adjustments using a constrained optimization where banks maximize their profits given that they have

to adhere to both liquidity ratios and the Basel III leverage standard. The simulation outcome uncovers large differences in the adjustments of small and big banks. While small banks tend to be pushed toward wholesale sources of funding, big banks are pointed toward retail and small NFC customers even if they have already a significant share of these types of deposits.

Based on the identified mechanism of monetary policy transmission, we estimate the impact of compliance with the liquidity standards using both ad-hoc and optimal balance sheet adjustments. The results suggest that complying with the NSFR will significantly reduce the relevance of the bank lending channel as it has just been identified in this paper. Conversely, complying with the LCR can potentially enhance the bank lending channel as it is currently working in Luxembourg. When we consider optimal balance sheet adjustments we can more adequately take into account potential substitution effects resulting from the balance sheet changes needed to adhere to the liquidity standards. The estimation of the long-term marginal effects on the growth rate of loans of a contractionary monetary policy shock using the optimal balance sheet changes shows that the monetary policy effects tend to be closer to zero but still significant.

One can further argue that complying with the new liquidity regulations might potentially modify the mechanism of monetary policy transmission. Then, we estimate a set of models based on the simulated bank level data. The results confirm previous conclusions; the bank lending channel in Luxembourg would tend to be less effective for cooling down the economy.

The introduction of the Basel III liquidity regulations in Luxembourg is, therefore, likely to lead to a banking sector that is, on the one hand, more resilient to crises but, on the other hand, also less likely to react to monetary policy shocks. We conclude that the short-term interest rate may lose part of its power as an instrument for central bank intervention.

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3 THE LEVERAGE CYCLE IN LUXEMBOURG'S BANKING SECTOR [1]

By
Gaston Giordana*
Ingmar Schumacher*

1 INTRODUCTION

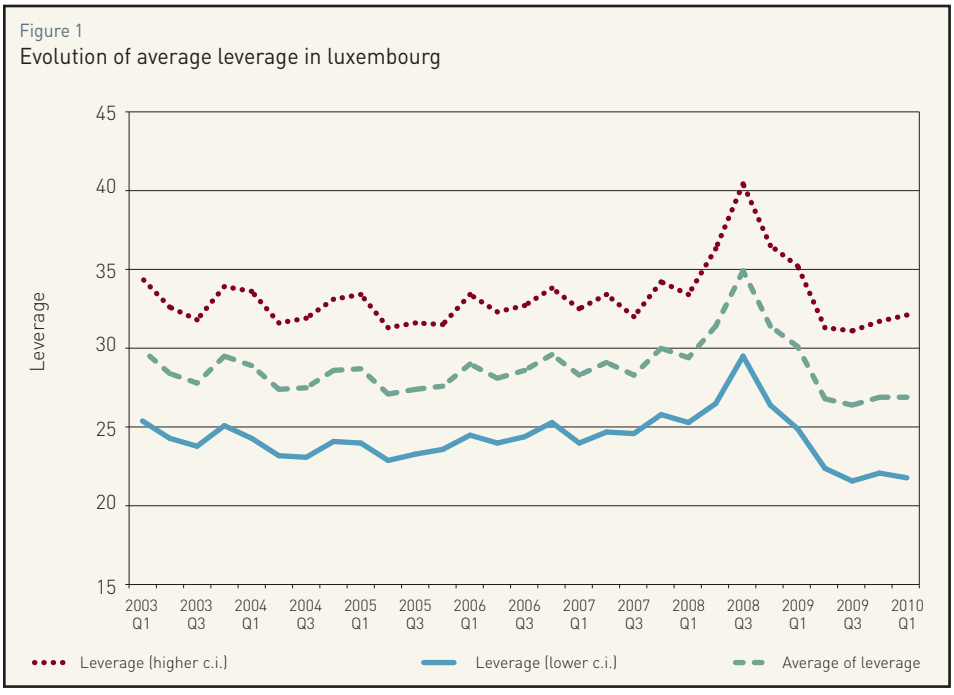
A variable that received quite some attention in the aftermath of the crisis was the leverage ratio. The leverage ratio is indicative for a bank's level of indebtedness and measures how much of a bank's own funds cover its assets. Banks tend to increase their profits by attracting more outside funding as outside funding is generally cheaper and easier to obtain than raising equity. However, relying on outside funding makes banks more susceptible to bank runs and sudden shifts in liabilities or risky assets. Therefore, one can associate a higher level of indebtedness, as measured by the leverage ratio (assets divided by own funds), with a higher probability of bank default and an increase in the impact of withdrawals of short-term liability.

It is, thus, useful to analyze why and when banks actually want to accept the higher risks that are associated with a higher indebtedness. To do this, we build a panel dataset with individual banks' balance sheet data covering the whole population of banks in Luxembourg and ranging from 2003 Q1 – 2010 Q1. We use macroeconomic indicators to study which factors drive the leverage cycle. Our real variables are the rate of unemployment and European GDP growth, the financial variables are the EuroStoxx 50 index and Euribor-OIS spread, while the expectation variables are the Luxembourgish consumer confidence indicator and a variable that we construct ourselves, which is new to the literature, and which we dub the herd effect. With this variable we want to capture at least a part of the herd behavior in the leverage process.

2 THE MECHANICS BEHIND THE LEVERAGE CYCLE

As Figure 1 shows, leverage in Luxembourg was procyclical during the boom of 2003 Q1 to 2008 Q1, increased sharply at the beginning of the financial turbulences in 2007 Q4, and then quickly decreased to its all time low with the materialization of the financial crisis in 2008 Q3. If banks expand their balance sheets by raising own funds, then leverage should decrease. As Figure 2 shows for individual bank data spanning the Luxembourgish banking sector from 2003 Q1 to 2010 Q1, this is clearly not the case in Luxembourg. Instead, increasing asset values are highly correlated with increasing leverage.

Figure 1
Evolution of average leverage in luxembourg



Source : BCL

* Financial Stability Department

1 This contribution is a non-technical summary of a forthcoming BCL working paper.

Figure 2
Leverage growth versus asset growth, 2003 Q2–2010 Q1

Thus, banks increase their assets mainly through increasing their liabilities (less own funds). Figure 3 demonstrates that the evolution of leverage is mainly due to assets. While own funds continued to grow at approximately the same rate as before the crisis, assets reduced significantly after the Lehman bankruptcy.

Taking a closer look at the main components of assets, Figure 4 shows that the major driver of the collapse in the stock of total assets was total credits. A somewhat more disaggregated look at credits allows us to conclude that credits to `monetary financial institutions' were the main source underlying the decline in total credits. The fact that mainly credits drive assets is supported through the observation that banks' portfolios in Luxembourg are, on average, composed to 75% of credits and to 15% of securities.

As Figure 3 shows, the increase in equity in the pre-crisis period cannot solely account for the growth in assets. Thus, the increase in assets must have come through attracting other liabilities. Similarly, since banks in Luxembourg reduced their assets from 2008 Q3 onwards while they continued to increase their equity, then this implies that they adjusted their balance sheets by changing other liabilities. Banks in Luxembourg did this especially through shedding deposits, which make up around 85% of liabilities on average. As Figure 5 shows, we observe a highly significant and positive correlation (82%) between asset growth and deposit growth. Thus, deposits are the main means of adjustment to match the asset and liability sides of banks' balance sheets in Luxembourg.

Figure 3
Evolution of assets and own funds

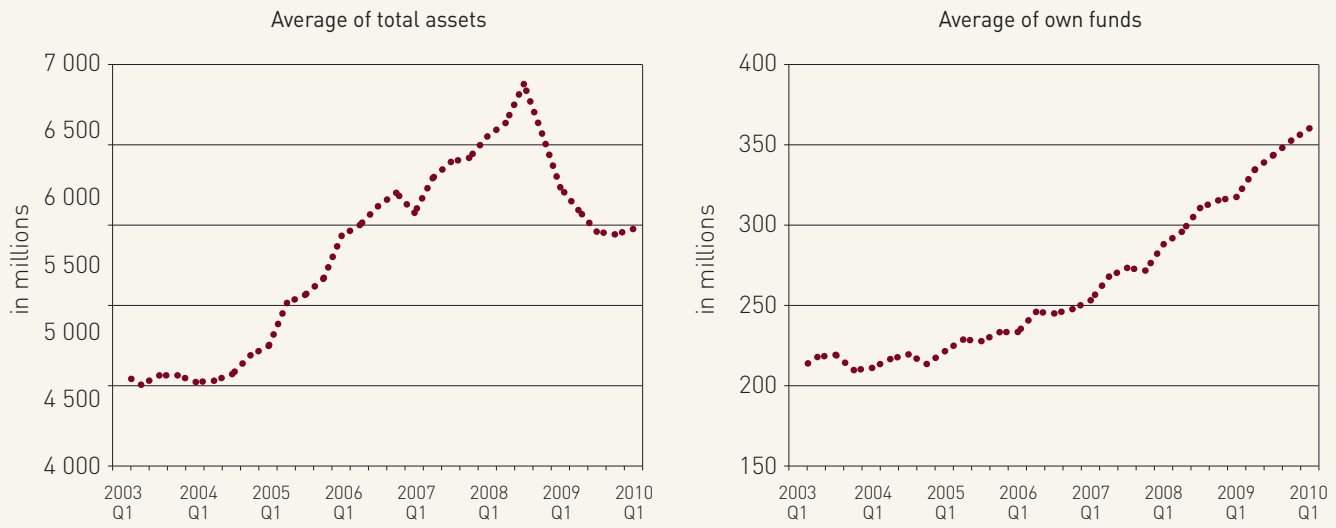


Figure 4
Evolution of credits and securities

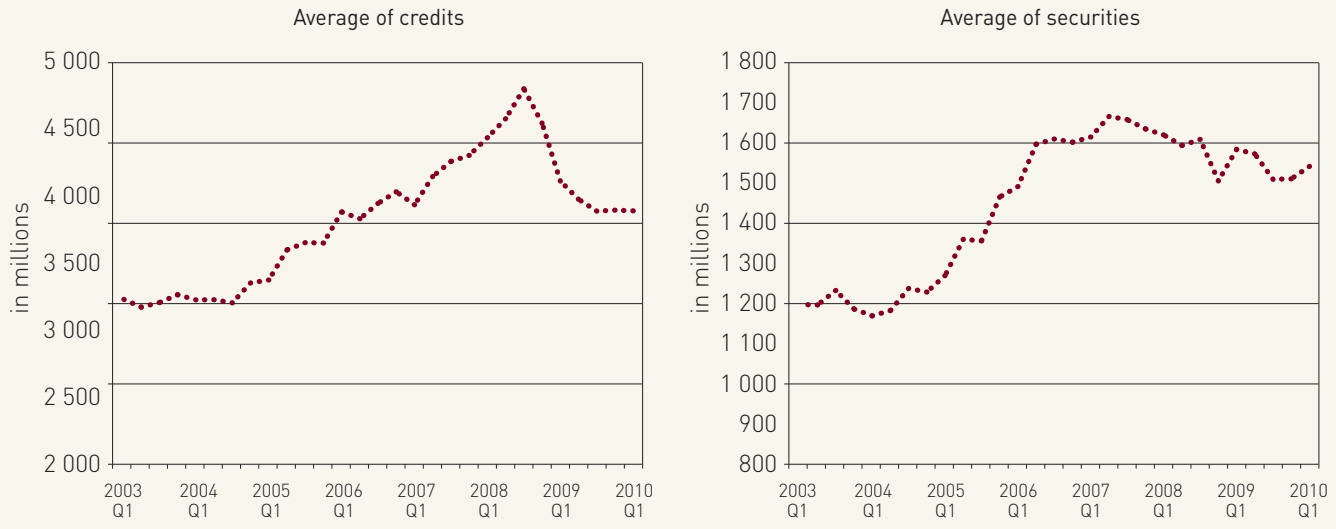
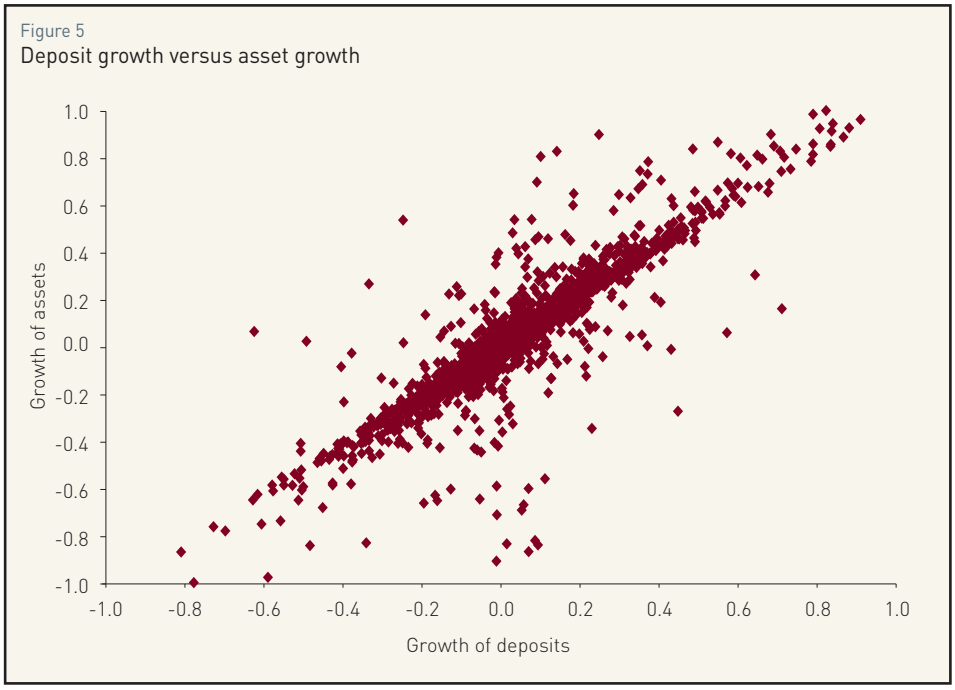


Figure 5
Deposit growth versus asset growth



3 DESCRIPTION OF ECONOMETRIC APPROACH

The dataset that we construct to complement the descriptive analysis above is an unbalanced panel dataset consisting of 153 banks for the period 2003 Q1 – 2010 Q1. We define leverage as total assets divided by own funds. Own funds include basic capital, assimilated capital and reserves.

We account for the crisis period by defining a dummy called crisis, which is equal to one for the period 2007 Q4 - 2010 Q1. The date 2007 Q4 coincides with the beginning of the turbulences, where confidence, industrial production, GDP and the stock index started to decline.

Table 1 presents the summary statistics. Since most of the macroeconomic expectation variables are highly correlated, we decided not to use these simultaneously in the regressions but study their respective impacts individually.

Table 1:
Summary statistics

Variable	Mean	Stand. Dev.	Min.	Max.	Source
Growth in leverage	0.005	0.194	-0.878	0.992	BCL statistical tables
Consumer confidence	-0.525	6.188	-17	8	BCL, seasonally adjusted
Euribor-OIS spread	0.335	0.305	-0.18	1.04	ECB SDW
Herd effect	-0.001	0.016	-0.046	0.045	Authors' calculations
Growth in EU GDP	1.024	2.304	-5.18	3.56	ECB SDW, seasonally adjusted
EuroStoxx 50 index	299.7	73.2	177.4	440.8	ECB SDW, seasonally adjusted
Unemployment (%)	4.405	0.701	3.276	6.035	BCL, annual % change, seasonally adjusted
Crisis	0.334	0.471	0	1	Authors' calculations

Our econometric model is

$$growth(L_{it}) = \alpha \times growth(L_{it-1}) + X_{it-1}\boldsymbol{\beta} + v_i + d_t + \varepsilon_{it}, \quad (1)$$

where we explain the growth in leverage by its lagged value (to account for dynamic effects), by a vector of variables X_{it} that we use to explain the macroeconomic environment (confidence, Euribor-OIS spread, EU GDP growth, EuroStoxx 50 index, unemployment and herd effect), by unobserved fixed effects v_i, seasonal dummies d_t and an error term ε_{it}.

The Arellano-Bond estimator is our preferred estimator here as we expect significant fixed effects which should give rise to the Nickell bias.

We now discuss our results variable by variable and present the coefficients of the estimates in brackets with stars denoting the significance levels (*** implies p-value <0.01; ** implies p-value <0.05; * implies p-value p<0.1).

4 OVERVIEW OF THE RESULTS

4.1 Unemployment

Cross-boarder commuters make up a large share of employment in Luxembourg. Since, furthermore, Luxembourg's banks are rather internationally-oriented, it would be surprising to find an impact from unemployment on leverage as a whole. Instead, what is interesting to study is whether the unemployment rate predicts the evolution of credits and deposits to households in Luxembourg. We find that credits to households in Luxembourg are unaffected by unemployment, most likely because banks expect the increase in unemployment to be short-run and they expect little changes to the local collateral values.

In contrast, unemployment affects deposits from households in Luxembourg negatively, albeit only in the crisis (-0.0846***). We believe that the increase in unemployment during the crisis seems to have reduced overall wealth sufficiently in order to be reflected in the amount of deposits held at the banks.

4.2 European GDP growth

Luxembourg is a strongly Europe-oriented banking sector with, on average, 42% of all deposits coming from monetary financial institutions (MFIs), and credits to MFIs averaging 72% of total credits. Thus, we expect European GDP growth to be a proxy for deposit supply and credit demand in Luxembourg.

We cannot find a significant effect from EU GDP growth to leverage growth in the pre-crisis period (-0.00841), but confirm a positive and significant effect during the crisis (0.0205*). This effect during the crisis comes through a positive impact of EU GDP growth on credits (0.0126**) and on deposits (0.0107**). These findings would suggest that the financial sector in Luxembourg, in the build-up to the crisis, might not have been driven by economic fundamentals. In general, one would be inclined to call this evidence for a bubble, with the financial sector getting detached from the real sector.

4.3 EuroStoxx 50 Index

The Dow Jones EuroStoxx 50 Index represents the 50 strongest Blue-chip companies in Europe. Higher collateral values or assets prices should impact leverage positively through an effect on the market-book value and an expectation effect. Our econometric results show that the EuroStoxx 50 Index affected the growth of leverage during both the pre-crisis (0.000169***) and crisis period (0.000347***), with a statistically significantly higher impact during the crisis.

We can show that changes in the EuroStoxx 50 Index impact leverage nearly exclusively through credits and deposits. Thus, we find that banks in Luxembourg do not react to changing asset prices *per se*, but *inter alia*, to the news that comes with changes in asset values. In this sense, changes in portfolios in Luxembourg are not necessarily related to marking-to-market but instead to changes in expectations and collateral values.

4.4 Euribor-OIS spread

The Euribor-OIS spread is the difference between the 3-month Euro interbank offered rate and the Overnight Index Average rate. The 3-month Euro interbank offered rate is the rate at which selected banks can lend three-month unsecured funds in the EU interbank market, and the Overnight Index Average rate is an average interest rate at which those banks can borrow unsecured overnight funding. In general, default risk and liquidity risk induce a positive difference between those two rates. As the financial crisis of 2007 was mainly driven by liquidity risk then the Euribor-OIS spread should reflect the market's view of liquidity problems. Since Luxembourg's banks are liquidity providers, we expect a positive impact from the Euribor-OIS spread on leverage.

We find that in the build-up to the crisis the Euribor-OIS spread is positively associated with leverage growth in Luxembourg (0.0445**) through its impact on credits (0.0679***) and deposits (0.0637***). However, we find no significant impact during the crisis. Thus, an increasing spread indicates that Luxembourg's banks are in a relatively good position to provide inter-group funds more cheaply than if they come from other sources, but we find that this relationship breaks down during the crisis.

4.5 Consumer confidence

The variable consumer confidence is derived from a monthly questionnaire answered by a representative sample of Luxembourg's citizens and is calculated as the average of four questions. These questions are related to the expected financial situation of households over the next year, the expected economic situation over the next year, the expected evolution of unemployment and the expected ability to save over the next twelve months. This variable should reflect the anticipated evolution of the economic situation in Luxembourg. We suggest that consumer confidence also reflects bankers' confidence, with increasing confidence inducing lower risk aversion and an increasing leverage (see also Kiyotaki and Moore, 1997).

Our results suggest that consumer confidence (or expectations) drive leverage during the crisis (0.00596***), but not during the pre-crisis period. Thus, we find that there is indeed a role for the deleveraging process with banks reducing debt (mostly deposits) and shedding assets with decreasing confidence. We, however, do not find that consumer confidence can explain the build-up in leverage. It seems that the build-up is mainly driven by the increasing asset values, suggesting that stock market values and potentially the Euribor-OIS spread are the best indicators for the build-up of leverage.

4.6 Herd effect in deleveraging

Bankers invest according to their expectations, and these should at least partly be driven by the macroeconomic environment and the expectations of others. When one bank sees that other banks sell assets or reduce leverage, then that bank might do the same for several reasons. One reason, taken from Kiyotaki and Moore (1997), is the effect of expectations on collateral. A banker who becomes less confident in the markets attaches a lower expected value to his loan portfolio, and will subsequently be inclined to reduce his lending to those agents whose loans he presumes are too risky. This, for example, arises through a worsening of the collateral values or payback rates. If sufficiently many bankers face this decline in confidence, this will impact collateral values across the markets and potentially generate fire sales of

assets leading to further pressure on asset and collateral values and finally inducing a vicious circle of forced deleveraging even on those banks that otherwise had a sufficiently riskless portfolio.

The argument above can be complemented with the approaches in the literature on herd behavior (see e.g. Chari and Kehoe, 2004; Devenow and Welch, 1996; Calvo and Mendoza, 1996). Herding arises when sufficiently many investors follow a specific behavior, which might induce other investors to disregard their own private information and follow the herd.

We define a bank i's herd effect as the growth rate of the mean of leverage across all banks in Luxembourg at each period, excluding bank i's leverage. This measures a bank's incentive for changing its leverage, given that it observes the average changes in leverage of all other banks in Luxembourg. If all banks deleverage at the same time, then this might induce other banks to deleverage as reductions in asset or collateral values require re-assessments of risks and subsequent portfolio restructurings. In addition to this, the herd effect variable will also take into account that banks might target a similar leverage ratio.

Our main findings are that the herd effect is active only during the crisis period, and it affects leverage growth positively (0.446***). Thus, leverage is strongly impacted by the fact that banks react to the actions of the other banks. However, whether this is due to fire sales or changing expectations is difficult to assess with this variable.

5 CONCLUSION

In this short contribution we studied the impact of several macroeconomic variables on the evolution of leverage in the banking sector in Luxembourg. We found that the only variables that can predict the build-up in leverage before the crisis are the EuroStoxx 50 index and the Euribor-OIS spread. We expect that the EuroStoxx 50 index is mainly indicative for changing collateral values and therefore explains the increase in credits and deposits. In addition, the positive impact of the Euribor-OIS spread on leverage reflects the fact that Luxembourg's banks are liquidity providers. During the crisis period, most macroeconomic variables have a statistically significant impact on leverage, which of course is also driven by the fact that they are all highly correlated. We would need a structural model that explains the relationship behind those macroeconomic variables in order to understand which of these truly forces changes in leverage.

We also find a significant role for the herd effect during the crisis, indicating that banks may react to the deleveraging process that is happening in other banks. This gives some evidence for the fire sales argument and a vicious circle in deleveraging.

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