Identifying risks in emerging market sovereign and corporate bond spreads

Summary of Working Paper no. 430 Gabriele Zinna

Monitoring emerging markets' (EMs') credit risk is of paramount importance, not only for emerging market economies (EMEs), but also for developed countries. In particular, the evolution of risks embedded in EM securities determines the riskiness of international portfolios. Underdiversified portfolios may expose international investors to severe losses, trigger sudden capital flow reversals, and raise financial stability concerns. Adverse events originated in EMEs can spill over to developed countries. But there may also be 'second-round' effects, whereby a crisis that originates in developed countries and is transmitted to EMEs worsens as it then feeds back to developed countries.

As EMEs have become more financially integrated, the EM asset class has become more important for the stability of global financial markets. Consequently, an increasing number of studies have focused on the EM asset class, and our understanding of sovereign EM credit risk has improved significantly. For example, some studies have documented a strong dependence of EM sovereign spreads on global risk factors, highlighting the urgency for EME governments to implement policies to insulate their economies from external shocks. However, in recent years, corporate bonds have increased to become an important member of the EM asset class. For instance, EM corporate issuance in 2007 matched that of the US high-yield sector. The rise of the corporate market brought with it new challenges for EM authorities. And, yet, the joint nature of sovereign and corporate risks remains largely unexplored.

We aim to shed light on the different behaviour of these two markets by jointly modelling indices of EM sovereign and corporate bonds. This not only allows us to emphasise the comovement of sovereign and corporate bonds but also to highlight their differences. In addition, instead of focusing on a particular region, we take a global perspective, whereby we jointly model regional indices of bond spreads for Latin America, Europe, Asia and the Middle East. But using so many bond indices comes at the cost of having too many parameters. As a result, we turn this original system of equations (a vector autoregression) into a more parsimonious model where the spreads depend on a small number of observable risk factors. This allows us to use time-varying responses of the spreads to changes in the risk factors; a feature of the model which enables us to monitor EM credit risk over the crisis. Moreover, time-varying coefficients can accommodate varying degrees of EM integration. In addition, we allow the volatility to change over time in order to account for the increased size of financial shocks during the recent market turmoil.

Our model is also a useful tool for building indicators of EM credit risk, as it informs us of changing risks across a number of dimensions. For example, these indicators are able to capture variations of credit spreads which are common across spreads ('common' indicators); variations which are regional specific ('regional' indicators); variations which are specific to the sovereign or corporate market ('variable specific' indicators); and variations due to global risks ('global risk' indicators). However, *a priori* a number of model specifications can look plausible. But, alternative model specifications reveal different information on the nature of systemic risks in EM bonds. To this end, we test for the model which best matches the data.

Our main result is that the behaviour of sovereign and corporate spreads differs because of their specific reactions to global risk factors (VIX, US corporate default risk, and overnight index swap (OIS) Treasury spread). In the aftermath of Lehman Brothers' default, EM corporate bonds were severely hit by spillovers from US corporate default risk. But the VIX and the OIS-Treasury spread, which proxy for global risk aversion and demand for liquid securities respectively, also contributed to widen corporate spreads. By contrast, sovereign spreads 'decoupled' from the US corporate bond market, as they narrowed in response to higher US corporate default risk. That said, the narrowing in sovereign spreads was largely attributable to a higher demand for liquid securities, whereas the effect of heightened risk aversion quickly reverted. In this way, our credit risk indicators highlight the differing responses of sovereign and corporate bonds as the crisis spread from advanced economies to EMEs.

Overall, we find that the financial turmoil spread to all EMs, as the common component of EM credit risk increased sharply around October 2008. But we also find that corporates were more affected than sovereigns, and the most affected region was emerging Europe.

Financial intermediaries in an estimated DSGE model for the United Kingdom

Summary of Working Paper no. 431 Stefania Villa and Jing Yang

Financial intermediaries play an important role in the transmission mechanism of the shocks hitting the economy, as the recent financial crisis has dramatically demonstrated. However, in the main macroeconomic literature with financial frictions, intermediation, when present, is largely a veil. Consequently, Mark Gertler and Peter Karadi introduced a model where financial intermediaries play an active role in the real economy. Their model also introduced credit policy as an additional tool for policymakers.

The aim of this paper is to estimate that model with financial intermediaries (but without credit policy) for the UK economy. In particular, we examine the capability of the model to mimic the path of financial variables. The microfoundation of the banking sector is one of the novelties of the paper; therefore, we ask whether this microfoundation has good empirical properties and whether the model reproduces the observed behaviour of financial variables. We also analyse the contribution of structural shocks to the fluctuations in the variables we examine.

The model has the following agents: households; financial intermediaries; intermediate goods firms; capital producers; retailers; and the policymaker. The set-up is pretty standard but for the financial intermediaries, where we face an agency problem. That is, the banks operate on behalf of households. As a result, their balance sheets are endogenously constrained because the assets the financial intermediaries can acquire depend positively on their equity capital.

To estimate the model, we use data on gross domestic product, investment, seasonally adjusted inflation, lending to private non-financial corporations and corporate bond spreads for the period 1979 Q2–2010 Q1.

This model exhibits a 'financial accelerator' mechanism because shocks affect the debt to equity ratio ('leverage') of financial intermediaries, which affects their ability to lend. The more leveraged they are, the larger is the impact of capital losses on the reduction in lending. This retrenchment in lending leads to a fall in banks' profits. Financial intermediaries can only rebuild their profit and capital base by increasing the lending rate; therefore, the spread rises. In the face of the increase in financing cost, firms reduce their demand for loans and therefore cut back investment and increase the utilisation rate of capital. Both investment and output suffer a protracted decline. Subdued aggregate demand feeds back to the banking sector resulting in lower profits. This, in turn, causes financial intermediaries to further tighten credit supply and raise lending spreads in order to satisfy their endogenous balance sheet constraint. Given the decline in lending volume, financial intermediaries can only try to increase profit by increasing spreads, which is likely to lead to a further fall in lending demand.

We have two main results. First, an evaluation of the model's empirical properties reveals that the fit of the estimated model is quite satisfactory, in particular for the financial variables. The results suggest that financial frictions play an important role in explaining UK business cycles. Second, the banking sector shocks explain about half of the fall in output during the recent recession. The sharp rise in spreads since the onset of the crisis can be mainly attributed to credit supply shocks, although in the last quarter in our sample, credit demand starts to play a role as well. Credit supply shocks seem to account for most of the weakness in bank lending.

An estimated DSGE model: explaining variation in term premia

Summary of Working Paper no. 441 Martin M Andreasen

Conventional bond prices (ie gilts) with different maturities to expiry give rise to a set of interest rates which are referred to as the nominal term structure. Similarly, the interest rates from bond prices where the pay-off is linked to inflation (real bonds) imply a real term structure. In each case, these take account of both the expected future sequence of short rates and risk premia, neither of which is directly observable. But if they can be unpacked, they potentially contain information which is of great relevance for policymakers. For instance, the nominal term structure reveals expectations of future one-period nominal interest rates and the compensation for uncertainty in interest rates with maturities beyond one period. This compensation, for the extra uncertainty in holding a nominal bond for more than one period, is called the nominal term premium. In general, expected nominal one-period interest rates are affected by changes in expected real consumption or expected inflation. Similarly, nominal term premia are affected by changes in real consumption uncertainty or inflation uncertainty. Decomposing the information content from term structure data in this way is potentially very useful for monetary policy. For example, the implications for policy to, say, an increase in nominal interest rates along the yield curve may differ according to whether it is due to higher real interest rates, higher inflation expectations or higher inflation uncertainty.

The purpose of this paper, therefore, is to decompose the information content in the two term structures. This is done with the aid of a dynamic stochastic general equilibrium (DSGE) model for the UK economy. This is a many-period model that uses economic theory to tell us how the dynamic behaviour of all the agents in the economy interact in the face of random ('stochastic') shocks. A key advantage of using a DSGE model in the current setting is that it provides a consistent framework for studying the effect of monetary policy and other structural shocks on the evolution of the nominal and real term structure. In our case, to account for asset pricing, it must allow for the presence of uncertainty in computing equilibrium prices that ensure supply equals demand in all markets, which is not necessary in models that ignore asset prices. That raises some technical problems, made more complicated by the need to allow effects to vary over time, that are addressed in an efficient way in the paper.

Our model is estimated on UK data from 1992 Q3 to 2008 Q2. We find a reduction in nominal term premia following the adoption of inflation targeting in 1992 and operational independence of the Bank of England in 1997. This is of course only one model among the many possibilities, and, as for all models, the precise estimates are subject to uncertainty. But given this caveat, in our model this fall in nominal term premia is mainly due to lower inflation risk premia. A decomposition of the ten-year inflation risk premium suggests that this fall was driven by negative shocks to the utility that households get from consumption, lower fixed production costs, positive investment shocks, and a more aggressive attitude to inflation by the Bank of England. Adopting the terminology from the finance literature, our model implies a gradual reduction in the market price of inflation risk (the amount of compensation markets require for a given quantity of inflation risk) during the 1990s. The quantity of inflation uncertainty itself is found to fall after the adoption of inflation targeting in 1992 and operational independence to the Bank of England in 1997.

The impact of QE on the UK economy — some supportive monetarist arithmetic

Summary of Working Paper no. 442 Jonathan Bridges and Ryland Thomas

In response to the intensification of the financial crisis and the onset of recession in 2008, the Monetary Policy Committee (MPC) loosened policy significantly. By March 2009 Bank Rate had been cut to just 0.5%, but the MPC judged that further stimulus was required. It was decided that the best way to loosen monetary policy further was to undertake a programme of asset purchases, financed by central bank money, known as quantitative easing (QE). Around £200 billion of assets, mainly government securities, were bought between March 2009 and February 2010. The ultimate aim of QE was to stimulate demand via a lower cost of external finance and stronger asset prices, and thus to bring about higher output growth and offset deflationary pressures. This was an exceptional policy response in the face of a severe recession and it was therefore uncertain what the precise effects would be. The Bank of England has explored the impact of QE in a number of different ways. This particular paper does so by adopting an explicitly monetarist perspective.

In order to do this, a simple money demand and supply framework is used to estimate the impact of QE. Many papers have looked at the impact of QE by undertaking event studies of asset price movements, either on impact or over the QE period. Other studies have taken these financial market impacts and then looked at the effect of these on the macroeconomy. The role of asset quantities and the money supply in the QE transmission mechanism is often implicit or left in the background in these studies. But the hypothesised transmission mechanism of QE, at least as implemented in the United Kingdom, can be viewed within a monetarist framework, provided that money is broadly defined and that sectoral differences in money demand behaviour are taken into account.

First, standard money accounting is used to try to establish the impact of asset purchases on broad money holdings. In other words we ask: how big was the money supply shock resulting from QE? We show that the initial impact of £200 billion of asset purchases on the money supply was offset by other 'shocks' to the money supply, most notably the substitution from bank debt to the capital markets by non-financial companies and increased debt and equity issuance by the banking system. Some of these offsetting shocks may have been, at least partially, a by-product of QE. We estimate that QE boosted the broad money supply by at least 5% and potentially by as much as 13%, depending on the extent to which the offsetting shocks would have occurred in its absence. By making a comparison with reasonable counterfactuals for these offsetting factors, our central case assumption is that the £200 billion of purchases boosted the stock of broad money by around £122 billion or 8%.

Next, our estimates of the impact of QE on the money supply are applied to a set of 'monetarist' econometric models that articulate the extent to which asset prices and spending need to adjust to make the demand for money consistent with the boost to the broad money supply. We first look at an aggregate model. The long-run ('co-integrated') relationships in this model are pinned down by the theoretical determinants of the demand for money. In order to explore the dynamics of the model, we use an approach known as a structural vector autoregression to estimate a system of equations, where each equation includes lagged values of all the variables examined. 'Structural' here means that we attempt to identify the economic causes, or 'shocks', that have buffeted the system, which is done using restrictions implied by economic theory. We introduce a QE-like shock into this system and observe how the aggregate variables in the system might have to evolve to restore monetary equilibrium.

Alongside our aggregate model, we also perform a similar experiment on a set of sectoral money demand systems. In these systems the money holdings of a particular sector are modelled jointly with other relevant sectoral variables, such as asset prices in the case of the financial company sector and consumption and investment in the case of the household and corporate sectors. The sectoral approach is particularly informative given that previous research has suggested that the linkages between money, asset prices and spending have tended to be clearer at a sectoral level in the UK data. Moreover, focusing on each sector in turn allows for a richer investigation of the transmission mechanism of asset purchases, given that QE is likely to have impacted the money holdings of different sectors differently and with different lags. In order to establish an economy-wide impact from this sectoral approach, we glue our sectoral models together with a number of aggregate assumptions. This offers a useful insight into how QE works, by allowing us to trace out the QE transmission mechanism from the initial increase in financial sector money holdings all the way through to the ultimate impact on GDP and inflation.

Using our preferred sectoral approach, we obtain a central case estimate that an 8% increase in money holdings may have pushed down on yields by an average of around 150 basis points over the QE period and increased asset values by approximately 20%, relative to what would otherwise have been the case. In turn, these effects may have had a peak impact on the level of real GDP of 2% by the middle of 2011, with an impact on inflation of 1 percentage point around a year later. These estimates are necessarily uncertain and we show the sensitivity of our results to different assumptions about the size of the shock to the money supply and the nature of the transmission mechanism. But taking a mean response across all of our aggregate and sectoral specifications, we obtain similar macroeconomic effects to those derived from our preferred specification.

We do not wish to claim too much from the empirical results, given the models we use are estimated over periods that have not, for the large part, been subject to money supply shocks of a similar nature to QE. And, given the way we work out the size of the money supply shock and apply it to our models, it would probably be best to describe our results as a set of illustrative 'arithmetic' calculations rather than precise statistical estimates. Nevertheless, we can use the results to get some idea of what the counterfactual path of the economy would have looked like in the absence of QE. We show that once the QE 'footprint' is removed from the data, the counterfactual path of money growth and velocity looks more similar to the experience in the 1990s recession than would otherwise seem the case. We also show that, in the absence of QE, the growth rates of asset prices and GDP would have been notably weaker in 2009 and 2010.

Assessing the economy-wide effects of quantitative easing

Summary of Working Paper no. 443 George Kapetanios, Haroon Mumtaz, Ibrahim Stevens and Konstantinos Theodoridis

This working paper describes research undertaken at the Bank to assess the macroeconomic impact of the Monetary Policy Committee's (MPC's) quantitative easing (QE) policy undertaken during March 2009 to January 2010. This, along with other work, fed into the article on 'The United Kingdom's quantitative easing policy: design, operation and impact', which was published in the *Bank of England Quarterly Bulletin*, 2011 Q3.

The sharp deterioration of the global financial crisis in late 2008 led to the increased risk of a severe downturn on a scale not seen since the Great Depression of the 1930s. In many countries, the fiscal and monetary authorities responded with a variety of conventional and less conventional measures aimed at mitigating the effects on financial stability and the real economy. Actions taken by central banks mainly consisted of liquidity support and large-scale asset purchases, commonly described as quantitative easing.

The MPC of the Bank of England reduced Bank Rate, the official UK policy rate, to ½% on 5 March 2009. But despite reducing interest rates to their effective lower bound, the MPC felt that additional measures were necessary to achieve the 2% CPI inflation target in the medium term. The Committee therefore also announced that it would begin a large programme of asset purchases financed by central bank money, mainly consisting of UK government bonds (gilts). The aim of the programme of asset purchases was to inject a large monetary stimulus into the economy, in order to boost nominal expenditure and thereby increase domestic inflation sufficiently to meet the inflation target. Between March 2009 and the end of January 2010 the Bank purchased a total of £200 billion assets, an amount equivalent to about 14% of UK GDP.

Asset purchases were expected to affect the real economy in a number of ways, but a key one was through the so-called portfolio balance channel. Through this channel, asset purchases push up the price of the assets being purchased, as well as the price of other assets that are closer substitutes for the purchased asset than money. This in turn stimulates demand through lower borrowing costs and increased wealth. Previous Bank work that examined the financial market impact of large-scale asset purchases suggested that it had had a significant effect on medium and long-term government bond (or gilt) yields. The main objective of this working paper is to gauge how the wider economy responded to the stimulus from QE by estimating the effects on output and inflation. However, analysing these effects is not an easy task. It calls for a counterfactual analysis of what would have happened to real GDP and CPI inflation if the QE policy had not been implemented. In order to construct our no policy counterfactual, we assume that the macroeconomic effects of QE come through the impact on government bond yields. This counterfactual is then compared with a baseline prediction which includes QE. The difference between the two scenarios is taken as a measure of the macroeconomic impact.

We construct conditional forecasts (for real GDP and CPI inflation) from three different empirical models, which are all variants of models known as vector autoregressions, or VARs. In general, VARs are systems of equations that each include lagged values of all the variables examined, which allows them to account for the complicated interrelationships in the data. The first model is a large Bayesian vector autoregression (BVAR), which is estimated over a rolling sample period, to allow for structural change. The BVAR incorporates a large amount of data but imposes minimum economic structure. The other two models are smaller models with more underlying economic structure. One is a Markov-switching or change-point structural VAR (MS-SVAR), where the parameters are allowed to change at a particular time, and the other is a time-varying parameter structural VAR (TVP-SVAR), where parameters can change gradually over time. The word 'structural' here means that we attempt to identify the economic causes, or 'shocks', that have buffeted the system. This is done using restrictions from economic theory, which tell us about the sign or absence of effects following particular types of shock. We conduct counterfactual analysis using all three models, examining both the macroeconomic impact of QE and the persistence of the effects.

Our empirical results suggest that without the QE programme real GDP would have fallen even more during 2009 and inflation would have reached low or even negative levels. Taking the more conservative average estimates across the three models suggests that QE had a peak effect on the level of real GDP of around 1½% and a peak effect on annual CPI inflation of about 1¼ percentage points. However, the magnitude of these effects varies considerably across the different model specifications, and with the assumptions made to generate the counterfactual simulations, so these estimates are subject to considerable uncertainty.

Asset purchase policy at the effective lower bound for interest rates

Summary of Working Paper no. 444 Richard Harrison

The financial crisis and subsequent global recession of 2008–09 prompted substantial responses from policymakers around the world and interest rates were reduced sharply to support aggregate demand. Short-term nominal policy rates in a number of countries reached historically low levels and in some cases were reduced to an effective lower bound (usually slightly positive). A number of central banks also deployed a broader range of policy tools than usual. In particular, some engaged in 'unconventional monetary policies' that involve the purchase of assets by the central bank. These policies are 'unconventional' because they are on a much larger scale and cover a broader range of assets than usual.

This paper studies monetary policy in a standard workhorse model that is extended to incorporate imperfect substitutability between short and long-term bonds. The standard features of the model include the assumption that prices are sticky and so do not immediately and fully adjust to changes in costs or demand. This gives rise to a 'Phillips curve' relating inflation to expected future inflation and the output gap. The modification to the standard model provides a channel through which asset purchases by the monetary policy maker can affect aggregate demand. Because assets are imperfect substitutes, asset purchases that alter the relative supplies of assets will also influence the prices of those assets.

In the model, aggregate demand depends on the prices (or interest rates) of both long-term and short-term bonds. To the extent that central bank asset purchases reduce long-term interest rates (over and above the effect of expected future short rates), aggregate demand can be increased, leading to higher inflation through the Phillips curve. So these types of policy responses may help to offset the effects of large falls in demand when the short-term nominal interest rate has already been reduced to the lower bound. This paper shows that using asset purchases as an additional policy instrument can improve economic outcomes in the face of a negative demand shock, even if asset purchase policies are also subject to (both upper and lower) bounds.

The imperfect substitutability between bonds that gives asset purchases their traction also reduces the potency of conventional monetary policy (that is, changes in the short-term nominal interest rate). This is because (other things equal), reductions in the short-term nominal interest rate reduce the relative supply of short-term bonds. This reduces the price of long-term bonds and hence pushes up long-term bond rates, reducing aggregate demand. For the model analysed in this paper, however, using asset purchase policies in the face of negative demand shocks more than offsets the reduced effectiveness of conventional interest rate policy resulting from the imperfect substitutability between bonds.

Does macropru leak? Evidence from a UK policy experiment

Summary of Working Paper no. 445 Shekhar Aiyar, Charles W Calomiris and Tomasz Wieladek

The regulation of bank capital to improve the resilience of the financial system and, related to this aim, as a means of smoothing the credit cycle are important elements of forthcoming macroprudential regimes internationally. For such regulation to be effective in controlling the aggregate supply of credit it must be the case that: (i) changes in capital requirements affect loan supply by regulated banks, and (ii) substitute sources of credit — or 'leakages' — are unable to offset fully changes in credit supply by affected banks. Despite the centrality of both these propositions to the macroprudential enterprise, empirical evidence on either proposition is scant.

The United Kingdom provides an ideal testing ground for these questions because of the country's policy regime in the 1990s and early 2000s, when the Financial Services Authority (FSA) set time-varying minimum capital requirements — so-called 'trigger ratios' — at the level of individual banks. These trigger ratios were set for all banks under the FSA's jurisdiction, ie for all UK-owned banks and all subsidiaries of foreign banks operating in the United Kingdom. The discretionary regime was intended to fill gaps in the early Basel I regime, which simply imposed a uniform minimum capital requirement of 8% of risk-weighted assets.

This study collects quarterly data on minimum capital requirements for all FSA-regulated banks between 1998 and 2007. Over the period the variation in minimum capital requirements as a percentage of risk-weighted assets was large, ranging from a minimum of 8% to a maximum of 23%. Moreover, although the FSA's mandate over the period was explicitly microprudential, the aggregate outcome of its bank-by-bank decisions was in fact countercyclical, just as one might expect in a future macroprudential regime.

Changes in bank lending to the real economy are regressed on several lags of changes in the trigger ratio. Control variables include GDP growth and a number of bank-specific balance sheet characteristics. Several different strategies are employed to control for demand shocks. A large and significant impact of changes in minimum capital requirements on bank lending is found across all specifications. A rise in the trigger ratio of 100 basis points is estimated to induce a cumulative reduction in the growth rate of bank lending of between 6% and 9%.

Next, the study investigates leakages. The United Kingdom is host to a large number of branches of foreign-owned banks, which are not subject to FSA regulation, but are regulated by the country authorities of the parent bank. When capital requirements are tightened on FSA-regulated banks, this confers a relative cost advantage on the foreign branches operating in the United Kingdom, which might raise lending in response. Of course, this is only one potential source of leakage (others include capital markets and cross-border lending), but it is likely to be the most important one.

The change in lending by foreign branches is regressed on several lags of the change in lending by a reference group of regulated banks. For each foreign branch, the reference group of regulated banks comprises banks that specialise in lending to the same sectors of the economy as the branch; thus the reference group captures the relevant set of competitor banks. A technique called instrumental variables is used to ensure that the changes in lending examined are restricted to those caused by changes in regulatory capital requirements.

It is found that foreign branches increase lending in response to a regulation-induced decline in lending by competing regulated banks. The average branch increases lending by about 3% in response to a decline in lending by its reference group of 1%.

An economy-wide aggregate assessment of leakages needs to further take into account that (i) foreign branches outnumber UK-regulated banks; and (ii) the average foreign branch is much smaller than the average UK-regulated bank. Accounting for these factors yields an estimate of aggregate leakages of about 32%. That is, for any given change in minimum capital requirements across the regulated banking system, leakages through foreign branches reduce the credit supply response by a third. The fact that the offset is only partial implies that, on balance, changes in capital requirements can induce a substantial impact on aggregate credit supply by UK-resident banks.

The business cycle implications of banks' maturity transformation

Summary of Working Paper no. 446 Martin M Andreasen, Marcelo Ferman and Pawel Zabczyk

Economists, including those at central banks, have a keen interest in understanding the impact of different types of disturbances and tracing how they work through the economy. Such analyses are often conducted using dynamic stochastic general equilibrium (DSGE) models. These models use theory to describe how all the actors in the economy behave, and how they interact over time to produce an economy-wide outcome. The word 'stochastic' indicates that there is a fundamental uncertainty pervading the economy, with different types of random 'shocks' affecting the dynamics of prices and quantities.

The recent economic crisis highlighted the importance of financial factors in the propagation of economic disturbances. While some analyses, most notably the well-known studies by Kiyotaki and Moore and Bernanke, Gertler and Gilchrist have studied the role of financial frictions, they did so without explicitly modelling the behaviour of the banking sector. A growing number of papers has therefore incorporated this sector into general equilibrium models. With a few exceptions, however, this literature abstracts from a key aspect of banks' behaviour — ie the fact that banks fund themselves using short-term deposits while providing long-term credit. This so-called 'maturity transformation' has the potential to affect the propagation of stochastic shocks, and the aim of this paper is to propose a DSGE model which helps to clarify how.

A general equilibrium approach is essential for our analysis, because we are interested not only in explaining how long-term credit affects the economy but also in the important feedback effects from the rest of the economy to banks and their credit supply. There are, however, several technical difficulties which mean that maturity transformation based on long-term credit has not been widely studied in a DSGE set-up. The framework we propose overcomes these difficulties and remains conveniently tractable. We assume, in particular, that firms need credit to purchase their capital stock and that they change their level of capital at random intervals — meaning they require financing for longer periods of time.

Importantly, we show that this set-up, by itself, has no implications for shock propagation. This means that the aggregate effects of maturity transformation we obtain are *not* a trivial implication of the infrequent capital adjustment assumption. It is only when we introduce banks, which use accumulated wealth and short-term deposits from the household sector to provide longer-term credit to firms, that maturity transformation starts playing a role.

We illustrate the quantitative implications of maturity transformation in two standard types of DSGE models — one in which firms can adjust their prices instantly, and one in which they can only reset them at infrequent intervals. We focus on stochastic shocks affecting productivity and nominal interest rates. Our analysis highlights the existence of a *credit maturity attenuator effect*, meaning that the response of output to both types of shocks decreases with higher degrees of maturity transformation.

A positive unexpected change in firm productivity has a smaller effect on output because banks' revenues respond less to the shock. In particular, many loans will have been granted prior to the shock, and cannot be adjusted quickly. This smaller increase in banks' net worth means that the increase in the amount of credit they can supply will also be smaller, constraining the increase in output — relative to the case of no maturity mismatch and no long-term lending.

In a model in which firms cannot adjust their prices instantly, increasing the degree of maturity transformation also attenuates the fall in output following an unexpected increase in interest rates. This can be explained by three main channels. First, the resultant fall in production lowers the price of capital. As above, changes in the price of capital have weaker effects on banks' revenues for higher degrees of maturity transformation, and this reduces the fall in output following the disturbance. Second, the shock generates a fall in inflation and raises the *ex-post* real interest rate on loans. The aggregate value of loans falls by less in the presence of maturity transformation (due to the first channel) and the higher *ex-post* real rate therefore has a larger positive effect on banks' balance sheets and output than without long-term loans. Finally, the smaller reduction in output (and income) following the shock implies that households' deposits fall by less with maturity transformation. Banks are therefore able to provide more credit and this reduces the contraction in output.

Implicit intraday interest rate in the UK unsecured overnight money market

Summary of Working Paper no. 447 Marius Jurgilas and Filip Žikeš

Almost all central banks differentiate between overnight and intraday liquidity in their monetary frameworks either explicitly, in terms of the interest rates charged, or implicitly, via different eligibility criteria for acceptable collateral. While the overnight market is the most liquid interbank market, there is no explicit private *intraday* money market in which counterparties contract to deliver funds at a specific time of the day. This is puzzling since various empirical and theoretical studies show that the participants of the payment systems have incentives to delay the settlement of non-contractual payment obligations.

We test the hypothesis of a positive intraday interest rate implicit in the UK overnight money market. Our hypothesis is that although there is no explicit intraday money market, the pricing of overnight loans of different lengths is consistent with the existence of an implicit intraday money market. We believe that overnight loans provide dual service to the participants of the money market. First, overnight loans allow banks to smooth day-to-day imbalances and achieve targeted end of the day reserve balance positions. Second, managing the timing of overnight loan advances and repayments allows banks to smooth intraday imbalances of payment flows. We show that these two components have different effects on the pricing of the overnight loans.

Our empirical results lead us to conclude that the pricing of overnight loans in the UK money market is consistent with the existence of an implicit intraday money market. While the average implicit hourly intraday interest rate is quite small in the pre-crisis period (0.1 basis points), it increases more than tenfold during the financial crisis (1.56 basis points). For an average loan of £65 million, advancing the loan one hour earlier in the day increases the interest payment by an estimated £2,778 in the crisis period. We also observe an increase in the implied loan rate during the last hour of trading. As expected, the end of the day effect is most pronounced during the period without reserves averaging as the settlement banks had to meet the 'target' of a non-negative overnight reserve balance each day.

The main policy implication of our work is that the opportunity cost of collateral pledged to obtain intraday liquidity from the Bank of England can become significant during market distress. This can create an incentive for banks to delay payments, as the intraday value of liquidity rises substantially. Through this channel the financial system under stress can become subject to further market pressure. To avoid possible payment delays, CHAPS participants are subject to throughput guidelines that prescribe a percentage of payments that need to be processed before certain thresholds during the day. But the Bank of England's *Payment Systems Oversight Report 2008* shows that even with throughput guidelines, CHAPS banks started delaying payments after the collapse of Lehman Brothers. In light of our results, we suggest that the implicit intraday interest rate can be used as an indicator of emerging intraday liquidity concerns in payment systems.