National and international financial market shocks and the real economy – an empirical view

The global financial and economic crisis of the past few years has highlighted the importance of financial markets for the real economy. The bursting of the real estate bubble in the United States caused problems in the US financial sector, which then spilled over to the US real economy as well as to the financial and real sectors of other countries, especially in Europe. The intensity and international scale of the subsequent crisis caught many observers by surprise and have widely been interpreted as posing a challenge to existing macroeconomic models' ability to explain the national and international transmission mechanisms between financial markets and the real sector.

Prior to the crisis, financial markets were generally not included in macro models, nor was this regarded as necessary since, for the most part, the financial markets were not themselves deemed to contain any potential to cause disruptions. In the wake of the crisis, however, financial markets have been increasingly integrated into empirical and theoretical macroeconomic models, so that such extended models can now be used to answer questions such as the following. What role is played by the financial markets in general, and the banks in particular, in generating cyclical fluctuations? Through what channels are financial market disruptions transmitted? What impact do national financial market developments have relative to those on international financial markets? Has the relationship between the financial markets and the real sector changed over time? Although these questions are difficult to answer, marked progress has been made over the past few years.

The present article illustrates these advances in research by examining the outputs of a category of empirical models developed and used at the Bundesbank. Specifically, it features a global vector autoregressive model (GVAR), which estimates the interaction between the macroeconomic variables and financial market variables of numerous advanced and emerging economies over the last three decades. This model measures the impact of an exogenous decline in the supply of credit to the non-financial private sector in Germany and in the United States to Germany and to other European countries. The transmission channels are also analysed closely. This model shows that a US credit supply shock can clearly affect GDP in other countries. The impact of a German credit supply shock would be of some importance for Germany itself but relatively irrelevant to the rest of the world.

Relationship between financial markets and the real economy: some empirical observations

The chart on page 37 shows the rate of change of real gross domestic product (GDP) and some financial market variables which capably model developments in key financial market segments – credit markets, equity markets and securities markets. The two countries examined in the model are Germany and the United States – the world's largest economy, and the most significant economy for the international financial markets – over the period 1970 to 2011. The tables on page 38 contain data on comovement, leads and lags of the relevant variables.

High national and international correlation in developments in the real economy and financial markets

Within each respective country, the real economy and the credit and equity markets are generally highly correlated. This tends to be stronger in the United States than in Germany. In addition, this correlation seems to have intensified recently. Equity price growth leads GDP growth in both countries, whereas credit growth co-moves with GDP growth in Germany and lags GDP growth in the United States. Long-term interest rates and GDP are positively correlated in Germany and the United States throughout. This indicates that monetary policy was not the main determinant of long-term interest rates in the period under observation, which would have suggested a negative correlation; instead, other factors that led to the positive comovement of growth in GDP and long-term interest rates prevailed.

If we examine the relevant variables for each of the two economies, we find that US financial market variables and real economic developments correlate positively with those in Germany. The correlation between changes in equity prices and in long-term interest rates exceeds that between real activity movements, followed by the correlation between credit developments. Whereas comovement is greatest for financial market variables, US GDP leads that of Germany by one quarter.[1] The close – national and international – correlation between financial markets and the real economy and the lead of some financial variables over GDP raise the question of whether a cause-and-effect relationship exists between financial markets and the real economy. This question cannot be answered using a simple correlation analysis. A better method is the multi-country model used below.

Empirical studies using a global vector autoregressive model[2]

Empirical multi-country model consists of ...

The multi-country model used here, a global vector autoregressive model (GVAR), enables us to model the dynamic interaction of large number of various countries' macroeconomic and financial market variables. The GVAR is a "reduced-form model" in which each of the model's variables is explained by its own past and by that of the other variables in the model. Such a model tends to be theoretically agnostic, thus requiring fewer *a priori* assumptions. Given that there are still many open theoretical questions regarding the relationship between financial markets and the macro economy, such an approach seems to make particular sense.

... small country models linked by the inclusion of foreign aggregates

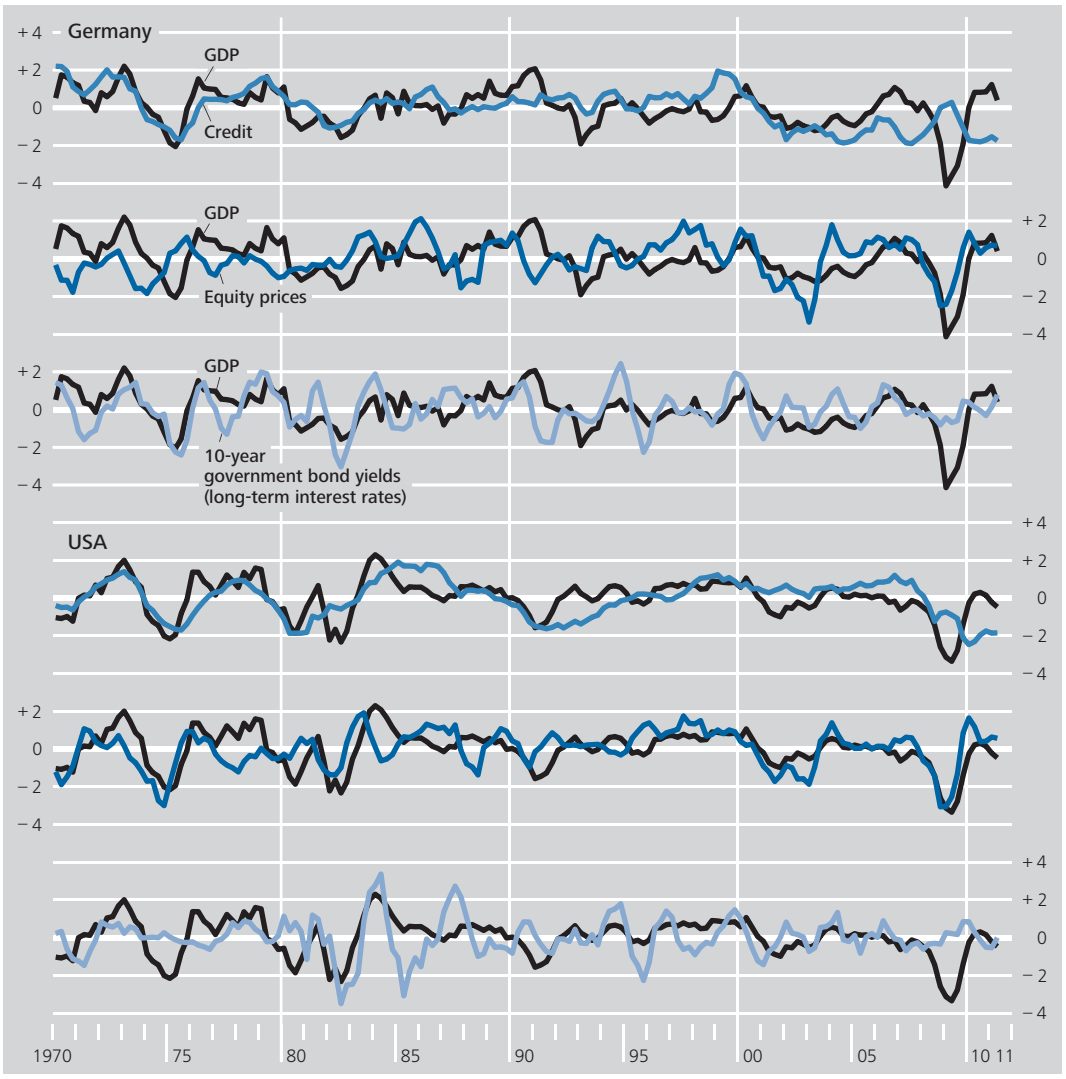
The GVAR consists of low-dimensional vector autoregressive (VAR) models for each country, in which each variable is explained by its own past and by that of other domestic variables. All variables can mutually influence one another. To answer the question at the centre of this article, it is also important, moreover, to

1 If one assumes that economic fluctuations are transmitted from the United States to Germany more frequently than in the other direction, this indicates that other transmission channels besides financial market integration play a role; for instance, trade, through which fluctuations probably tend to be transmitted with a lag. This is also suggested by the fact that GDP fell more sharply in Germany during the crisis than the financial market variables under review (see chart on p 37).

2 The Bundesbank analysis presented in this article is based on S Eickmeier and T Ng (2011), How do credit supply shocks propagate internationally? A GVAR approach, Deutsche Bundesbank Discussion Paper, Series 1, No 27/2011.

Selected real economic and financial variables

Mean-adjusted and standardised annual percentage change, quarterly data



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capture the global dimension. For statistical and methodological reasons, however, it is impossible to include every other country individually in the country VARs, as this would lead to an outsized model. The international interlinkages between countries are therefore modelled by including foreign aggregates in the country VARs. These foreign aggregates are weighted averages of the variables of all other countries, and the weights reflect bilateral trade or financial market linkages between countries. Since the weights vary from country to country, the foreign aggregates are country-specific, as are the responses to foreign influences. This takes account of the heterogeneity across countries. The model also recognises potential long-run relations between national variables and between national and international variables produced, for instance, by globally identical productivity growth. (For details on the model and how it is estimated, see the box on pages 39 to 42.)

The analysis in this article focuses on German and US financial market events and their transmission to Germany and Europe. However, it is important to include not only European and US variables but also those of other countries in order to capture various types of third-country effects.

Correlation between German and US GDP and financial market developments

Annual percentage change

Item[1]	GDP	Credit	Equity prices	Long-term interest rates
Correlation (x(*t*),y(*t*))	0.50	0.26	0.74	0.65
Maximum absolute correlation (x(*t*+*j*),y(*t*))	0.55	0.26	0.74	0.65
Lag *j*, which maximises correlation (x(*t*+*j*),y(*t*))	– 1	0	0	0

1 x: German data; y: US data.
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Correlation between national developments in the real economy and on the financial markets

Annual percentage change

Item[1]	Germany	USA
Correlation (x(*t*),y(*t*))		
Credit	0.38	0.55
Equity prices	0.18	0.50
Long-term interest rates	0.41	0.30
Maximum absolute correlation (x(*t*+*j*),y(*t*))		
Credit	0.38	0.62
Equity prices	0.38	0.62
Long-term interest rates	0.44	0.30
Lag *j*, which maximises correlation (x(*t*+*j*),y(*t*))		
Credit	0	2
Equity prices	– 2	– 1
Long-term interest rates	– 1	0

1 x: financial market variables; y: GDP.
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countries covers a large part of the global economy. It reflects, in particular, that overwhelmingly large part of the global economy to which Germany and the United States are exposed through financial transactions and goods trade. As a case in point, it covers over 70% of Germany's foreign trade.

In order to adequately reflect the national and international financial influences, it is also important to include variables which capture potential transmission channels. To this end, the following quarterly variables are included, where available, for each country: real GDP, consumer prices, short and long-term interest rates, volume of credit, credit spreads, real equity prices, and the real bilateral exchange rate against the US dollar. The observation period runs from 1984 to 2009. This means that, in principle, it is also possible to account for events since the beginning of the crisis. (The box on page 42 provides details on the data.)

This shows clearly that GVAR models are very complex, highly reflect the close relationships between various countries and variables and are, to that extent, superior to smaller models that include fewer variables. What sets the GVAR (like other reduced-form models) apart from other popular model frameworks, such as dynamic stochastic general equilibrium (DSGE) models, which are likewise often used to study the transmission of financial market shocks, is that it is relatively agnostic and requires little in the way of theoretical background. Although the results are sometimes more difficult to interpret, they are, at the same time, probably more robust since the results of more theoretical models depend more heavily on assumptions.

Model contains macro and financial market variables of 29 advanced and emerging economies

The model contains 29 countries: four core euro-area countries (Germany, France, Italy and Spain); the United Kingdom; three other non-euro-area EU member states; the United States; Canada; five Latin American countries; nine Asian countries (including Japan and China); Australia; and New Zealand. This group of

Identified credit supply shocks

"Shocks" can be interpreted by imposing restrictions

The analysis in this article is focused on US and German credit supply shocks. In the model framework used here, as in similar frameworks,

Methodological notes on the global vector autoregressive study

Model

The global vector autoregressive (GVAR) model used in this analysis consists of low-dimensional vector autoregressive (VAR) models for each country.[1] The economic dynamics for country i can be described using equation (1)

$$x_{i,t} = a_{i,0} + a_{i,1}t + \sum_{j=1}^{q_i} \alpha_{i,j} x_{i,t-j} + \sum_{j=0}^{q_i^*} \beta_{i,j} x^*_{i,t-j} + \sum_{j=1}^{l_i} \gamma_{i,j} d_{t-j} + u_{i,t} \quad (1),$$

where $x_{i,t}$ is a $k_i \times 1$-dimensional vector of endogenous variables, $x^*_{i,t}$ is a $k^*_i \times 1$-dimensional vector of country-specific foreign variables, d_t is a vector of global variables, and $a_{i,0}$ and $a_{i,1}t$ denote the effects of a constant and a linear trend. $u_{i,t}$ is a $k_i \times 1$ vector of serially uncorrelated innovations $u_{i,t}$: $iid(0,\Sigma_{u,i})$. $\alpha_{i,j}$, $\beta_{i,j}$ and $\gamma_{i,j}$ are coefficient matrices and denote country-specific effects of national and international influences on the corresponding variables.

The foreign variables in the country VARs are constructed as weighted averages of other countries' variables. The gth element of $x^*_{i,t}$ can be written as

$$x^*_{i,g,t} = \sum_{j=0}^{N} w_{i,g,j} x_{j,g,t} \quad (2),$$

where $w_{i,g,j}$ is a weight which captures the exposure of country i to country j coming from variable g. $\sum_{j=0}^{N} w_{i,g,j} = 1$ and $w_{i,g,j} = 0$ apply for $i = j$.

The country VARs can be combined to form a high-dimensional GVAR

$$x_t = b_0 + b_1 t + \sum_{j=1}^{p} F_j x_{t-j} + \varepsilon_t \quad (3),$$

where the parameters in equation (3) are composed of the estimated parameters in equation (1) and the observed weights in equation (2) and p is the maximum country-specific number of lags on endogenous and exogenous variables.

Estimation

We estimate the VARs separately for each country, allowing for possible cointegration among endogenous variables and among endogenous and exogenous variables.[2] We use the Akaike Information Criterion to establish how many lags on variables to include in the model.

All country VARs except that for the United States include, as endogenous variables (if available), gross domestic product (GDP), consumer prices, the volume of credit, real stock prices, the exchange rate and the interest rates and spreads between corporate bond yields and the government bond yield and, as exogenous variables, the corresponding values (apart from the exchange rate) as weighted averages of the other countries' variables and the oil price. The endogenous variables in the US model are GDP, consumer prices, the volume of credit, real stock prices, interest rates and spreads and the oil price; the exogenous variables are the weighted averages of the GDP, consumer prices and exchange rates of all other countries. One condition for estimating the VAR models separately for each country is an absence of long-run feedback from the

1 The GVAR is derived from H Pesaran, T Schuermann and S Weiner (2004), Modelling regional interdependencies using a global error-correcting macroeconometric model, Journal of Business and Economic Statistics, 22 (2), pp 129-162.
2 Tests for the presence of a unit root are carried out using symmetric ADF tests. The rank order of each VAR is calculated using Johansen's trace statistic.

domestic variables to the foreign aggregates in the corresponding model equations (weak exogeneity). Given that the United States plays a dominant role in the world financial markets and that foreign financial market variables cannot be assumed to be weakly exogenous for US variables, the US model does not contain foreign financial market variables.[3,4]

We model the variables of the (largest) individual euro-area countries in separate VARs.[5] This allows us to look explicitly at credit supply shocks in Germany and to examine heterogeneity within the euro area regarding adjustments following credit supply shocks in more detail. Although this type of modelling does not take full account of the fact that the euro area has had a single monetary policy since 1999, it is justifiable because monetary policy is not the main focus of the analysis. We identify a credit supply shock in Germany only (and not in any other euro-area country) and distinguish it from a German monetary policy shock (which is hypothetical from 1999 onwards). As the biggest euro-area country, Germany would probably have the largest weight in the European Central Bank's impulse response function anyway.

Identification of credit supply shocks

We identify credit supply shocks on the basis of intuitive, theoretical assumptions regarding the direction in which certain variables move shortly after such shocks (sign restrictions). It is important to select restrictions which distinguish the shocks under analysis from other shocks which may also have played a role in the observed movements (eg macroeconomic or monetary policy shocks).[6] The table on page 41 shows the imposed restrictions.[7] We assume that the volume of credit and lending rates move in opposite directions after credit supply shocks and in the same direction after credit demand shocks in order to distinguish between these two types of shock. Furthermore, credit and GDP are assumed to fall following a credit supply shock, as is the credit-to-GDP ratio. The restriction imposed on the credit-to-GDP ratio allows a distinction to be drawn between macroeconomic (supply and demand) shocks. Following macroeconomic demand shocks, GDP can be expected to move more strongly than the volume of credit, at least in the short term, meaning that the credit-to-GDP ratio will rise after a negative macroeconomic shock. In addition, the difference between the lending rate and yields on government bonds with (roughly) the same maturity – the credit risk premium – is assumed to increase, as is the difference between the lending rate and the short-term interest rate. The latter restriction distinguishes the credit supply shock from a contractionary monetary policy shock, following which the short-term interest rate should move more forcefully than the lending rate in the short run. We do not impose any restrictions on the other variables in the model. The identification approach used in this analysis is consistent with theoretical

3 Eickmeier and Ng (2011) show that the assumption of weak exogeneity is very rarely rejected.
4 S Dées, F di Mauro, H Pesaran and V Smith (2007), Exploring the international linkages of the euro area: A global VAR analysis, Journal of Applied Econometrics, 22(1), pp 1-38, Xu (2010), and Beaton and Desroches (2011) all take a similar approach.
5 This is unlike the model used by Eickmeier and Ng (2011), which includes the euro area as a single entity.
6 Other (VAR) studies instead assume that certain variables respond to shocks with a lag. However, this identification approach would be very difficult to justify when examining monetary and financial variables in particular, which tend to change rapidly, and often daily.
7 The sign restrictions are implemented such that the impulse responses are ≤ 0 and ≥ 0.

general equilibrium models[8] and existing empirical studies.[9]

In order to identify US and German credit supply shocks, we orthogonalise the reduced form residuals of the two country VARs ($u_{i,t}$) using a Cholesky decomposition of the covariance matrix. We then rotate the orthogonalised residuals and impose the sign restrictions.[10]

This method ensures that the credit supply shocks are uncorrelated with other domestic shocks,[11] but not that they are uncorrelated with other foreign shocks. The question of whether the identified shocks can actually be interpreted as country-specific therefore depends on the degree of correlation between the countries. The fact that the foreign aggregates are included in equation (1) contemporaneously should help to sharply reduce the correlation between the residuals of different countries. Calculations show that the pairwise correlation between the residuals is in fact very low. The correlation between the two identified credit supply shocks is also only -0.13 and thus virtually negligible. The shocks can therefore be interpreted as essentially country-specific.

We calculate the uncertainty associated with estimating the parameters using a bootstrap approach based on 200 draws. The charts display the medians and the 90% confidence bands of the impulse response functions.

Restrictions imposed to identify credit supply shocks*

Variable	Restrictions
Gross domestic product	↓
Credit	↓
Lending rate	↑
Credit spread	↑
Credit-GDP	↓
Lending rate-short-term interest rate	↑
Inflation, short-term interest rate, long-term interest rate, real stock prices, exchange rate	None

* The sign restrictions are imposed on the impulse responses of GDP and credit for the first four quarters after the shocks and contemporaneously for the other variables. They are implemented such that the impulse responses are ≥ 0 and ≤ 0.

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8 See Gerali et al (2010); Atta-Mensah and Dib (2008); Gertler and Karadi (2011); V Cúrdia and M Woodford (2010), Credit spreads and monetary policy, Journal of Money, Credit and Banking, 42(6), pp 3-35.
9 Helbling et al (2011); Peersman (2010); N Hristov, O Hülsewig and T Wollmershäuser (2011), Loan supply shocks during the financial crisis: Evidence for the euro area, CESifo Working Paper, 3395; C Bean, M Paustian, A Penalver and T Taylor (2010), Monetary policy after the fall, unpublished manuscript; G De Nicoló and M Lucchetta (2010), Systemic risks and the macroeconomy, IMF Working Paper, 10/29; U Busch, M Scharnagl and J Scheithauer (2010), Loan supply in Germany during the financial crisis, Deutsche Bundesbank Discussion Paper, Series 1, No 05/2010.
10 The methods proposed in R Fry and A Pagan (2007), Some issues in using sign restrictions for identifying structural VARs, NCER Working Paper, 14 and in J Rubio-Ramírez, D Waggoner and T Zha (2010), Structural vector autoregressions: Theory of identification and algorithms for inference, Review of Economic Studies, 77(2), pp 665-696 are used to apply the identification restrictions.
11 Most existing GVAR applications generally use a "generalised impulse response functions" approach. The underlying shocks are not independent of one another, making it almost impossible to interpret them economically. The identification approach used in this analysis thus improves on these studies.

Dataset on the Global VAR study

The dataset comprises variables that are typically used in macroeconomic models, as well as financial market variables. Specifically, it contains real gross domestic product (GDP), consumer prices, short-term money market rates, interest rates on long-term government bonds, real equity prices and bilateral real exchange rates with the US dollar. The majority of the dataset is based on Deés et al (2007). In addition, credit and corporate bond spreads – where available – are included for each country.[1] Credit is comprised of loans to the non-financial private sector and debt securities and is included in real terms (divided by the GDP deflator). Credit spreads are the difference between the interest on corporate bonds and that on ten-year government bonds.[2] The sources of credit are the Basel Committee on Banking Supervision (2010),[3] the International Financial Statistics of the International Monetary Fund (IMF) and national institutions. The data on interest rates on corporate bonds are provided by the Bank for International Settlements (BIS) and Datastream.

A broad credit aggregate is used here because the study by the Basel Committee on Banking Supervision (2010) revealed that financial stress is indicated more effectively by such credit aggregates. Moreover, shocks originating from a broad credit segment may be expected to have a greater international impact than shocks from a narrower segment. Corporate bond rates are preferred over bank lending rates since the latter do not exclusively reflect the price of credit but contain contractual elements, too. The observation period runs from 1983 to 2009.

The foreign aggregates $x^*_{i,t}$ are constructed using weights which are based on data on the bilateral links between country i and all other countries. Eickmeier and Ng (2011) studied the extent to which the goodness of fit of the model and the results are dependent on the selected weights. The results of this study show that the estimated transmission of credit supply shocks is not influenced significantly by the weights, but that a model which includes trade weights as well as bilateral inward foreign direct investment (FDI) fits the data relatively well. It is for this reason that trade weights are used to construct foreign aggregates for GDP and inflation, whereas inward FDI is used for the aggregation of foreign financial market variables. Trade weights are defined as the sum of export and import volumes (on average over the period from 2005 to 2008), which are taken from the IMF's Direction of Trade Statistics. Bilateral FDI data are available for 2009 only and were drawn from the IMF's Coordinated Direct Investment Survey.[4]

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1 Interest rates and spreads are included in levels and all other variables as logarithms.
2 Ten years is approximately the maturity of corporate bonds.
3 Basel Committee on Banking Supervision, Guidance for national authorities operating the countercyclical buffer, December 2010.
4 Seven different weighting schemes were analysed. GDP and inflation are always aggregated using trade weights. For the aggregation of the remaining (financial market) variables trade weights, outward portfolio investment, inward portfolio investment, outward FDI, inward FDI, outward claims of domestically-domiciled banks and inward claims of foreign-domiciled banks are employed alternatively. It was found that both inward FDI and outward banks' claims provide relatively good in-sample forecasts and low values of information criteria. The goodness of fit of the models that use trade links exclusively is perceptibly poorer, while the goodness of fit of models that use foreign banks' inward claims, inward portfolio investment, outward portfolio investment or outward FDI is only slightly poorer. The most important results regarding the German and international transmission of credit supply shocks, however, are not altered significantly by the choice of weighting scheme.

"shocks" are initially defined as unexpected changes in an economy, or such changes not explained by the model. As error terms, they are initially impossible to interpret in economic terms. However, there are various ways of ultimately assigning shocks estimated from the model to events that can be interpreted from an economic standpoint. In this study, it is assumed that a certain economic event sets several variables in motion in certain directions. A shock which shows such defined characteristics can then be assigned to this economic event. Thus, for instance, in a simple model of a market for a good, a (positive) supply shock increases the quantity and lowers the price, whereas a demand shock increases the quantity and price of the good in question. This logic is used to identify credit supply shocks in this much more complex model.

Credit supply shocks of particular interest

It is therefore of particular interest specifically to measure the effect of credit supply shocks on the real economy because a deterioration in the banks' situation is seen as having triggered the crisis. Studies on numerous countries over a relatively long time horizon have also shown that there is a particularly close relationship between lending and the real economy and between various countries in terms of credit developments.[3,4]

Credit supply shocks represent deterioration in investors' financial position

Negative credit supply shocks are largely defined here as shocks which cause a decline in lending and a simultaneous increase in lending rates and the credit risk premium. They can be caused, for instance, by a deterioration in collateral quality or an increase in the probability of default[5] or also by an exogenous decline in banks' capital.[6] However, they can also be triggered by an increase in risk aversion of banks or other investors which is independent of credit defaults.[7] Regulatory changes – such as with regard to capital or liquidity requirements – can also cause such a credit supply shock.[8] However, it is impossible to draw a further distinction between these potential causes of shocks. It is quite conceivable, though, that the identified German credit supply shocks can be associated more (or less) closely than US credit supply shocks with one or another of these aspects. This needs to be taken into account when comparing both types of shocks and their impact.

Transmission of domestic credit supply shocks to Germany

Negative German credit supply shock followed by lasting reduction in GDP

The chart on page 44 shows the impact of a German credit supply shock on the observed variables in Germany over the next 16 quarters. This is a "typical" shock, ie its size is one standard deviation. It causes the credit volume to decrease instantly by around 0.5%, with a maximum decline of 4% after three years. Credit spreads rise instantly by 0.1 percentage point, and the effect is likewise very persistent. The

3 See A Kose, S Claessens and M Terrones (2011), Financial cycles: What? How? When?, IMF Working Paper 11/76; A Kose, S Claessens and M Terrones (2011), How do business and financial cycles interact?, IMF Working Paper 11/88.

4 Only very few empirical papers thus far have addressed the international transmission of financial market shocks, and even fewer look at the impact of credit shocks. Exceptions are Q Chen, D Gray, P N'Diaye, H Oura and N Tamirisa (2010), International transmission of bank and corporate distress, IMF Working Paper 10/24; K Beaton and B Desroches (2010), Financial spillovers across countries: the case of Canada and the United States, Bank of Canada Discussion Paper 2011-1; T Xu (2010), The role of credit in international business cycles, unpublished manuscript; T Helbling, R Huidrom, A Kose and C Otrok (2011), Do credit shocks matter? A global perspective, European Economic Review 55, pp 340-353.

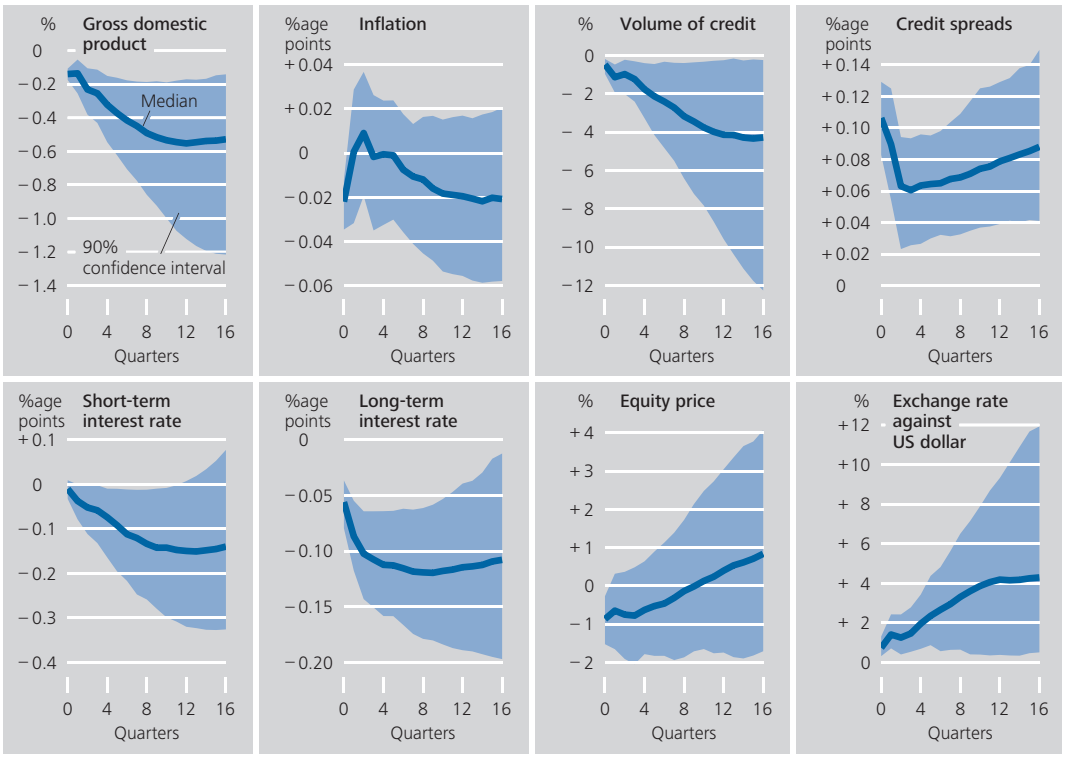
5 M Gertler and P Karadi (2011), A model of unconventional monetary policy, Journal of Monetary Economics 58, pp 17- 34; S Gilchrist, V Yankov and E Zakrajsek (2009), Credit market shocks and economic fluctuations: Evidence from corporate bond and stock markets, Journal of Monetary Economics, 56(4), pp 471– 493; L Christiano, R Motto and M Rostagno (2010), Financial factors in economic fluctuations, ECB Working Paper 1192; J Atta-Mensah and A Dib (2008), Bank lending, credit shocks, and the transmission of Canadian monetary policy, International Review of Economics and Finance, 17(1), pp 159–176.

6 See A Gerali, S Nerri, L Sessa, and F Signoretti (2010), Credit and banking in a DGSE model of the euro area, Journal of Money, Credit and Banking, 42(6), pp 108-141.

7 See Gilchrist et al (2009).

8 In addition, financial market innovations, such as securitised lending, can be responsible for a (positive) credit supply shock. See G Peersman (2010), Macroeconomic consequences of different types of credit market disturbances and non-conventional monetary policy in the euro area, unpublished manuscript; Atta-Mensah and Dib (2008).

Impact of German credit supply shocks* on Germany



* Shock size is one standard deviation.
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effect on German GDP is significantly negative. GDP falls instantly after the onset of the shock by just under 0.2% and reaches its maximum decline of around 0.5% after three years.

Inflation, interest rates and equity prices likewise fall

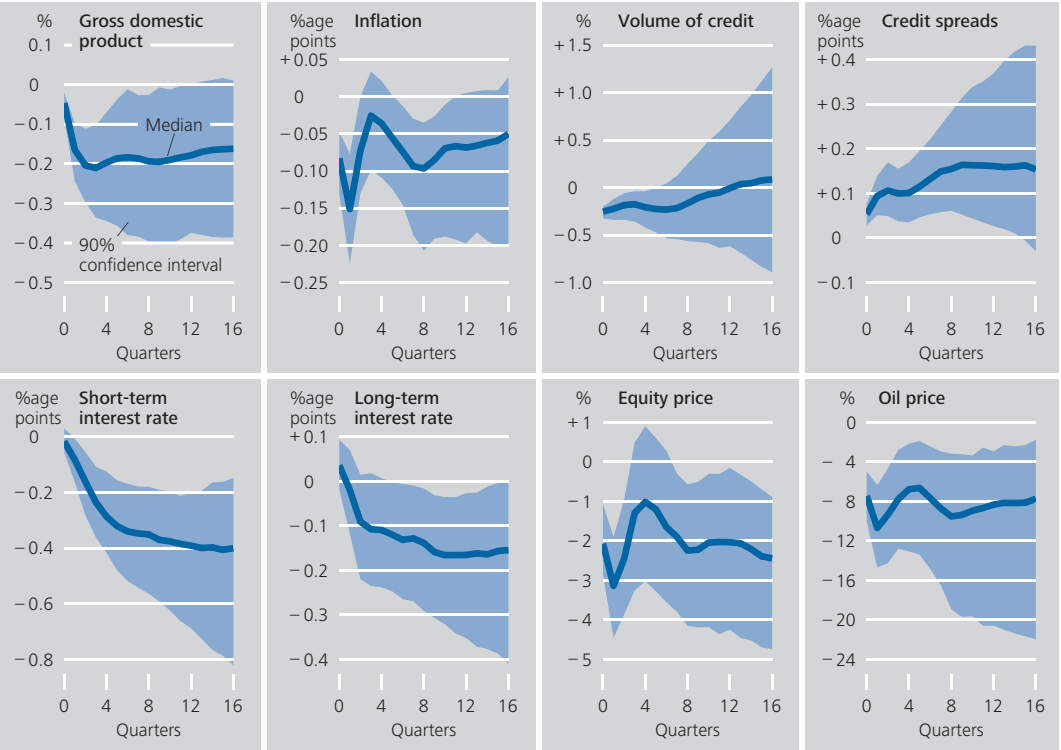
Macroeconomic demand effects dominate macroeconomic supply effects, as not only GDP but also inflation falls, even though the statistical significance of this effect is marginal. Short and long-term interest rates also fall along with inflation. Monetary policy is therefore evidently loosened in response to a reduction in the credit supply or in inflation. Equity prices likewise fall temporarily, although this effect is statistically hardly significant. This is consistent with diminished expectations for growth and an increase in the price of loans to enterprises resulting from higher credit spreads. Lastly – consistent with lower domestic interest rates – the German currency depreciates against the US dollar. The interest rate and exchange rate reactions have a positive impact on consumption, investment and exports in Germany and thus at least partly offset the negative effect of the deterioration in financing conditions.

Transmission of US credit supply shocks to Germany and other European countries

US credit supply shock has similar impact in the USA

The debate over the past few years has been centred on the global impact of a credit crunch triggered by problems in the US banking system. Prior to studying these international transmissions of the US credit supply shock, however, it pays to look at their impact on the USA itself. This impact, in fact, is in many ways similar to that of the German credit supply shock on Germany (see chart above). A typical US shock is smaller than a typical German shock, measured in terms of the immediate response of credit spreads (0.05 percentage point) and credit (-0.25%). In these terms, the maximum

Impact of US credit supply shocks* on the USA



* Shock size is one standard deviation.
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decline of US GDP, at 0.2% after three quarters, is remarkably sharp. The transmission of a shock standardised to the same size therefore has similar effects in Germany and the United States. However, there are, in fact, recognisable differences in the transmission channels of credit constraints to the respective economies: the significant decline in US inflation and the correspondingly much stronger decline in US interest rates (compared to Germany) mitigate the cyclical downturn caused by the negative credit supply shock in the USA. This effect has probably been made up for three factors: equity prices in the United States, which are typically more important to US consumers than German equities for German households, fell by nearly three times as much and more persistently; the US dollar appreciated after the US shock (whereas the D-Mark and later the euro depreciated after the German shock); and the negative feedback effects owing to the stronger international transmission of the US shock were more pronounced.

Strong and persistent decline in German GDP following negative US credit supply shock

The effects of the US credit supply shock on Germany are very similar to those on the United States (see chart above). The impact on German GDP is significantly negative and reaches a minimum of just under -1% after around two years. Remarkably, the effect on German GDP surpasses that on US GDP. This is consistent with studies which have a similar focus and use comparable methods.[9]

Considerable decline in credit in Germany ...

One possible explanation for this is that credit in Germany sustained a relatively sharp decline following a US shock. This effect is attributable to the response by internationally diversified investors and globally active US banks,[10] which, given a credit supply shock in the United States

9 See Helbling et al (2010) and Eickmeier et al (2011).
10 R Kollmann, Z Enders and G Müller (2011), Global banking and international business cycles, European Economic Review, 55(3), pp 407-426; G Gorton (2009), Information, liquidity, and the (ongoing) panic of 2007, American Economic Review, 99(2), pp 567-572; C Borio, R McCauley and P McGuire (2011), Global credit and domestic credit booms, BIS Quarterly Review, September.

Impact of US credit supply shocks* on Germany

* Shock size is one standard deviation.
Deutsche Bundesbank

and a deterioration in their balance sheets, mainly scaled back their lending abroad – a phenomenon also discussed as the "international financial multiplier".[11]

… and in equity prices; falling interest rates and euro depreciation against US dollar mitigate negative effect

In both countries, inflation, interest rates and equity prices respond similarly strongly. The co-movement between equity prices and long-term interest rates is consistent with arbitrage mechanisms and confidence effects (which are difficult to measure).[12] The depreciation of Germany's currency against the US dollar following the US shock, however, is likely to have mitigated the negative impact on Germany's real economy and amplified that on the US real sector.

Germany affected somewhat more strongly by US credit supply shocks than other euro-area countries

What is also interesting is how the US credit crunch impacts on the other European countries and whether this leads to disparities particularly within the euro area. This is shown by the chart on page 47 (compared to Germany).[13] The effects on the real economy in France, Italy, Spain or the United Kingdom are weaker than for Germany. By contrast, the responses in the other European countries (excluding Germany) are barely distinguishable from one another. A look at the developments in selected variables following the shocks sheds light on differences and similarities in the transmission mechanism. First, credit in the euro-area countries falls somewhat more sharply than in the United Kingdom, although only in Germany is this reflected in a stronger response of GDP. Second, long-term interest rates fall relatively sharply in Spain and Italy. This is one possible

11 See E Van Wincoop (2011), International contagion through leveraged financial institutions, NBER Working Paper 17686; P Krugman (2008), The international financial multiplier, unpublished manuscript; M Devereux and J Yetman (2010), Leverage constraints and the international transmission of shocks, Journal of Money, Credit and Banking, Supplement to No. 42(6), pp 71-105; M Devereux and A Sutherland (2011), Evaluating international financial integration under leverage constraints. European Economic Review, 55, pp 427-442.
12 See van Wincoop (2011).
13 To save space, only median responses are shown.

explanation of why the effects on Italian and Spanish GDP are less than those on German GDP. Third, the equity prices of all countries drop more or less in sync. Fourth, there is a "flight to safety" phenomenon, which manifests itself in an appreciation of the US dollar against the pound sterling and, prior to 1999, the euro-area countries' national currencies.

German credit supply shocks perceptibly influence lending but not the real economy in other European countries

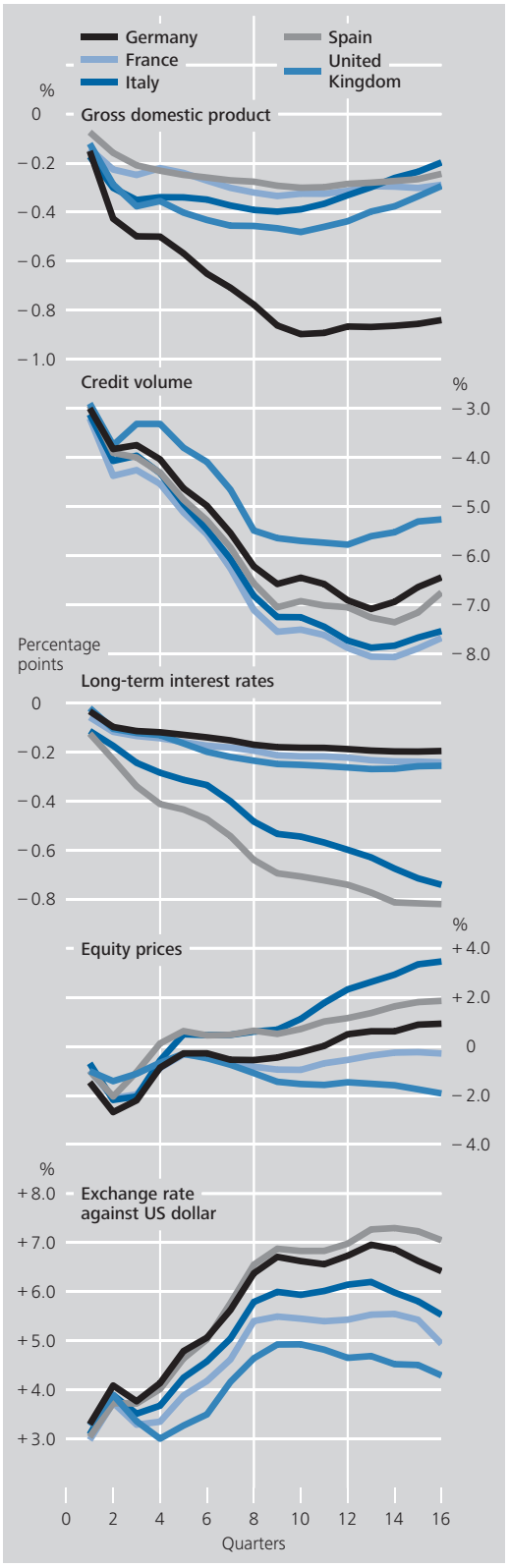
Lastly, German credit supply shocks have a much smaller impact on the real economy in other European countries than US credit supply shocks do.[14] The differences within Europe are once again not particularly great, most likely because the European financial systems are tightly interwoven via the interbank market, investors' shared customers, and global financial institutions.

The explanatory power of US and German credit supply shocks for the real economy

German and US credit supply shocks have 8% and 15% impact respectively on German real economy

Not only the dynamic domestic and international impacts of the credit supply shocks are of interest but what importance such shocks have had in the past for real economic developments relative to other shocks. The table on page 48 shows the calculated percentage of GDP variation for which the two shocks are responsible.[15] US credit supply shocks explain between 6% and 15% of GDP forecast error in the European countries. Germany is the most severely affected country. German credit supply shocks explain a much smaller percentage, between zero in the United States and 8% in Germany itself. France and Italy are the countries affected most.

Impact of US credit supply shocks* on selected variables in European countries



* Shock size is one standard deviation. The charts show median impulse responses.

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14 The results are omitted here.
15 Strictly speaking, we are decomposing the GDP forecast error here.

Decomposition of the forecast error variance for GDP – contributions by US and German credit supply shocks*

Country	Credit supply shocks in the USA	Credit supply shocks in Germany
USA	10.8	0.1
Germany	15.2	7.6
France	13.1	3.2
Italy	10.0	5.7
Spain	9.6	1.9
United Kingdom	5.7	2.2

* The chart shows the forecast error variance shares (in per cent) over a four-year-horizon. The forecast error variance is calculated as squared impulse responses cumulated over the horizons.

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Limitations of the analysis and additional findings from other research

Credit supply shocks cover only part of exogenous financial market developments; the analysis does not account for time variation in the parameters either

The limitations of the approach used here show up in two particular areas. First, there are other types of financial market shocks – although these are not examined in depth in the analysis and, to a degree, are not well-modelled by the variables examined here – which could be active alongside credit supply shocks. As a case in point, the recent crisis was characterised by a confluence of various shocks ranging from an unexpected drop in asset prices to a sudden drying-up of certain financial market segments. This would suggest studying more broadly defined financial market shocks rather than a credit supply shock in isolation, as is done here. Second, the parameters of the multi-country model used here are assumed to be constant. However, various lines of thinking suggest that the transmission mechanism could have changed either permanently or at least intermittently over time.

Only very few studies thus far have looked at time variation in the parameters and the impact of more broadly defined financial market shocks on the real economy. Three very recent studies deserve particular mention here. Eickmeier et al (2011)[16] look at shocks which impact on an index of financial market conditions comprising 45 US financial market variables (including credit aggregates, interest rates and spreads, monetary aggregates, credit conditions obtained from surveys and asset prices). Hubrich and Tetlow (2011)[17] and Holló et al (2011)[18] look at indices composed of financial stress indicators (such as interest rate spreads, implied volatilities, correlations between interest rates and asset prices) for the United States and the euro area. (No such studies specifically referring to Germany have been published yet.)

Paucity of studies thus far examining more broadly defined financial market shocks and variations in the relationship between financial markets and real economy

The latter two papers use a small VAR and distinguish between two regimes – financial stress phases and "normal" periods – under which the size of the financial market shocks and their transmission can differ. Eickmeier et al (2011) use a factor model for nine advanced economies to estimate how US financial market shocks impacted on the USA itself and internationally. Their model is additionally able to display lasting changes since the parameters change gradually, unlike in Hubrich and Tetlow (2011) and Holló et al (2011).

Large financial market shocks and stronger effects plausible in crisis periods

In some cases, it may be important to permit such variations to the model in order to adequately measure the effects that are of interest. It therefore seems plausible to assume that, in crisis periods, financial shocks hit a particularly large number of financial market segments at the same time or that credit defaults multiply; in models which permit changes to the size of the shock, this is reflected in very

16 S Eickmeier, W Lemke and M Marcellino (2011), The changing international transmission of financial shocks: Evidence from a classical time-varying FAVAR, Deutsche Bundesbank Discussion Paper, Series 1, No 27/2011.
17 K Hubrich and R J Tetlow (2011), Financial stress and economic dynamics: The transmission of crises, unpublished manuscript.
18 D Holló, M Kremer and M Lo Duca (2011), CISS – a composite indicator of systemic stress in a financial system, unpublished manuscript.

large shocks.[19] At the same time, it can be presumed that the transmission of shocks to the real economy is stronger during crisis periods than in periods of normality. The main reasons for such asymmetries lie in agency problems between lenders and borrowers. Such problems are more pronounced in crisis periods, which for their part can amplify the effects of shocks on the real economy. Agency problems occur, for instance, when collateralised loans are granted. When asset prices fall, lending is accordingly also constrained.[20] Furthermore, greater information asymmetry between lenders and borrowers in crisis periods can drive a wedge between the costs of equity and debt capital and drive up the costs of monitoring (known as a "financial accelerator").[21] Moreover, during crisis periods, households' willingness to hold illiquid funds diminishes. The decline in deposits reduces the external funding that borrowers can draw upon (known as the "borrower's balance sheet channel").[22,23] Lastly, structural changes in an economy are also a potential cause of permanent or gradual changes to parameters. It is argued, for instance, that globalisation has made economic relationships closer and that financial market innovations have made it easier to access alternative forms of finance, thereby amplifying the role of the financial markets for the real economy. If the model does not allow such changes, this can lead to a distorted assessment of transmission.

Financial market shocks particularly large in periods of financial stress

All three studies show, consistent with the above considerations, that financial shocks are particularly large in periods of crisis or stress. Eickmeier et al (2011) also find that the global financial and economic crisis is the largest post-WWII financial shock.

Gradual increase in the effects of global financial market shocks on Germany

What the last-listed study also finds is that the transmission of financial shocks (of the same size) to the US real economy increased in the early 1980s. The stated reason for this is a change in monetary policy, which led to an improved anchoring of inflation expectations and consequently a less steep rise in short-term interest rates following positive financial shocks. The study finds that, for Germany (and most other euro-area countries in the study), transmission also gradually became stronger, a fact attributed to greater global financial market integration. The contribution of US financial market shocks to explaining GDP growth in the United States and Germany ranges from negligible in normal periods to 40% during the recent crisis, which is higher than the 11% and 15%, respectively, on average over the observation period, which the aforementioned GVAR analysis attributes to credit supply shocks (see the table on page 48).

Mixed evidence regarding asymmetry in transmission

The two studies which look at US shocks do not find any significant differences between crisis periods and normal periods with regard to the transmission of similar-sized financial market shocks. By contrast, Holló et al (2011) find, for the euro area, a strong and statistically highly significant real economic effect in periods of financial stress. During periods of calm, the effect is hardly significant.

Conclusions

In summary, US credit supply shocks can be said to significantly affect GDP in other countries. Credit squeezes in Germany are of some relevance particularly for Germany itself and for its European neighbours. The transmission of German credit supply shocks in Germany itself

19 At the same time, it must be conceded that models do a relatively poor job of reflecting crisis periods, irrespective of whether they have time-constant or time-varying parameters; this likewise probably manifests itself in larger estimated shocks (or residuals).
20 See N Kiyotaki and J Moore (1997), Credit cycles, Journal of Political Economy, 105(2), pp 211– 248.
21 See B Bernanke, M Gertler and S Gilchrist (1999), The financial accelerator in a quantitative business cycle framework, in J B Taylor and M Woodford (eds), Handbook of Macroeconomics, Elsevier, pp 1341-1393.
22 See L J Christiano, R Motto and M Rostagno (2003), The Great Depression and the Friedman-Schwartz hypothesis, Journal of Money, Credit and Banking, 35(6), pp 1119-1197.
23 Lenders' risk aversion and greater uncertainty are additional amplifying elements during crises. See Holló et al (2011).

occurs via a perceptible and persistent decline in credit, a rise in risk premiums and a short-term decline in equity prices. These negative impacts on the real economy have been partly offset by a depreciation of the euro and a decline in interest rates. US credit supply shocks are propagated internationally by a largely parallel deterioration in developments in the financial markets. The comovement of equity prices and long-term interest rates is consistent with arbitrage mechanisms and confidence effects. The sharp decline in loans is compatible with an "international financial multiplier".

Credit supply shocks, however, are just a subset of the disruptions that emanate from the financial markets. In addition, the model underlying the analysis make the controversial assumption that the parameters are time-constant, even though there is evidence that the international propagation of financial market shocks has gradually grown stronger over time. Further efforts will be necessary in the future to better understand the international and national effects of financial market disruptions. This is a key precondition for the development of suitable economic policy measures and instruments to contain future crises and their repercussions for the real economy. This includes, not least, identifying the gamut of specific financial market shocks and modelling nonlinearities in the relationship between the individual financial market variables as well as between financial market and real economic variables.