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Global Banking, Trade, and the International Transmission of the Great Recession

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Global Banking, Trade, and the International Transmission of the Great Recession

February 28, 2015

The global financial crisis of 2007-2009 spread through different channels from its origin in the United States to large parts of the world. In this paper we explore the financial and the trade channels in a unified framework and quantify their relative importance for this transmission. Specifically, we employ a DSGE model of an open economy with an internationally operating banking sector. We investigate the transmission of the crisis via the collapse of export demand and through losses in the value of cross-border asset holdings. Calibrated to German and UK data, the model attributes around half of the observed maximum output decline in Germany to these channels, and 87% for the UK. While the trade channel explains 30% of the empirical output decline in both countries, the financial channel plays a much larger role in the UK than in Germany. The UK's larger vulnerability to financial shocks is due to higher foreign-asset holdings, which simultaneously serve as an automatic stabilizer in case of plummeting foreign demand. The transmission via the financial channel triggers a much longer-lasting recession relative to the trade channel, resulting in larger cumulated output losses and a prolonged crisis particularly in the UK. Stricter bank capital regulations would have deepened the initial slump while simultaneously speeding up the recovery.

Keywords: Financial Crisis, International Transmission
International Business Cycles, Global Banks

JEL-Codes: F44 F41 E32

1 Introduction

The financial crisis of 2007-2009 started in a small segment of the US financial market and spread rapidly around the world, infecting in particular the large and globalized banking systems of advanced economies. It soon spilled over to the real economy, leading to a massive collapse in international trade and a simultaneous global recession. Alternative narratives attribute important roles for its international transmission to the trade collapse (trade channel) on the one hand, and to losses in cross-border asset holdings (financial channel) on the other. It is, however, neither empirically nor theoretically clear which of the two dominates the global transmission of the crisis. As the nature and the importance of the financial channel have changed during the financial globalization of the recent decades, this question is particularly relevant for forming an understanding of international linkages nowadays and in the future.

In this paper, we therefore investigate the effects of the trade and the financial channel in a unified framework and assess which of the two was more important in the transmission of the crisis. For this purpose, we put forward a model that features both channels in order to assess their quantitative relevance. The mutual interdependence of the financial and the trade channel are likely, at least to some extent, to complicate purely empirical investigations of the two (reviewed below). For example, reduced exports can indirectly affect banks' capital and their ability to supply loans while the degree of financial linkages can influence the responses to a trade shock. A deeper investigation of the transmission channels by means of a structural model seems hence necessary and worthwhile. Our international business cycle model features a small open economy integrated with the rest of the world through trade in goods and through the banking sector, which holds foreign assets. The assumption of a small open economy allows us to treat the specific origin of the last crisis as exogenous to the economy in question. Without having to take a stand on how the financial crisis originated, infected banks' balance sheets, and led to the collapse of global trade, the applicability of the theoretical results is broadened to generic financial and trade crises. In the case of a financial shock, losses on foreign assets destroy a part of the banks' capital.¹ The bank has to use some of its own funds for financing loans and foreign asset holdings and consequently reacts by restricting lending, leading to long-lasting declines in investment and output. In the case of a trade shock, foreign demand for home goods falters, leading to a relatively short-lived reduction in exports and output. Calibrating the sizes of the two shocks to the recent financial crisis, we can then analyze how the economy reacted to each shock and assess which of them had the greater share in the output decline. Furthermore, the model allows us to investigate policy measures aimed at limiting the adverse effects of the shocks. We exemplarily look at stricter bank capital regulation, which simultaneously deepens and shortens the recession.

In order to derive quantitative results, we proceed by calibrating the model to German and UK data. We take Germany and the UK as insightful cases on the receiving side of the crisis transmission, as

¹While there is no clear consensus which elements are counted towards the financial channel, we focus on the transmission via losses on cross-border holdings on banks' balance sheets. These played a major role in the recent financial crisis, as shown below.

they are well integrated with the rest of the world. In particular, trade *and* financial links between Germany and the UK on one side and the US on the other are strong, where Germany is a traditionally strong exporter, while the UK has established London as a global financial center. They hence lend themselves to investigate the relative importance of both channels. Furthermore and in line with the model, the financial crisis was arguably exogenous to Germany and the UK, which both featured robust growth before the crisis. Germany did not experience a housing or financial asset bubble, while falling house prices in the UK only had a minor autonomous impact on real activity.² To be clear, however, we want to disentangle the relative contributions of the international trade and the financial channel to the decline in real activity in Germany and the UK, but do not aim to explain the entire decline. In contrast, our results suggest that in particular Germany was suffering from further detrimental effects on top of the impact via the trade and the financial channel, as both explain only around half of the observed output decline.³ These additional factors seemed to be of limited importance for the UK, for which both considered channels add up to 87% of the empirical fall in output.

Regarding the relative contributions, it turns out that the trade channel accounts for around two thirds of the explained GDP movement for Germany, while the transmission via the financial channel is responsible for the remaining third. For the UK, the relative contributions reverse. Both can be explained to a large degree by the higher presence of foreign assets in the UK banking sector at the onset of the recession. The depreciation of the terms of trade, following a reduction in external demand, increases the value of foreign assets in banks' balance sheets in terms of domestic goods. Banks are hence relatively more willing to hand out loans, such that foreign-asset holding serve as an automatic stabilizer as regards the trade channel. While beneficial in this case, high foreign-asset holdings are also responsible for the negative effects of the financial channel: higher exposure directly leads to larger losses. The transmission via the trade channel triggers a relatively short recession in both countries. The financial channel, in contrast, has longer-lasting effects. It is therefore crucial in accounting for the fact that German output in the last quarter of 2010 was still below its level two years before, and even more so in the UK. This finding for the recent financial crisis is in line with general results established by Reinhart and Rogoff (2009) and others, showing that financial crises lead to protracted recessions. Also the Bank for International Settlements (2014) points out that balance-sheet recessions are followed by slower recoveries. We also explore the effects of a stricter banking regulation in the form of higher costs for violating the capital requirement. For financial shocks, this policy deepens the initial recession, but leads to a quicker recovery.

Within the theoretical literature, our analysis is particularly related to the studies analyzing the inter-

²In particular, Germany's house prices were flat for an extended period before the crisis. The UK experienced a larger increase in housing prices, but the construction of new units and employment in the construction sector remained modest due to strict planning laws. The following reduction in house prices, which turned into an upswing in 2009, is hence likely to have had relatively minor effects on aggregate activity, compared to, e.g., the US, Spain or Ireland. See International Monetary Fund (2010b).

³Bacchetta and van Wincoop (2013), for example, argue that a self-fulfilling business cycle panic has contributed to the simultaneous decline in output in the US and elsewhere. Enders et al. (2014) show theoretically and empirically that overly pessimistic (and optimistic) expectations contribute significantly to business cycle fluctuations.

national transmission of financial shocks via a global banking sector. Using a one-good two-country model, Kollmann et al. (2011) show how a banking sector subject to a bank capital requirement can transmit a loan default shock originating in one country. Attributing a prominent role to the banking sector fits well to the UK and Germany, as firms there rely more heavily on bank lending as in, e.g., the US. In comparison to Kollmann et al. (2011), we study a two-good model, which enables us to analyze the transmission via the trade channel in more detail in addition to the transmission via the banking sector. Another difference is that we abstract from the foreign economy and instead model a small open economy, thereby avoiding a detailed specification of the origins of the crisis. Lastly, while Kollmann et al. (2011) focus on the effects of loan losses in one of the two countries in the model, we consider losses on foreign assets held by domestic banks. Estimating their cyclical properties, we find them to be much more volatile than loan losses, giving them a larger role in shaping business cycles. Other contributions with global banking sectors include Ueda (2012), who shows how financial constraints and the net worth of creditors contribute to business cycle synchronization, and Olivero (2010), who models an imperfectly competitive banking sector, but does not consider financial shocks. Analyzing a model with financial constraints, Mendoza and Quadrini (2010) show how financial contagion can spread across countries through shocks to bank equity. However, they do not consider business cycles.

Related to our research question, several papers in the empirical literature investigate the transmission of the 2007-2009 financial crisis, including the trade and financial channel.⁴ Eickmeier et al. (2011) study empirically the transmission of US financial shocks to a set of advanced economies, using a factor-augmented VAR. They find that the recent negative shock was large compared to previous financial shocks. While they are not able to cleanly disentangle how the financial shock was transmitted via the different channels, they can show that both trade and financial channels contributed to the transmission. Other studies analyze whether the cross-country variation in crisis incidence - measured by severity and duration of output decline as well as business cycle correlation - can be attributed to pre-crisis indicators. Several empirical papers find that advanced economies were hit harder by the crisis (Lane and Milesi-Ferretti, 2011; Rose and Spiegel, 2011; Claessens et al., 2010) and that the financial channel was relatively more important for the crisis transmission than the trade channel. The results of Olafsson and Pétursson (2011) show that the financial channel—associated with relatively large banking sectors and strong global financial linkages—together with the macro channel—visible in inflation reactions, current account deficits, and a leveraged private sector—plays an important role for the propagation of the US shock, whereas there is little evidence for transmission via the trade channel. Likewise, considering business-cycle correlations, the financial channel was more important for the diffusion of the US shock to OECD countries, whereas non-OECD countries were mainly affected

⁴Other transmission channels involve, e.g., a global increase in risk aversion and reliance on foreign finance (Lane and Milesi-Ferretti, 2011) as well as a macro channel represented by macroeconomic vulnerabilities and imbalances, and an institutional channel (Olafsson and Pétursson, 2011).

through the trade channel, according to Imbs (2010).⁵ Claessens et al. (2010) find that fewer of the impact measures they use—decline duration, severity and relative adversity—were affected by trade measures and that countries were hit through the financial channel earlier than through the trade channel. Lane and Milesi-Ferretti (2011) come to similar results, where real variables like trade openness are correlated with output declines to a lesser extent than financial factors.

On the other hand, Rose and Spiegel (2011) identify few consistent results linking pre-crisis indicators and crisis intensity. Furthermore, considering the transmission to financial variables like credit default swap premia, bank stock prices or equity portfolios, there is little direct evidence that US exposure or external exposure via trade or financial openness leads to higher contagion (Kamin and DeMarco, 2010; Bekaert et al., 2014). Transmission via the financial channel, however, played a role for the comovement of a country's stock market returns with those of the US (Didier et al., 2010). To summarize, the financial channel seems to have played in general a stronger role in the transmission of the US financial crisis. However, the links between pre-crisis indicators and crisis incidence are not entirely clear cut. Given the relatively inconclusive results of the empirical literature, and the need for counterfactual simulations to disentangle the two channels, we think that our analysis through the lens of an appropriate dynamic stochastic general equilibrium model is worthwhile.

The rest of the paper is organized as follows. The next section presents evidence how the German and UK economies were affected by the recent financial crisis. Section 3 describes the model setup and its calibration. Section 4 discusses the results, while Section 5 concludes.

2 The German and UK economies during the 2007-2009 financial crisis

This section presents how the German and UK economies were affected by the 2007-2009 financial crisis. In line with the two transmission channels presented in the introduction, we focus on the behavior of trade and the developments in the financial sector. The main aspects are captured in Figures 1-4, which show year-on-year growth rates for GDP, investment, exports and imports to/from main trading partners, and loans to non-financial corporations for the period 1992Q1-2012Q4. The shaded areas indicate the latest US recession (according to the NBER). For Germany, the figures show the unprecedented nature of the recent recession, considering the post reunification period in Germany.⁶ In 2009, German GDP fell annualized by 4.7%, with a growth rate of -6.9% in the first quarter of 2009 (compared to the same quarter 2008). The growth decline in UK was only slightly smaller than in Germany. While German GDP had almost returned to its pre-crisis level by the end of 2010, the growth rebound in the UK was much smaller, reaching only half of its pre-crisis GDP

⁵For the crisis transmission to emerging markets, Blanchard et al. (2010) and Berkmen et al. (2012) both find that the financial channel dominated the trade channel. In the former study, the financial channel is represented by capital outflows, while in the latter the financial channel is represented inter alia by bank lending linkages to advanced economies.

⁶Although not strictly comparable due to methodological differences, the growth decline was also the largest considering the time after the second world war (see Statistisches Bundesamt, 2009).

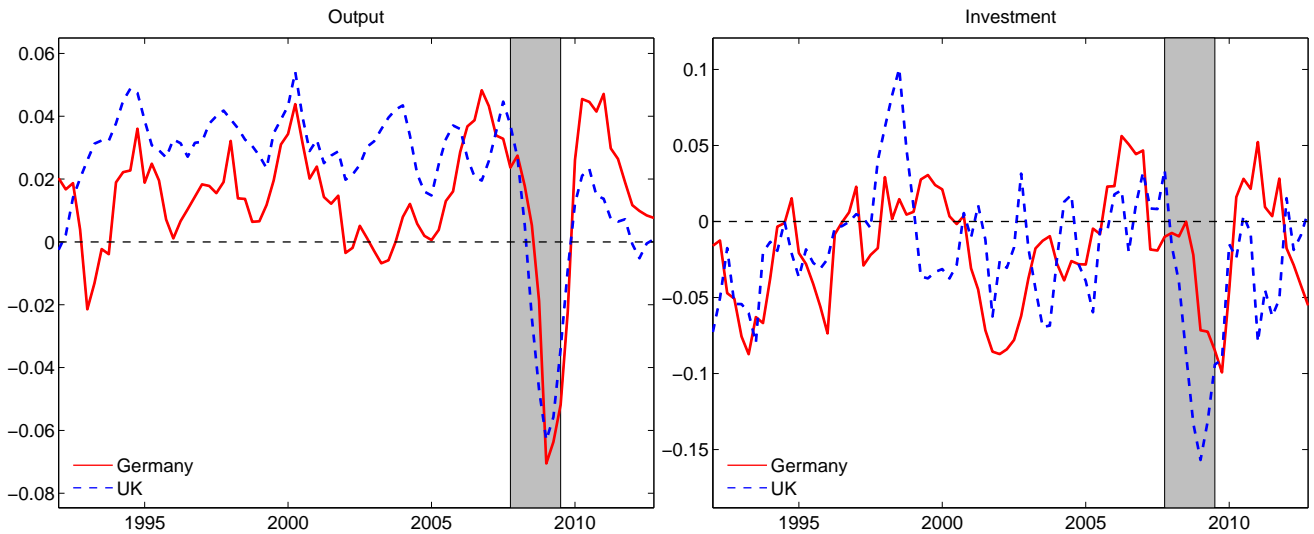


Figure 1: Growth rates of GDP and investment.

Left panel shows yoy growth of German GDP (solid line) and of UK GDP (dashed line). Right panel shows yoy growth of German investment (solid line) and of UK investment (dashed line). Shaded area indicates the latest NBER-dated recession for the US.

growth. Investment also experienced a strong decline, more so in the UK compared to Germany. Related to the trade channel, German exports experienced a similarly unprecedented downturn. Total exports fell by almost 20% (Figure 2, left panel) in the first quarter of 2009 relative to the previous-year quarter. In a previous episode of negative export growth, during the recession following the reunification boom, the decline was around half of the recent decline. The UK, starting from mostly smaller export growth rates before the crisis, was affected somewhat less. Nevertheless, exports dropped by around 12% in the beginning of 2009. The massive reduction in German and UK exports goes hand in hand with the major slump in global trade hitting the world by the end of 2008 and the beginning of 2009. The global trade collapse was considerably larger than the accompanying world output decline, which has sparked an ample search for the underlying reasons.⁷ The key factor explaining the massive trade collapse is suspected to be a deterioration in global demand, explaining 60% to 80% of the trade collapse (di Mauro et al., 2010; Cheung and Guichard, 2009; Behrens et al., 2013). In particular, using a trade-weighted demand measure, the trade collapse does not seem extraordinary given external demand (Bussière et al., 2013). Besides a faltering exogenous demand, the reduction in exports is also driven by an endogenous reaction to terms-of-trade adjustments and various other factors.⁸ In order to develop a proxy for the exogenous drop in demand, we aggregate total imports of a broad set of trading partners for Germany and the UK, including the respective top 10 trading partners for

⁷Real world GDP fell by 7.9 % (annualized) in the first quarter of 2009, while real world trade contracted by 15% in the same period (Bems et al., 2010).

⁸Other factors contributing to the trade deterioration include tighter conditions for trade finance (Amiti and Weinstein, 2011; Ahn, 2011; Coulibaly et al., 2011; Chor and Manova, 2012), increased vertical supply integration (Behrens et al., 2013; Levchenko et al., 2010), the concentration of the demand decline on export intensive goods and durables (Bems et al., 2010; Eaton et al., 2011), or inventory adjustment (Alessandria et al., 2010).

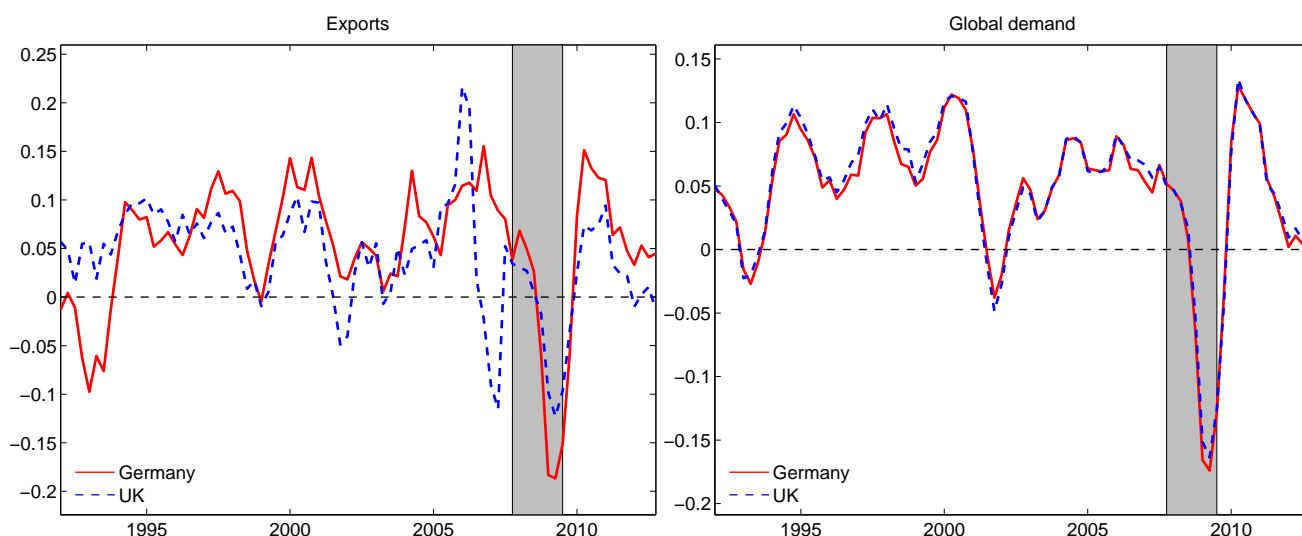


Figure 2: Exports and Imports.

Left panel shows yoy growth of German exports (solid line) and of UK exports (dashed line) to the respective remaining G7 countries. Right panel shows yoy growth of imports of the respective top 10 trading partners, trade weighted for Germany (solid line) and the UK (dashed line).

both countries. Since the imports are trade weighted and these weights differ between Germany and the UK, we obtain two slightly different series for Germany and the UK (see Appendix for details). Figure 2 shows a close relationship between this measure and German as well as UK export growth. As this measure consists of overall imports, it mainly reflects developments in the trading partners, instead of events in Germany or the UK, respectively.

Next, we turn to the developments in the banking sector. Both, the UK and German banking sectors were hit hard by the financial crisis. Laeven and Valencia (2010) identify a systemic banking crisis in the UK starting in 2007 and in Germany, starting in 2008. They base their identification on various banking policy intervention measures of which at least three had to take place to define a banking crisis. For Germany the following interventions occurred: extensive liquidity support, significant guarantees on liabilities and a significant bank nationalization (Hypo Real Estate in 2008). For the UK, in addition to the ones mentioned for Germany, two additional measures applied: significant restructuring costs and significant asset purchases.⁹ The estimations of Laeven and Valencia (2010) show that total assets of failed and government assisted banks in Germany amounted to 7% and 29% of total banking assets, respectively, and in the United Kingdom to 25% and 4%.¹⁰ In comparison, US banks that failed or received government assistance accounted for 24% of total banking assets, while, e.g., in France a total of 78% of assets in the banking system belonged to banks that either failed or received government assistance.

The banking sector faced massive writedowns on its loans and securities holdings, draining the capital

⁹In the UK, Northern Rock and Royal Bank of Scotland were nationalized.

¹⁰If the government becomes the majority stakeholder of a bank, it is counted towards the failed bank category. Government assisted banks have received fresh capital from the government, which remains a minority stakeholder.

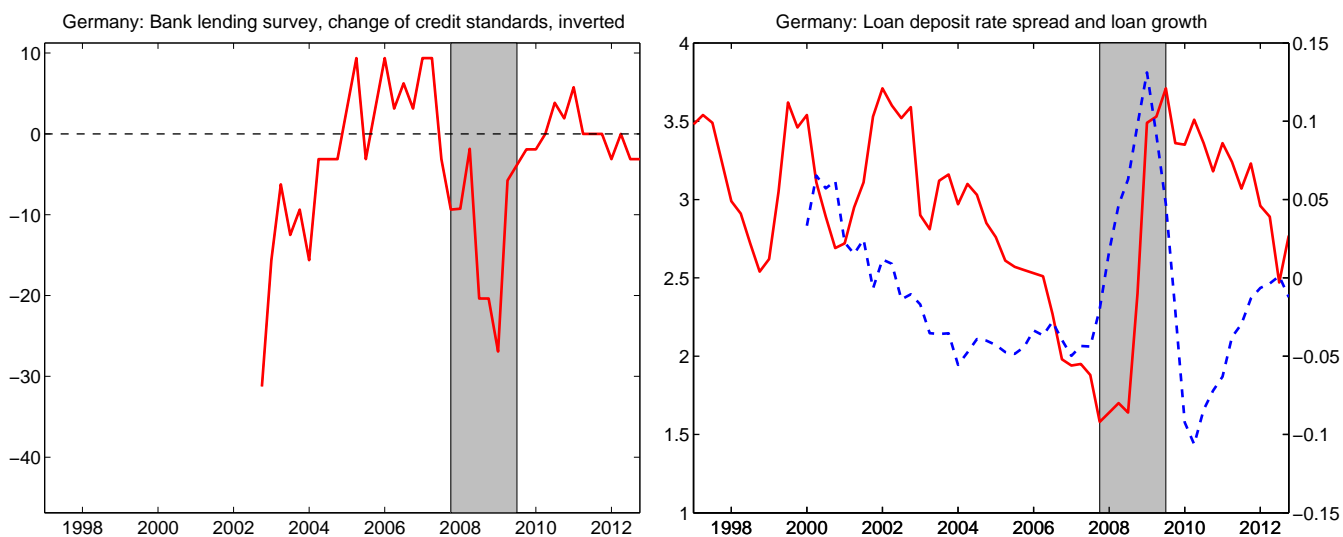


Figure 3: Germany: Change of credit standards, loan-deposit rate spread and loan growth.

Left panel presents the results of the bank lending survey regarding overall credit standards. It shows the difference between the weighted sums of answers to “credit standards were tightened” and answers to “credit standards were eased” (each in percent of total answers given). A negative value means that a higher proportion of banks has tightened credit standards. Right panel contrasts the spread between the loan and deposit rates measured in percentage points (solid line, left axis) with yoy growth of loans to non-financial corporations (dashed line, right axis).

position and leading inter alia to failure or the need for some kind of assistance. Comparing Germany to the UK, we observe that the UK had the higher foreign loan and securities holdings (UK: 3.19 trillion US\$ vs. 1.49 trillion in Germany) due to London’s role as a financial center. German banks, however, held more vulnerable foreign assets. Foreign securities in particular imposed hefty losses on German banks. The International Monetary Fund (2010a) estimates that German banks faced cumulative writedowns on their total loans and securities portfolio of 314 billions US dollars between 2007-10. For foreign loans and securities this amounts to an implied cumulative loss rate of 10%. UK banks faced an amount of 455 billion US dollars of cumulative writedowns on total loans and securities, with a large part being foreign loans and securities (loss rate of 7.25% on foreign loans and securities). These substantial losses lead to strains on banks’ balance sheet, forcing them to deleverage. One way to accomplish this is to restrict lending, thereby transmitting the financial shock to the real economy. Figures 3 and 4 shows that the growth rates of the loan volume to non-financial corporations also exhibited pronounced falls, albeit later in Germany than in the UK (right panels, dashed line, right axis). Furthermore, loan growth in Germany first increased and then declined a few quarters later than GDP and export growth.¹¹ In the UK, loans had already started a downward trend before the crisis. The strongest decline happened in 2010. However, the decreasing loan volume can either be an expression of bank-sided factors that lead banks to restrict their loan supply or it can stem from the demand side, with firms demanding lesser loans during times of faltering exports and GDP growth.

¹¹Explanations involve drawing of previously contracted credit lines and their slow re-negotiations or banks’ initial reduction of other assets, such as interbank assets or equities, before reducing lending (Blaes, 2011).

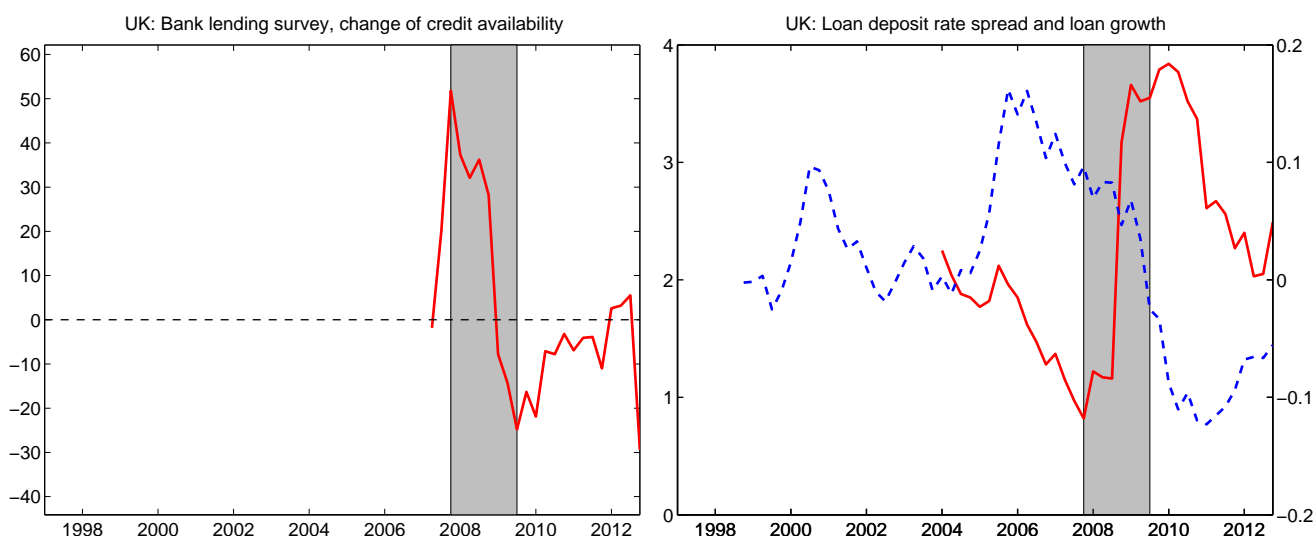


Figure 4: UK: Change of credit availability, loan-deposit rate spread and loan growth.

Left panel presents the results of the bank lending survey regarding availability of credit provided to the corporate sector. It shows net percent balances that are calculated by weighting the responses of the lenders by their market shares. A positive balance means that lenders, on balance, reported a higher availability of credit than over the previous three-month period. Right panel contrasts the spread between the loan and deposit rates measured in percentage points (solid line, left axis) with yoy growth of loans to non-financial corporations (dashed line, right axis).

Although the German central bank did not find signs for a broad credit crunch (Bundesbank, 2009, 2010), there is some evidence for negative loan supply shocks and bank-sided factors having had a dampening effect on loan growth.¹² Busch et al. (2010) analyze the dynamics of loans to non-financial corporations in Germany using a Bayesian VAR with sign restrictions and find high negative loan-supply shocks at the end of 2008 and in the beginning of 2009. Specifically, the loan-supply shocks had a lagged effect on loan volumes, which might give rise to the initial upturn and the following lagged decline of loan growth in Figure 3. Drawing on the German Bank Lending Survey, Blaes (2011) shows that both demand and purely bank-side determinants contributed to the loan dynamics during the crisis years with bank-related supply factors having its highest impact in the last two quarters of 2009. Similarly, Hristov et al. (2012) find that for Euro Area members including Germany, loan-volume changes and a part of the decline in GDP growth resulted from adverse loan-supply shocks. In particular, the adverse effects developed in Germany during 2009 and the first quarters of 2010. Similar results for bank-side factors affecting loan supply come from Aiyar (2011), who finds that banks in the UK substantially decreased domestic lending after a shock to foreign funding, and Barnett and Thomas (2014), who show for the UK that credit supply shocks can explain most of the slowdown in bank lending during the crisis. Looking at consumer loans, Puri et al. (2011) find that banks with a high exposure to US toxic assets restricted loans more strongly than banks without this

¹²Similarly, results by Schmidt and Zwick (2012) using a dynamic disequilibrium model of the German credit market also suggest that a broad credit crunch did not occur in Germany, however banks more affected by the financial crisis restricted their credit supply more than others.

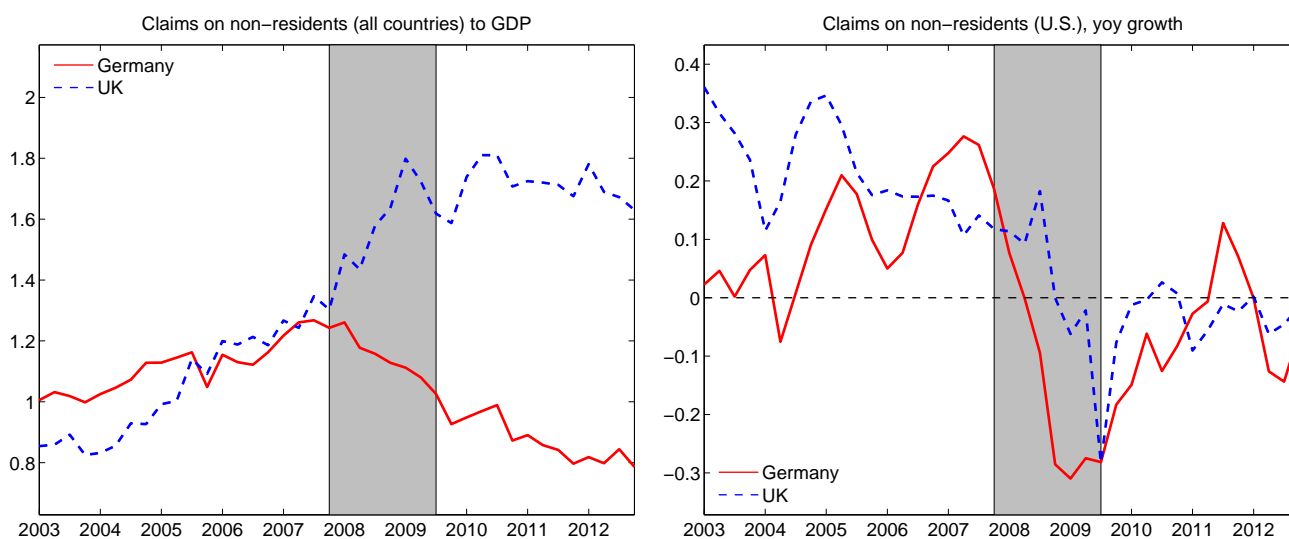


Figure 5: Foreign claims by German and UK banks.

Left panel shows claims on non-residents (all countries) as a ratio to GDP. Right panel shows claims on non-residents (US securities), yoy growth.

exposure. Similarly, Rottmann and Wollmershäuser (2013) demonstrate that large firms, who mostly rely on those banks hit hardest by the crisis (German state-owned ‘Landesbanken’ and commercial banks) faced a heightening unwillingness of banks to grant credit.

Figures 3 and 4 also display how credit standards and the spread between loan and deposit rates have reacted during the financial crisis. A high proportion of German and UK banks tightened credit standards considerably around 2008, after a four-year long period of easing credit standards. While credit was easiest to obtain exactly at the beginning of the crisis in the UK, German banks started tightening before its onset. Interestingly, they eased conditions for a short period after the crisis started. At the same time the spread between loan and deposit rates has widened strongly, increasing from an all-time low in early 2008 by approximately 2 percentage points in Germany and the UK (Figures 3 and 4, right panels, solid line, left axis). This development had an adverse impact on loan growth. During times of high loan-rate spreads, loan growth was very small or negative and vice versa. In particular, in the beginning of the crisis period the spread was very low, while loans to non-financial corporations exhibited high growth rates. This relation turned upside-down during the course of the crisis.

Both the UK and the German banking sectors operate on a global scale with claims on non-residents amounting to over 100% of GDP in both countries, making them vulnerable to adverse financial developments in the rest of the world. At the same time, UK and German bank portfolios differed in size and composition. In particular, the UK was the second largest holder of United States long-term corporate asset-backed securities, owning a total amount of 142 billions US dollars right before the crisis in June 2007 (Department of the Treasury, 2008). Of these, 63% constituted mortgage-backed securities. While smaller, the German banking system also held a considerable amount of US long-term corporate

asset-backed securities, namely 42 billion US dollars, of which 80% were mortgage-backed securities. Lane and Milesi-Ferretti (2011) observe that several industrial countries with heavily affected financial institutions held large amounts of asset-backed securities. Figure 5 shows the development of claims on non-residents by German and UK banks from 2003 to 2012. German claims on all countries increased until an all-time high of 134% of GDP in the third quarter of 2007 and have since been mostly declining (Figure 5, left panel). A similar picture emerges considering yoy growth of one segment of foreign claims, namely holdings of US securities (Figure 5, right panel). These assets fell substantially during the crisis years. Developments in the UK were quite distinct, as foreign claims on all countries continued to increase in the crisis. They took a hit, however, in 2009. Similarly, yoy growth of US security holdings was positive longer compared to Germany, before collapsing. After analyzing how the German and the UK economies were affected during the financial crisis, in particular the effects on trade and the banking sector, we discuss a model of a small open economy that is calibrated to capture and disentangle these developments.

3 The Model

We use a small open economy variant of the model proposed in Kollmann et al. (2011). The economy is inhabited by a representative worker, an entrepreneur, and a bank. There are two goods, a home intermediate good produced by the entrepreneur and a foreign intermediate good produced in the rest of world. Both intermediate goods are combined into a final good that is used for consumption by the three agents and for investment by the entrepreneur. The economy is connected to the rest of the world through trade in intermediate goods representing the trade channel and through trade in foreign assets representing the financial channel.

3.1 The Worker

The worker's utility depends on consumption of the final good C_t , bank deposits D_{t+1} and hours worked N_t :

$$U_t = E_t \sum_{s=0}^{\infty} \beta^s \left[\frac{(C_{t+s} - \psi_w C_{t+s-1})^{1-\sigma_w} - 1}{1-\sigma_w} + \Psi^D \frac{(D_{t+1+s})^{1-\sigma_w} - 1}{1-\sigma_w} - \Psi^N N_{t+s} \right], \quad (1)$$

where β is the subjective discount factor, $\sigma_w > 0$ governs the worker's intertemporal elasticity of substitution, and $\Psi^D, \Psi^N > 0$ are preference parameters. The consumers have habits in consumption, where ψ_w measures the degree of internal habit persistence.¹³ Additionally to paying interest, deposits provide liquidity services to the worker. That way the worker can have the same subjective discount factor as the entrepreneur and the banker and still hold positive deposits. The budget constraint of the

¹³Consumption habits are often assumed in the literature, as they bring consumption volatility closer to empirical observations.

representative worker in terms of the final good, which is used as the numéraire, is

$$C_t + p_t^a D_{t+1} = p_t^a W_t N_t + p_t^a D_t R_{t-1}^D. \quad (2)$$

The household earns income from supplying labor to the entrepreneur and from interest payments on deposits held with the bank. The wage rate W_t is measured in terms of the home intermediate good. Thus, labor income in terms of the final good is $p_t^a W_t N_t$, where p_t^a is the relative price of the home intermediate good. R_{t-1}^D is the gross interest rate on deposits made last period, D_t , measured in terms of the home intermediate good as well. The worker either consumes her income or saves in new deposits D_{t+1} . Maximizing the worker's utility subject to her budget constraint yields the following first-order conditions:

$$\lambda_{w,t} p_t^a W_t = \Psi^N \quad (3)$$

$$(C_t - \psi_w C_{t-1})^{-\sigma_w} - \psi_w \beta (C_{t+1} - \psi_w C_t)^{-\sigma_w} = \lambda_{w,t} \quad (4)$$

$$\Psi^D \left(\frac{D_{t+1}^{-\sigma_w}}{\lambda_{w,t}} \right) + \beta E_t \left[p_{t+1}^a R_t^D \left(\frac{\lambda_{w,t+1}}{\lambda_{w,t}} \right) \right] = p_t^a, \quad (5)$$

where $\lambda_{w,t}$ is the multiplier on the budget constraint. The first equation shows the trade-off between consumption and labor. The third first-order condition is the Euler equation. It differs from a standard Euler equation through an additional term representing liquidity services provided by deposits.

3.2 The Entrepreneur and Final Good Production

The entrepreneur produces the home intermediate good a_t by combining capital and labor provided by the worker via a Cobb-Douglas production function:

$$Y_t = z_t K_t^\alpha N_t^{1-\alpha}, \quad (6)$$

where α is the capital share and z_t is total factor productivity following an $AR(1)$ process:

$$\log(z_t) = \rho_z \log(z_{t-1}) + \varepsilon_{z,t}. \quad (7)$$

The capital stock, owned by the entrepreneur, depreciates with rate δ and increases through gross investment I_t :

$$K_{t+1} = (1 - \delta) K_t + I_t, \quad (8)$$

The entrepreneur uses the final good for investment. However, the final good cannot be transformed costlessly into capital. Instead, to produce investment I_t , the amount $\xi(I_t)$ of final goods needed is:

$$\xi(I_t) = I_t + 0.5\Xi \left(\frac{I_t}{I} - 1 \right)^2, \quad \Xi > 0. \quad (9)$$

To finance parts of her operations, the entrepreneur borrows from the bank one-period loans L_t , on

which she has to pay the gross loan rate R_{t-1}^L . The entrepreneur's budget constraint is

$$p_t^a L_t R_{t-1}^L + \xi(I_t) + p_t^a W_t N_t + d_t^E = p_t^a L_{t+1} + p_t^a Y_t, \quad (10)$$

where d_t^E is the entrepreneur's dividend income. The entrepreneur derives utility from consuming this income according to the following utility function:

$$U_t = E_t \sum_{s=0}^{\infty} \beta^s \left[\frac{\left(d_{t+s}^E - \psi_E d_{t+s-1}^E \right)^{1-\sigma_E} - 1}{1 - \sigma_E} \right]. \quad (11)$$

The entrepreneur's risk aversion differs from the risk aversion of the worker. Below we will fix σ_E to be lower than σ_w , making the entrepreneur less risk averse than the worker (implying that less risk-averse people are more likely to become entrepreneurs). However, as mentioned above, the subjective discount factor β is the same for all agents. Like the worker, the entrepreneur has habits in consumption, with ψ_E being the habit parameter. The first-order conditions corresponding to the maximization of the entrepreneur's utility (11), taking into account the constraints (8)-(10), are:

$$(1 - \alpha) z_t \left(\frac{K_t}{N_t} \right)^\alpha = W_t \quad (12)$$

$$\beta E_t \left[\left(\frac{\lambda_{E,t+1}}{\lambda_{E,t}} \right) \left(p_{t+1}^a \alpha z_{t+1} \left(\frac{K_{t+1}}{N_{t+1}} \right)^{\alpha-1} + \xi'(I_{t+1}) (1 - \delta) \right) \right] = \xi'(I_t) \quad (13)$$

$$\beta E_t \left[\frac{p_{t+1}^a}{p_t^a} \left(\frac{\lambda_{E,t+1}}{\lambda_{E,t}} \right) R_t^L \right] = 1 \quad (14)$$

$$\left(d_t^E - \psi_E d_{t-1}^E \right)^{-\sigma_E} - \psi_E \beta \left(d_{t+1}^E - \psi_E d_t^E \right)^{-\sigma_E} = \lambda_{E,t}.$$

The final good F_t used for consumption and investment is bundled from home and foreign intermediate goods, a_t and b_t , via the following CES-aggregator:

$$F_t = \left(\omega^{\frac{1}{\theta}} (a_t)^{\frac{\theta-1}{\theta}} + (1 - \omega)^{\frac{1}{\theta}} (b_t)^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}},$$

where θ is the elasticity of substitution between home and foreign goods and $0 \leq \omega \leq 1$ is the share of the home intermediate good used for the final good in case of equal prices. $\omega > 0.5$ corresponds to a home bias in consumption and investment. A cost-minimization argument yields the demand functions for a_t and b_t with p_t^b denoting the relative price of foreign intermediate goods in terms of the final good:

$$a_t = \omega (p_t^a)^{-\theta} F_t$$

$$b_t = (1 - \omega) (p_t^b)^{-\theta} F_t.$$

3.3 The Bank

The bank collects deposits from the worker, makes loans to the entrepreneur, and trades foreign assets with the rest of the world. Foreign assets A_{t+1} are measured in terms of foreign intermediate goods.¹⁴ The value of foreign assets in terms of the home intermediate good is therefore $p_t A_{t+1}$, where $p_t = p_t^b/p_t^a$ are the terms of trade defined as the ratio of import to export prices. p_t^b is set constant due to our small open economy assumption. As in Kollmann et al. (2011), the bank faces a capital requirement. The capital in period t , $L_{t+1} + p_t A_{t+1} - D_{t+1}$, should not fall below a fraction γ of the bank's assets $L_{t+1} + p_t A_{t+1}$. When the bank does not meet the capital requirement and capital falls short of the required fraction γ , the bank incurs costs. These costs might be imposed by the regulators or by market discipline and depend in an increasing way on the amount of capital falling short of the requirement. In this case the excess capital x_t , defined as $x_t = (1 - \gamma)(L_{t+1} + p_t A_{t+1}) - D_{t+1}$, turns negative. The cost function $\phi(x_t)$ has the following convex form:¹⁵

$$\phi(x_t) = \phi_1 x_t + \frac{\phi_2}{2} (x_t)^2.$$

If capital is below the requirement and excess capital is negative the bank faces positive costs, whereas holding more capital than required reduces the chance of falling below the constraint, thereby easing market operations and leading to a reduction of the following operation costs by adding $\phi(x_t) > 0$. All bank operations - collecting deposits from workers, handing out loans to entrepreneurs, and holding foreign assets - lead to linear operation costs Γ . The bank's budget constraint is:

$$\begin{aligned} p_t^a \left(L_{t+1} + D_t R_{t-1}^D + \Gamma(D_{t+1} + L_{t+1} + A_{t+1}) + \phi(x_t) + \frac{\chi_A}{2} (A_{t+1} - \bar{A})^2 \right) \\ + p_t^b A_{t+1} + d_t^B = p_t^a \left(L_t R_{t-1}^L + D_{t+1} \right) + p_t^b A_t R_t^A Q_t. \end{aligned} \quad (15)$$

Here, d_t^B is the banker's dividend income. To induce stationarity we assume that the foreign assets are subject to quadratic portfolio adjustment costs (see Schmitt-Grohé and Uribe, 2003). Specifically, holding foreign assets that are different from their steady-state value \bar{A} is costly. The foreign asset pays a risky return, such that R_t^A is the expected gross return of foreign assets accumulated in period $t - 1$. The return is exogenous and follows an $AR(1)$ -process:

$$\log(R_t^A) = (1 - \rho_R) \log(\bar{R}^A) + \rho_R \log(R_{t-1}^A) + \varepsilon_{R,t}.$$

¹⁴Actually, more than half of the claims by German banks on non-residents are denominated in Euro. However, here we focus on a financial shock originating in the US financial market and the vast majority of German banks' claims on the US are denominated in US dollar, on average around 90%. The same percentage applies to overall claims on non-residents by UK banks.

¹⁵This form guarantees that the bank has an incentive to return to the steady-state bank capital after shocks in the linearized model. Note that an approximation of ϕ' , which plays an important role in the bank's first-order conditions below, features ϕ_2 times actual excess capital. The parameter ϕ_2 hence determines the effects of having bank capital deviating from its target on the bank's costs. See Kollmann et al. (2011) for a more extensive discussion.

In addition, foreign assets are subject to an unpredictable i.i.d. valuation shock Q_t . With this structure we split the return of the foreign asset into returns under normal circumstances and into a valuation shock that represents more fundamental re-evaluations, such as writeoffs. Thus, the valuation shock will subsequently represent the foreign financial shock of the crisis. The banker consumes her dividend income and maximizes her utility function

$$U_t = E_t \sum_{s=0}^{\infty} \beta^s \left[\frac{(d_{t+s}^B)^{1-\sigma_B} - 1}{1 - \sigma_B} \right]$$

by choosing $L_{t+1}, A_{t+1}, D_{t+1}$, subject to the budget constraint (15). The corresponding first-order conditions are:

$$\beta E_t \left[\frac{p_{t+1}^a}{p_t^a} \left(\frac{d_{t+1}^B}{d_t^B} \right)^{-\sigma_B} R_t^L \right] = 1 + \Gamma + \phi'(x_t)(1 - \gamma), \quad (16)$$

$$\beta E_t \left[\frac{p_{t+1}^b}{p_t^b} \left(\frac{d_{t+1}^B}{d_t^B} \right)^{-\sigma_B} R_{t+1}^A Q_{t+1} \right] = 1 + \frac{\Gamma}{p_t} + \phi'(x_t)(1 - \gamma) + \frac{\chi_A}{p_t} (A_{t+1} - \bar{A}), \quad (17)$$

$$\beta E_t \left[\frac{p_{t+1}^a}{p_t^a} \left(\frac{d_{t+1}^B}{d_t^B} \right)^{-\sigma_B} R_t^D \right] = 1 - \Gamma + \phi'(x_t). \quad (18)$$

3.4 Market clearing and definitions

We assume that the costs incurred by the bank are paid in terms of the home intermediate good. The bank has to buy these resources from the entrepreneur. Thus, market clearing for the home intermediate good requires

$$Y_t = a_t + a_t^* + \phi(x_t) + \Gamma(D_{t+1} + L_{t+1} + A_{t+1}) + \frac{\chi_A}{2} (A_{t+1} - \bar{A})^2, \quad (19)$$

where a_t^* is the amount of the home intermediate good exported to the rest of the world. The demand from the rest of the world for home intermediate goods is specified as (see, e.g., Justiniano and Preston, 2010):

$$a_t^* = (1 - \omega) (p_t^{*a})^{-\theta} Y_t^*. \quad (20)$$

The foreign demand depends on the relative price for the home intermediate good in the rest of the world p_t^{*a} , which is inversely related to the terms of trade p_t , and on foreign demand Y_t^* that follows an $AR(1)$ process

$$\log(Y_t^*) = \rho_Y \log(Y_{t-1}^*) + \varepsilon_{Y,t}. \quad (21)$$

Net exports scaled by GDP are

$$nx_t = \frac{a_t^* - p_t b_t}{Y_t}. \quad (22)$$

Finally, market clearing for the final good requires that the production of final goods equals the sum of aggregate consumption, which is the sum of worker, entrepreneur and banker consumption, and the goods used for investment:

$$F_t = C_t + d_t^E + d_t^B + \xi(I_t). \quad (23)$$

3.5 Calibration

The model is calibrated to match properties of the German and UK economies. The overview of the calibration exercise is shown in Table 1. If not otherwise specified, the sample period runs from the first quarter of 1991 to the fourth quarter of 2012. A detailed description of all data sources can be found in the appendix. A period in the model corresponds to one quarter. The elasticity of substitution between home and foreign goods θ is fixed at 1.5, a standard value in the literature (see Backus et al., 1994). Physical capital depreciates with a rate of $\delta = 0.025$ per quarter. Similar to Davis (2010), the parameter governing portfolio adjustment costs is assumed to take a small value, $\chi_A = 0.005$. We set the parameter ω such that trade openness in the model $1 - \omega$ matches the average trade openness of Germany and the UK during the sample period. The capital shares in production α are 0.3 and 0.35, which correspond to the average capital shares in Germany and the UK over the sample period. We use the investment adjustment cost parameter Ξ to match the relative volatility of investment of the model, i.e. the standard deviation of investment relative to the standard deviation of GDP, with the empirical counterparts of 2.48 and 3.22 (see Tables 2 and 3). To calculate the relative investment volatility of the model, we simulate the model including all simultaneous shocks, see below.

The approximate capital ratio of German banks, i.e. the ratio of bank equity to total bank assets (not risk-weighted), over the period 2000-2011 was 4.35%, whereas for the UK the ratio of bank equity to total bank assets over the period 2000-2010 was 6.5%. Thus, we set the steady-state bank capital ratio to $\gamma = 0.0435$ for Germany as well as $\gamma = 0.065$ for the UK. The steady state deposit and loan rates are set to their respective averages over the period 1997-2012, 2.69% p.a. and 5.60% p.a. for Germany and 3.73% and 5.91% for the UK. Thus, the spreads in steady state are 2.91% and 2.18%, implying values for Γ of 0.0035 for Germany and 0.0026 for the UK. This parameter has to be set simultaneously with ϕ_1 . Excess capital in steady state is zero. We also need to fix the parameters of the excess capital cost function, ϕ_1 and ϕ_2 . Together with the bank's costs Γ for handling deposits, loans, and foreign assets, ϕ_1 determines the deposit and loan rates, and hence the spread. These parameters are therefore set to match both interest rates (see above) for both countries. For the curvature of the excess cost function, we follow Kollmann et al. (2011) and set $\phi_2 = 0.25/Y$. As demonstrated in detail in Kollmann et al. (2011) and supported by micro evidence cited therein, this value is consistent with the empirical relation between loan-to-deposit ratios and interest rate spreads. The loans to physical capital ratio, which together with $x = 0$ determines Ψ^N and Ψ^D , is set such that the ratio

Table 1: Calibration

<i>Parameter</i>		GE	UK	Target/Source
Trade price elast.	θ	1.5	1.5	BKK (1994)
Depreciation rate	δ	0.025	0.025	Annual δ
Portfolio adj. cost	χ_A	0.005	0.005	Davis (2010)
Home bias	ω	0.63	0.71	GE/UK data
Capital share	α	0.30	0.35	"
Investment adj. costs	Ξ	0.0314	0.0261	$\sigma_I/\sigma_Y = 2.48$ (GE), 3.22 (UK)
St. st. bank capital	γ	0.0435	0.065	GE/UK data
Operation costs	Γ	0.0035	0.0026	Spread = 2.91% (GE), 2.18% (UK)
St. st. slope of costs	$\phi'(0)$	-0.0037	-0.0027	$r_D = 2.69\%$ (GE), 3.73% (UK)
Convexity of costs	$\phi''(0)$	0.25/Y	0.25/Y	Kollmann et al. (2011)
Labor Supply	Ψ^N	2.45/Y	3.15/Y	L/Y = 34% (GE), 27% (UK)
Preference for deposits	Ψ^D	0.022	0.021	$x = 0$
St. st. A/L	A/L	0.58	1.37	GE/UK data
Discount factor	β	0.986	0.985	$r_L = 5.6\%$ (GE), 5.91% (UK)
IEOS	$\sigma_B = \sigma_w$	1	1	Log utility
Entrepreneur IEOS	σ_E	0.01	0.01	Risk neutral
Utility parameter	$\psi_w = \psi_E$	0.85	0.85	Gerali et al. (2010)
Autocorr. trade	ρ_{Y^*}	0.95	0.96	SUR estimation
Std. Dev. trade		1.53%	1.51%	"
Autocorr. TFP	ρ_z	0.76	0.93	"
Std. Dev. TFP		1.05%	0.64%	"
Autocorr. for. return	ρ_R	0.097	0.076	"
Std. Dev. for. return		4.37%	4.46%	"
Corr. TFP & trade	$\text{Corr}(\varepsilon_z, \varepsilon_{Y^*})$	0.39	0.46	"
Corr. TFP & for. return	$\text{Corr}(\varepsilon_z, \varepsilon_R)$	0	0.28	"
Corr. trade & for. return	$\text{Corr}(\varepsilon_{Y^*}, \varepsilon_R)$	0.28	0.27	"
<i>Crisis Shocks</i>				
Financial shock	ε_Q	-10%	-7.25%	For. writeoffs
Trade shock	ε_{Y^*}	-10.76%	-10.35%	For. demand
Autocorr. trade shock	ρ_{Y^*}	0.53	0.53	yoy ΔY^*

of loans to annual GDP in steady state matches the mean of the empirical counterparts for Germany and the UK during the sample period, which are 34% and 27%, respectively. We also fix the ratio of loans to foreign assets in steady state. Empirically, the ratios of foreign securities to domestic loans are approximately 58% for Germany and 137% for the UK. The loan interest rate also determines the subjective discount factor, which is $\beta = 0.9862$ for Germany and $\beta = 0.9855$ for the UK. This follows from the Euler equation of the entrepreneur, see equation (14). We follow Kollmann et al. (2011) and assume log utility for the worker and the banker, $\sigma_w = \sigma_B = 1$, and almost risk-neutral entrepreneurs, i.e. $\sigma_E = 0.01$.¹⁶ As in Gerali et al. (2010), entrepreneurs and workers have the same consumption habits of $\psi_E = \psi_w = 0.85$.

¹⁶Besides the positive influence of lower risk aversion on the decision to become entrepreneurs, evidence cited in Kollmann et al. (2011) shows that the implied higher volatility of entrepreneurial consumption is in line with the empirical finding of a higher volatility of wealthier people, as entrepreneurs are typically wealthier.

The foreign demand process is approximated using a series constructed for the trade-weighted overall imports of the respective top 10 trading partners for Germany and the UK (see Figure 2). The global demand series have an autocorrelation of 0.95 for Germany and 0.96 for the UK and a standard deviation of 1.53% and 1.51%. The $AR(1)$ process for TFP is matched to linearly detrended German log TFP. Based on this measure, we set $\rho_z = 0.76$ and the unconditional standard deviation of German TFP to 1.05%. The same is done for the UK, whose TFP has an autocorrelation of 0.93 and an unconditional standard deviation of 0.64%. For the return process of foreign assets we combine data on stock and corporate debt returns, see the Appendix for details. This series gives us an autocorrelation of 0.097 and a standard deviation of 4.37% for Germany, and an autocorrelation of 0.076 and a standard deviation of 4.46% for the UK.

We also match the empirical correlations between the three data series. The correlation between TFP and foreign demand is 0.39 in the case of Germany and 0.46 in the case of UK, while the correlations between foreign demand and foreign returns are 0.28 for Germany and 0.27 for the UK. In contrast, the correlation between the returns to foreign assets and home TFP for Germany is not significantly different from zero, for the UK, on the other hand, it is 0.28.

4 Results

4.1 Business Cycle Statistics

Before we analyze how the financial crisis was transmitted in our model, we first examine whether the model is able to capture features of normal German and UK business cycles. For this purpose, we compare second moments of HP-filtered German and UK data for the period 1991Q1-2012Q4 with unconditional HP-filtered moments of the model.¹⁷ For the three shock processes for TFP, trade and foreign-asset returns, we use the fitted $AR(1)$ processes as described in the previous section. The valuation shock does not play a role under normal circumstances. Hence, we only include the shock process for ‘normal’ foreign asset returns.

Tables 2 and 3 present moments of the data (Column 1), of the model with all shocks (Column 2), and of the model including TFP, trade, and foreign asset return shocks individually (Columns 3-5). The model is able to capture many features of German and UK business cycles. GDP volatility generated by the model including all shocks is somewhat higher than the one in the data. However, the relative volatilities of the other variables and their correlations with GDP are matched well. As in the data, aggregate consumption is less volatile than GDP. Investment adjustment costs were calibrated such that relative investment volatility matches the data exactly. Loans show a higher relative volatility than deposits in the model, similar to the empirical observations. Deposits and loans are a lot more volatile in the UK than in the German data. The model successfully replicates this difference in volatilities. For Germany, as in the data, investment is more procyclical than consumption. While the model is

¹⁷We use a smoothing coefficient of 1600 and take logs of all variables before filtering, except for net exports and the interest rate spread, as these variables are already expressed in percentage points.

Table 2: Business Cycle Statistics of German data and the model

	Data	Model				
	(1)	All (2)	TFP (3)	Trade (4)	FA ret. (5)	No fin. fric. (6)
Std. dev. output	1.48	1.88	1.78	0.04	0.63	1.73
<u>Relative standard deviations</u>						
Consumption	0.49	0.69	0.56	2.50	1.34	0.55
Investment	2.48	2.48	2.33	7.97	2.98	2.48
Employment	0.40	0.63	0.45	1.52	1.41	0.42
Deposits	1.01	0.78	0.42	6.79	1.76	0.52
Loans	1.65	1.53	0.94	8.29	3.93	0.88
Interest rate spread	0.40	0.12	0.02	0.84	0.37	0.00
Net Exports	0.52	0.29	0.12	6.68	0.71	0.19
<u>Correlation with GDP</u>						
Consumption	0.42	0.70	0.77	0.34	0.78	0.74
Investment	0.88	0.92	0.95	-0.79	0.76	0.95
Employment	0.44	0.86	0.97	0.97	1.00	0.97
Deposits	0.04	0.17	0.32	-0.88	-0.02	0.32
Loans	-0.02	-0.01	0.04	0.29	-0.15	0.10
Interest rate spread	-0.40	-0.44	-0.95	-0.74	-0.98	-0.61
Net Exports	0.30	0.16	0.21	-0.59	-0.49	0.44

not able to generate the negative correlation between deposits and GDP for the UK, the signs of all remaining variables with GDP are predicted correctly for both countries. The most striking difference between Germany and the UK in terms of correlations is the opposing sign for the relatively strong positive (negative) correlation of the net export-to-GDP correlation for Germany (UK), which is also predicted by the model.

Considering the three shocks individually shows that the model including only the TFP shock strongly underpredicts the relative volatilities of the financial variables and net exports. It also generates a too large correlation between deposits and GDP. This underlines the importance to include also the trade and financial shocks to account for business-cycle moments. The trade shock contributes relatively little to output fluctuations. However, it is not only the main driver of the current account, but has also a large impact on deposits (in Germany) and loans (in both countries). On the other hand, its predictions for the correlations of deposits and loans with GDP are quite far away from the empirical values. The financial shock brings these correlations closer towards the data (for Germany it is the only one that predicts the correct sign for loans' correlation with GDP). It is furthermore responsible for a large part of the fluctuations in loans (in both countries) and deposits (in the UK), and generates volatilities of the spread that are in line with the data.

Table 3: Business Cycle Statistics of UK data and the model

	Data	Model				
	(1)	All (2)	TFP (3)	Trade (4)	FA ret. (5)	No fin. fric. (6)
Std. dev. output	1.16	2.24	1.28	0.19	1.61	1.24
<u>Relative standard deviations</u>						
Consumption	0.90	0.97	0.66	1.16	1.16	0.59
Investment	3.22	3.22	2.66	1.61	3.46	3.22
Employment	0.45	1.14	0.51	1.46	1.48	0.48
Deposits	2.19	1.26	0.73	0.80	1.53	0.80
Loans	3.86	3.51	2.04	4.68	4.38	1.98
Interest rate spread	0.45	0.27	0.05	0.46	0.37	0.00
Net Exports	0.42	0.33	0.09	1.18	0.46	0.15
<u>Correlation with GDP</u>						
Consumption	0.77	0.82	0.81	0.95	0.86	0.72
Investment	0.77	0.90	0.91	0.17	0.90	0.92
Employment	0.54	0.94	0.99	1.00	0.99	0.99
Deposits	-0.14	0.06	0.23	-0.67	-0.01	0.29
Loans	0.40	0.03	0.17	-0.06	-0.01	0.23
Interest rate spread	-0.61	-0.86	-0.98	-0.97	-0.98	-0.18
Net Exports	-0.20	-0.76	-0.73	-0.98	-0.93	-0.02

Lastly, we also demonstrate the importance of the financial friction in this model. Column (6) in Tables 2 and 3 shows the results of simulating the model with $\phi_2 = 0.0001$.¹⁸ Up to a first-order approximation, costs and benefits from taking further deposits or handing out loans do not depend on bank capital in this case. The bank has therefore no incentive to return to the required bank capital. Hence, the spread does not depend on the level of bank capital in the linearized model, effectively eliminating the effect of the financial friction on the model dynamics. As visible in the tables, the results are close to those obtained if only TFP shocks occur. We conclude that the financial friction is essential in generating realistic business cycle fluctuations in our model. Contrary to us, Kollmann et al. (2011) find a limited role for financial frictions for normal business cycles in a distinct but related model. This can be explained by the different types of financial shocks considered. While they focus on loan-default shocks, which were at the center of the financial crisis in the US, we consider variable returns on foreign asset holdings, as they were an important transmission channel from the US to financially connected countries. These returns are much more volatile than losses on loans, pointing to higher risk-taking when acquiring foreign assets by German and UK banks. Furthermore, writedowns on

¹⁸We avoid a unit root by setting this parameter to a very small but positive number. Investment adjustment costs are adjusted to generate the observed relative investment volatilities.

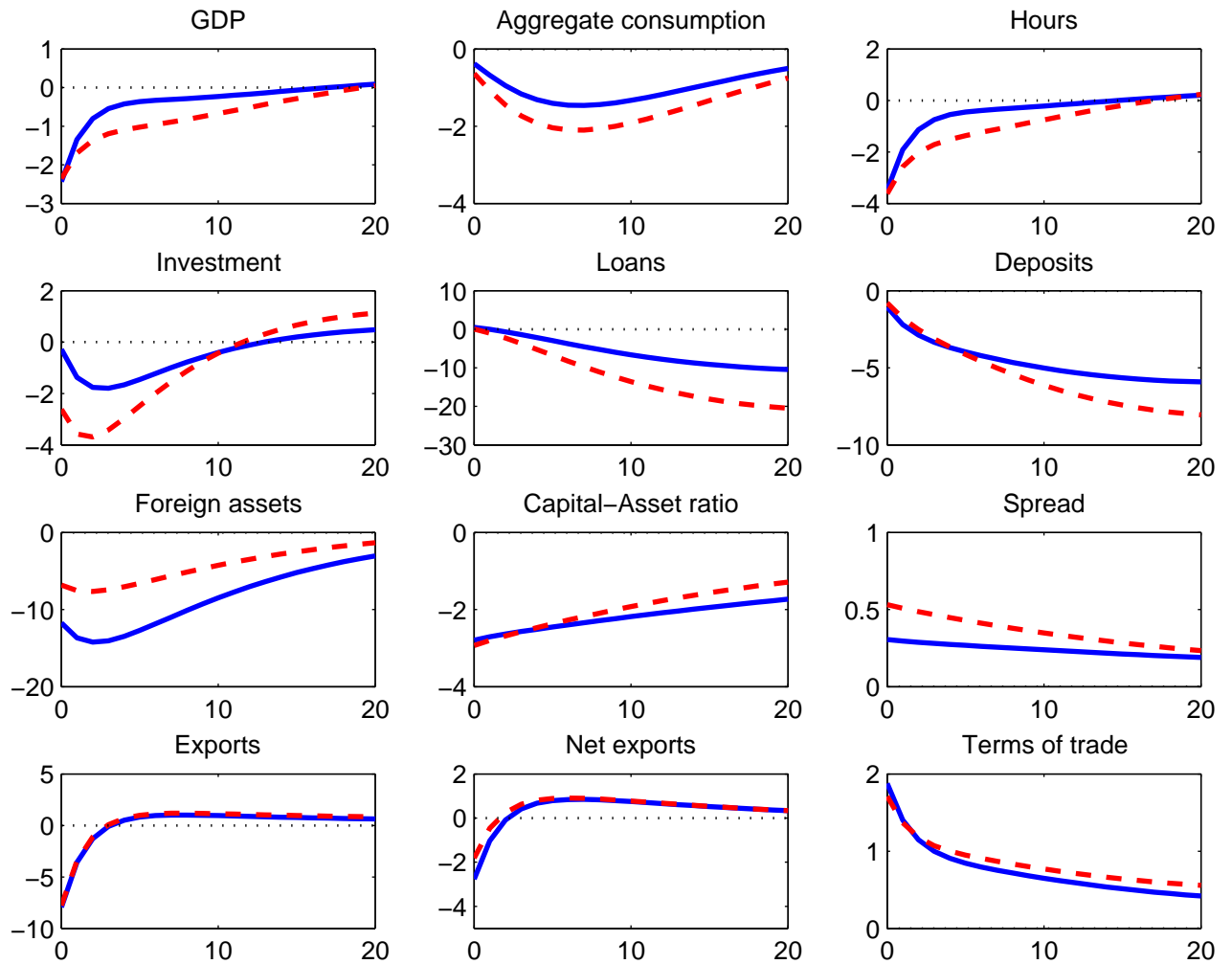


Figure 6: Impulse-response functions to simultaneous trade and financial shocks.

Solid lines represent IRFs for Germany, dashed lines for the UK. Variables are expressed in percentage deviations from steady state, except spread (in percentage points p.a.), capital-asset ratio, and net exports over GDP (both in percentage points).

domestic loans are equivalent to transfers to the defaulting entrepreneurs in Kollmann et al. (2011). In our model the lost resources do not appear in other agents budget constraints, as they represent transfers to the foreign country. Having shown that the proposed model captures the properties of German and UK business cycles statistics quite well, we now continue to analyze how the latest financial crisis was transmitted to the German and to the UK economy.

4.2 Crisis Transmission

In this section, we assess whether the model economy can capture characteristics of the German and UK economies during the financial crisis when hit simultaneously by a trade and a financial shock. Their combined impact reduces foreign demand and destroys part of the bank capital. The magnitudes

of the shocks are chosen to match the observed declines in trade and asset values. The financial shock for Germany is set to -10%, to match the estimated losses on foreign loans and securities incurred by German banks, whereas the financial shock for the UK is set to -7.25% (see Section 2). Hence, foreign assets are hit by a one time valuation shock $\varepsilon_{Q,t}$ of -10% and $\varepsilon_{Q,t}$ of -7.25%, respectively. The trade shock is set to -10.8% for Germany and -10.4% for the UK, based on out trade measures (see Figure 2). The autocorrelation of the trade shock is adjusted to 0.53 for both countries, different to the previous section. We hereby intend to capture the length of the compressed demand in the crisis.¹⁹

Figure 6 represents the impulse responses to a negative trade and a simultaneous financial shock for Germany (solid line) and the UK (dashed line).²⁰ As visible, the model predicts reductions in output, investment, exports, banks' foreign assets, bank capital, loans, and an increase in the loan-deposit interest rate spread, all in line with our observations of Section 2. Additionally, also consumption, deposits, and hours worked are predicted to fall, while the terms of trade depreciate. The main differences between Germany and the UK occur in the responses of loans, deposits, the spread, and investment. The initial impact on GDP following the simultaneous shocks is slightly higher for Germany, while the UK suffers from a more sluggish recovery. We will provide intuition for these results when discussing the reactions to the individual shocks below.

In order to quantitatively compare the model predictions with the developments in Germany and the UK, we calculate the maximum deviations of individual variables over the course of 2009 from their average value in the second half of 2008. While an exact measurement of the impact of the financial crisis is impossible, we think that this procedure gives us estimates that are not too dependent on assumptions about the exact timing. Naturally, shocks and policies that are not included in the model have surely played a role during that time. Remember, however, that we merely want to investigate the impact of the trade and financial shocks on the German and UK economies. To the extent that, e.g., quick policy responses had additional positive effects and/or further shocks added negative pressures, the theoretical predictions will deviate from our empirical measures. These deviations then allow us to gauge the net effects of additional developments present during this episode. Table 4 compares the maximum responses in the data (Column 1) and as predicted by the model (Column 2 for both shocks; maximum responses in the four quarters following the shocks) for the German calibration, while Table 5 presents results for the UK calibration. The model is able to explain 43.5% of the output decline in the data for Germany, indicating that Germany was exposed to further negative shocks and/or transmission channels that are not subject of this paper. The UK experience, on the other hand, can be sufficiently well explained by the financial and trade transmission channels, which explain approximately 87.4% of the maximum output decline.

The tables also display the reactions triggered by each shock individually. For both countries, the

¹⁹See the appendix for all calculations and data sources.

²⁰To be clear, here and in the following we simulate the model either for simultaneous or for isolated occurrences of the financial and/or the trade shock. We set the correlation between shocks to zero, such that TFP and the respective other shock remain constant in the case of isolated shocks.

Table 4: Model Responses Germany

	Data	Model					
		Maximum response			Cumulative response		
		Both shocks	Trade	Financial	Both shocks	Trade	Financial
Output	-5.59	-2.43	-1.67	-0.88	-5.13	-1.79	-3.34
Consumption	-0.81	-1.16	0.25	-1.30	-3.18	0.81	-3.99
Investment	-12.71	-1.79	3.19	-3.47	-5.21	5.91	-11.12
Employment	-0.26	-3.48	-2.39	-1.17	-7.27	-2.71	-4.57
Deposits	-4.40	-3.34	-2.03	-1.31	-9.49	-6.40	-3.09
Loans	-6.06	-1.38	1.45	-2.83	-1.55	5.21	-6.76
Interest rate spread	1.50	0.31	-0.08	0.38	1.17	-0.30	1.47
Net exports	-2.27	-2.77	-3.17	0.56	-3.48	-5.47	1.99

Notes: First column displays empirical moments for Germany. Other columns show results from simulation of the model calibrated to Germany, with either both shocks (second and fifth column), only the trade shock (third and sixth column) or only the financial shock (fourth and seventh column) operating.

trade shock (Column 3) explains around 30% of the observed drop in output. The isolated financial shock (Column 4) triggers a reduction in output of 15.7% and 60.4% of the empirical output drop for Germany and the UK, respectively. The fraction of the theoretically explained output decline that can be attributed to each channel is hence exactly opposite for both countries. While in Germany the trade shock alone generates an output drop of 68.7% of the decline generated by both shocks together, the trade shock triggers 36.2% of this response.²¹ For the UK the proportions are 34.7% for the trade shock and 69.1% for the financial shock.

The fall in net exports is predicted well for Germany, showing that the reduced trading activity is explained quite accurately by the trade channel. German deposits, which are to a relatively large extent driven by the trade channel (see above), are also explained fairly well. The financial channel plays a smaller role for the output drop, but is essential to bring about a decline in loans and an increase in the spread. It also has a much more detrimental effect on investment than the trade shock, although the model strongly underpredicts the investment slump. Arguably, risen uncertainty after the crisis, which is a channel not present in the model, might have contributed to this extreme response in the data.

For the UK, the model predictions are closer to the data, suggesting that the two considered channels combined played a larger role. Drops in output and consumption are similar to their empirical counterparts. The fall in investment is again underpredicted, but less than in the German case. Although loans, as in the data, are predicted to fall more than in Germany (see Figure 6), they took an additional and unexplained hit in the UK. As in the German calibration, the trade shock is the main driver of

²¹The numbers add up to more than 100% for some variables, as the maximum responses following individual shocks can occur at different times.

Table 5: Model Responses UK

	Data	Model					
		Maximum response			Cumulative response		
		Both shocks	Trade	Financial	Both shocks	Trade	Financial
Output	-2.70	-2.36	-0.82	-1.63	-6.62	-0.23	-6.39
Consumption	-2.25	-1.73	0.40	-2.06	-4.90	1.44	-6.34
Investment	-9.26	-3.69	4.35	-6.96	-13.29	8.13	-21.42
Employment	-0.29	-3.62	-1.26	-2.39	-9.93	-0.59	-9.34
Deposits	-4.11	-3.12	-0.94	-2.18	-8.21	-3.01	-5.20
Loans	-18.11	-3.72	2.70	-6.42	-6.95	8.72	-15.67
Interest rate spread	1.37	0.53	-0.16	0.69	1.99	-0.59	2.59
Net exports	-0.79	-1.81	-2.50	0.79	-1.40	-4.42	3.02

Notes: First column displays empirical moments for the UK. Other columns show results from simulation of the model calibrated to the UK. See Table 4 for a description of columns.

the trade balance, whose response is, however, overpredicted for the UK. The financial shock, on the other hand, is more dominant for the UK than for Germany. It exerts strong negative pressure on consumption, investment, deposits, and loans. It also pushes up the spread in the crisis. In both countries, employment fell much less than expected, given the size of the shocks. At least for Germany, this reduced employment reaction together with a surprisingly low drop in consumption might be due to the government-subsidized short-time work.²²

To summarize, the model does well in predicting the reactions of important variables in the crisis, with some exceptions. To account for the impact of the financial crisis on Germany and the UK, it turns out to be crucial to consider the simultaneous occurrence of the trade and financial shocks. In particular, the model responses show a decline in macroeconomic activity, with output, consumption, investment, and hours decreasing on impact. Similarly, deposits, loans, and net exports fall, while the interest rate spread rises.²³ The model predicts the correct sign for all of these features of the financial crisis for Germany and the UK.

To gain more insights into the dynamic responses triggered by the two shocks, we display the impulse-response functions for the financial and the trade shocks separately in Figures 7 and 8 and provide some intuition. Both shocks have the same magnitudes as before. Both lead to a decline in output and hours, where the financial shock is triggering hump-shaped responses. The reactions of other variables, in particular bank capital and exports, differ more starkly across shocks. As already visible in Tables 4 and 5, we will see that the developments in Germany and the UK can only be explained by a combination of the trade and the financial shock. Both shocks would predict the wrong sign for key variables if they occurred in isolation.

In the case of the financial shock, the deteriorating value of foreign assets in domestic currency leads

²²See Balleer et al. (2013) for a discussion of the job-saving properties of this scheme.

²³Since the considered shocks are idiosyncratic to the foreign country, they naturally have stronger effects on relative variables than common shocks. They also generate co-movement between Germany and the UK as those economies are hit by similar external shocks.

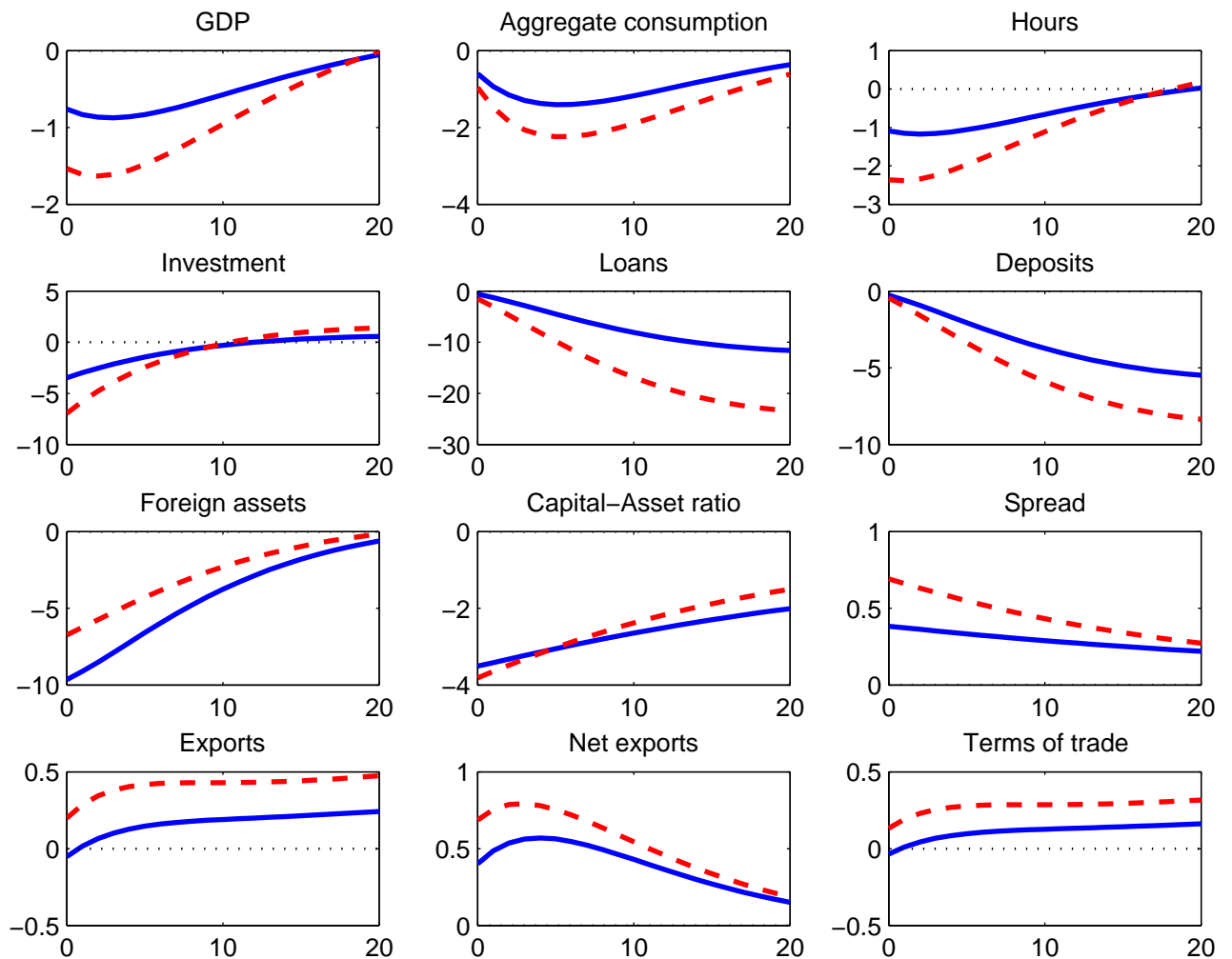


Figure 7: Impulse-response functions to financial shock.

Solid lines represent IRFs for Germany, dashed lines for the UK. Variables are expressed in percentage deviations from steady state, except spread (in percentage points p.a.), capital-asset ratio, and net exports over GDP (both in percentage points).

to a decline in bank capital. Interestingly, the relatively lower writeoffs on UK foreign asset holdings, resulting from the better portfolio choice of UK banks relative to their German counterparts, translates into a larger drop of the capital-asset ratio because of the much larger ratio of foreign assets to loans (and to GDP) in the UK. Correspondingly, the spread increases more strongly and the output drop is more pronounced in the UK. Specifically, the shock sets off an increase in the loan-deposit rate spread by about 0.4 percentage points for the German model and by about 0.7 percentage points for the UK, which translates into a fall of loans and deposits. The larger increase in the spread reduces aggregate consumption and investment relatively more in the UK, which lowers prices of domestically produced goods. The resulting depreciated terms of trade increase exports slightly, by less than 0.5% over four years, while imports fall. Germany, on the other hand, experiences a smaller depreciation of the terms of trade and hence a more subdued expansion of exports.

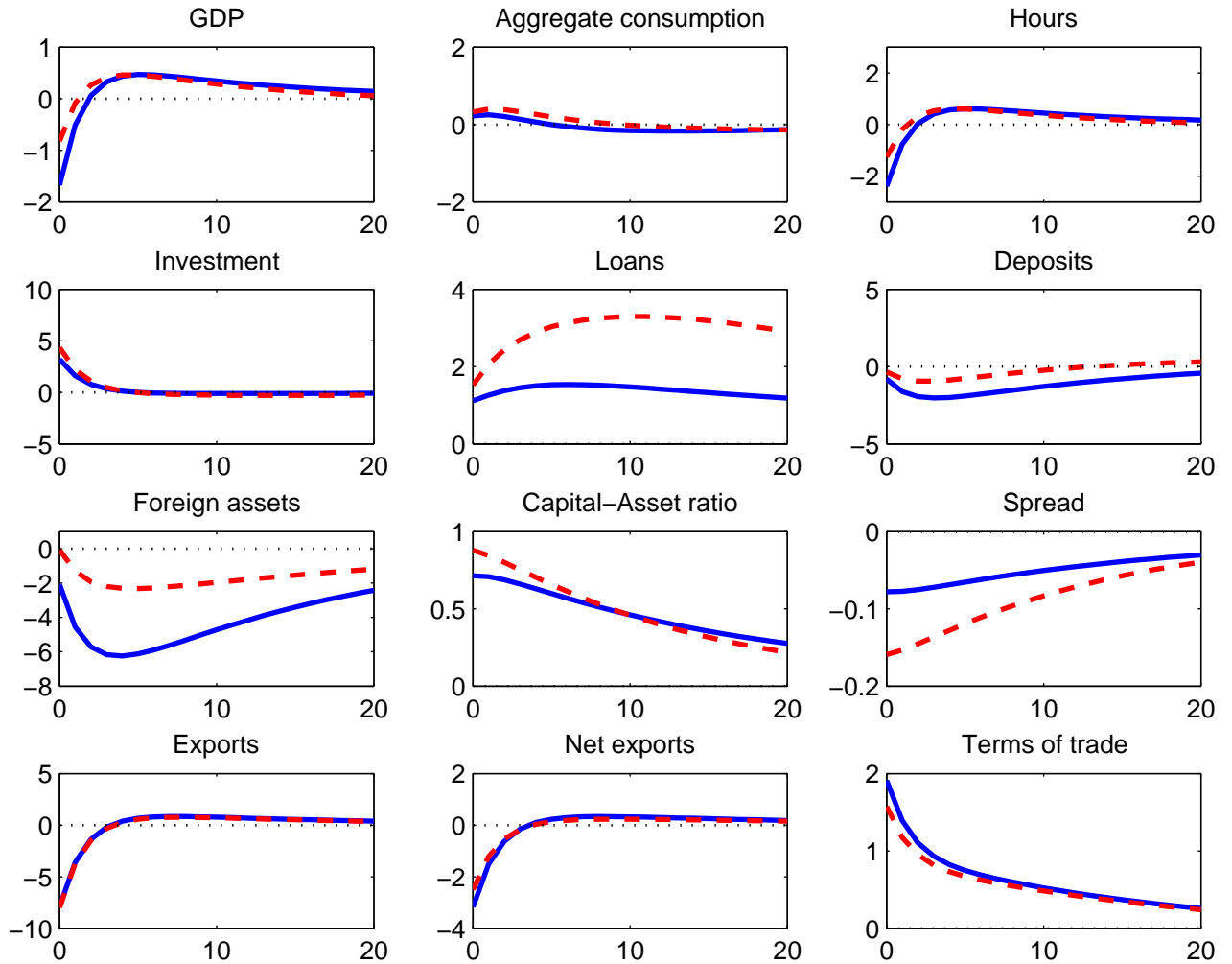


Figure 8: Impulse-response functions to trade shock.

Solid lines represent IRFs for Germany, dashed lines for the UK. Variables are expressed in percentage deviations from steady state, except spread (in percentage points p.a.), capital-asset ratio, and net exports over GDP (both in percentage points).

In contrast, bank capital increases in the case of the trade shock, putting downward pressure on the spread. This is driven by a positive response of loans and a reduction of deposits during the first few quarters, both used for smoothing out the impact of the shock on consumption. Foreign assets on the other hand decline, as the bank shifts its assets towards more loans. The initial slight increase of aggregate consumption following a trade shock is mainly driven by consumption of entrepreneurs because of intertemporal consumption shifting, triggered by a lower loan rate. This lower loan rate, in turn, results from an expected appreciation of the terms of trade, i.e. back towards the steady state after the initial depreciation that follows the reduction in demand. Expected returns on foreign assets in domestic currency hence fall and by arbitrage also domestic loan rates. Because they are almost risk neutral, entrepreneurs react strongly to interest-rate movements. Bankers' consumption also increases, but its share in aggregate consumption is very low. On the other hand, consumption of workers, which

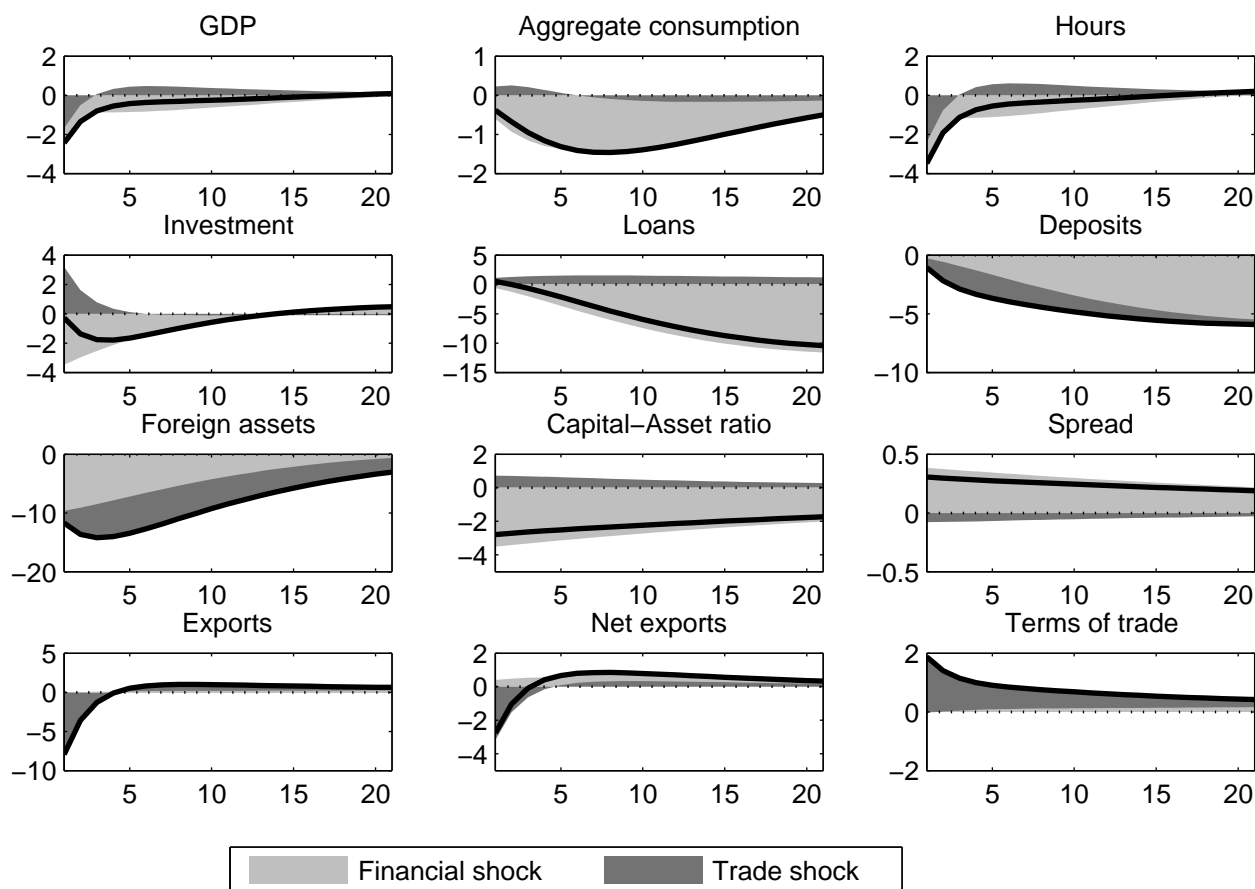


Figure 9: Relative impact of trade and financial shock for Germany.

Dark grey areas represent effects of the trade shock, light grey areas show effects of the financial shock. Thick black lines depict the aggregate response. Variables are expressed in percentage deviations from steady state, except spread (in percentage points p.a.), capital-asset ratio, and net exports over GDP (both in percentage points).

constitutes the largest part of aggregate consumption, falls. Lower interest rates and higher net exports, which turn into a surplus because of the continued depreciation of the terms of trade, lead to a quick and overshooting recovery of GDP. The main difference between the German and the UK reaction to the trade shock is again due to the larger foreign-assets-to-loans ratio in the UK. The depreciation of the terms of trade increase the value of foreign assets in terms of domestic goods, such that bank capital rises further than in Germany.²⁴ The resulting stronger reduction in the spread stimulates the economy more in the UK. The large exposure to foreign assets, which leads to detrimental effects in case of the financial shock, hence serves as an automatic stabilizer after a trade shock.

Comparing the output responses for the two shocks shows that the initial impact of the trade shock is higher relative to the financial shock for Germany and vice versa for the UK. However, in both cases output needs a much longer time to recover from the financial shock. Given that German and even

²⁴Remember that bank capital in period t is $L_{t+1} + p_t A_{t+1} - D_{t+1}$, where the terms of trade p_t unexpectedly rise following a trade shock.

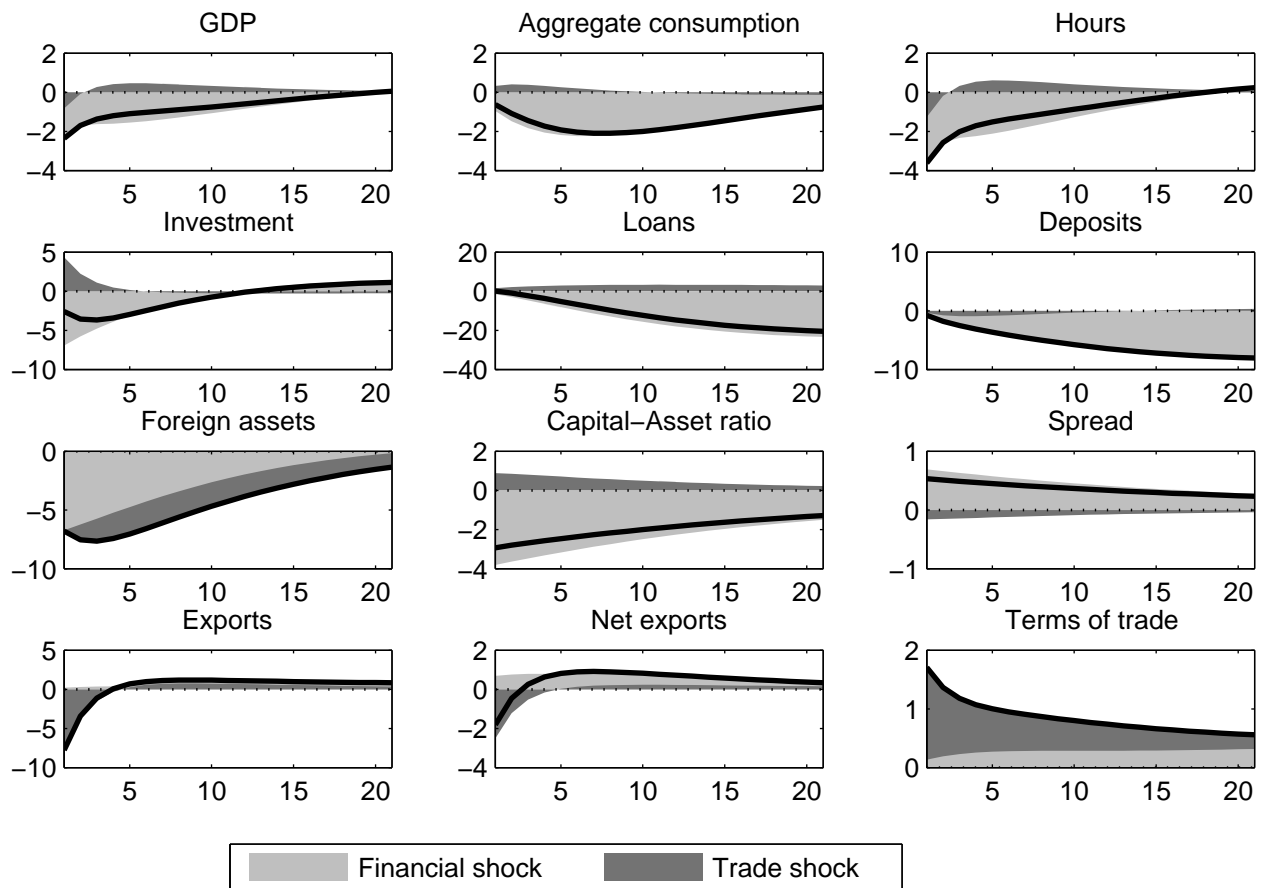


Figure 10: Relative impact of trade and financial shock for the UK.

Dark grey areas represent effects of the trade shock, light grey areas show effects of the financial shock. Thick black lines depict the aggregate response. Variables are expressed in percentage deviations from steady state, except spread (in percentage points p.a.), capital-asset ratio, and net exports over GDP (both in percentage points).

more so UK output in the third quarter of 2010 was still below its level two years before, the financial shock plays an important role to explain the prolonged recovery. To visualize these aspects, we plot the relative contributions of both shocks in Figure 9 for Germany and Figure 10 for the UK. The dark grey area depicts the contribution of the trade shock, the light grey area represents the contribution of the financial shock, while the thick black line shows the aggregate response. As visible, the trade shock explains almost all of the movements of net exports and the terms of trade, while the financial shock is responsible for most of the reactions of consumption and the financial variables. Deposits in Germany and foreign assets in both countries, however, are also driven to a non-negligible amount by the trade shock. Concerning GDP, the trade shock's relative influence is largest on impact, especially in Germany. Longer horizons, on the other hand, are dominated by the financial shock. This is also reflected in the cumulative responses, presented in Columns (5)-(7) of Tables 4 and 5. We accumulate the quarterly values of individual responses over the course of one year. In both countries, the financial channel has the stronger accumulated, contractionary impact on almost all variables, except for net

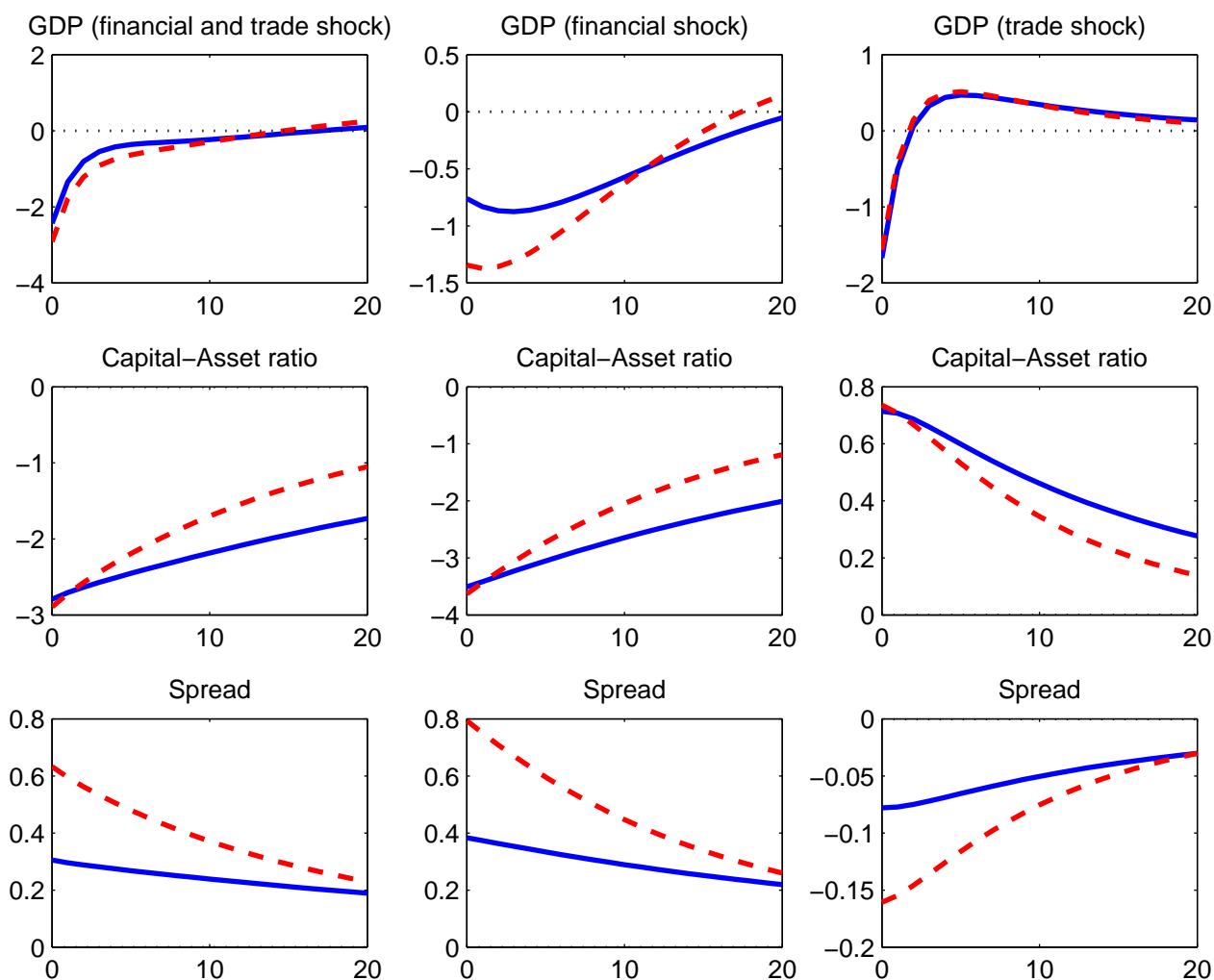


Figure 11: Germany: Impulse-response functions to financial and trade shocks, different bank capital costs.

Compares responses for $\phi_2 = 0.25/Y$ (solid line) with responses for $\phi_2 = 0.5/Y$ (dashed line). Variables are expressed in percentage deviations from steady state, except spread (in percentage points p.a.), capital-asset ratio, and net exports over GDP (both in percentage points).

exports that are predominantly depressed by the trade shock. Moreover, deposits in Germany are also more strongly affected by the trade shock over time. This is due to the stronger fall in the spread in the UK (see above), which dampens the reduction in deposits.

4.3 Stricter capital regulation

As a response to the crisis, some authors have asked for stricter capital requirements.²⁵ In the following, we will assess to which extent a stricter enforcement of the capital requirement can contribute to a lower and/or shorter recession after the considered external shocks. So far, the parameter for the

²⁵See, among others, Admati and Hellwig (2013).

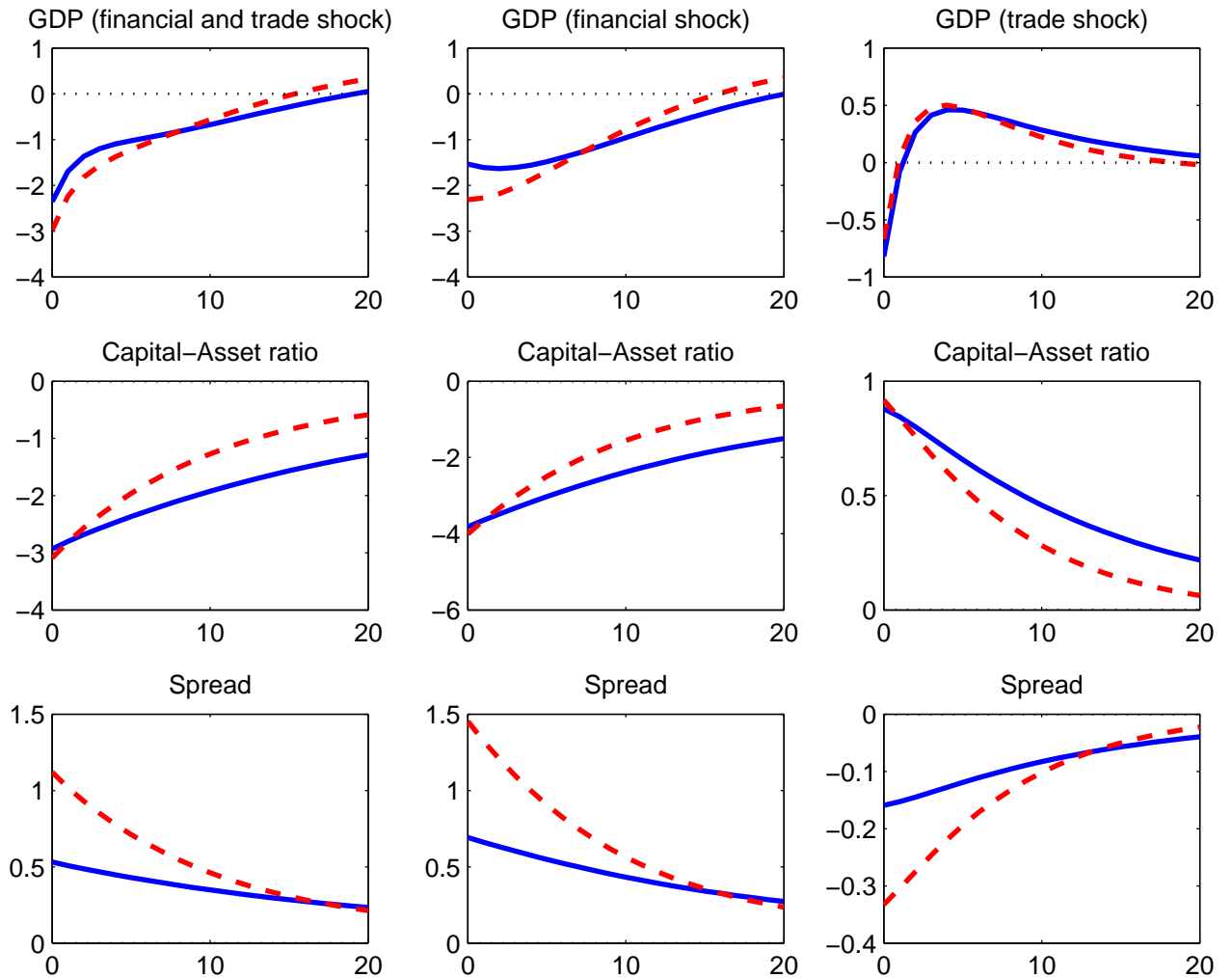


Figure 12: UK: Impulse-response functions to financial and trade shocks, different bank capital costs. Compares responses for $\phi_2 = 0.25/Y$ (solid line) with responses for $\phi_2 = 0.5/Y$ (dashed line). Variables are expressed in percentage deviations from steady state, except spread (in percentage points p.a.), capital-asset ratio, and net exports over GDP (both in percentage points).

bank capital cost function was set at $\phi_2 = 0.25/Y$. A stricter banking regulation would lead to larger punishments of violations of the requirement. Therefore, in a next step, we explore the implications of higher costs for the bank to violate the capital requirement, i.e. we double ϕ_2 to $0.5/Y$. Figure 11 shows how output, bank capital, and the loan-deposit spread react for the German case, while Figure 12 depicts the UK scenario.

The initial response of bank capital to simultaneous financial and trade shocks (Column 1) or to either one (Columns 2 and 3) is almost the same in the case of a stricter enforcement. However, bank capital reverts faster back to its steady-state value, changing the dynamics of the spread. This response translates into a shorter recession after simultaneous trade and financial shocks. Mainly responsible for this outcome is the altered reactions to the financial shock. By raising the spread, banks manage to rebuild bank capital relatively swiftly. The negative GDP response in case of a

financial shock is therefore shifted forward, i.e. a stronger initial response is followed by a quicker recovery. Due to the larger banking sector, these effects are stronger in the UK. In case of the trade shock, the responses hardly change. Given the relatively lower importance of the financial shock for Germany, the responses are less affected in case of a stricter regulation. The reaction of the spread doubles from 0.31 to 0.63, but the maximum output decline changes from 2.43% to only 2.91%. As visible in Figure 11, the duration of the recession shortens by 3 quarters (16 vs. 19 periods of GDP below trend). The maximum output drop in the UK is 2.98 with stricter regulation, compared to 2.36 before. Responsible for the stronger reaction is the spread, which shoots up to 1.21 instead of only 0.53. As bank capital returns to normal values quicker, the recession is 4 periods shorter (17 against 21, see Figure 12). To conclude, a stricter bank regulation can induce a deeper but shorter recession in reaction to financial shocks. In case of the recent global financial crises, however, this effect would have been overshadowed to a relatively large degree by the impact of the trade shock.

5 Conclusion

In this paper, we have analyzed how the recent financial crisis was transmitted internationally. For this purpose, we have employed a quantitative business cycle model featuring trade with the rest of the world as well as a globally acting banking sector. Calibrated to German and UK data the model can account for key features of regular German and UK business cycles as well as of the recent financial crisis. It is able to capture 43% of the drop in output observed in Germany and 87% in the UK, pointing to a considerable role for additional transmission channels in Germany. Analyzing the relative importance of the two transmission channels shows that the trade channel was responsible for the same share of the output decline, while the financial channel played a larger role in the UK and a lower one in Germany. Specifically, the German banking system had to write down a larger share of its foreign assets, but the resulting effects were less severe due to the relatively smaller banking sector. This underlines the greater vulnerability of the UK economy to the kind of financial shocks considered here, i.e. losses on foreign assets. In case of a trade shock, however, larger holdings of foreign assets serve as an automatic hedge because of the triggered terms-of-trade depreciation.

Since the transmission via the financial channel triggers a longer-lasting recession than the trade channel, it is responsible for the prolonged recessions that followed the shocks, in particular in the UK. By the same token, the cumulated effects of the financial channel are more contractionary than for the trade channel, except for the reaction of international trade. Regarding possible policy regulations, we consider the effects of a stricter bank capital regulation that would induce higher bank capital costs in case of falling short of the capital requirement. It turns out that this would frontload parts of the recession, as banks increase the spread by more to rebuild capital quicker. This result might be of relevance in the discussion of stricter rules on bank capital.

Appendix: data construction and sources

- **GDP, its components, and employment:** We use quarterly German and UK data for GDP, gross fixed capital formation, consumption of households and non-profit institutions serving households, exports and imports of goods and services, and total employment from the OECD Economic Outlook 92. The data runs from 1991Q1 to 2012Q4.
- **Loans, deposits, and interest rates:** We use data on loans and deposits from the Bundesbank and the Bank of England. The data on loans to domestic non-financial corporations (private non-financial corporations for the UK) starts in 1999Q1 for Germany (series ID: BBK01.OXA8A4) and 1997Q4 for the UK (series ID: LPMBC57).
Deposits for Germany (deposits from domestic non-banks, series ID: BBK01.OU0220) are available until 2010Q4. The series for the UK (deposit liabilities, series ID: BSI.M.GB.N.A.L20.A.1.U6.1000.Z01.E) is taken from the ECB and available from 1999Q1 until 2011Q3.
For the German interest rate spread, we combine data on deposit and loan rates from the Bundesbank (1997-2003) and the ECB (from 2003 onwards). Deposit rate: average rate on savings deposits with higher rates of returns, with agreed notice of 3 months and a duration of up to and including 1 year (Bundesbank, series IDs: BBK01.SU0527); annualized agreed rate on deposits with agreed maturity up to 1 year from households and non-profit institutions serving households (ECB, series ID: MIR.M.DE.B.L22.F.R.A.2250.EUR.N). Loan rate: effective interest rate on long-term fixed-rate loans to enterprises and self-employed persons of 500000 and up to 5 million Euro (Bundesbank, series IDs: BBK01.SU0509); annualized agreed rate on loans other than revolving loans and overdrafts, convenience and extended credit card debt to nonfinancial corporations with a maturity of at least 1 and up to 5 years of up to and including 1 million Euro (ECB, series ID: MIR.M.DE.B.A2A.I.R.0.2240.EUR.N).
The UK interest spread is calculated on the basis of data from the ECB, which is available from 2004 onwards. Deposit rate: annualized agreed rate on deposits with agreed maturity up to 1 year from households and non-profit institutions serving households (series ID: MIR.M.GB.B.L22.F.R.A.2250.GBP.N). Loan rate: annualized agreed rate on loans other than revolving loans and overdrafts, convenience and extended credit card debt to nonfinancial corporations with a maturity of at least 1 and up to 5 years (series ID: MIR.M.GB.B.A20.I.R.A.2240.GBP.O).
- **Claims on non-residents by German and UK banks:** For claims on non-residents by German and UK banks we use data from the BIS consolidated banking statistics (Foreign Claims, Immediate Borrower Basis, Tables 9A and 9B), with quarterly data starting in 2002.
- **Change of credit standards:** The bank lending survey conducted by the Eurosystem provides a measure for the change of credit standards.²⁶ For this survey 86 (now 124) banks in the Euro area including 17 (since 2008: 30) German banks are posed a set of qualitative questions. These

²⁶For a detailed description of the survey and its purpose see ECB (2003).

questions ask whether credit standards changed over the last three months and what factors affected loan supply as well as loan demand. The data series is available starting in the fourth quarter of 2002. The Bank of England's credit conditions survey started in the second quarter of 2007 and includes around 30 lenders (UK banks, building societies and other (non-bank) specialist lenders) based on a market share of at least 1% in the secured, unsecured or corporate lending markets.²⁷

- **Global demand:** We construct the global import series by aggregating overall imports obtained from the OECD Economic Outlook 92 (MGSV: Imports of goods and services, volume) of Australia, Austria, Belgium, Canada, China, Finland, France, Ireland, Italy, Japan, Netherlands, Norway, Poland, Spain, Sweden, Switzerland, and the United States, as well as Germany for the UK aggregate and vice versa. These countries include the top ten trading partners for the UK and Germany. In order to avoid national basis effects, we construct the global import series by first calculating quarterly growth rates of overall real imports of goods and services for each trading partner and then aggregating the weighted series. Weights are calculated as the time-varying percentage shares of trade (merchandise imports+exports, obtained from the OECD Monthly Statistics of International Trade) with the respective country (lagged four quarter rolling window). The aggregated growth rates are then cumulated from the normalized base year in order to transform the series into levels. Given that imports of goods and services are not available for China, we use imports of goods (value) for China and the GDP deflator for the United States (to obtain volumes), both from the OECD Main Economic Indicator database. Values for imports of goods for 1991, which were still quite low, are extrapolated from later observations, starting in 1992.
- **Foreign asset returns:** We construct the return process for foreign assets using data on US stock prices and the value of US corporate debt. For the former, we use data of the S&P 500 total return index (from Bloomberg), while for the latter we use the Bank of America Merrill Lynch US Corp Master Total Return Index Value that tracks investment grade rated corporate debt, taken from the FRED database. The two series are deflated with the US GDP deflator and weighted by the average share of equity and corporate debt in German and UK long-term portfolio holdings of US securities. The data for German and UK long-term portfolio holdings of US securities is taken from various reports on foreign portfolio holdings of US securities published by the Department of the Treasury together with the Federal Reserve Bank of New York and the Board of Governors of the Federal Reserve System.
- **TFP:** To construct the TFP measure, we use the following quarterly data from the OECD Economic Outlook 92: Gross domestic product, volume, market prices; Total Employment; Hours worked per employee, total economy (the last two are available only until 2011Q4). The UK capital share, which is also used in the calibration, is calculated by employing averages of nom-

²⁷For a description see Driver (2007).

inal GDP, compensation of employees, and gross self-employment income received by households from the same source. Because of missing data for self-employed workers, the German capital share is calculated on the basis of corresponding data from the Federal Statistical Office. Because of a lack of data for the capital stocks, we set capital to a constant in both estimations.

- **Shock processes and crisis shocks:** We use the series for the log of TFP, the log of global demand, and the foreign asset returns in a SUR regression from 1991Q1-2009Q1 to estimate the shock processes in ‘normal times’. Log-variables were detrended with a linear trend before estimation. We insert a dummy in 2009Q1 and use its impact on global demand as the crisis shock of the trade channel. The autocorrelations for the trade shock are set to values that imply the same recoveries after one year (in percentage terms) as the observed recoveries of our global demand measures for Germany and the UK, respectively. The crisis shock for the financial channel corresponds to the writedowns on foreign loans and securities between 2007 and 2010 as estimated in International Monetary Fund (2010a). For Germany we assume that the ratio of foreign to domestic loans and securities, both for holdings and for writedowns, is equal to the euro area average, as a breakdown in foreign and domestic loans and securities is not available. The empirical maximum response used to evaluate the crisis impact corresponds to the deviation that represents the maximum deviation of the absolute values of each HP-filtered variable in 2009 from its average value in 2008Q3/Q4.

References

- Admati, A. R. and Hellwig, M. (2013). *The Bankers' New Clothes: What's Wrong With Banking and What to Do About It*. Princeton University Press.
- Ahn, J. (2011). A theory of domestic and international trade finance. IMF Working Paper 11/262.
- Aiyar, S. (2011). How did the crisis in international funding markets affect bank lending? Balance sheet evidence from the United Kingdom. Bank of England Working Paper No. 424.
- Alessandria, G., Kaboski, J. P., and Midrigan, V. (2010). The great trade collapse of 2008-09: An inventory adjustment? *IMF Economic Review*, 58(2):254–294.
- Amiti, M. and Weinstein, D. E. (2011). Exports and financial shocks. *The Quarterly Journal of Economics*, 126(4):1841–1877.
- Bacchetta, P. and van Wincoop, E. (2013). The great recession: A self-fulfilling global panic. NBER Working Paper No. 19062.
- Backus, D. K., Kehoe, P. J., and Kydland, F. E. (1994). Dynamics of the trade balance and the terms of trade: the J-curve? *The American Economic Review*, 84(1):84–103.
- Balleer, A., Gehrke, B., Lechthaler, W., and Merkl, C. (2013). Does short-time work save jobs? A business cycle analysis. IZA Discussion Paper No. 7475.
- Bank for International Settlements (2014). *84th Annual Report*, chapter III. Growth and inflation: drivers and prospects.
- Barnett, A. and Thomas, R. (2014). Has weak lending and activity in the United Kingdom been driven by credit supply shocks? *The Manchester School*, 82:60–89.
- Behrens, K., Corcos, G., and Mion, G. (2013). Trade crisis? What trade crisis? *The Review of Economics & Statistics*, 95(2):702–709.
- Bekaert, G., Ehrmann, M., Fratzscher, M., and Mehl, A. (2014). Global crises and equity market contagion. *The Journal of Finance*, 69(6):2597–2649.
- Bems, R., Johnson, R. C., and Yi, K.-M. (2010). Demand spillovers and the collapse of trade in the global recession. *IMF Economic Review*, 58:295–326.
- Berkmen, P., Gelos, G., Rennhack, R., and Walsh, J. P. (2012). The global financial crisis: Explaining cross-country differences in the output impact. *Journal of International Money & Finance*, 31:42–59.
- Blaes, B. (2011). Bank-related loan supply factors during the crisis: An analysis based on the German bank lending survey. Deutsche Bank Discussion Paper 31/2011.

- Blanchard, O., Faruqee, H., and Das, M. (2010). The initial impact of the crisis on emerging market countries. *Brookings Papers on Economic Activity*, Spring:263–307.
- Bundesbank (2009). Zum Risiko einer Kreditklemme im Sektor der nichtfinanziellen Unternehmen. *Monthly Bulletin*, 61(9):17–36.
- Bundesbank (2010). Zum Risiko einer Kreditklemme im Sektor der nichtfinanziellen Unternehmen. *Monthly Bulletin*, 62(10):39–47.
- Busch, U., Scharnagl, M., and Scheithauer, J. (2010). Loan supply in Germany during the financial crisis. Deutsche Bundesbank Discussion Paper 05/2010.
- Bussière, M., Callegari, G., Ghironi, F., Sestieri, G., and Yamano, N. (2013). Estimating trade elasticities: demand composition and the trade collapse of 2008-09. *American Economic Journal: Macroeconomics*, 5(3):118–51.
- Cheung, C. and Guichard, S. (2009). Understanding the world trade collapse. OECD Economics Department Working Papers No. 729, OECD Publishing.
- Chor, D. and Manova, K. (2012). Off the cliff and back? Credit conditions and international trade during the global financial crisis. *Journal of International Economics*, 87(1):117–133.
- Claessens, S., Dell’Ariccia, G., Igan, D., and Laeven, L. (2010). Cross-country experiences and policy implications from the global financial crisis. *Economic Policy*, 25:267–293.
- Coulibaly, B., Sapriza, H., and Zlate, A. (2011). Trade credit and international trade during the 2008-09 global financial crisis. International Finance Discussion Papers No. D2011-4, Board of Governors of the Federal Reserve System.
- Davis, S. (2010). The adverse feedback loop and the effects of risk in both the real and financial sectors. Federal Reserve Bank of Dallas Working Paper No. 66.
- Department of the Treasury (2008). Report on foreign portfolio holdings of U.S. securities, Department of the Treasury, Federal Reserve Bank of New York, and Board of Governors of the Federal Reserve System.
- di Mauro, F., Forster, K., and Lima, A. (2010). The global downturn and its impact on euro area exports and competitiveness. ECB Occasional Paper Series No. 119.
- Didier, T., Love, I., and Pería, M. S. M. (2010). What explains stock markets’ vulnerability to the 2007-2008 crisis? World Bank Policy Research Working Paper No. 5224.
- Driver, R. (2007). The Bank of England credit conditions survey. *Bank of England Quarterly Bulletin*, Q3:389–401.

- Eaton, J., Kortum, S., Neiman, B., and Romalis, J. (2011). Trade and the global recession. NBER Working Paper No. 16666.
- ECB (2003). A bank lending survey for the euro area. *ECB Monthly Bulletin*, April:65–75.
- Eickmeier, S., Lemke, W., and Marcellino, M. (2011). The changing international transmission of financial shocks: Evidence from a classical time-varying FAVAR. CEPR Discussion Paper No. DP8341.
- Enders, Z., Kleemann, M., and Müller, G. J. (2014). Growth expectations, undue optimism, and short-run fluctuations. CESifo Working Paper No. 4548.
- Gerali, A., Neri, S., Sessa, L., and Signoretto, F. M. (2010). Credit and banking in a DSGE model of the euro area. *Journal of Money, Credit and Banking*, Supplement to Vol. 42(No. 6):108–141.
- Hristov, N., Hülsewig, O., and Wollmershäuser, T. (2012). Loan supply shocks during the financial crisis: Evidence from the Euro Area. *Journal of International Money & Finance*, 31(3):569–592.
- Imbs, J. (2010). The first global recession in decades. *IMF Economic Review*, 58(2):327–354.
- International Monetary Fund (2010a). Global financial stability report. April 2010.
- International Monetary Fund (2010b). United Kingdom: 2010 article IV consultation—staff report. *IMF Country Report No. 10/338*.
- Justiniano, A. and Preston, B. (2010). Can structural small open-economy models account for the influence of foreign disturbances? *Journal of International Economics*, 81(1):61–74.
- Kamin, S. B. and DeMarco, L. P. (2010). How did a domestic housing slump turn into a global financial crisis? International Finance Discussion Papers No. 994, Board of Governors of the Federal Reserve System.
- Kollmann, R., Enders, Z., and Müller, G. (2011). Global banking and international business cycles. *European Economic Review*, 55:307–442.
- Laeven, L. and Valencia, F. (2010). Resolution of banking crises: The good, the bad, and the ugly. IMF Working Paper 10/146.
- Lane, P. R. and Milesi-Ferretti, G. M. (2011). The cross-country incidence of the global crisis. *IMF Economic Review*, 59:77–110.
- Levchenko, A. A., Lewis, L. T., and Tesar, L. L. (2010). The collapse of international trade during the 2008-09 crisis: In search of the smoking gun. *IMF Economic Review*, 58(2):214–253.
- Mendoza, E. G. and Quadrini, V. (2010). Financial globalization, financial crises and contagion. *Journal of Monetary Economics*, 57:24–39.

- Olafsson, T. T. and Pétursson, T. G. (2011). Weathering the financial storm: The importance of fundamentals and flexibility. In Beblavý, M., Cobham, D., and Ódor, L., editors, *The Euro Area and the Financial Crisis*. Cambridge University Press.
- Olivero, M. P. (2010). Market power in banking, countercyclical margins and the international transmission of business cycles. *Journal of International Economics*, 80:292–301.
- Puri, M., Rocholl, J., and Steffen, S. (2011). Global retail lending in the aftermath of the us financial crisis: Distinguishing between supply and demand effects. *Journal of Financial Economics*, 100:556–578.
- Reinhart, C. M. and Rogoff, K. S. (2009). The aftermath of financial crises. *American Economic Review*, 99(2):466–472.
- Rose, A. K. and Spiegel, M. M. (2011). Cross-country causes and consequences of the crisis: an update. *European Economic Review*, 55:309–324.
- Rottmann, H. and Wollmershäuser, T. (2013). A micro data approach to the identification of credit crunches. *Applied Economics*, 45(17):2423–2441.
- Schmidt, T. and Zwick, L. (2012). In search for a credit crunch in Germany. Ruhr economic papers no. 361.
- Schmitt-Grohé, S. and Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, 61:163–185.
- Statistisches Bundesamt (2009). *Wirtschaft und Statistik*, 03/2009.
- Ueda, K. (2012). Banking globalization and international business cycles: Cross-border chained credit contracts and financial accelerators. *Journal of International Economics*, 86(1):1–16.