The gains from delegation revisited: price-level targeting, speed-limit and interest rate smoothing policies

Summary of Working Paper no. 415 Andy Blake, Tatiana Kirsanova and Tony Yates

In the standard monetary policy model, the monetary authorities face a commitment problem that has been termed the 'stabilisation bias'. When a shock hits that threatens to push up inflation, the policymaker would like to generate the expectation that inflation will be low in the future, because this will help anchor inflation today, and in so doing allow it to tighten policy by less, which itself is beneficial. To generate this expectation of a muted rise in inflation, the policymaker promises that tight policy will be tight not only today, but also tomorrow. However, when the threat to inflation has waned, tight policy is costly to sustain, and it is better to renege at that point. Anticipating this, observers do not believe the promise of tight policy at the outset, inflation expectations rise, and the authority is forced to tighten policy by more today than would have been necessary if its promise had been believed. Such a policymaker is said to operate under discretion. A policymaker that can commit (that is, is forced by some means not to reconsider its plans when the threat to inflation abates), can achieve inflation control at the expense of much less variability in the real economy. This is because it does not have to tighten policy so much today, and can instead rely on policy being a little tighter today and tomorrow.

It has been claimed that the benefits of this policy can be obtained even in the absence of a commitment if the monetary authority is handed an objective to follow that is modified with respect to the one that society ultimately prefers. A few schemes have been proposed that do this, but the one that has received most attention and is easiest to explain is the price-level target. This target involves replacing the term in inflation that would normally appear in the policymaker's objective function with deviations of the price level from some target path. This scheme does its job by making the objective that the discretionary policymaker faces tomorrow depend in part on what happened today. If the inflation rate turns out high today, then, in order to meet the price-level target, inflation needs to be correspondingly lower tomorrow. The expectation that this will happen leads people to forecast that inflation will be low, and this mimics the outcome obtained under commitment.

Our paper shows that the benefits from schemes like price-level targeting obtain with much less generality than previously thought. The analysis sketched above was carried out in the simplest possible monetary policy models that abstract from dynamics caused by features like capital accumulation. In such models, it was correctly assumed that there was only one possible equilibrium when policymakers were assumed to be operating under discretion. However, in the more realistic model that we deploy which features capital accumulation, we invariably find that there is more than one equilibrium. We show that when we introduce the delegation schemes — such as price-level targeting, but including others too — this feature of having more than one equilibrium survives. The significance of this finding is that in our model it is not possible to say whether using a price-level target (or one of the other schemes) would make a discretionary policymaker better off or not. In some cases, the worst equilibria under the delegation schemes are inferior to the best equilibria when the policymaker tries to maximise the original, unmodified objective function. These results hold for all the delegation schemes we study (price-level targeting, hybrid price-level and inflation targeting, interest rate smoothing, and the speed-limit policy, one which ensures policy pays attention to the change, rather than the level in the gap between actual output and potential). The results also hold for two different variants on our model of capital accumulation.

An efficient method of computing higher-order bond price perturbation approximations

Summary of Working Paper no. 416 Martin M Andreasen and Pawel Zabczyk

Economists have a keen interest in understanding what determines changes in attitudes to risk and how they work through the economy. This in part explains why policymakers analyse the behaviour of bond and equity prices, as these reflect people's preferences for risk-taking. 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. The word 'stochastic' indicates that there is a fundamental uncertainty pervading the economy, with different types of random disturbances affecting the dynamics of prices and quantities.

The economic relationships underlying the model uniquely determine the evolution of the interconnected system, and finding a rule which pins down that evolution is called solving the model. Unfortunately, in most cases exact solutions are unknown and therefore economists need to approximate them. This is typically done using linearisation, which often delivers very good approximations. However, this method ignores the impact of uncertainty on the transmission mechanism of shocks, and so is inadequate in an asset pricing context.

There exist many alternatives to linearisation, with 'higher-order perturbation' methods being one of them. In practice, however, there is a trade-off between accuracy and speed. In the past, this trade-off has meant that researchers studying prices of long-maturity bonds needed to rely on at most second-order perturbation approximations. This occurred because it was computationally very demanding to allow for higher-order effects, which are present in the true — though unknown — solution to any DSGE model.

The simple aim of this paper is to propose a method which speeds up the process of approximating bond prices by exploiting the relationships which they satisfy. Our method comprises two steps. In the first step, standard solution packages can be used to approximate all the variables other than bond prices. In the second step, we use the fundamental pricing equation to solve for bond prices recursively, ie using approximations to shorter-term bonds to find those for longer-term bond prices.

We show that our two-step method can reduce the time it takes to solve models by more than 100 times. This is achieved with the same level of accuracy as using standard perturbation methods. The paper also compares the accuracy of bond price approximations obtained using perturbation methods to that of computationally feasible alternatives. It shows that for the models analysed third-order perturbations generate the most accurate approximations to bond yields.

How non-Gaussian shocks affect risk premia in non-linear DSGE models

Summary of Working Paper no. 417 Martin M Andreasen

The current financial crisis and the recession that followed have highlighted the close link between the macroeconomy and asset prices. Unfortunately, standard economic tools are not well suited to examine this relationship. Economists often use dynamic stochastic general equilibrium (DSGE) models when studying the economy. These models use economic theory to describe how all agents in the economy interact through time. The term 'stochastic' refers to the crucial feature that there is uncertainty in the economy (ie the economy is constantly being hit by 'shocks', also known as innovations), and this affects agents' behaviour.

The relationships implied by DSGE models determine all quantities and prices in the economy, and finding a set of rules which ensure that all markets clear is called solving the model. The exact solutions to most DSGE models are unfortunately unknown and economists therefore have to resort to approximations. This is normally done using linearisation, assuming that relationships are close to linearity near the equilibrium. This often delivers a fairly accurate approximation. But this method does not capture effects of uncertainty in the model; ie agents are effectively assumed to behave as if there were no uncertainty. This is an unfortunate assumption to impose, in particular in an asset pricing context, because it constrains all risk premia to be zero.

Luckily, there are many alternative solution methods to linearisation. The one considered in this paper is to approximate the solution by second and third-order expansions around the model's deterministic steady state (ie the point at which the economy would arrive in the long run if there were no uncertainty). These expansions introduce the curvature that is needed to capture the consequences of risk. We then analyse how three types of 'non-Gaussian' shocks affect risk premia in a wide class of DSGE models. Gaussian shocks are well behaved; ie they follow a normal distribution which is unchanged over time. In practice, this assumption frequently does not hold. The first type of shock we consider captures rare disasters, which refer to the possibility that the economy may be hit by a very large negative shock on rare occasions, for instance four times during a century (roughly the frequency of major recessions). We then show that rare disasters do not affect risk premia in a second-order

approximation but do affect the level of risk premia at third order. The variability of risk premia is however not affected at either second or third order by the presence of rare disasters in the model. The second type of shock we analyse are stochastic volatility shocks which refer to the possibility that the variability of the fundamental innovations may change at random time points. One can think of stochastic volatility shocks as disturbances to the confidence level of the economic agents. We show that stochastic volatility may affect the mean level but not the variability of risk premia at second order. For a third-order approximation, stochastic volatility may affect the mean level and the variability of risk premia. The final non-Gaussian shock distribution we analyse is structural disturbances with a type of time variation known as generalised autoregressive conditional heteroscedasticity (GARCH). We find that GARCH may affect the mean level but not the variability of risk premia at second order, whereas GARCH may affect both the level and the variability of risk premia in a third-order approximation.

To explore the quantitative effects of these non-Gaussian shocks, we then examine how rare disasters, stochastic volatility, and GARCH in productivity shocks affect the ten-year nominal term premium in an otherwise standard New Keynesian DSGE model solved to third order. We find that the chosen specification of rare disasters can have substantial effects on the level of the term premium and values of skewness and kurtosis (which measure aspects of asymmetry and the probability of extreme events occurring) for several macro variables. However, rare disasters hardly affect the standard deviation of most macro variables. We also find that stochastic volatility can generate sizable variation in the term premium without distorting the model's ability to match characteristics of a number of key macroeconomic series. The effects of GARCH are slightly different from those generated by stochastic volatility. In particular, GARCH increases both the mean level and the variability of the term premium.

This analysis is unavoidably technical but it is not arcane. It is essential if we wish to understand the consequences of extreme shocks to the economy in an uncertain world. Never has this been more important than in the past few years.

Cyclical risk aversion, precautionary saving and monetary policy

Summary of Working Paper no. 418 Bianca De Paoli and Pawel Zabczyk

Monetary policy making in central banks calls for an understanding of how the economy responds to shocks. Economists work with models to achieve this. One type of model that has become increasingly used is the dynamic stochastic general equilibrium framework. Theory is used to describe how all the actors in the economy behave, and to spell out the dynamic evolution of the interconnected economy. The 'stochastic' part indicates that there is a fundamental uncertainty pervading the economy.

Most such policy analyses are conducted using linear models. That is, the underlying decision rules, which will often be non-linear, are approximated by 'first-order' linear relationships. These can be very good approximations, but while they may be able to replicate salient features of macroeconomic dynamics, there are important areas where their ability to 'match data' is less satisfactory. In particular, all such models ignore the impact of uncertainty on the transmission mechanism of shocks.

Specifically, there are two important aspects of household behaviour that cannot be captured in linear models. First, there is no reason for households to require compensation for holding risky assets, in contrast to reality. Second, there is no 'precautionary' motive for saving — meaning that the models ignore households' desire to build up reserves of wealth to buffer them against the possibility of episodes of bad luck. So to the extent that precautionary savings are a clear feature of macroeconomic data and that risk premia are significant determinants of asset price data, using models so badly misspecified along these dimensions could result in systematically biased policy recommendations. This paper investigates the issue in more depth. To address these points, our framework allows uncertainty to affect saving. This channel is ruled out by assumption in (first-order) linear models but is incorporated in our solution method which accounts for (higher-order) uncertainty effects. We assume that the utility households get from consumption is driven by 'external habits'. That is, they value consumption according to the difference between it and a slow-moving reference value. This introduces some cyclical variation into attitudes to risk. The critical thing for the policymaker is that these cyclical swings in risk attitudes affect the cyclical behaviour of the 'natural' rate of interest.

We find that properly accounting for swings in risk appetite and the desire to save in this way reduces the optimal size of monetary policy responses to productivity shocks. Following a positive productivity shock central bankers striving to maintain price stability cut rates to boost demand and prevent falls in the price level. However, since a persistent positive productivity shock also reduces households' desire to save, the cut in rates required to boost demand is smaller ie the desire to save to smooth consumption is partially offset by the desire to save for precautionary reasons. Conversely, given that a positive demand shock merits interest rate hikes to prevent inflation rising — and since associated falls in precautionary motives exacerbate the increases in demand policy needs to respond more strongly once changes in precautionary savings are accounted for. Overall, the precautionary channel introduces a 'contractionary bias' during booms and an accommodative slant during downturns. The model is highly stylised and illustrates rather than estimates the size of these effects, but helps to clarify the mechanism.

A global model of international yield curves: no-arbitrage term structure approach

Summary of Working Paper no. 419 Iryna Kaminska, Andrew Meldrum and James Smith

Monetary policy makers routinely analyse financial market variables to extract information for policy. Of particular interest are the yields associated with government bonds of different maturities (the 'term structure of interest rates') and the exchange rates between different currencies. The term structure contains information about expectations of future short-term risk-free rates, such as Bank Rate. Longer-maturity bond yields will also reflect a 'risk premium' - a component that compensates investors for the additional risk associated with those bonds. Most previous work that estimates these risk premia has assumed that each country is a closed economy. There is, however, strong evidence that bond yields are affected by some factors that are common across countries, as well as by local factors such as domestic monetary policy. This paper presents estimates of bond risk premia that allows for a mix of common and local factors across the United Kingdom and its largest trading partners the United States and the euro area — in the same consistent framework

Movements in exchange rates should partly reflect differences in short-term interest rates across countries. For example, when interest rates in a 'home' country are relatively high, in the absence of any exchange rate movements investors could obtain unlimited risk-free arbitrage profits by borrowing overseas and buying home bonds. Uncovered interest parity (UIP) states that if interest rates at home are high (low) relative to overseas, investors must expect the home currency to depreciate (appreciate) in order to equalise the overall return on home and foreign bonds. But it is well documented that currencies in high interest rate countries have tended to appreciate on average. One possible explanation for this is a 'foreign exchange risk premium' that compensates investors in high interest rate currencies for some additional risk. The model estimated in this paper also provides estimates of foreign exchange risk premia for sterling, the US dollar and the euro.

The approach taken is to model bond yields and exchange rates as functions of unobserved risk factors, assuming that there are no arbitrage opportunities available from investing in foreign or domestic bonds or bonds of different maturity. The resulting model is fitted to bond and exchange rate data for the three currency areas mentioned above for the period October 1992–June 2008.

In the preferred model, bond yields in each country are driven by two 'global' factors that are common across countries and one factor that is specific to the local economy. It turns out that there is a high correlation between the two global factors and measures of global output and inflation, while the local factor is highly correlated with the local short-term interest rate (ie the instrument of monetary policy). This is consistent with previous findings in the literature that consider only two countries.

The model estimates of expected changes in exchange rates suggest that the broad trends were expected by investors. This is consistent with foreign exchange risk being an important factor explaining deviations from UIP. The model does not fit the volatility in exchange rates observed on a month-by-month basis, but this is not surprising given the well-documented difficulty in modelling exchange rates.

Tailwinds and headwinds: how does growth in the BRICs affect inflation in the G7?

Summary of Working Paper no. 420 Anna Lipińska and Stephen Millard

Much has been written about the impact of globalisation on the economy. It is fairly clear that its pace increased after the early 1990s and an important part of this was the emergence of the so-called 'BRIC' economies — Brazil, Russia, India and, perhaps most importantly, China — which experienced rapid rises in productivity and GDP over this period. Many authors argued that increased trade with the BRIC economies helped keep inflation low in the developed world - so-called 'tailwinds' — by depressing import prices and increasing the share of imports in demand in the developed world. Furthermore, more intense global competition is likely to have reduced mark-ups and put downward pressure on wages in developed countries, as well as raising productivity growth, as firms were put under increasing pressure to innovate. Production costs also fell as firms increasingly found it easier to off-shore activities to low-cost countries and source low-cost labour from abroad. All these factors have been used to help explain why inflation was so low in the developed world over the past decade. But, there may have been an inflationary 'headwind' acting to counteract the tailwind. Rapid growth in emerging economies pushed up the global price of commodities such as oil and steel. Given such a rise in commodity prices, all countries importing these commodities suffered an increase in their production costs putting upwards pressure on their aggregate inflation rates. Although recent events following the world financial crisis have overlaid this picture, the underlying factors remain relevant in the longer term. But, in order properly to understand the processes at work, we need an organising framework for thinking about this problem.

Consequently, in this paper, we develop a stylised calibrated structural model within which we can begin to assess the quantitative impacts of the continuing rise of the BRIC economies on inflation in the developed world. Our aim is primarily to understand the mechanisms at work, so although we try to make broad features realistic it is a highly simplified and abstract model, which does not use actual data. Thus, for example, we consider only one commodity, 'oil'.

We build a three-country model in which there are two oil-importing countries — home and foreign, which can be

thought of as the G7 and the BRIC economies, respectively and one oil-exporting country, which sells its endowment of oil and spends the associated revenues on consumption of goods from both the developing and developed world. Oil is used to produce intermediate tradable goods and is also consumed directly. Final goods in each country are produced using intermediate goods from both countries. International financial markets allow some borrowing and lending between countries, but are not complete (which means that it is impossible to buy insurance to completely remove international risks). In each country, a monetary authority sets interest rates in order to keep inflation close to target.

We use this model to examine the effects of a productivity shock in the foreign economy, such as was seen in the BRIC economies in recent years. In our baseline calibration, it turns out that the tailwinds outweigh the headwinds and home inflation is reduced as a result of the shock, suggesting that the rise of the BRIC economies acted to help keep inflation low in the developed world. This is, of course, not to say that at the time of writing the recent rises in non-agricultural commodity prices are unconnected with the resumption of growth in emerging economies.

We then perform several experiments where we try to disentangle the importance of different factors that can shape inflation dynamics in the home country when the foreign country is hit by a persistent productivity shock. These factors are wage stickiness, the role of the oil sector and its share in both consumption and production, foreign monetary policy and the degree of completeness of financial markets. We find that the tailwinds effect, lowering inflation in the home economy, dominates the headwinds effect only as long as there is scope for borrowing and lending across countries and the foreign country's production is not too oil intensive. This suggests that we need to examine the extent to which the BRIC economies use oil if we are to obtain a final answer to our question. Indeed, an exact quantification of the effects of the rise of the BRIC economies would require a more careful calibration of the model, in particular, proper estimation of asymmetries between the developed and developing economies.

Global rebalancing: the macroeconomic impact on the United Kingdom

Summary of Working Paper no. 421 Alex Haberis, Bojan Markovic, Karen Mayhew and Pawel Zabczyk

Global current account imbalances widened sharply in the years preceding the financial crisis of 2007–08. And, although since the onset of the crisis global imbalances have narrowed somewhat, they remain substantial. The implications of an unwinding in global imbalances are of great interest to policymakers and academics and further global rebalancing is widely thought to be desirable for the world economy.

This paper considers the implications for the United States, the United Kingdom and the rest of the world (ROW) of shocks that may contribute to a further reduction in global current account imbalances using a dynamic stochastic general equilibrium model. These models are a standard tool for analysing macroeconomic relationships. The phrase 'dynamic general equilibrium' indicates that they allow for interrelationships between the different parts of the economy (and, in this case, between countries) that take time to unfold; the word 'stochastic' that random shocks arrive to disturb the equilibrium.

We consider a positive demand shock in the ROW, which is interpreted as representing countries with current account surpluses. This is calibrated to be consistent with features of past surplus reversals as studied by the IMF. A similarly sized negative demand shock in the United States (and the United Kingdom) is also considered. Finally, we consider the effects of a supply shock that raises US productivity growth relative to other countries, which is calibrated to match the United States' productivity advantage over its trade rivals in the recent past. We consider the effects of these shocks under the assumptions that nominal exchange rates are flexible and also when the ROW pegs to the dollar.

We find that the demand shocks, calibrated as above, in either the ROW or the United States would lead the US current account position to close from its end-2009 level. The supply shock we consider would not be sufficient to close the deficit. The quantitative differences to the simulation results under the different assumptions about the ROW's exchange rate regime are small. This is because, in our model, inflation in the ROW and the United States adjusts to deliver the real exchange rate movements, and associated expenditure switching. This may, of course, not accurately reflect what happens in practice.

The implications for UK output and inflation and the sterling real effective exchange rate depend on the nature of the shock that drives global rebalancing. A rebalancing of surplus countries' demand towards consumption would boost UK demand, pushing up on firms' real marginal costs, thereby raising inflationary pressures in the United Kingdom. This shock would be associated with a depreciation of the sterling real effective exchange rate. Further weakness in domestic demand in the United States would contribute to weaker output and inflation in the United Kingdom, and a real appreciation of sterling. Productivity gains in the United States would lead the United Kingdom to import more US goods, weighing down on UK output. Inflationary pressures would also be reduced in this scenario, and there would be a real depreciation.

Understanding the macroeconomic effects of working capital in the United Kingdom

Summary of Working Paper no. 422 Emilio Fernandez-Corugedo, Michael McMahon, Stephen Millard and Lukasz Rachel

Working capital is defined as the difference between a firm's current assets and its current liabilities. However it is the economic concept, rather than the accounting definition, that matters; firms have a financing gap between payment for their inputs to production (such as labour) and receipt of the revenue from sales of output, which typically comes much later. Having the right amount of working capital at the right time is crucial for the efficient operation of businesses. As a result, firms spend much time managing their working capital, especially in recessions, and perhaps even more so in banking crises when the availability of credit is affected more than usual. However, most macroeconomic models do not consider an explicit role for either working capital or a banking sector. While there are a few existing papers that incorporate working capital considerations, and there is a growing literature that models a banking sector, there is little evidence on the important interactions of the two. This paper attempts to address this gap.

Decisions about working capital are driven mainly by liquidity considerations and, unlike capital investment decisions, tend to be reversible and short term. The financial crisis affecting the world economy that started during the summer of 2007 put a premium on liquidity not only on the financial sector but also on the corporate sector. In particular, the 'credit crunch' put pressure on firms' working capital positions, causing them to cut back on investment. In addition to the demand side of the economy, working capital problems may also affect the supply side of the economy. For example, problems in the financial sector may increase the cost of raising liquidity for firms, leading to an increase in their overall costs. Uncertainty about receiving payments for goods and services, together with difficulties obtaining trade credit insurance, may lead some firms to delay production (possibly affecting employment) until the uncertainty dissipates. Moreover, working capital difficulties may result in firm insolvencies and, thus, capital scrapping and higher unemployment. According to these supply-side arguments, weak working capital positions may result in lower employment and output and higher inflation.

The purpose of this paper is to understand how the responses of key macroeconomic variables such as investment,

inventories, employment, output and inflation to economic shocks are affected by the need for firms to raise working capital. To this end, we first document the behaviour of working capital over UK business cycles, as well as over the recent financial crisis.

We then develop a model that introduces an explicit role for its components. This model differs from others in the literature in that we consider inventory behaviour, a key element of the story and a major input to the production process, as well as trade credit, albeit in a simple way. Our model also incorporates a stylised banking sector that generates spreads between borrowing and lending rates of interest, which allows us to use our model to examine how a financial crisis affects the economy. It is the combination of these shocks from the banking sector with working capital considerations that is important for the results in this paper.

We first use the model to examine the response of macroeconomic variables to movements in productivity and monetary policy. We find that the responses of variables to shifts in productivity are almost identical to a standard model, though working capital considerations tend to dampen the responses of hours, stocks, investment and output to the shock, and there is a greater price response. But, this otherwise standard flexible price model allows monetary policy to have real effects, since it can directly affect firms' costs by affecting the price of their borrowing to finance working capital.

We then use the model to investigate the effect on the macroeconomy of a financial crisis similar to that recently experienced in the United Kingdom. We find that disruptions to the supply of credit would have had large and persistent effects on the real economy through the working capital channel. This finding may help to explain the large and persistent effects of financial crises that have been found in numerous empirical studies and also suggests that this channel was important in explaining the dynamics of the recent downturn in the United Kingdom. We also find that monetary policy, by offsetting widening spreads faced by borrowers in the economy, worked to offset this shock.

Shifts in portfolio preferences of international investors: an application to sovereign wealth funds

Summary of Working Paper no. 423 Filipa Sá and Francesca Viani

This paper develops a framework for understanding the implications for the dollar, interest rates, asset markets and global imbalances of a shift in the portfolio preferences of foreign investors. It develops a dynamic general equilibrium model with two regions (the United States and the rest of the world (ROW)) and two goods (US and ROW-produced goods). A distinctive feature of the model is the presence of two asset classes: equities and government bonds. This allows us to study the implications of two types of changes in the portfolio preferences of foreign investors: a reduction in their preference for US assets and a diversification away from US debt and into US equity assets.

To illustrate how the model works, this paper uses it to analyse the implications of an expansion in sovereign wealth funds (SWFs). SWFs are expected to manage an increasing share of foreign exchange reserves. Compared to central banks, SWFs have higher risk tolerance and invest less in US assets. Their growth may have implications for real activity and external balance.

The information available on the investment strategies of SWFs suggests that their portfolios are typically more diversified than traditional reserves held by central banks, with a larger share invested in equities and a wider geographical dispersion. Given these differences in investment strategies, the shift of reserve assets from central banks to SWFs could have implications for asset prices, the flow of funds between countries, exchange rates and the evolution of global imbalances. In particular, SWFs may increasingly diversify away from dollar assets. This might lead to a reduction in capital inflows into the United States, a depreciation of the dollar and an increase in returns on dollar assets. SWFs may also diversify their portfolios away from low-risk, short-term debt instruments, and into longer-term equity assets, which might lead to changes in asset prices and rates of return. The changes in asset returns generated by the growth in SWFs might induce a reduction in the so-called 'exorbitant privilege', ie the difference between the return the United States receives on its foreign assets relative to the return it pays on its foreign liabilities.

We simulate a scenario where all 'excess reserves' currently held by central banks in emerging market economies are transferred to SWFs, where 'excess reserves' are defined as being above the level that would be required for liquidity purposes. Two diversification paths are considered: one in which SWFs keep the same asset allocation as central banks, ie the same investment shares in equities and bonds, but diversify away from dollar assets (path 1); and another in which they keep the same currency composition, but shift towards a riskier portfolio in the US market, with a larger share invested in US equities and a smaller share invested in US bonds (path 2).

The simulation results show that, in path 1, the dollar depreciates in the period immediately after the shock, leading to a reduction in the US trade deficit and net debt. In subsequent periods, the return on US assets must increase to clear asset markets. This generates a rebalancing of the portfolios of foreign investors towards holding more dollar assets, which leads to an appreciation of the dollar. The 'exorbitant privilege' in the United States decreases and US net debt increases over time. In path 2, the dollar depreciates and the US trade deficit decreases. However, US net debt increases over time due to a reduction in the 'exorbitant privilege'.

The model is general enough to be usable for a variety of experiments. It could be calibrated to countries outside the United States. For example, it could be used to study the implications of the sudden reversals in capital flows that occurred in Iceland, Greece and Ireland during the global financial crisis and to analyse the consequences for other countries with high debt levels if foreign investors were to withdraw their investment. The model could also be used to understand the implications of the 'flight to safety' observed during the crisis, with foreign investors moving away from US equities and corporate debt into US government debt.

How did the crisis in international funding markets affect bank lending? Balance sheet evidence from the United Kingdom

Summary of Working Paper no. 424 Shekhar Aiyar

How did problems originating in one asset class in one country propagate internationally, sparking the Great Recession? A standard stylised explanation relies on the globalisation of the banking system, and has two parts. First, stress in the US banking system (and others directly exposed to US mortgages/structured products) spread internationally through international funding markets. Second, this shock to the foreign funding of various countries' banking systems was transmitted domestically through a reduction in credit supply. While there is a substantial empirical literature documenting the first step above, evidence on the second step is rather slim. This paper tests the transmission to domestic lending of the shock to UK-resident banks' external funding during the crisis.

As a global financial centre, the United Kingdom hosts a large and heterogeneous set of banks, some of which are UK-owned, but many of which are branches or subsidiaries of banks headquartered in other countries. During the financial crisis, these UK-resident banks were subject to an unprecedented shock to foreign funding, with an aggregate fall in external liabilities of about 24% (by way of comparison, the previous largest fall was 9%, during the Exchange Rate Mechanism crisis). This study examines the transmission of this shock to domestic lending. It uses a novel data set, created from detailed and confidential balance sheet data — reported quarterly to the Bank of England — on about 140 UK-resident banks.

The study aims to estimate the impact of the change in a bank's external liabilities on its domestic lending during the crisis. But in principle, of course, causation between these variables can run in both directions, and moreover, domestic lending can be affected by a host of factors that are omitted from the study. To ensure accurate identification of the causation from the change in external liabilities to the change in domestic lending, an econometric technique called instrumental variables is used. Provided that certain statistical conditions — which are mostly verifiable in the data — are satisfied, this technique circumvents the problems of reverse causality and omitted variables.

The main finding is that each 1% reduction in banks' external funding caused a 0.5% to 0.6% contraction in domestic lending, a substantial impact. Given the large shock to banks' external funding that actually occurred, it is likely that this was a crucial channel for transmitting the financial shock to the real economy. The estimated relationship is robust to a wide range of specifications and sensitivity tests. Foreign subsidiaries and branches on average reduced lending by a larger amount than domestically owned banks, while the latter calibrated the reduction in domestic lending more closely to the size of the funding shock. There is little evidence that foreign assets buffered domestic lending against shocks to foreign liabilities.

The transmission of the external shock to different subcomponents of domestic lending is also explored. Evidence is found that the shock caused a significant cutback in lending to businesses, to other banks, and to other financial institutions, with the caveat that these subsamples of the data are smaller and noisier. But no evidence is found for an impact on household lending. This could be because the financial crisis led to the unravelling of the securitisation model of household mortgage lending and caused banks to take mortgage securities back onto their balance sheets, a development which would tend to increase reported bank lending to households.

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International transmission of shocks: a time-varying factor-augmented VAR approach to the open economy

Summary of Working Paper no. 425 Philip Liu, Haroon Mumtaz and Angeliki Theophilopoulou

Understanding and quantifying the international transmission mechanism whereby economic shocks are propagated around economies is important for formulating possible policy responses to developments in the world economy. This is one of the reasons why a substantial empirical literature has focused on this issue. But the existing work on this issue shares two shortcomings. First, analyses do not allow for the possibility of time variation in the parameters of the model. This feature is surprising as changing dynamics of variables such as inflation and output have been highlighted by many studies of macroeconomies. Second, most empirical studies on the international transmission of shocks are based on small-scale vector autoregressions (VARs) (models that relate each variable in the system to past values of all included variables). Arguably, central banks across the world monitor (and possibly respond to) a far wider information set than is typically assumed in these small VARs, leaving them open to the possibility of misspecification. Moreover, from a practical perspective small VARs are unable to provide inference on a large number of variables that may be of interest to policymakers.

The aim of this paper is to fill these gaps in the empirical literature on international transmission. We attempt to do this by devising an empirical model that: allows for time variation in the international transmission mechanism; and allows the simultaneous estimation of the response of a large set of UK variables to foreign monetary policy, demand and supply shocks. In particular, this paper proposes an open economy factor-augmented VAR (FAVAR) which incorporates time-varying coefficients. This captures the widely accepted idea that most macroeconomic variables can be thought of as being largely driven by a small number of common factors. Those included in our proposed FAVAR can be thought of as weighted averages of a large panel of international and UK data. Consequently the proposed model contains significantly more information than the small-scale VARs used in the existing literature.

The empirical results, using quarterly data from 1974 to 2005, indicate that there have been important changes across time in the response of UK variables to international shocks. For example, while real activity responded strongly to foreign money expansion during the 1970s, this response was muted during the period 1992–2005. These results are consistent with a fall in the degree of exchange rate pass-through to import prices. Foreign aggregate demand shocks had a large positive impact on UK GDP during the years 1980–90. However, the impact over the subsequent period was substantially smaller. Foreign supply shocks had a persistent impact on UK inflation and wages during the period 1990–2005.

Labour supply as a buffer: evidence from UK households

Summary of Working Paper no. 426 Andrew Benito and Jumana Saleheen

How households adjust their behaviour in response to macroeconomic shocks, such as unexpected changes to their income, has a key bearing on how the economy responds to those shocks — and what the appropriate policy response should be.

Discussions of households' responses to shocks often emphasise households' spending response. But another key decision made by households is their labour supply. That decision has a key bearing on the overall supply side of the economy. The two sets of decisions on spending and labour supply are also likely to be connected to one another. So understanding households' labour supply behaviour may also help us understand the demand-side consequences of various shocks for the economy. Put simply, if households respond to shocks by altering their labour supply this places less onus on any spending response. It will also have important consequences for wages and prices.

This paper explores empirically the use of labour supply as a 'buffer', in the sense that it helps a household absorb some shock. That response has been highlighted in recent models of household behaviour. These relax an assumption present in earlier models that focused exclusively on households' spending and saving behaviour, and took their labour supply as fixed. Flexible labour supply in response to uncertainty may also help account for some 'puzzles' in household behaviour. That includes understanding why households work relatively long hours while young — when wages are relatively low, but future incomes are highly uncertain — and work shorter hours while old, when wages are typically much higher. It could also help rationalise why estimated spending responses to changing asset prices have often seemed 'small' relative to the predictions of a standard life-cycle model. An ability to respond through labour supply means less emphasis need be placed on spending to achieve some adjustment.

There is, however, little empirical evidence on the use of labour supply as a response to shocks, although there is a long tradition of estimating elasticities of labour supply to income and wages. This paper focuses on labour supply as a response to financial shocks whatever their source — using individual-level data on around 80,000 person-year observations in Britain, available from the British Household Panel Survey. The indicator for a 'financial shock' is based on whether an individual is surprised by how their financial situation changed over the past year, compared to how they had expected it would change one year earlier.

An important constraint on the use of hours of work as a response to a financial shock is the incidence of hours constraints. Many jobs offer limited scope to adjust paid hours by working paid overtime, and there are significant costs incurred in trying to find an alternative or second job. Our analysis begins by documenting the scope for hours adjustment through working paid overtime and second jobs. While that flexibility is greater in manual than non-manual occupations, many individuals do have significant scope to adjust their remunerated hours without changing job. Around one half (one fifth) of manual (non-manual) male employees work paid overtime. A somewhat lower proportion of women employees work paid overtime, with a much higher proportion of women working in non-manual occupations. Around 8%–10% of employees have a second job. Among those that do work 'extra' hours, the hours worked average around one quarter of their regular contracted hours. Simple stylised facts like this suggest many individuals have scope to adjust to any financial shocks by changing their desired hours.

Our results for hours adjustment suggest employees' hours of work respond positively to an adverse financial shock. Moreover, this effect is largely restricted to those who change job during the year in question. That suggests that hours constraints within jobs are important and labour mobility between jobs is key for facilitating individuals' labour supply response to a financial shock.

The presence of hours constraints within jobs may determine whether participation responds in addition to hours worked. For instance, in response to a financial shock, individuals may delay retirement rather than increase their current hours of work. So we look at the participation decision and how this varies with the experience of a financial shock, while controlling for other factors that are related to individuals' propensity to participate. Our analysis finds that this margin of labour supply adjustment does respond to a financial shock. We find this applies to both men and women. Perhaps surprisingly, we find no evidence that the effect is larger among the old, for whom the decision of delaying retirement is more pertinent.

Some recent theoretical models suggest labour supply responses may interact with credit constraints faced by some households, particularly those with high levels of debt. More indebted households may have less of an available borrowing capacity to respond to any adverse shock and may face a stronger motive to respond to the shock by raising their labour supply. Our analysis addresses this possibility.

At the time that some shock affects the economy, reflected in a fall in financial wealth or other factors that have a bearing on households' financial situation, labour demand may also weaken. The financial turmoil and recession of 2007–09 would appear to be a prime example of that. As labour demand weakens, this may make it difficult for households to realise an increase in labour supplied. That does not mean that labour supply issues can be ignored — only that one has to look at both labour supply and labour demand together. That is likely to be important to understand the cyclical properties of labour quantities and real wages.

System-wide liquidity risk in the United Kingdom's large-value payment system: an empirical analysis

Summary of Working Paper no. 427 Marcelo Perlin and Jochen Schanz

Intraday liquidity requirements in large-value real-time gross payment systems can substantially exceed the liquidity that its direct members hold overnight on their accounts with the central bank. As an illustration, UK banks' aggregate holdings of reserves balances with the Bank of England fluctuated around £30 billion in 2008, while the daily amount of liquidity that banks pass through the United Kingdom's large-value payment system, CHAPS, was in the order of £250 billion. To be able to process these payments, banks borrow additional liquidity intraday from the central bank, and recycle liquidity during the day: that is, they partly rely on incoming funds to settle their outgoing payments.

Banks contribute liquidity to the system by sending more payments than they received. We empirically investigate the effects that a hypothetical change in a single bank's payments behaviour has on the liquidity position of its counterparties. Our objective is to highlight the consequences for system-wide risk if these counterparties do not adapt their normal-time behaviour to the changed behaviour of this bank. To this effect, we first estimate banks' payments behaviour: that is, we attempt to find in the data a 'payments rule' that relates a bank's outgoing payments to its available liquidity and incoming payments. We then combine these rules to simulate payments behaviour in the system. In particular, we are interested in the effects that a change in a single bank's payments rule would have on the liquidity position of its counterparties.

We investigate two such hypothetical changes. First, a bank simply stops sending payments — perhaps because of an operational problem. If its counterparties continue to send payments to that bank, they transfer liquidity without receiving any in return from the bank that stops sending payments. Their liquidity buffer may shrink in response. Following our estimated payment rules, the counterparties reduce the value of payments they make, in turn causing the liquidity buffer of their counterparties to fall. We incorporate these spillovers in our simulation and compute, for each counterparty, the time and probability with which it is likely to run out of funds. Assuming that its counterparties do not deviate from their estimated rule, we find that the probability of at least one counterparty becoming liquidity constrained within the first hour is substantial. (In practice, the probability might be smaller, as banks' liquidity management is more sophisticated than we can capture with our model.)

The second change assumes that a bank stops providing additional liquidity to the system — perhaps because it finds itself short of liquidity, or because it becomes concerned about the other banks' ability or willingness to add liquidity to the system. Instead, it only sends out exactly what it has received. We show that such a tit-for-tat strategy would also reduce its counterparties' available liquidity. Again, we compute the time and probability with which the counterparties are likely to run out of funds, assuming that they continue to follow our estimated payment rules. We find that the probability of at least one counterparty becoming liquidity-constrained within the first hour is still substantial, although lower than in the previous case.

Finally, we attempt to identify factors that explain why changing some banks' payments behaviour has a greater effect on their counterparties than changing the behaviour of other banks. A possible reason is that some banks are larger than others, or that they occupy more important positions in the interbank network. In our case, size appears to explain most of the variability of the average effect on the counterparties. More detailed information about the network helps to identify which counterparties are most at risk.

Intraday two-part tariff in payment systems

Summary of Working Paper no. 428 Tomohiro Ota

Timely and liquidity-efficient settlement of payments is an important policy objective for central banks. Settlement delay is, however, recognised as a potential problem in major payment systems. This paper studies two possible solutions to the problem of settlement delay, throughput guidelines and a time-varying tariff, compares their performances, and discusses the design of a time-varying tariff.

The economics of payment literature generally assumes that early payments are always good. Banks have an incentive to delay their payments to minimise the cost of liquidity. By delaying payments until other banks make payments to them, they can free-ride the cash inflow to make their own payments. Since every bank delays aiming at the free-riding, no bank can successfully recycle payment inflow from others. The 'competition of delay' is socially inefficient. This paper also confirms the inefficiency of the 'competition of delay', but finds that delaying payments is not always inefficient. It is socially optimal for a bank with a higher cost of liquidity to delay its payments and for a bank with a lower cost to make early payments. By doing so, the payment system can establish an efficient role-sharing to minimise the aggregate cost of intraday liquidity. That is, the low-cost bank prepares more intraday liquidity than a high-cost bank, and the high-cost bank can recycle the payment inflows (cash) from the low-cost bank for its payments for free. The delay need not be long — just until the bank with the higher cost of liquidity has received funds in.

The typical solution to the delay, the throughput guidelines adopted by the United Kingdom and others, is to penalise a

bank if it fails to make a certain fraction of payments by predetermined deadlines. The model in this paper shows that these guidelines have potential drawbacks. First, they do not penalise payment delay until the deadline. As a result, they may create a bunching of payments just before the deadline, as the guidelines provide greater incentives for banks to make last-minute payments. Second, they impose the same deadline on all banks in the payment system even if they have different liquidity costs. This inhibits heterogeneous banks from the efficient role-sharing.

The second solution, the time-varying tariff adopted by Switzerland and others, penalises late payments in a different way. A payment system with such a tariff charges member banks a fee (tariff), which is increasing over time, on each payment. This paper shows that a linear time-varying tariff can overcome the potential drawbacks of throughput guidelines. The tariff allows each member bank to determine its optimal payment schedule, according to its cost of liquidity. The efficient delays are retained, while the inefficient 'competition of delay' is eliminated. The tariff itself is independent of the cost — ie a system operator does not need to monitor each bank's cost of liquidity, which would be costly or infeasible, to design the optimal tariff.

We also show that the tariff fails to encourage early payments in the specific situation where banks simultaneously experience a large rise in liquidity cost, as in a liquidity crisis. Otherwise, the tariff improves the efficiencies of the payment system by minimising the aggregate cost of liquidity and discouraging inefficient settlement delay, compared with the throughput guidelines.

Domestic financial regulation and external borrowing

Summary of Working Paper no. 429 Sergi Lanau

The financial crisis of 2007–08 has prompted an intense debate on the role of financial regulation. An extended global credit boom has been one of the defining features of the 2000s and is possibly one of the major causes of the crisis. In many major economies banks' balance sheets expanded rapidly and lending to the private sector skyrocketed. One of the alternatives policymakers have to control these credit booms is an improvement in bank regulation. This paper focuses on the international dimension of such a policy option. If the goal is to reduce the leverage of non-banks, is unilateral domestic regulation enough? Perhaps regulation will decrease lending by domestic banks but will non-banks borrow more from banks abroad and remain excessively leveraged?

This paper uses cross-border banking data for the period 1978–2005 to shed some light on these questions. More precisely, the paper tests whether there is a link between domestic financial regulation and non-banks' borrowing from foreign banks. A positive and robust relationship between tighter domestic regulation and borrowing from foreign banks would suggest that financial regulation needs an international angle to be completely effective.

The concept of 'foreign bank' used in this paper includes all non-resident banks regardless of their nationality of ownership. For instance, the UK-based branches of a bank headquartered in Switzerland are not considered 'foreign banks' and their loans to UK residents are not international lending. In contrast, any loans from the Swiss headquarters to UK residents match our definition of international lending.

Financial regulation is measured by an index of financial deregulation which aggregates six dimensions of regulation: credit controls, interest rate controls, banking sector entry barriers, banking supervision, public ownership and the development of securities markets. The effects of capital account restrictions are also taken into account but are not aggregated into the index. It is worth stressing that we identify the effects of unilateral changes in financial regulation. An analysis of global regulatory trends is beyond the scope of this paper.

The data set contains annual cross-border flows from banks to non-banks for 1,390 country pairs. Obviously, financial regulation is not the only determinant of borrowing that evolves over the period 1978–2005. This paper uses econometric techniques that ensure that the effects of other relevant economic factors are not erroneously attributed to financial regulation. The role of important static factors such as distance between countries and cultural links is also taken into account.

Using a generic index of financial deregulation, it is found, all else equal, non-banks borrow more from foreign banks under tighter domestic financial regulation. More specifically, a country on the upper quartile of the deregulation index distribution borrows 20% more than a country with the lightest regulation.

The paper also establishes which components of the generic deregulation index are driving our results. The imposition of interest rate controls and entry barriers to the banking sector have a positive and significant effect on foreign borrowing. For example, the adoption of branching restrictions increases foreign borrowing by 15%. Bank privatisation also has a positive impact on foreign borrowing by non-banks. In contrast, credit controls, the adoption of Basel standards and the development of bank supervisory agencies do not have a significant effect on foreign borrowing. Importantly, the results also hold for the subsample of advanced economies.

The findings in this paper suggest that an international perspective is essential to design effective financial stability tools. In response to increased domestic regulation, non-banks might compensate to some extent for the reduction in domestic credit by borrowing more abroad. It is worth emphasising that this paper does not claim that domestic regulation is ineffective at reducing leverage: leverage would fall if the reduction in domestic credit is larger than the increase in foreign borrowing we document in this paper.

Consistency in international policy, as could be supported by fora such as the European Systemic Risk Board and the Financial Stability Board, could limit the scope of the effects highlighted in this paper.