### Contagion in financial networks

#### Summary of Working Paper no. 383 Prasanna Gai and Sujit Kapadia

In modern financial systems, an intricate web of claims and obligations links the balance sheets of a wide variety of intermediaries, such as banks and hedge funds, into a network structure. The advent of sophisticated financial products, such as credit default swaps and collateralised debt obligations, has heightened the complexity of these balance sheet connections still further. As demonstrated by the financial crisis, especially in relation to the failure of Lehman Brothers and the rescue of American International Group (AIG), these interdependencies have created an environment for feedback elements to generate amplified responses to shocks to the financial system. They have also made it difficult to assess the potential for contagion arising from the behaviour of financial institutions under distress or from outright default.

This paper models two key channels of contagion in financial systems. The primary focus is on how losses may potentially spread via the complex network of direct counterparty exposures following an initial default. But the knock-on effects of distress at some financial institutions on asset prices can force other financial entities to write down the value of their assets, and we also model the potential for this effect to trigger further rounds of default. Contagion due to the direct interlinkages of interbank claims and obligations may thus be reinforced by indirect contagion on the asset side of the balance sheet — particularly when the market for key financial system assets is illiquid.

Our modelling approach applies statistical techniques from complex network theory. In contrast to most existing theoretical work on interbank contagion, which considers small, stylised networks, we demonstrate that analytical results on the relationship between financial system connectivity and contagion can be obtained for structures which reflect the complexities of observed financial networks. And we provide a framework for isolating the probability and spread of contagion when claims and obligations are interlinked.

The model we develop explicitly accounts for the nature and scale of macroeconomic and bank-specific shocks, and the complexity of network structure, while allowing asset prices to interact with balance sheets. The interactions between financial intermediaries following shocks make for non-linear system dynamics, whereby contagion risk can be highly sensitive to small changes in parameters.

Our results suggest that financial systems may exhibit a robust-yet-fragile tendency: while the probability of contagion may be low, the effects can be extremely widespread when problems occur. The model also highlights how seemingly indistinguishable shocks can have very different consequences for the financial system depending on whether or not the shock hits at a particular pressure point in the network structure. This helps explain why the evidence of the resilience of the system to fairly large shocks prior to 2007 was not a reliable guide to its future robustness.

The intuition underpinning these results is as follows. In a highly connected system, the counterparty losses of a failing institution can be more widely dispersed to, and absorbed by, other entities. So increased connectivity and risk sharing may lower the probability of contagious default. But, conditional on the failure of one institution triggering contagious defaults, a high number of financial linkages also increases the potential for contagion to spread more widely. In particular, high connectivity increases the chances that institutions which survive the effects of the initial default will be exposed to more than one defaulting counterparty after the first round of contagion, thus making them vulnerable to a second-round default. The effects of any crises that do occur can, therefore, be extremely widespread.

# The geographical composition of national external balance sheets: 1980–2005

### Summary of Working Paper no. 384 Chris Kubelec and Filipa Sá

Financial globalisation has been one of the most striking phenomena happening in the world economy in the past two decades. Until recently, very little was known about the size and composition of countries' external financial assets and liabilities. This gap was partly narrowed by the work of Lane and Milesi-Ferretti, which provides estimates of the total external financial assets and liabilities of 145 countries, from 1970 to 2004. These data show that there has been a marked increase in the ratio of foreign assets and liabilities to GDP, particularly since the mid-1990s. This increase has been especially pronounced among industrial countries, where financial integration has exceeded trade integration. However, very little is known about the geographical composition of assets and liabilities. This paper contributes to a better understanding of the geographical composition of countries' external positions by constructing a data set of stocks of bilateral assets and liabilities for a group of 18 countries, covering the period from 1980 to 2005.

The data distinguish between four asset classes: foreign direct investment, portfolio equity, debt, and foreign exchange reserves. For the first three asset classes, missing data are constructed using gravity models, which have been extensively applied to explain cross-border trade and have been increasingly used to explain financial stocks and flows. These models explain bilateral assets by the geographical and historical proximity between the source and host countries, including variables such as distance, time difference, whether the source and host countries share a common border, a common language, or have colonial links. These models tend to have a large explanatory power, suggesting that financial markets are not frictionless, but are segmented by information asymmetries and familiarity effects. For reserves, a two-step procedure is adopted. First, data on the currency composition are collected and then are translated into geographical composition.

To give a flavour of the data set and identify the key stylised facts that emerge from it, a number of tools from network

analysis are applied. The international financial system is represented as a network, where nodes represent countries and links represent bilateral financial assets. The evolution of the global financial network over time shows that there has been a remarkable increase in interconnectivity over the past two decades. Financial links have become larger and countries have become more open. Financial links are centred around a small number of nodes, which have many and large links. In addition, the average path length of the global financial network has decreased over time and the clustering coefficient has increased. These are properties of 'small-world' networks which, from a stability perspective, are robust yet fragile. Because these networks are highly interconnected and some nodes have multiple and large links, they are susceptible to targeted attacks affecting the key financial hubs. Disturbances to the key hubs would be transmitted rapidly and widely throughout the network.

For comparison, the same type of analysis is applied to the global trade network. There are some common features with the financial network. In particular, the trade network also shows an increase in interconnectivity over time and is centred around some key hubs. However, there are important differences between the trade and financial networks. While the financial network is centred around the United States and the United Kingdom, which have large links and are connected to most other countries, the trade network shows strong intracontinental links and is arranged in three clusters: a European cluster (centred on Germany), an Asian cluster (centred on the United States).

This data set can be used for a number of applications. For example, it can be used to examine how financial links affect the international transmission of shocks. Other possible applications include an analysis of whether emerging markets have decoupled from advanced economies and whether business cycles in the G7 have become more synchronised.

### Imperfect credit markets: implications for monetary policy

#### Summary of Working Paper no. 385 Gertjan W Vlieghe

This paper aims to address the following questions. If credit markets do not work perfectly, how does that affect the overall economy? Furthermore, if monetary policy can influence the level of economic activity in the short run, how should monetary policy be set optimally in the presence of credit market imperfections? This is a timeless issue, but of course the global financial crisis that started in 2007 has renewed interest in the topic of credit frictions and monetary policy.

It is thought that credit markets may not operate perfectly because of limitations on how much information a lender has about the quality of the borrower, or limitations on how well contracts between lenders and borrowers can be enforced. One consequence of such credit market imperfections might be that borrowing can only take place (or take place more cheaply) against collateral, such as land, buildings and machines. If that is the case, then changes in the value of collateral will affect the ability of firms and households to borrow. This could have important consequences for aggregate economic activity.

I consider in particular a case where there are two types of firms, those with high productivity and those with low productivity. Ideally, those with low productivity would lend all their resources to high productivity firms, so that high productivity firms can carry out all production. But when there are collateral constraints, some production is also carried out by low productivity firms. The total level of output is therefore determined by how much of the economy's productive resources are held by the high productivity firms. High productivity firms still end up borrowing from low productivity firms, but not as much as would be desirable in the absence of borrowing constraints.

Following a shock that reduces current output or the price of capital (which is used as collateral), the net worth of high productivity firms falls by more than the net worth of low productivity firms, because high productivity firms are highly leveraged. This means that high productivity firms can afford less capital for production in the following period. Because capital shifts to those with lower productivity, this reduces expected future returns on capital, which depresses the value of capital today, and exacerbates the initial redistribution of net worth. Output falls further in the subsequent period, as the economy's resources are now used much less efficiently. It takes time for the high productivity firms to rebuild their share of the capital stock, and output is therefore depressed for many periods, even if the initial disturbance only lasted a single period.

How does this mechanism interact with monetary policy? First, the transmission mechanism of interest rates in this model works through sticky goods prices as well as a reallocation of resources to less efficient producers. So the output response to monetary shocks is larger than in a model without borrowing constraints. Second, when responding to productivity shocks, the monetary policy maker faces a trade-off. It is efficient for output to fall immediately following an adverse productivity shock. So, considered in isolation, there is no reason for a monetary policy maker to offset the initial output fall by letting inflation rise temporarily. But the presence of borrowing constraints means that there is a trade-off between short-term inflation and output fluctuations because of their effect on future output. The larger the immediate fall in output, the larger the reallocation of resources away from the most productive firms, which will lead to future output being inefficiently low. By allowing inflation to rise temporarily and thereby dampening the initial output fall, monetary policy can mitigate inefficiently large future output fluctuations in subsequent periods.

But monetary policy cannot accommodate inflation too far, as inflation expectations must remain anchored, and inflation variability itself is costly too. So this begs the question of how much inflation variability it is optimal to tolerate. I answer this question formally by assuming that the monetary policy maker maximises the welfare of the private sector. There are two frictions in the economy: credit market frictions and sticky prices. The policymaker has a single instrument available, the nominal interest rate, to offset the inefficiencies generated by these frictions. I find that the cost of responding to inflation too aggressively can be large, by creating excessive variability in output. By allowing only a small amount of inflation variability, policy can achieve a large reduction in output variability. This trade-off between inflation variability and output variability is consistent with the remit of the Monetary Policy Committee, which aims for price stability partly as a precondition for the wider economic goal of economic stability. Thus in this paper we are able to provide a new aspect of the transmission mechanism that supports that remit.

# Evolving UK macroeconomic dynamics: a time-varying factor augmented VAR

#### Summary of Working Paper no. 386 Haroon Mumtaz

After the introduction of inflation targeting in 1992, the United Kingdom experienced a period of low inflation and stable output growth often referred to as the 'great stability'. Recent research into this phenomenon has suggested that this stability had been unmatched since the gold standard. A growing empirical literature has examined this apparent change in the dynamics of the UK economy, perhaps due to shifts in the monetary policy regime. These papers usually employ empirical models that contain a limited amount of macroeconomic variables - typically using systems of equations known as vector autoregressions (VARs): a set of equations where the explanatory variables in each equation are the complete set of lagged variables in the system. GDP growth, inflation and the nominal interest rate are the typical variables included in VARs that describe the transmission mechanism of monetary policy. If, in reality, the central bank examines a wider set of variables when setting policy, estimates of the monetary policy shock derived from these small empirical models may be biased — ie not completely disentangled from non-policy shocks. As a consequence an accurate assessment of structural shifts may be hampered.

This paper therefore explores the dynamics of the United Kingdom's macroeconomy using a VAR model that incorporates a larger amount of economic information than a typical tri-variate model. In particular, we use an extended version of the 'factor augmented VAR' (FAVAR) model recently proposed in the literature. The idea behind the FAVAR model is that the bias created by the difference in the information set of the researcher and the agents described in the model can be alleviated by augmenting the standard VAR with common factors that are extracted from a large set of macroeconomic indicators. These common factors summarise the relevant information in the macroeconomic indicators and therefore provide a proxy for the information set of agents in the model.

Our FAVAR model for the United Kingdom contains common factors extracted from data on real activity, inflation, money and credit and asset prices in addition to a short-term nominal interest rate. We allow the coefficients of the model and the variances of the shocks to vary over time. The model is estimated over the period 1970 Q1 to 2004 Q2, thus restricting attention to the period before and during the great stability.

In accordance with previous studies, our estimates show a decline in the volatility of shocks to inflation and real activity. In addition, the results suggest that this stability extends to money, credit and asset prices. The average response of the variables in the FAVAR to monetary policy shocks is similar before and after the introduction of inflation targeting. The response of inflation to a (contractionary) monetary policy shock appears to be more plausible than previous studies — in particular not displaying an anomalous (initial) positive response (ie the 'price puzzle'). This may point to the fact that the extra information included in this model improves the identification of the monetary policy shock. Shocks to monetary policy contribute little to inflation and the interest rate during the inflation-targeting period.

# Shocks to bank capital: evidence from UK banks at home and away

#### Summary of Working Paper no. 387 Nada Mora and Andrew Logan

Does bank capital matter for lending? Benjamin Friedman has pointed out that a view among some economists was that holding capital was a 'macroeconomic irrelevance'. But others counter that a shortage of bank capital leads to a fall in lending, hurting overall economic activity. For this to occur two informational failures need to exist. First, banks must have a problem raising fresh capital because potential financiers cannot tell apart a bad bank with poor lending opportunities from a good bank needing capital to fund profitable new projects. Second, borrowers must depend on bank loans in order to fund their investment because they too face problems convincing uninformed markets that they are a risk worth funding. It is easier for banks to overcome this information problem because they are better at screening potential borrowers, establishing relationships and monitoring those that they choose to finance. This means that when banks cannot lend, borrowers will in turn be unable to invest, so lowering economic growth.

In this paper, we explore what the first failure means for bank lending, that is how do banks behave when they cannot offset capital losses by raising more capital or cutting dividends? This is clearly a relevant question in the context of the banking crisis and current recession. Our empirical analysis provides a historic perspective insofar as it relates to a period preceding the current crisis. One concrete problem with much empirical work is that finding an association between bank capital and loans is not the same thing as saying that a hit to bank capital causes a drop in lending. Non-performing loans and write-offs, which can cause banks to lose capital, tend to be negatively correlated with the economic cycle. This may mean that capital limits begin to influence the supply of bank loans when economic growth falters. But at the same time, a slowdown in growth is likely to impact individual and corporate borrowers' incomes and net worth, their expectations about the future path of the economy and the prices of the goods and assets they want to purchase. A deterioration in economic conditions is likely to translate into lower demand for loans meaning that the supply of loans could be adjusting passively.

How is it then possible to identify and attribute lending changes to bank capital? We draw on three methods. First we take advantage of historic data on banks' balance sheets from 1990 to 2004 to investigate shocks to different portfolio components. Along with the time dimension, we use cross-bank differences in a panel of UK banks to extract the important comovements among capital, loans, securities and liabilities. This approach is known as a panel vector autoregression specification. We find that innovations in a bank's capital in the sample period, other things equal, were coupled with a loan response that lasted up to three years and the effect was especially strong among small banks.

Our second method uses indicators of regulatory capital pressure from confidential supervisory returns. We use this information to test whether banks responded differently to capital innovations depending on how close they were to their minimum capital requirements set by the regulator during the sample period. Banks approaching their regulatory minimum were found to cut lending. But they also responded to an increase in capital by lending more. A further result is that banks were less compelled to raise their deposit interest rate to attract funds when they received positive capital shocks starting from a constrained position.

Our third method is the least vulnerable to the problem that the lending response may be contaminated by demand conditions or by factors driving both demand and supply. We identify a possible exogenous shock to bank capital, in the form of a shock originating in a different geographical region. Because many UK banks take deposits from and lend to non-residents, we take advantage of data on write-offs on loans to non-residents. These write-offs will tend to reduce bank's capital (relative to the counterfactual), and are independent of a bank's lending to UK residents. For example, the East Asian crisis led to an increase in non-resident write-offs but was not associated with a rise in write-offs on resident loans. We find some evidence that a shock to non-resident write-offs caused a significant and sustained fall in UK lending. We also isolate the movements in bank capital coming from non-resident write-offs and find a significant positively correlated effect on UK resident lending (controlling for resident write-offs, liquidity and other measures). The effect was strongest on private non-financial corporation (PNFC) loans, and in contrast, lower bank capital had a positive effect on household loans. This indicates that — in this pre-crisis period — banks substituted away from risky PNFC loans into potentially less risky loans when capital was short.

The results show that the external transmission of capital shocks may be present under a more general environment than previous work, which has demonstrated a specific transmission from Japanese parent banks to their external branches in the 1990s. Second, the importance of bank capital for lending also means that the distribution of bank capital matters because information problems impede an optimal transfer of capital from capital-rich lenders to capital-poor banks. This will in turn exclude some firms from bank loans and they will also be unable to substitute to the public debt and equity markets.

## An economic capital model integrating credit and interest rate risk in the banking book

### Summary of Working Paper no. 388 Piergiorgio Alessandri and Mathias Drehmann

Banking activities are subject to various types of risk, including credit, market and liquidity risk. As part of their risk management, banks need to monitor and quantify these risks on a continuous basis, maintaining capital and liquidity buffers that are sufficient to protect them against large, negative shocks. Various analytical tools have been developed to look at these risks in isolation, especially for credit and market risk. However, no unified economic capital model exists which integrates risks in a consistent fashion. Therefore, banks generally analyse risks in isolation, deriving total economic capital by some rule of thumb. Indeed, a common rule consists of calculating risk-specific buffers and then simply adding them up (possibly subject to a correlation adjustment) to calculate a bank's total capital. The conventional wisdom is that, since risks are only imperfectly correlated, adding up always delivers a conservative capital buffer. However, recent research and experience in the financial sector has shown that this is a fallacy; under some circumstances, risks actually amplify one another and additive rules of thumb do become dangerous. This is an important result for both practitioners and regulators, and it represents a crucial motivation for this work: the main aim of the paper is to investigate to what extent standard, traditional banking (in a sense to be defined below) is subject to this risk amplification problem.

The conceptual contribution of this paper is the derivation of an economic capital model which consistently integrates credit and interest rate risk in the banking book. The paper does not address the issue of what the appropriate level of capital for a bank is; we focus instead on the narrower question of how this level of economic capital is influenced by interactions between risks. According to industry reports, credit and interest rate risk represent the most important sources of risk for a standard 'banking book'. Furthermore, there are good reasons to believe that these risks interact in a non-trivial way. Interest rates and default frequencies are linked to the state of the business cycle; hence, they are implicitly driven by a common set of macroeconomic factors. Interest rates are themselves an important determinant of credit risk: borrowers are more likely to default when interest rates are high. Finally, a bank's interest income depends on its credit risk profile in that credit losses reduce the stock of assets that generate interest payments.

Credit and interest rate risk are modelled in line with standard practices. The credit risk component is based on the same conceptual framework as Basel II and the main commercially available credit risk models. Interest rate risk, on the other hand, is captured by earnings at risk, a well-established metric among practitioners. The key innovation of the paper is in the way risks are integrated. The model explicitly links the systematic component of these risks to a common set of macroeconomic factors. Furthermore, net interest income is modelled dynamically, taking into account the fact that interest rates adjust in response to shifts in the risk-free yield curve and/or changes in the riskiness of the underlying credit exposures. This makes it possible to capture any income compression due to the repricing mismatch between long-term assets and short-term liabilities. The model is applied to a stylised bank whose portfolio is designed to broadly replicate a standard UK banking book in terms of types of exposures (including corporate, mortgage and credit cards loans), size of the loans and pricing maturities. All loans are assumed to be held to maturity and subject to book value accounting. By running numerical simulations, we derive distributions of profits and losses under a range of possible macroeconomic scenarios. We then compare 'simple' (ie additive) economic capital to an 'integrated' capital that takes into account interactions across risks.

The main result of the analysis is that in the narrow set of circumstances tested here the conventional wisdom holds up: simple capital exceeds integrated capital. In other words, in this particular exercise, a simple approach to aggregating credit risk and interest risk in the retail loan book does not lead to an underestimation of risk, compared to an approach that takes into account the interactions between the two sources of risk. The difference between the two depends on various features of the bank, such as granularity of the portfolio, funding structure and pricing behaviour, but it is positive under a broad range of circumstances. Various factors contribute to generating this result. A relatively large portion of credit risk is idiosyncratic, and thus independent of the macroeconomic environment, and the correlation between systematic credit risk factors and interest rates is itself not perfect. Furthermore, as long as the bank's portfolio can be repriced relatively frequently, any increase in credit risk can be partly passed on to borrowers.

Some caution is warranted on the generality of the exercise. The results cannot be used to argue that *in general* an economic capital model that fully integrates all risks would result in lower capital than that implied by simple aggregation rules. Neither does the paper address the issue of what is the appropriate level of capital for a bank. Since the paper focuses only on traditional banking book risks, it does not deal with insights relating to the recent crisis. Securitisation, derivatives and liquidity management, which were at the core of the turmoil, remain outside the scope of this work, and mark-to-market accounting is not taken into consideration. We also assume that banks recover a fixed fraction of any defaulted loan, thus abstracting from the impact of asset prices on recovery rates. Finally, we demonstrate that 'traditional' banking book risks do not generate perverse interactions. However, many banks manage large, complex portfolios that expose them to a wider range of risks than the ones we analyse here: our conclusions cannot be generalised to those cases. Furthermore, complexity might imply a stronger non-linearity in banks' returns than the ones we examine here. As a consequence, banks should generally work on the assumption that additive rules are not reliable and could in some circumstances lead to underestimating economic capital. Developing integrated economic capital models is arguably a key priority for the industry going forward.

# Liquidity-saving mechanisms in collateral-based RTGS payment systems

### Summary of Working Paper no. 389 Marius Jurgilas and Antoine Martin

There is a growing recognition of the key role played by interbank payments systems in modern economies. Research on these payment systems has been motivated by the important design changes that have occurred in the past 30 years, and has shown that the incentives embedded in a payment system are sensitive to its design, highlighting the importance of a better understanding of these incentives.

There are two main types of real-time settlement payment systems that differ in the way banks can obtain access to intraday liquidity from the central bank. In a collateral-based system, such as TARGET 2 (European Union), CHAPS (United Kingdom), or SIC (Switzerland), banks can obtain intraday liquidity at no fee against collateral. In contrast, in a fee-based system such as Fedwire (United States) banks can obtain intraday liquidity without collateral but at a fee.

Recently, central banks and other public authorities of some countries have started implementing enhancements to the real-time settlement systems that would allow their banks to reduce liquidity needs without introducing new risks. Among the modifications is the introduction of a variant of an offsetting algorithm. In a nutshell, an offsetting algorithm, usually popularly referred to as a 'liquidity-saving mechanism' (LSM), settles offsetting payments with finality in real-time without any, or very minimal, funds. Several real-time settlement systems, ie TARGET 2 (European Union), SIC (Switzerland), RITS (Australia), and BoJNet (Japan), have already adapted offsetting algorithms.

There is a trade-off. Introducing LSMs does not inevitably improve outcomes in all types of payment systems since particular design features affect the way banks respond to the LSM. In all payment systems there are potential benefits, but previous work has shown that in real-time settlement systems that provide unsecured intraday overdrafts for a fee, for example Fedwire (United States), introduction of an LSM may be undesirable. The intuition is that the presence of an offsetting facility provides incentives for banks to delay some payments intraday which, in the absence of an LSM, would have settled earlier. The undesirable effect of an offsetting facility is that it provides an insurance mechanism against having to borrow funds intraday from the central bank. The key contribution of this paper is in showing that such a trade-off does not arise in payment systems that have a collateralised intraday overdraft facility, like CHAPS.

The key difference of a collateralised intraday liquidity payment system, like CHAPS, compared to a fee-based intraday liquidity system, like Fedwire, is that in the collateralised system payment behaviour during the day does not affect the cost of the intraday overdraft once the collateral is pledged with the central bank. While it is technically feasible to adjust the amount of collateral pledged during the day, this happens rarely. In the absence of an LSM banks with sufficient funds therefore settle their payment obligations sooner, while banks with insufficient funds delay their payment outflows. Introducing an LSM in such an environment would provide incentives for banks with insufficient intraday liquidity to submit their payments to an offsetting facility. Thus the presence of an offsetting facility makes settlement earlier in the day more likely.

If the cost of obtaining collateral intraday is sufficiently high then an offsetting algorithm would provide large liquidity savings, while if collateral can be obtained at a low cost during the day the benefits of LSMs are smaller. In our model a payment system with an LSM always performs better than a payment system without the facility to offset payments.

Unlike some possible LSMs, a central queue of the type described here does not create the possibility of reintroducing credit risk into a real-time gross settlement (RTGS) system. Indeed, there is evidence that already RTGS settlement banks queue their payments in internal schedulers. Replacing internal queues with a central queue that allows for offsetting of payments would not reintroduce settlement risk.

### Technology shocks, employment and labour market frictions

### Summary of Working Paper no. 390 Federico S Mandelman and Francesco Zanetti

A key question in macroeconomics is what driving forces generate aggregate fluctuations? An understanding of this is obviously vital to macroeconomic policy makers. According to Nobel recipients Finn Kydland and Edward Prescott, this question can be addressed by modelling the decision processes of the agents who populate the economy, and then examining to what extent the simulated model is able to replicate the 'stylised' facts in the data that help to summarise the dynamics of key variables. The general aim is to derive the economic model from optimal individual behaviour (a process described as providing 'microfoundations'), and then to calibrate the structural parameters which represent preferences and technology to simulate the model. Proponents of this 'real business cycle' (RBC) view argue that persistent shocks to technology are able to replicate the main empirical regularities of the business cycle in models with optimising representative agents, perfectly competitive markets, flexible prices and the unexplained (and therefore outside the model, or 'exogenous') technology shocks. 'Real' here refers to the fact that behaviour is largely unconnected from changes in quantities measured in money (or 'nominal') terms. The reason for this is that the framework assumes flexible prices. So nominal shocks, such as monetary policy shocks or cost-push shocks, are either absent or have a

minimal role in explaining aggregate fluctuations. A key result that follows from this theoretical framework is the positive response of employment to technology shocks. Recent empirical evidence, however, conflicts with this prediction, thereby calling the validity of the RBC framework into question.

This paper investigates whether the presence of labour market frictions, in the form of imperfections that prevent firms from costlessly hiring workers, could reconcile the functioning of the RBC model with the empirical evidence. To this end, the paper sets up an otherwise standard model that allows, but does not require, labour market frictions to affect the functioning of a prototype RBC model. It then takes the model to the data and estimates its structural parameters to investigate whether the model based on labour market frictions makes the RBC model consistent with the negative response of employment to technology shocks. We use a method of estimation known as Bayesian, which is particularly useful for estimating models such as this where the theory has a lot to say about the dynamics of the data. The findings of this exercise show that the evidence does support the version of the model in which labour market frictions generate a negative response of employment to technology shocks.

# Deep habits and the cyclical behaviour of equilibrium unemployment and vacancies

### Summary of Working Paper no. 391 Federico di Pace and Renato Faccini

Understanding the determinants of unemployment fluctuations along the business cycle is an important topic for policymakers, since the degree of slack in the labour market affects both wage and price inflation. However, there is no agreement as yet on the sources of fluctuations in unemployment and vacancies. The standard model which attempts to explain these quantities allows for 'matching' of vacant jobs to unemployed workers. In the US data, a standard test bed for labour market models, employment and vacancies are about ten times more volatile than productivity, and the standard textbook matching model of the labour market fails to replicate this fact.

The most successful extension of the standard model that manages to replicate the high degree of volatility in labour market variables is based on the assumption that wages of all workers are sticky. However, recent studies show that what matters for the decision of job creation is only the volatility of the wages of newly hired workers. Intuitively, the decision on whether to create a marginal job only depends on the profitability of the marginal worker, which is only a function of his or her productivity and wage. Empirical evidence shows that the wages of newly hired workers do not exhibit sticky behaviour. Hence, the assumption of sticky wages cannot explain the volatility of unemployment and vacancies over the business cycle.

This paper provides a new mechanism of fluctuation in labour market variables, which does not rely on the assumption that wages for the newly hired workers are sticky. It is based on the notion of 'habits' in consumption, where households' utility from consumption depends partly on past levels of aggregate ('external') consumption, sometimes described as 'catching up with the Joneses' behaviour. This has proved to be very helpful in explaining many features of the economy. The new variant that we apply to the labour market is that workers form habits in consumption on particular varieties of goods, rather than on the average consumption basket in the economy. So some households will form habits on the consumption of cars, others on the consumption of clothes, food, or various amenities, and so on. If this is the case, each firm should internalise the impact of their pricing policy on habit formation. In other words, when setting prices firms anticipate that higher consumption in the current period implies higher habits and higher future consumption. In a model with deep habits, firms exploit the upturns of the business cycle to increase the stock of habits. In order to do so, they need to increase employment. The assumption of deep habits therefore helps making the behaviour of vacancies and employment more strongly procyclical.

We show that a model with deep habits is able to replicate successfully the qualitative and quantitative behaviour of labour market variables along several dimensions. Our paper therefore reinforces the idea that deep habits have a wide range of macroeconomic implications. Previous work in the literature has shown that deep habits can account for the countercyclicality of mark-ups, the positive response of consumption to a government expenditure shock, the price puzzle and the incomplete pass-through. Our work uncovers an important implication of deep habits for the labour market.

## Time-varying inflation expectations and economic fluctuations in the United Kingdom: a structural VAR analysis

### Summary of Working Paper no. 392 Alina Barnett, Jan J J Groen and Haroon Mumtaz

Since World War II, the United Kingdom has experienced a broad range of economic dynamics. The economy was faced with relatively low inflation and economic growth volatility in the period preceding the 1970s, an unprecedented period of high inflation and depressed economic growth during the 1970s, and with more stable inflation and growth prospects from the 1980s up to the end of our sample in 2007, in particular after the introduction of inflation targeting in 1992. Subsequently, the United Kingdom, in common with most of the world, has suffered a severe recession following the onset of the financial crisis in 2008, but our analysis is not intended to shed light on these very recent events.

These economic changes were associated with shifts in the behaviour of monetary authorities. For example, Bank of England work in 2004 suggested that the response of the Bank to expected inflation was stronger after the introduction of inflation targeting in 1992. Similar results are thought to hold for the United States, with the decrease in inflation and output volatility in the post-1979 period coinciding with an increase in the weight placed by the Federal Reserve on stabilising inflation.

Other commentators argue that the credibility of monetary policy might have had an impact on inflation dynamics by changing the manner in which inflation expectations are formed. According to this literature when the economy is hit by large, inflationary shocks (an 'Inflation Scare') and the central bank hesitates to respond promptly, this may result in a persistent increase in longer-term inflation expectations. This in turn presents the central bank with a choice; either substantially contracting policy to deflate this rise in expectations (and hence cause an economic slowdown); or to accommodate it and let these higher inflation expectations become entrenched in the economy (resulting in persistently higher actual inflation).

There have not been many studies that have looked at the observed time-varying economic dynamics of the UK economy by explicitly using measures of inflation expectations. The work which has been done on this topic is generally focused on the US economy. Some used surveys on inflation expectations from the *Survey of Professional Forecasters* while others

used surveys such as the *Livingston Survey*. They typically find that monetary policy accommodated temporary shocks to inflation expectations in the pre-1979 sample, a period with high inflation persistence, but not in the post-1979 Volcker-Greenspan period (a period with low inflation persistence).

Our study contributes to this debate by employing a complementary approach to analyse UK macroeconomic dynamics by using explicit measures of inflation expectations. We use a system of equations (a vector autoregression) where we use theory to identify the underlying structure. We then apply a time-varying structural methodology to generalise the analysis done for the US economy, allowing for shifts in the coefficients of our system that are caused by changing behaviour (are 'endogenous'). We also explicitly consider the role of demand and supply shocks.

Using this structure, we investigate two main questions relating to the UK economy between 1965 and 2007 (and therefore excluding the effects of the financial crisis and its aftermath). First, how has the impact of the mix of real and nominal shocks on the UK economy evolved over time and did this have a specific impact on UK inflation expectations? Second, has there been an autonomous impact of inflation expectations on the UK economy and has this changed over time?

Our results suggest that shocks to inflation expectations had important effects on actual inflation in the United Kingdom in the 1970s, but that this impact declined significantly towards the end of our sample in 2007. This seems to be mainly due to a relatively stronger response of monetary policy to these shocks during the inflation-targeting years. Similarly, oil price shocks and real demand shocks led to important changes in macroeconomic variables in the 1970s. Beyond that period oil price shocks become less significant for the dynamics of actual inflation and output growth, but real demand shocks, on the other hand, have in the latter part of our sample become a more important determinant for fluctuations in those series. The changing response of monetary policy to the real demand shock appears to be crucial for this result.