DEUTSCHE
BUNDESBANK

Business Cycle Transmission from the US to Germany – a Structural Factor Approach

Sandra Eickmeier

Discussion Paper
Series 1: Studies of the Economic Research Centre
No 12/2004

Deutsche Bundesbank, Wilhelm-Epstein-Strasse 14, 60431 Frankfurt am Main,
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 9566-1
Telex within Germany 41227, telex from abroad 414431, fax +49 69 5601071

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address or via fax No +49 69 9566-3077

ISBN 3–935821–93–X

Abstract:

This paper investigates the transmission of US macroeconomic shocks to Germany by employing a large-dimensional structural dynamic factor model. This framework allows us to investigate many transmission channels simultaneously, including 'new' channels like stock markets, foreign direct investment, bank lending and the confidence channel. We find that US shocks affect the US and Germany largely symmetrically. Trade and monetary policy reactions to strong price effects seem to be most relevant; financial markets may have become more important over time. The speed of transmission does not seem to have increased. Negative domestic influences apparently more than compensated positive US influences in the German economy between 1995 and 2000, but the US recession in 2001 seemed mainly responsible for the German slump.

Keywords: International business cycles, international transmission channels, dynamic factor models, structural VAR techniques

JEL-Classification: F02, F41, C13, C32

Non Technical Summary

In this paper, we have investigated the transmission of US macroeconomic shocks to the German economy between 1975 and 2002. This question which is relevant for policy makers and forecasters is investigated by means of a large-scale structural dynamic factor model. This framework allows us to assess simultaneously the responses of a large set of real and nominal German variables to US shocks and to investigate the role of many transmission channels, including so called 'new' channels like stock markets, foreign direct investment, international bank lending and the confidence channel. To that extent, it has advantages over other models used in this context, which are not able to investigate as many transmission channels simultaneously.

In the paper, we identify two shocks which have their origin in the US, one medium-run supply shock and one short-run real demand shock. We find that these shocks affect the US economy and the German economy symmetrically. That is, the supply shock raises output and lowers prices and interest rates, and the demand shock increases all three variables in both countries. The supply shock displays mainly medium-run effects, and the demand shock displays short-run effects in both the US and Germany.

As concerns the transmission channels: trade, influenced by movements of relative prices, seems to play a dominant role in the transmission. Besides trade, monetary policy reacts to relatively strong German price movements and seems to influence the impact of US shocks in the medium run. When we consider the entire period, no clear conclusion can be drawn on the role of financial markets and the confidence channel. However, German capital flows and stock prices are much more affected by US shocks between 1994 and 2002 than in the previous period. Greater access to capital markets may have improved German investment opportunities and raised productivity. Capital markets may thus have become more important as a transmission channel and may have increased business cycle co-movement. German confidence has been driven notably by US shocks only since the end of the 1990s. This might indicate that the confidence channel has only become relevant in the last few years. In contrast to what might have been expected, the transmission has not become faster over time.

In our linear approach we finally find that negative domestic factors more than compensated positive US influences during the US boom between 1995 and 2000 in Germany. By contrast, the US recession in 2001 seemed to be mainly responsible for the German slump.

Nicht technische Zusammenfassung

In diesem Diskussionspapier wird die Übertragung US-amerikanischer makroökonomischer Schocks auf Deutschland für den Zeitraum 1975 bis 2002 untersucht. Die für die Prognose sowie für die Politik relevante Fragestellung wird anhand eines großen strukturellen dynamischen Faktormodells behandelt. Dieser Modellrahmen erlaubt, die Reaktionen einer großen Anzahl realer und nominaler deutscher Variablen auf US-Schocks und die Bedeutung einer Vielzahl von Übertragungskanälen gleichzeitig zu untersuchen. Darunter fallen auch so genannte "neue" Kanäle, wie die Aktienmärkte, ausländische Direktinvestitionen, die internationale Kreditvergabe und der Vertrauenskanal. Von daher besitzt der hier gewählte Ansatz Vorteile gegenüber anderen bislang auf das Thema der internationalen Konjunkturübertragung angewandten Modellen, die nur eine begrenzte Anzahl an Übertragungskanälen berücksichtigen können.

In dem Papier werden zwei Schocks identifiziert, die in den Vereinigten Staaten ihren Ursprung haben: ein mittelfristiger Angebotsschock und ein kurzfristiger Nachfrageschock. Diese Schocks scheinen beide Volkswirtschaften symmetrisch zu betreffen. Das bedeutet, dass der Angebotsschock in beiden Ländern die wirtschaftliche Aktivität erhöht und Preise und Zinsen verringert, während der Nachfrageschock alle drei Größen steigert. Wie in den Vereinigten Staaten entfaltet der Angebotsschock auch in Deutschland mittelfristige und der Nachfrageschock kurzfristige reale Effekte.

Im Hinblick auf die Übertragungskanäle scheint der Handel, beeinflusst durch die Veränderung der relativen Preise, die Konjunkturübertragung zu dominieren. Daneben scheint die auf verhältnismäßig starke Preisschwankungen in Deutschland reagierende Geldpolitik die Auswirkungen der US-Schocks in der mittleren Frist zu beeinflussen. Wird der gesamte Betrachtungszeitraum zugrunde gelegt, lässt sich den Finanzmärkten und dem Vertrauenskanal keine eindeutige Rolle zuweisen. Allerdings sind deutsche Kapitalströme und Aktienpreise zwischen 1994 und 2002 merklich stärker von US-Schocks betroffen als in der vorangegangenen Periode. Ein verbesserter Zugang zu Kapitalmärkten könnte die deutschen Investitionsmöglichkeiten erweitert und die Produktivität gesteigert haben. Kapitalmärkte könnten somit für den konjunkturellen Gleichlauf beider Länder über die Zeit an Bedeutung gewonnen haben. Das Vertrauen deutscher Marktteilnehmer wird erst seit Ende der neunziger Jahre maßgeblich von der US-amerikanischen wirtschaftlichen Entwicklung bestimmt. Das könnte darauf hindeuten, dass dem Vertrauenskanal erst in den letzten Jahren eine Bedeutung zugekommen ist. Entgegen der Erwartungen vieler lassen sich keine Hinweise darauf finden, dass sich die Übertragungsgeschwindigkeit erhöht hat.

In unserem linearen Ansatz finden wir schließlich, dass negative heimische Faktoren positive Einflüsse aus den Vereinigten Staaten während der US-amerikanischen Expansion 1995 bis 2000 in Deutschland überkompensiert haben. Hingegen scheint die US-Rezession im Jahr 2001 die wirtschaftliche Stagnation in Deutschland maßgeblich mitverantwortet zu haben.

Contents

Lists of Tables and Figures

Business Cycle Transmission from the US to Germany - a Structural Factor Approach*

1 Introduction

Recently, international business cycle linkages have again become a focus of public interest. This renewed interest has its roots in the worldwide economic downturn in 2001. Its remarkable strength, speed and synchronicity across industrial countries were apparently unexplainable in terms of trade linkages alone. At the same time, financial markets and confidence measures around the globe were particularly affected during the downturn. However, the burgeoning literature on international business cycle linkages does not confirm a clear increase in the co-movement of industrial countries' business cycles. Most studies even find a weakening of business cycle linkages in the 1990s compared to the 1970s and the 1980s (e.g. IMF (2001a), Doyle and Faust (2002), Helbling and Bayoumi (2002), Angeloni and Dedola (1999)).

The latter first puzzled many business cycle analysts in the light of the ongoing globalization process. Artificial trade barriers and capital controls have been removed gradually during the past decades. This has contributed to a rise in the trade volume and an acceleration of international capital flows and the correlation of financial prices (for stylized facts, see IMF (2001a), Brooks, Forbes and Mody (2003)). More recently, advances in telecommunications could have linked international confidence measures more closely. Due to the integration process in general and the possibly increased relevance of 'new' channels like stock markets and confidence linkages, in particular, many have expected international business cycles to be more tightly linked and shocks to be propagated faster.[1]

---

* Affiliations: Deutsche Bundesbank and University of Cologne.
Address: Deutsche Bundesbank, Economic Research Center, Wilhelm-Epstein-Str. 14, D-60431 Frankfurt/M., Email: sandra.eickmeier@bundesbank.de

This paper was written while I was visiting the Université Libre de Bruxelles and the Deutsche Bundesbank. It has been presented at the ECB workshop 'The external dimension of the euro area: trade, capital flows and international macroeconomic linkages' held on March 2004 in Francfurt and at seminars at the Deutsche Bundesbank, the German Council of Economic Experts and the University of Cologne. I am especially grateful to Jörg Breitung, Harald Uhlig, Christian Schumacher, Jörg Döpke, Olivier de Bandt and Juergen B. Donges for very helpful comments and suggestions. Thanks also go to Jacopo Cimadomo, Giovanni Lombardo, Jens Weidmann, Jens Ulbrich, Ralf Fendel, Michele Lenza, Heinz Herrmann for valuable comments. All errors are my own.

[1] Artis, Galvão and Marcellino (2003) also emphasize that an increased importance of financial markets should enhance the speed of transmission.

From a theoretical point of view, however, the effect of globalization on business cycle transmission is unclear. Let us explore this a little further. In terms of trade, higher import demand in one country, for example, will boost exports in other countries (e.g. Canova and Dellas (1993)). Also, productivity advances may spread internationally through vertical integration (e.g. Kose and Yi (2001), Elliott and Fatás (1996)). Through these two mechanisms, trade should strengthen the international business cycle co-movement. However, if trade is accompanied by a larger degree of inter-industrial specialization, linkages should be lowered in the presence of industry-specific shocks (e.g. Frankel and Rose (1998)).

How exchange rates move in response to a shock depends crucially on the type of shock and on frictions in the economy, such as trade barriers, nominal rigidities, the size of the non-tradables sector and pricing-to-market behaviour (Prasad (1999), Ahmed, Ickes and Wang (1993), Clarida and Galí (1994), Rogoff (1996)). The theoretical impact of exchange rate movements on economic activity is ambiguous as well (IMF (1998)). Suppose, for example, that a positive shock abroad causes a depreciation of the domestic currency. The depreciation leads to a gain in competitiveness and a rise in net exports. Thus far, a currency depreciation strengthens the transmission mechanism. However, mechanisms also exist which cause a depreciation to weaken the transmission mechanism. If the depreciation is coupled with an increase in import prices, this represents a negative wealth effect. Moreover, a depreciation can lead to imported inflation - in turn, causing a rise in interest rates and dampening domestic demand.

Financial integration enables agents to diversify their risk by investing in different markets, and financial prices become more highly synchronized through arbitrage. Financial price fluctuations in one market can therefore influence economic activity in different countries (Kose, Prasad and Terrones (2003a,b), Doyle and Faust (2002)). Again, besides this positive effect of financial integration on synchronization, there can be a negative effect. Mobile capital may be reallocated to economies where it is used most productively, inducing specialization in goods production and, as for trade induced inter-industry specialization, loosening business cycle co-movement after industry-specific shocks (Canova and Marrinan (1998), Kalemli-Ozcan, Sørensen and Yosha (1999), Imbs (2004), Heathcote and Perri (2000)).

The last channel on which we focus is the confidence channel. Imperfect information on foreign variables or on the transmission of external shocks to the domestic economy, combined with costs of forming expectations, may cause domestic agents to make persistent expectational errors. If agents base their consumption and investment decisions on expectations with respect to foreign variables, expectational errors trigger real effects in addition to the impact that would have resulted from the transmission via trade and financial markets. Whether the confidence channel strengthens or weakens the transmission mechanism therefore depends on whether agents overestimate or underestimate the spillovers.

Given the conflicting theories, the question of how globalization affects the international propagation of macroeconomic shocks has to be solved empirically. Existing empirical studies generally find overall positive effects of trade and financial integration on business cycle co-movement (e.g. Otto, Voss and Willard (2001), Kose, Otrok and Whiteman (2003a,b) and Imbs (2004)). While there is some empirical evidence of the role of confidence or expectations for the international spreading of financial crises, there is not much evidence of the confidence channel in normal cyclical periods and for developed countries.

The present paper contributes to this literature by examining the transmission of US shocks to the German economy. We make use of the large-dimensional structural dynamic factor model developed by Giannone, Reichlin and Sala (2002) and based on Stock and Watson (1998, 2002a). This model has the particularly useful feature that it allows us to examine the responses of many variables to macroeconomic shocks. Hence, it can be employed to assess simultaneously the relevance of a large number of transmission channels, including the 'new' channels. Therein lies the main advantage of our approach compared with previous work. To the best of our knowledge, this paper is the first to examine the international business cycle transmission channels in such a framework.

Besides the transmission channels, we will address the following questions: To what extent do US shocks spill over to German output, employment, prices and policy variables? Has the transmission mechanism changed over time and, if so, how? To what extent does the propagation depend on the type of shock? All these questions are particularly relevant for forecasters. In addition, they are important for policymakers, especially in the light of well-known policy transmission lags.

This paper is organized as follows. Section 2 gives an overview of the models usually employed to study the topic of international business cycle linkages. We then present our model and describe the data. We estimate the model, and identify US macroeconomic shocks making use of the identification scheme developed by Uhlig (2003a). Section 3 illustrates the relevance of US shocks for the movement of German key variables, including variables covering the transmission channels.

Section 4 assesses whether the transmission mechanism has changed over time. Section 5 analyzes the contribution of US shocks to economic activity in Germany since the mid-1990s. Section 6 contains the conclusion.

2 The model, estimation and identification

2.1 Model selection

International business cycle linkages have been examined by means of various empirical models, ranging from vector autoregressive (VAR) models[2], cross-country regression models[3], fully structural macroeconometric multi-country models[4], and factor models[5]. VAR models and factor models generally focus on the aggregate business cycle linkages. Cross-country regression models and multi-country macroeconometric models are usually employed to investigate a subset of transmission channels.

A major drawback of VAR models and cross-country regression models is that they cannot be used to examine a large number of transmission channels simultaneously. VAR models can only include a limited number of variables. Otherwise, the researcher may run into collinearity problems, and parameters are less precisely estimated. In cross-country regression models some measure of co-movement is regressed on variables covering trade and financial integration. As for VAR models, such models have to cope with the collinearity of explanatory variables. In addition, cross-country regression models need to deal with endogeneity problems. In contrast to these models, fully structural multi-country macroeconometric models contain a large number of variables. The reactions of many variables to shocks can be assessed. These models at present, however, do not contain all channels. For instance, stock markets, confidence, foreign direct investment, and bank lending are generally missing. The reason may be a lack of consensus on how to model these 'new' channels in a wholly structural framework. These models are found to be not able to fully account for the international cyclical co-movement, which suggests that the missing channels are of some importance (IMF (2001), GCEE (2001)). One might consider it a further drawback that

2 for example, Canova and Marrinan (1998), German Council of Economic Experts (GCEE, 2001), Artis, Osborn and Perez (2003)

3 for example, Otto, Voss and Willard (2002), Kose, Prasad and Terrones (2003b), Imbs (2003)

4 for example, Dalsgaard, André and Richardson (2001), IMF (2001b), GCEE (2001)

5 for example, Stock and Watson (2003), Monfort, Renne, Rüffer and Vitale (2003), Kose, Otrok and Whiteman (2003a,b), Lumsdaine and Prasad (2003), Kose, Prasad and Terrones (2003a), Bayoumi and Helbling (2003), Norrbin and Schlagenhauf (1996)

these models rely on theoretical assumptions which may be overly restrictive. Finally, most of the above-mentioned factor approaches are based on small-scale factor models, generally including only output measures of few industrial countries and investigating the co-movement of these measures.[6] In addition, structural analysis is limited.[7]

We employ a large-scale structural dynamic factor model because we believe that this model overcomes some of the limitations of previous work. One key advantage is that the model can illustrate the reactions of a large number of variables to shocks.

These variables comprise diverse transmission channels, including the 'new' channels. Endogeneity and collinearity of the variables are no problem in our framework. Moreover, there is no need to have an exact idea of how these 'new' channels work. Thus, we need to make only a minimum of assumptions - focused on the identification of structural shocks - and let the data speak for itself. This advantage is accompanied by one obvious drawback: the interpretation of the outcome is difficult for such a largely reduced form model. A further disadvantage of our model is that we can assess how trade variables, financial market variables etc. react to the shocks, but we do not know how movements in each of these variables *ceteris paribus* affect economic activity in Germany.

The class of large-scale dynamic factor models contains three models developed by Stock and Watson (1998, 2002a), Forni, Hallin, Lippi and Reichlin (2000) and Kapetanios and Marcellino (2003). All perform similarly well in terms of forecasting accuracy (Kapetanios and Marcellino (2003), Forni, Hallin, Lippi and Reichlin (2003)). We employ the Stock and Watson (1998, 2002a) model. The reason is that it can be estimated by means of static principal component analysis. This is much easier to apply than the Forni, Hallin, Lippi and Reichlin (2000) model, which relies on dynamic principal component analysis,[8] and the state-space model of Kapetanios and Marcellino (2003) which involves using a subspace algorithm.

Large-scale factor models have long been used as a purely statistical tool. The co-movement of the variables has been exploited, common factors have been estimated and used for prediction or to build an economic indicator. Generally, the common factors have no direct structural interpretation. Recently, however, these models have been extended and can now be used to perform structural analysis. It is assumed that the

[6] An exception is Bayoumi and Helbling (2003) who include 35 series of output, investment, consumption and exports of G7 countries and estimate the dynamic factor model developed by Forni, Hallin, Lippi and Reichlin (2000).

[7] Some of the studies regress common international factors on potentially explanatory series, like US shocks, which were previously identified outside the model, and oil price shocks (Stock and Watson (2003), Kose, Otrok and Whiteman (2003a,b), Monfort, Renne, Rüffer and Vitale (2003)).

[8] The concept of dynamic principal components goes back to Brillinger (1981) to whom we refer.

common factors are driven by interpretable common macroeconomic shocks. Methods generally employed in structural VAR analyses are used to identify these shocks and to compute the statistics of interest. Papers combining the factor approach and structural VAR techniques are the ones by Forni and Reichlin (1998), Sala (2001), Giannone, Reichlin and Sala (2002), Cimadomo (2003) and Forni, Lippi and Reichlin (2003). While the first two studies rely on the dynamic factor model developed by Forni, Hallin, Lippi and Reichlin (2000), the latter three employ the Stock and Watson (1998, 2002a) model or a modified version. Most studies focus on the US only, an exception is Sala (2001) who concentrates on the Euro area.

2.2 The model, estimation techniques and data

We proceed as follows. Out of a data set containing a large number of both US and German macroeconomic variables we extract common factors according to Stock and Watson (1998, 2002). The common factors are assumed to be driven by common structural shocks. We argue that these structural shocks include US shocks which spill over to the German economy. We identify such US shocks making use of the identification scheme developed by Uhlig (2003a). We ultimately assess the responses of German variables to these shocks. Let us now explain these steps in detail.

We build an *N*-vector of variables y_{it}, $\mathrm{Y}_t = [y_{1t} \quad y_{2t} \quad ... \quad y_{Nt}]'$, with $i = 1,....,N$ and $t = 1,....,T$. We rely on a large data set with $N = 296$ variables observed over $T = 112$ quarters from 1975 to 2002. This period is chosen mainly because the last capital controls have been abolished in the US and in Germany in 1973 and 1974 respectively. Moreover, this period corresponds to the post-Bretton Woods era of a flexible exchange rate system. The data set contains domestic real and nominal variables of the US economy and the German economy. In addition, it includes measures covering the international integration of both countries, namely trade and financial variables and confidence indicators. Global influences are captured by world oil prices and other world export prices. The series are standardized to have variances equal to 1. In addition, if original series were not covariance-stationary, they were made stationary through differencing and/or deterministic detrending. For details on the construction of the data set and the treatment of the series we refer to Appendix A and Table 1.

The model now assumes that Y_t can be represented as the sum of two unobservable *N*-dimensional vectors, $\mathrm{X}_t = [x_{1t} \quad x_{2t} \quad ... \quad x_{Nt}]'$ and $\Xi_t = [\varepsilon_{1t} \quad \varepsilon_{2t} \quad ... \quad \varepsilon_{Nt}]'$, x_{it} and ε_{it} being scalars:

$$Y_t = X_t + \Xi_t.$$

X_t is the product of a *r*-dimensional vector of common factors F_t, where *r* is the number of common factors, and a $N \times r$-matrix $C = [c'_1 \quad ... \quad c'_N]'$ of factor loadings, where c'_i is of dimension $r \times 1$:

$$X_t = CF_t.$$

Because F_t is common to all variables y_{it}, X_t is called the common component. Ξ_t varies across y_{it} and is called the idiosyncratic (variable-specific) component. Variable *i* may thus be written as

$$y_{it} = c_i F_t + \varepsilon_{it}.$$

Behind the common factors lie common shocks which are global shocks and/or idiosyncratic shocks that are propagated to other variables. Those factors and shocks are the same for all variables, but reactions to changes in the common shocks may differ. This can be seen from the loadings which depend on *i*. Vector Ξ_t, by contrast, contains influences which are specific to individual variables or small groups of variables. Behind Ξ_t, thus, lie idiosyncratic shocks which do not or barely spread to other variables. Ξ_t may also reflect measurement error. The idiosyncratic component is allowed to be serially correlated and weakly cross-correlated.[9] Moreover, it can be weakly correlated with the common component. In this framework, lagged (dynamic) factors are treated as additional (static) factors, and therefore, the vector of common factors F_t may contain lagged factors besides contemporaneous factors. Hence, *r* is typically larger than the number of common structural shocks.

The next step is to estimate the model. In order to estimate the common component, the collinearity of the variables is exploited, and it is supposed that few common forces or factors drive our set of variables. Stock and Watson (1998, 2002a) show that the common component can be estimated consistently by means of static principal component analysis applied to Y_t as $T, N \to \infty$ and $T / N \to 0$. We therefore perform an eigenvalue-eigenvector decomposition of $\text{cov}(Y_t)$. The estimated vectors of

---

[9] For the latter reason, the model is called an approximate factor model. It is more general than the strict factor model which requires errors to be uncorrelated with each other.

common factors, factor loadings and common component depend on V, the $N \times r$ matrix of the eigenvectors which correspond to the first r eigenvalues of $\text{cov}(\text{Y}_t)$:

$$\hat{\text{F}}_t = \text{V'Y}_t, \hat{\text{C}} = \text{V}, \hat{\text{X}}_t = \hat{\text{C}}\hat{\text{F}}_t = \text{VV'Y}_t.$$

The idiosyncratic component is simply estimated as $\hat{\Xi}_t = \text{Y}_t - \hat{\text{X}}_t$. The number of static principal components r is determined by means of the formal criteria derived by Bai and Ng (2002). For our data set, the criteria suggest $r = 8$.[10]

The next step is to model the estimated common factors. We follow Giannone, Reichlin and Sala (2002) and assume that F_t is well described by a VAR(p) model. p is determined by means of the usual information criteria developed for time series models and is found to be 1.[11] The VAR(1) model is then written as follows:

$$\text{F}_t = \text{BF}_{t-1} + \text{u}_t,$$

with B being the coefficient matrix of dimension $r \times r$ and F_t and u_t being r-vectors. The reduced form model is estimated with OLS applied to each equation.

2.3 Identification scheme

The aim is now to identify interpretable structural US shocks out of the reduced form VAR residuals. Those are related linearly to the structural shocks w_t: $\text{u}_t = \text{Dw}_t$. In order to find D (or some part of it), we make use of the identification scheme developed by Uhlig (2003a). The proceeding is in three steps. First, we orthogonalize the reduced form VAR residuals. Second, we identify the main driving forces of the US economy. This is achieved by extracting the shocks which maximize the forecast error variance of US economic activity out of the orthogonalized residuals. Third, we rotate these not yet fully identified shocks in order to give them a structural meaning. In the following, we explain in detail how we applied this technique to our model and then spell out the reasons for our strategy and differences to previous approaches.

First step: the residuals u_t are orthogonalized, as in Uhlig (2003a), by means of the Cholesky decomposition, but any other orthogonalization would work as well. Hence $\text{cov}(\text{u}_t) = \text{AA'}$, with A being the $r \times r$ lower triangular Cholesky matrix. The vector of orthogonalized residuals is $\text{v}_t = \text{A}^{-1}\text{u}_t$ and $E(\text{v}_t \text{v'}_t) = \text{I}$. The vector of impulse

[10] We also varied r, but results did not change much.
[11] Results did not change notably with $p = 2$.

response functions of y_{it} in period k to v_t is $\varphi_{ik} = \mathrm{c}_i \mathrm{B}^{\mathrm{k}} \mathrm{A}$, and the corresponding variance of the k-step ahead forecast error is $\varphi_{i0}\varphi'_{i0} + \ \ldots \ + \varphi_{ik}\varphi'_{ik}$.

Second step: we identify the main driving forces or shocks of the US economy. We label the vector of these shocks $\omega_t = (\omega_{1t} \quad \omega_{2t} \quad \ldots \quad \omega_{rt})'$, with ω_{jt}, $j = 1,\ldots,r$, being scalars, and we suppose that v_t is linearly related to them through the $r \times r$ matrix Q: $\mathrm{v}_t = \mathrm{Q}\omega_t$. The aim is to choose Q so that the first shock explains as much as possible of the forecast error variance of US GDP over a certain horizon k, the second shock explains as much as possible of the remaining forecast error variance etc. US GDP is a proxy for economic activity. We choose k to be 19, which yields the variance of the five years ahead forecast error.[12]

Because v_t is the vector of orthogonal shocks, we can write the forecast error variance accounted for by r shocks as the sum of the forecast error variance accounted for by each shock. Let us now focus on a single or the first shock. The forecast error variance accounted for by this shock is $\varphi_{i0}\mathrm{q}_1\mathrm{q}'_1\varphi'_{i0} + \ \ldots \ + \varphi_{ik}\mathrm{q}_1\mathrm{q}'_1\varphi'_{ik}$, where i stands for US GDP and q_1 is the first column of Q. Uhlig (2003a) shows that q_1 should be chosen so that $\mathrm{q}'_1 \mathrm{S}_{ik}\mathrm{q}_1$ is maximized, where $\mathrm{S}_{ik} = (k+1-0)\varphi'_{i0}\varphi_{i0} + \ \ldots \ + (k+1-k)\varphi'_{ik}\varphi_{ik}$, subject to $\mathrm{q}'_1\mathrm{q}_1 = 1$, which is a normalization condition.[13] The Lagrangian may be set up as follows:

$$L = \mathrm{q}'_1 \mathrm{S}_{ik}\mathrm{q}_1 - \gamma(\mathrm{q}'_1\mathrm{q}_1 - 1),$$

where γ is the Lagrange multiplier. The solution to this problem q_1 is the first eigenvector of S_{ik} and γ is the corresponding eigenvalue. The shock associated with q_1 may therefore be called first principal component shock. Hence, Q is the matrix of eigenvectors of S_{ik}, $(\mathrm{q}_1 \quad \mathrm{q}_2 \quad \ldots \quad \mathrm{q}_r)$, where q_j is the eigenvector corresponding to the j^{th} principal component shock and $j = 1,\ldots,r$.

Two shocks are sufficient to explain the bulk, i.e. 97%, of the variance of the forecast error of the common component of US GDP, given by the sum of the first two eigenvalues of S_{ik}. Hence, we concentrate on two principal component shocks, represented by $(\omega_{1t} \quad \omega_{2t})'$, and neglect the remaining ones.

Third step: up to now, the principal component shocks are identified up to a rotation. This means that we can pre-multiply $(\omega_{1t} \quad \omega_{2t})'$ with any 2×2-dimensional orthonormal matrix R and the resulting vector of orthogonal two shocks, referred to as

---

[12] Uhlig (2003a) and Altig, Christiano, Eichenbaum and Linde (2003) also choose US output and $k = 19$.
[13] For a detailed derivation see Uhlig (2003a).

$(w_{1t} \quad w_{2t})'$, will still explain in total all the variation accounted for by the first two eigenvalues of S_{ik}.

$$\begin{pmatrix} w_{1t} \\ w_{2t} \end{pmatrix} = \mathrm{R}\begin{pmatrix} \omega_{1t} \\ \omega_{2t} \end{pmatrix}, \text{ where } \mathrm{R} = \begin{pmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{pmatrix}.$$

Rotations can be performed for the angles $\theta \in [0,...,\pi/2[$. This allows us to systematically search among all orthogonal shocks. Note that further rotations only result in repetitions (possibly with a flipped sign).

The objective is now to fix a rotation which yields plausible results in terms of impulse response functions and variance decompositions. Suppose that the first two columns of AQ correspond to the $r \times 2$-dimensional impulse matrix associated with the first and the second principal component shocks, called Λ. Then the vector of the impulse response functions associated with the first two principal component shocks can be computed as $\psi_{ik} = c_i B^k \Lambda R$ and the corresponding forecast error variance as $\psi_{i0}\psi'_{i0} + \ ... \ + \psi_{ik}\psi'_{ik}$. We finally follow Uhlig (2003a) and choose $\theta = 0$, because this rotation yields reasonable results, as we will explain below.

Our strategy obviously differs from the identification schemes usually employed in the structural VAR and structural dynamic factor literature. There are three reasons for this, the first two being related.

First, there exists a large number of studies identifying shocks in a closed economy framework. Such studies generally consider a supply, a real demand, and some sorts of nominal shocks. Identification of these shocks is normally achieved by directly restricting parameter values. However, in a multi-country framework, there is less evidence of the prevalent shocks. Hence, in order to properly identify our common shocks, we cannot just multiply the orthogonalized residuals with a single matrix and fully identify the shocks by imposing restrictions (such as long-run restrictions or zero-contemporaneous restrictions) on the parameter values. Instead, we would need to apply a more agnostic identification procedure, like those employed by Peersman (2003) and Canova and de Nicoló (2003).[14] In our framework, this would first require to determine the number of structural common shocks, call it q, and to search among all possible $q \times q$ rotations for the one which enables the researcher to give the shocks a structural meaning.

[14] Peersman (2003) chooses the rotation for which the signs of the short term impulse response functions are compatible with structural shocks; Canova and de Nicoló (2003) focus on conditional covariances.

A way to determine q is to follow Forni, Hallin, Lippi and Reichlin (2000) and to apply dynamic principal component analysis. In particular, these authors suppose that the number of structural shocks equals the number of dynamic principal components. They require that q dynamic principal components explain together a certain share, say 50% or 60%, of the variation of the total system on average over all frequencies.[15] On the basis of these (rather informal) criteria and our data set, q = 5 or 6.[16]

This leads us to the second reason for our strategy: such a large rotation is computationally infeasible for reasonably small rotation angles.[17] Uhlig's (2003a) method provides a way out of this difficulty because it represents a very useful sort of reduced-form identification scheme. It can be expected that fewer shocks are relevant for US economic activity than for the whole system. With two principal component shocks being enough to explain most fluctuations of US GDP, we indeed need to perform no greater than a 2×2 rotation.

The third reason for our strategy is that it is difficult to disentangle US shocks that spill over to Germany and other common shocks, which can underlie the common factors. Uhlig's (2003a) method of focusing on the main driving forces of the US economy seems a natural way to directly identify US shocks.

We find much evidence, that the two principal component shocks just identified are shocks that have their origin in the US. Let us anticipate some of our results: it turns out that the two main driving forces of the US economy explain a larger variance share of US than of German GDP fluctuations. Moreover, US GDP reacts contemporaneously to the first principal component shock whereas German GDP responds only with a delay. The contemporaneous reactions of US and German GDP to the second principal component shock, however, do not differ significantly. In order to check further whether we identified US shocks or other common shocks, we perform the factor analysis and the identification for a data set containing US variables only. The impulse responses of US variables based on this reduced data set and on the bi-national data set look very similar. We finally find that the contribution of the principal component shocks to the variance of the forecast error of world oil prices and other world export

[15] Alternatively, each dynamic principal component may be required to explain at least some critical share, say 5%, of the variance of the total system.

[16] Our q is notably larger than the q of 2 or 3 found, for instance, by Giannone, Reichlin and Sala (2002). The reason for the difference to our finding is that they use on a more homogenous data set which relies on US variables only and on a shorter period.

[17] In the case of a 5×5 rotation for instance, there are 5(5-1)/2 = 10 bivariate rotations of different elements of the VAR model for a fixed angle. If we chose the number of angles between 0 and π to be 12, as in Peersman (2003) or Canova and de Nicoló (2003), this amounts to 12^{10} = 61917364224 rotations. For comparison, Peersman (2003) performs a 4×4 rotation, which requires much fewer (12^6 = 2985984) rotations.

prices is low, indicating that the extracted shocks are not world oil price or other global commodity price shocks which could also drive the common component.

Overall, we therefore conclude that the two identified principal component shocks are US shocks. This is consistent with Ahmed and Park (1993) and Ahmed, Ickes, Wang and Yoo (1993) who find that country-specific shocks are more important in explaining output fluctuations in OECD countries than external shocks. While even a large and relatively closed economy like the US may be substantially influenced by external shocks during specific crises periods, this is not plausible for a longer period such as the one considered here.

2.4 Characterization of the US shocks

Impulse response functions of US variables to principal component shocks of one standard deviation and variance decompositions associated with $\theta = 0$ can be seen in Figure 1 and Table 2. The contemporaneous reactions of US GDP to the principal component shocks are normalized to be non-negative.[18] We report the median impulse responses and the 90% confidence intervals which are constructed applying bootstrap techniques. For details on the construction of the confidence bands see Appendix B.

The first principal component shock accounts for 90% and the second principal component shock captures 7% of the forecast error variance of US GDP over five years.[19] The first principal component shock looks like a medium-run or supply shock: it explains 92% of the variance of the forecast error of US GDP in the medium run (three to five years) and 66% in the short run (up to one year).[20] Impulse responses

---

[18] We also pre-multiply the impulse response functions by the standard deviation of the variables in order to reverse the standardization. Accumulated impulse responses are shown for previously differenced variables.

[19] It would be more precise to refer to the forecast error of a variable's common component. But for brevity, we refer to the forecast error of a variable in the text. Given that the common component accounts for 70% of US GDP growth (Table 3) and that the covariance between the common component and the idiosyncratic component is approximately zero here, the variance share of the first principal component shock is roughly comparable to Uhlig (2003a), whose first principal component shock explains 70% of the variance of the forecast error of US GDP over 0 to 19 quarters and for $\theta = 0$. The variance share of the second principal component shock seems to be lower compared to Uhlig's (2003a) estimate of 15%. However, comparison should not be made without caution: GDP growth, not GDP itself, is decomposed into common and idiosyncratic component, whereas the variance of the forecast error is computed with respect to levels. We could have computed the variance decomposition of the forecast error with respect to growth rates too. But we decided not to do so in order to provide comparability to Uhlig (2003a), who estimates his VAR model in levels and reports variance decompositions with respect to levels.

[20] The variance of the common component of US GDP explained by the first principal component shock in the medium run is largest for $\theta = 0$. Our choice of θ is therefore consistent with the view that productivity or technology shocks are the main movers of economic activity in the medium run (Uhlig (2003b)). This may also represent a criterion to discriminate between different rotation angles.

show that it raises US output and lowers prices and interest rates. This is consistent with the standard aggregate supply-aggregate demand framework, but also with more complex models like the dynamic stochastic general equilibrium model developed by Smets and Wouters (2002) which accounts for nominal rigidities.[21] In such a model, a productivity shock raises production, lowers marginal cost and hence prices and interest rates, the latter being determined by a Taylor-style monetary policy reaction function. Note also that the interpretation as a supply shock and the large explanatory power of this shock for fluctuations of US GDP finally is consistent with the real business cycle view.[22] Magnitudes are similar to Uhlig (2003a).

By contrast, the second principal component shock captures 32% of the forecast error variance of US GDP in the short run and only 5% in the medium run. Hence, it may be seen as a short-run shock. However, its structural meaning is harder to determine. Output, prices and interest rates rise in response to the shock, suggesting a real demand shock behind the second principal component shock, again consistent with the above mentioned models. However, government expenditures do not go up significantly, and private consumption only increases shortly before exhibiting a prolonged decline. Private investment increases quite strongly. If one supposes that the price effect precedes the capacity effect, the second principal component shock could therefore be related to investment rather than to private consumption or fiscal policy. But one should be careful when interpreting the second principal component shock, and from now on, we refer to it as a short-run shock.[23]

None of the two principal component shocks explains much of the variation in world export prices. The first shock captures 6% of the forecast error variance of world oil prices and only 12% of other world export prices over horizons 0 to 19. The second

[21] See also Canova and de Nicoló (2003) who sketch theoretical models consistent with our impulse responses.

[22] This literature claims that productivity shocks account for the bulk of output variation. On the other hand, we are aware that the contribution of these shocks to business cycle fluctuations crucially depends on the identification scheme (see, for example, Galí (1999), Peersman (2003), Canova and de Nicoló (2003) who all apply distinct identification techniques and find relatively low contributions of productivity shocks).

[23] Uhlig (2003a) also has difficulties to explain the second principal component shock. In contrast to our model, consumption only responds with a delay in his model. He thus prefers to interpret the second principal component shock as a wage push shock possibly provoked by blurred productivity signals, leading to inflationary pressure and contractionary monetary policy, rather that a real demand shock. However, this interpretation does not seem to be compatible with our impulse response function of consumption, which rises on impact and then declines.

shock explains 8% and 13% respectively.[24] Hence, oil price or other commodity price shocks do not seem to lie behind the two principal component shocks.

As a last check, we plot the two shock series for the period from 1994 to 2002 (Figure 2). The graphs are consistent with a widely shared view of a large productivity shock being dominant in the second half of the 1990s. At the end of the 1990s, the short-run or demand shock may have stimulated economic activity. The first principal component shock exhibited repeatedly negative values since the end of the 1990s, the second principal component shock since the end of 2000; both shocks may have induced the US recession in 2001. This is consistent with our structural interpretation of the shocks.

3 Impact on the German economy and transmission channels

Let us now focus on impulse responses and variance decompositions of German economic variables to the two US shocks. According to Figure 1, the US shocks display effects in Germany that are symmetric to the effects in the US.

The first US principal component or medium-run shock leads to a gradual long-lasting rise in German real GDP of up to 0.5%. The effect becomes significant after about two years. The median contribution of this shock to the variance of the forecast error of German GDP amounts to 10% for horizons 0 to 19, to 2% in the short run and to 12% in the medium run.[25] The positive response of GDP can be explained by an increase in investment, whereas consumption does not change significantly. Note the significantly positive reaction in employment. Prices respond strongly to the shock. They decline significantly on impact and decrease further up to -0.9%, where they remain. Monetary policy seems to play a role in accommodating the medium-run US shock.

The second US principal component or short-run shock has an immediate impact on German GDP of +0.4%. The impact declines thereafter until becoming insignificant after roughly one year. The corresponding median variance contribution is 6%. This share is quite large given the relatively low explanatory power of this shock for US economic activity. The contribution of this shock is larger in the short run (14%) than in the medium run (4%). Investment, consumption, employment, capacity utilization, and productivity also increase. Prices rise gradually up to +0.4% after almost three years where they remain. Monetary policy strongly counteracts the short-run shock.

---

[24] The shares of the common component are 35% and 32% for world oil prices and other world export prices respectively.

[25] The variance share of the common component of German GDP growth is 77%.

Next, we describe the impact of the US shocks on the variables covering the transmission channels. We focus on real trade variables, exchange rates and the terms of trade, stock prices, long-run interest rates and capital flows, as well as German confidence measures. We treat exchange rates within the trade block, although they are determined by capital flows as well. Note that we focus only on total trade and capital flow measures of each country. We could have also taken into account bilateral trade and capital flows separately. This would have allowed us to examine the relevance of direct versus third market effects. However, this is left for future research. Finally, it is difficult to isolate the confidence channel. We focus on survey-based confidence measures, but we keep in mind that financial prices and short-term capital flows also reflect movements in confidence.

- Real trade and relative prices. The first principal component shock reduces net exports in Germany. Behind this reduction stands an immediate decline in German exports. Export responses turn insignificant after three quarters. In addition, German imports become significantly positive after six quarters. The decline in German net exports is accompanied by a real appreciation of the currency - possibly because German prices decline less than US prices during the first year after the shock - and an improvement in the terms of trade due to strongly declining import prices.[26] The second principal component shock, by contrast, triggers a significantly positive and permanent response of the trade balance, caused by persistently rising exports. Imports also exhibit a positive response, which is, however, transitory and smaller than the response of exports. In contrast to the first principal component shock, the terms of trade worsen and the German currency strongly and permanently depreciates in real terms. The variance decompositions also show that trade is substantially affected by the US shocks. The medium-run shock explains 5% of the forecast error variance of exports and 14% of imports, and the short-run shock captures 33% of exports and 8% of imports. The former accounts for 29% and 21% of the terms of trade and the real effective exchange rate, the corresponding values with respect to the latter are 12% and 16%.
- Financial markets. The first principal component shock leads to a long-lasting increase in German stock prices, paralleling US stock prices. German long-term interest rates decline. Net outflows of foreign direct investment and securities decrease on impact, the impulse responses are insignificant again after about two

[26] Impulse response functions and variance decompositions of import and export prices are not reported here.

years. Moreover, net inflows of credits provided by non-banks rise slightly after more than three years. The second principal component shock does not have a significant impact on US stock prices; consequently, German stock prices are barely affected. Long-term interest rates rise after a delay. Net outflows of credits decrease. In addition, net inflows of foreign direct investment and credits rise. Net inflows of securities decline, which is, however, difficult to interpret. Variance decompositions underline the fact that the medium-run shock has a larger influence on financial prices than the short-run shock does, explaining 24% compared with 6% of the forecast error variance of the DAX and 35% compared with 15% of the forecast error variance of long-term interest rates.

- Confidence. The medium-run shock triggers positive responses of the two confidence measures. The short-run shock in contrast affects only business confidence positively in the short run. It declines thereafter. Consumer confidence also turns negative. Declines in confidence are however difficult to interpret.

In summary, trade seems to dominate the transmission. The medium-run shock may have increased the US supply of inputs, lowered German import prices and raised German real imports. The short-run shock may have triggered an increase in US import demand and hence German exports. Moreover, trade seems to be influenced by relative prices. Real exchange rates and the terms of trade alter competitiveness and consumer spending power and, thus, trade in Germany and dampen the transmission of the medium-run shock and enhance the propagation of the short-run shock. The trade channel seems to be somewhat more important for the propagation of the short-run shock than for the propagation of the medium-run shock. Monetary policy reacts as expected to the strong price movements, accommodating the medium-run shock and dampening the impact of the short-run shock. It seems to display real effects in the medium run, consistent with the transmission lags of monetary policy. It is difficult to draw unambiguous conclusions on the role of financial markets and confidence. Stock price and confidence movements could have enhanced the transmission of the medium-run shock, but not of the short-run shock. Capital flows seem to be supportive of the shock transmission. However, the picture is somewhat blurred. At present, it is not possible to draw conclusions on which categories of capital flows are particularly relevant.

Our results regarding the aggregate impact of US shocks on Germany are consistent with results obtained on the basis of VAR models (e.g. GCEE (2001), Artis, Osborn and Perez (2003), Canova and Marrinan (1998)). The effects found in the present paper are somewhat larger than what is usually found by means of structural macroeconometric multi-country models (e.g. Dalsgaard, André and Richardson (2001), IMF (2001), GCEE (2001)) - as expected, given that not all channels are included in those models. Our findings with respect to the transmission channels are roughly in line with those of Artis, Galvão and Marcellino (2003) and Canova, Ciccarelli and Ortega (2004): the former study finds that exchange rates and monetary policy are most important for the international shock transmission and that capital flows may also be supportive. The latter points out a significant role for trade, monetary policy and the spending power of consumers.

4 Has the transmission changed over time?

In order to investigate whether the transmission has changed over time, we divide our sample into two sub-periods, 1975 to 1990 and 1994 to 2002. We choose these periods in order to exclude the first years after German unification, which might distort the results in small samples.[27] Descriptive correlation statistics should yield an initial impression of how business cycle co-movement has evolved over time:

- The correlation coefficient between US and German GDP growth has slightly decreased over time, from 0.33 in the first period to 0.27 in the second period. Note that the correlation for the total period amounts to 0.24, suggesting that the cyclical co-movement did decrease as a result of German unification.[28]
- The simple (static) correlation coefficient only accounts for contemporaneous or in-phase co-movement. By contrast, the dynamic correlation measure, which is defined as the sum of the squared cospectrum and the squared quadrature spectrum, divided by the product of the spectral densities of two series, also takes into account out-of-phase co-movement.[29] According to Figure 3, the dynamic correlation between US and German GDP growth has slightly increased over time for the business cycle frequency band ($\pi/16$ to $\pi/3$, which corresponds to 1.5 to 8 years). It is unclear, however, whether the lines differ significantly. The phase

[27] Other studies focussing on the co-movement of a larger panel of countries demarcate different periods. Most often the period up to the mid-1980s is compared to the period since the mid-1980s (see, for example, Kose, Otrok and Whiteman (2003a,b)). The first period is generally associated with the global shock period. The second period is seen as the globalization period with a large increase in cross-border asset trade. We also performed our estimation for these periods. The estimation based on 1975 until the mid-1980s yields similar results to the estimation based on 1975 to 1990. Results obtained for the period from the mid-1980s to 2002 are barely interpretable. We thus stick to our first choice.

[28] Helbling and Bayoumi (2003) find a similarly large influence of unification period.

[29] This measure has been developed by Croux, Forni and Reichlin (2001) to whom we refer for further details.

delay provides information on by how many periods one series would need to be shifted in order to exhibit the largest co-movement with another series. This measure is reported in Figure 3. It yields 1/2 to 2 quarters of the US economy leading the German economy, depending on the frequency within the business cycle frequency band, and does not provide evidence of a faster transmission.[30]

These statistics show that it is not sufficient to consider only the static correlation coefficient when one is interested in how business cycle co-movement has evolved over time. Let us now focus on impulse response functions.[31] There is some evidence that the transmission of US shocks to the German real economy has become somewhat stronger over time[32], and the impact longer-lasting (Figure 4). However, impulse responses of German GDP do not differ significantly across the sub-periods, although the impact on investment (and productivity for the short-run shock) has increased significantly, mainly in the medium run.

This change in the transmission pattern may be due to the accumulation of four principle factors. First, financial markets are affected much more strongly than before. Stock price and most capital flow variables rise significantly in response to the shocks between 1994 and 2002, whereas they exhibited no significant change before. Differences between the two periods are quite impressive.[33] Improved access to international financial markets may have raised investment and triggered productivity gains. Second, in contrast to the first period when the German or European currency appreciated in real terms, it depreciated in the second period after the medium-run shock, possibly due to expected persistent productivity differentials between the US and the German economies and reflected in a large delayed increase in the US real interest rate differential. The exchange rate thus did not dampen exports as before. Higher exports, however, have been offset by higher imports. This leads us to the third factor. The rise in imports might have been associated with an increase in imports of intermediate high-tech goods, which might have contributed to the increase in

[30] The phase delay is defined as the phase divided by the frequency. The phase $\delta(\omega)$ represents the radian angle satisfying $sin(\delta(\omega))/cos(\delta(\omega)) = qu(\omega)/co(\omega)$, with *qu* being the quadrature spectrum and *co* the cospectrum of two series and ω the frequency. For a detailed explanation of frequency based multivariate measures, we refer to Hamilton (1994, 268-278).

[31] We do not focus on variance decompositions because those relate the forecast error variance explained by a shock to the variance of the common component. However, the common components are not likely to be the same for different periods, which is also reflected in different *r*'s: *r* is found to be 6 for the earlier period and 3 for the period between 1994 and 2002.

[32] This is consistent with the finding of Artis, Osborn and Perez (2003) and GCEE (2001), who find a slight increase in the transmission of US output shocks to Germany when the beginning of the 1990s is discarded from the sample.

[33] However, in some cases, signs are difficult to interpret. Note that only flows of credits provided by non-banks seem to have played a role between 1975 and 1990.

productivity and investment. This is supported by a much larger percentage increase of imports of information and communication technology (ICT) goods compared to total imports of goods.[34] Fourth, the medium-run shock triggered a longer-lasting price decline and the short-run shock a smaller price increase in the period from 1994 to 2002. This is possibly due to the fact that central banks today have better control over inflation expectations than before. Consequently, monetary policy had to react less strongly to the short-run shock and displayed smaller contractionary effects. Note finally, that no clear pattern can be observed regarding possible changes in the relevance of the confidence channel.

Consistent with our spectral measures, impulse responses do not show any evidence of the transmission having become faster over time. This may be explained by the fact that trade and monetary policy still seem to play an important role for the shock transmission and that it takes some time for them to display real effects. Moreover, besides securities, which contain besides short-run also long-run capital flows, a role appears to be played by more stable and longer-lasting capital flows like foreign direct investment after the medium-run shock and credits after both shocks. In addition, equity may still not be important enough in consumers' portfolios and for investment financing to display real effects in Germany with its bank-based financial system.

When interpreting the results, it must be remembered that the period 1994 to 2002 was rather special with the large productivity boom in the US and overreactions in financial markets, and may not be representative of the future. In addition, in the present paper, we do not distinguish between changes in the impulse response functions, which are due to changes in the shock volatility, and those, which are caused by changes in the propagation of the shocks. The former is also contained in matrix A. Artis, Osborn and Perez (2003) and Stock and Watson (2002b) have shown that the volatility of US shocks has decreased over time. This would show up in smaller absolute impulse responses, even if the propagation mechanism had remained constant, suggesting that we underestimate the rise of the strength of business cycle transmission over time. This should be kept in mind when looking at our impulse responses.[35]

---

[34] ICT nominal imports rose by 107% between 1995 and 2000, whereas total goods imports increased by 59% (Statistisches Bundesamt (2003)).

[35] By means of a counterfactual analysis, Artis, Osborn and Perez (2003) demonstrate that German impulse responses to US shocks in the 1990s would have been larger if the volatility of US shocks had remained constant.

5 Latest US boom and recession - to what extent was Germany affected?

In this Section, we assess the role of the US shocks for the Germany economy since 1995. In particular, we investigate to what extent Germany could benefit from the boom in the US between 1995 and 2000, and whether the current German slump was caused by the US recession in 2001.

We assess the historical decomposition of German economic activity with respect to the shocks derived from the model based on the periods from 1975 to 2002 and from 1994 to 2002. For this purpose we ask how the series would have evolved if they had been driven solely by the US shocks? We generate hypothetical series using the vector of the two principal component shocks $(w_{1t} \quad w_{2t})'$, the parameter matrices $\mathrm{R}(\theta)$, Λ, $\hat{\mathrm{B}}$ and $\hat{\mathrm{C}}$ as well as a starting value for F_t; we choose $\mathrm{F}_{1975:1}$ or $\mathrm{F}_{1994:1}$ respectively. Growth rates are converted into log levels. We then plot the true series against our hypothetical series.

From Figure 5 it can be seen that German GDP was notably lower than it would have been if it had been driven solely by US shocks between 1995 and 2000: the mean (annualized) growth rate of German GDP was 0.9%, the corresponding rates for the hypothetical series are 1.9% (based on 1975 to 2002) and 1.8% (based on 1994 to 2002).[36] Country-specific influences (or other external factors) must have held down economic activity in Germany and overcompensated positive US influences. Both lines are roughly parallel since the beginning of 1999 suggesting that US influences mainly caused the short upward movement of the series and the subsequent slump in Germany. The mean growth rate of German GDP in 2001 was 0.3%, whereas the rate of change of the hypothetical series was slightly lower and negative (- 0.1%) for both models. The negative movement of employment and investment in the first half of the period considered here when compared with the movement if only driven by US shocks is striking and supports the widely held view that domestic influences, like over-capacities in the construction sector after the unification and small productivity gains coupled with relatively high nominal wage increases in the eastern part of Germany, suppressed these two variables. Consistent with what we found above, prices were mainly determined by US influences, although the series itself is more volatile than the hypothetical series. The model based on the entire period yields a picture of real variables, prices and

[36] We also assessed the contribution of each shock separately, but this did not yield much additional information. We therefore only report the hypothetical series of German variables associated with both US shocks together.

monetary policy instruments similar to that in the model based on the period 1994 to 2002.

By contrast, as far as the transmission channels are concerned, the results given by the two models differ. The lines for the series and the hypothetical series derived from the model based on 1994 to 2002 indicate larger US influences than do the lines derived from the model based on the entire period. This holds especially for financial market variables. Most integration measures highlight the large influence of the US. Interestingly, confidence was not much influenced by US shocks in the mid-1990s, but the lines move much more in parallel by the end of the 1990s. This may simply reflect the stronger business cycle transmission via trade or financial markets by the end of the sample period. However, another interpretation is that the confidence channel has only become relevant in the last few years. This would also indicate that it is too early to expect this channel to show up in existing empirical studies.

It should also be noted that our model probably overestimates the contribution of the US to the German expansion and underestimates the contribution of the US recession to the German slump. The reason for this is that our linear model cannot account for asymmetries in the transmission. Studies employing non-linear empirical models find that negative real shocks are transmitted to a larger extent internationally than positive shocks (Artis, Galvão and Marcellino (2003), GCEE (2001), Canova, Ciccarelli and Ortega (2004)). These asymmetries can be explained in terms of nominal rigidities, which are stronger downwards than upwards, menu costs, difficulties for firms facing a stronger demand to expand their capacities, and informational asymmetries between lenders and borrowers (Ball and Mankiw (1994), Peersman and Smets (2001)).

6 Conclusion

In this paper, we have investigated the transmission of US macroeconomic shocks to the German economy between 1975 and 2002 by means of a large-scale structural dynamic factor model. This framework allows us to assess simultaneously the responses of a large set of real and nominal German variables and to investigate the role of many transmission channels, including so called 'new' channels like stock markets, foreign direct investment, international bank lending and the confidence channel. To that extent, it has advantages over other models used in this context, which are not able to investigate as many transmission channels simultaneously.

We have identified two US shocks, one medium-run supply shock and one short-run real demand shock. We find that these shocks affect the US economy and the German economy symmetrically. That is, the supply shock raises output and lowers prices and interest rates, while the demand shock increases all three variables in both countries. The supply shock displays mainly medium-run effects, and the demand shock displays short-run effects in both the US and Germany.

As concerns the transmission channels: trade, influenced by movements of relative prices, seems to play the dominant role in the transmission. Besides trade, monetary policy reacts to relatively strong German price movements and seems to influence the impact of US shocks in the medium run. When we consider the entire period, no clear conclusion can be drawn on the role of financial markets and confidence. However, German capital flows and stock prices are much more affected by US shocks between 1994 and 2002. Greater access to capital markets may have improved German investment opportunities and raised productivity. Capital markets may thus have become more important as a transmission channel and may have increased business cycle co-movement. German confidence has been driven notably by US shocks only since the end of the 1990s. This might indicate that the confidence channel has only become relevant in the last few years.

In contrast to what might have been expected, the transmission has not become faster over time. This may be due to the dominance of trade and monetary policy reactions to external shocks for which it takes time to display real effects. Finally, stable and longer-lasting capital flows such as foreign direct investment, credits and long-run securities might have been affected to a greater extent in the later period than short-term capital flows. Another explanation is that equity is still not important enough in consumers' portfolios and for investment financing to display real effects in Germany with its bank-based financial system.

Historical decompositions finally show that negative domestic factors more than compensated positive US influences during the US boom between 1995 and 2000 in Germany. By contrast, the US recession in 2001 seemed to be mainly responsible for the German slump.

Appendix A

The data set incorporates a large number of variables ($N = 296$). This allows us to exploit as much information as possible. The data are selected so that the US and the German economy as well as the international integration of both countries are represented in a balanced way. Less data are generally available for Germany than for the US. We thus mainly confine ourselves to including series which are available for both countries. No consensus exists yet on whether to include both aggregated and disaggregated or only disaggregated data. We include both because we are interested in the responses of aggregate series to shocks.

The data set can be divided into four blocks. The first two blocks contain variables covering the real side and the nominal side of the US economy and the German economy. When selecting the series for these blocks, we closely follow Giannone, Reichlin and Sala (2002), Stock and Watson (1998, 2002a), and Kapetanios and Marcellino (2003) who use data covering the US economy only. In particular, our data are on GDP, employment, industrial production, capacity utilization, labor productivity and unit labor costs, wages and salaries, personal income and savings, prices, money supply, credits, and interest rates.

The third block contains variables approximating the international economic integration of the two countries. Trade variables include real trade flows (goods and services), export prices, import prices and terms of trade, here defined as export prices divided by import prices, as well as exchange rates. The international financial markets are covered by net capital outflows and inflows, divided into foreign direct investment, securities, credits provided by banks and credits provided by non-banks. The third block also contains financial prices and survey-based confidence measures. The fourth block, finally, contains variables capturing global factors such as world oil prices and other world export prices. These variables help to better disentangle global shocks from US shocks.

The data are derived from various national and international sources. They are seasonally adjusted and quarterly. This frequency is chosen in order to include national accounts series, which are generally not available on a monthly basis. Originally monthly series were converted into quarterly series. The X11 seasonal adjustment method was applied to originally not seasonally adjusted series.

The study is carried out for the period from the first quarter of 1975 to the fourth quarter of 2002. One reason for selecting this period is that important capital controls were abolished in Germany in 1974. In the US, the last capital controls were abandoned in 1973. Moreover, this period corresponds to the post-Bretton Woods flexible exchange rate regime period. Another advantage of this starting date is that potential extraordinary influences of the first oil price shock in 1973-74 are eliminated.

When constructing the data set, a problem to be addressed is the break in the series resulting from German unification. Most German series are extended by applying west German growth rates to the German levels retrospectively from 1991 onwards. It might be argued that unification led to an investment boom which delayed the recession in Germany, and loosened the business cycle linkages with the US, at least temporarily, and that this effect was apparent after 1991. In contrast to a regression framework, where structural breaks can be accounted for easily by means of dummy variables, factor approaches like the one used here cannot easily cope with structural changes. One possibility would be to allow for time variation in the factor loadings, as in Stock and Watson (1998, 2002a). But we prefer the simpler approach pursued here. Alternatively, one might want to use west German data up to 1994, which is a common procedure (e.g. GCEE (2001)). However, this is not possible for many disaggregated series because most west German national account data under the new statistical classification ESA95 are unavailable after 1991. For the purposes of this paper, this problem is hopefully not too severe. Visual inspection of the series does not suggest a break after extending the German series beyond 1991 using earlier west German growth rates.

The consistent estimation of the factors requires the series to be stationary. This is a particularly difficult issue. It is well known in macroeconometrics that the usual unit root tests are not very powerful. This problem is also relevant for the present data set. For example, unit roots for the interest rates, inflation, the terms of trade and the current account balance are detected even if, theoretically, there should be none. We address this problem by performing the analysis with several data sets which differ in the treatment of the series. Results are robust across these data sets. A detailed description of the set finally used may be found in Table 1.

Logarithms are taken for all non-negative series that were not already in rates or percentage units. The series are normalized to have mean zero and variance equal to 1. This is done to account for differences in measurement units within the data set which can influence the factor estimation. Moreover, it guarantees that the variables exhibiting a relatively large variance do not dominate when estimating the common factors.

Appendix B

In order to compute the standard errors for the impulse response functions, we mainly follow Giannone, Reichlin and Sala (2002). The authors argue that the only source of uncertainty to be taken into account in computing confidence intervals is the one regarding the estimation of the VAR model for F_t.[37] The vector of reduced form residuals is resampled 1000 times from the vector of empirical reduced form residuals. The new common factors are generated by simulation, using the newly generated residuals, the first 1 to *p* previously estimated common factors as starting values and $\hat{B}$. The new common factors are taken to re-estimate B and u_t. Principal component shocks are again extracted and the impulse responses of Y_t are computed.

The standard percentile confidence intervals, going back to Efron and Tibshirani (1993), make a bias in the estimated impulse responses apparent. A bias is defined as the difference between the mean of the bootstrapped statistic and the point estimate. This is a well-known problem that can occur in VAR models. It can be explained by the small sample in the factor-VAR model or by the fact that the statistic of interest is a non-linear function of the estimated parameters of the VAR model. The more persistent the data-generating process, the larger is the bias. In addition, we convert the impulse responses of growth rates into impulse responses of levels. This also increases the bias.

There are several methods to account for the bias when constructing confidence bands for impulse responses. The most well-known techniques are probably the BC_α (bias corrected and accelerated) percentile interval developed by Efron and Tibshirani (1993), the percentile interval method by Hall (1992), or Kilian's (1998) bootstrap-after-bootstrap method. The BC_α method is used to construct standard percentile intervals which depend on the bias in the statistic of interest and on the rate of change of the statistic's standard deviation with respect to the true statistic (acceleration). Hall's (1992) percentile interval method consists in sorting the difference between the bootstrapped statistic and the point estimate and in subtracting this difference from the point estimate. Both methods directly apply the bias correction to the statistic of interest, in this case the impulse responses. By contrast, Kilian's (1998) method removes the bias from $\hat{B}$ by means of resampling techniques prior to bootstrapping. We tried all three methods. It turns out that Kilian's (1998) approach only alleviates the bias in the impulse responses, but does not fully eliminate it, probably as a result of non-linearities. Hall's (1992)

[37] They point out that if $N >> T$, the error in the estimation of the factors and factor loadings can be ignored, and the factors can be considered as known when constructing confidence intervals.

method and the BC_α method yield very similar results. We use the former and report the median and the upper and lower bounds of the 90% confidence bands.

We compute standard percentile confidence bands for the variance decompositions. The reason is that Hall's (1992) method does not guarantee that the bootstrapped statistic will lie between zero and one. The same holds for the BC_α method. The bootstrap-after-bootstrap technique circumvents this problem. However, we have seen previously, that much of the bias in the statistics is due to non-linearity. We prefer to revert to the simplest and most straightforward standard percentile confidence intervals for the variance decomposition.

References

Ahmed, S., B. W. Ickes, P. Wang, B. S. Yoo (1993), "International business cycles", *The American Economic Review*, 83(3), June 1993, 335-359.

Ahmed, S., J. H. Park (1993), "Sources of macroeconomic fluctuations in small open economies", Journal of Macroeconomics, 16(1), 1-36.

Altig, D., L. J. Christiano, M. Eichenbaum, J. Linde (2003), "Technology shocks and aggregate fluctuations", manuscript, http://www.moneyworkshop.ch/documents/papers/christiano2.pdf.

Angeloni, I., L. Dedola (1999), "From the ERM to the Euro: new evidence on economic and policy convergence among EU countries", ECB Working Paper 4.

Artis, M. J., M. Ehrmann (2000), "The exchange rate - a shock absorber or source of shocks? A study of four open economies", CEPR Working Paper 2550.

Artis, M. J., A. B. Galvão, M. Marcellino (2003), "The transmission mechanism in a changing world", CEPR Discussion Paper 4014.

Artis, M., D. Osborn, P. J. Perez (2003), "The international business cycle in a changing world: volatility and the propagation of shocks", manuscript, http://www.eabcn.org/agenda/programme0302.htm.

Bai, J., S. Ng (2002), "Determining the number of factors in approximate factor models", *Econometrica*, 70(1), 191-221.

Ball L., N. Mankiw (1994), "Asymmetric price adjustment and economic fluctuations", *The Economic Journal*, 104, 247-261.

Bayoumi, T., T. Helbling (2003), "Are they all in the same boat? The 2000-2001 growth slowdown and the G-7 business cycle linkages", IMF Working Paper WP/03/46.

Brillinger, D. R. (1981), "Time series - data analysis and theory", Holden-Day, Inc., San Francisco.

Brooks, R., K. Forbes, A. Mody (2003), "How strong are global linkages?", manuscript, http://www.imf.org/external/np/res/seminars/2003/global/pdf/over.pdf.

Canova, F., M. Ciccarelli, E. Ortega (2004), "Similarities and convergence in G-7 countries", ECB Working Paper 312.

Canova, F., H. Dellas (1993), "Trade interdependence and the international business cycle", *Journal of International Economics*, 34, 23-47.

Canova, F., G. de Nicoló (2003), "On the sources of business cycles in the G-7", *Journal of International Economics* 59, 77-100.

Canova, F., J. Marrinan (1998), "Sources and propagation of international output cycles: common shocks or transmission?", *Journal of International Economics*, 46, 133-166.

Christiano, L. J., M. Eichenbaum, R. Vigfusson (2003), "What happens after a technology shock?", Federal Reserve Board International Finance Discussion Paper 768.

Cimadomo, J. (2003), "The effects of systematic monetary policy on sectors: a factor model analysis", manuscript.

Clarida, R., J. Galí (1994), "Sources of real exchange rate fluctuations: how important are nominal shocks?", NBER Working Paper 4658.

Croux, C., M. Forni, L. Reichlin (2001), "A measure for comovement for economic variables: theory and empirics", *The Review of Economics and Statistics*, 83(2), 231-241.

Dalsgaard, T., C. André, P. Richardson (2001), "Standard shocks in the OECD Interlink model", OECD Economics Department Working Paper 306.

Doyle, B. M., J. Faust (2002), "An investigation of comovements among the growth rates of the G-7 countries", *Federal Reserve Bulletin*, October, 427-437.

Efron, B., R. J. Tibshirani (1993), "An introduction to the bootstrap", Chapman and Hall, New York.

Elliot, G., A. Fatàs (1996), "International business cycles and the dynamics of the current account", University of California at San Diego, Economics Working Paper 96-07.

Forni, M., M. Hallin, F. Lippi, L. Reichlin (2000), "The generalized dynamic factor model: identification and estimation", *The Review of Economics and Statistics*, November 2000, 82(4), 540-554.

Forni M., M. Hallin, F. Lippi, L. Reichlin (2003), "The generalized dynamic factor model - one-sided estimation and forecasting", ECARES-ULB Working Paper, www.dynfactors.org.

Forni, M., F. Lippi, L. Reichlin (2003), "Opening the black box: structural factor models versus structural VARs", ECARES-ULB Working Paper, www.dynfactors.org.

Forni, M., L. Reichlin (1998), "Let's get real: a factor analytic approach to disaggregated business cycle dynamics", *Review of Economic Studies*, 65, 453-474.

Frankel, J. A., A. K. Rose (1998), "The endogeneity of the optimum currency area criteria", *The Economic Journal* 108 (July), 1009-1025.

Galí, J. (1999), "Technology, employment, and the business cycle: do technology shocks explain aggregate fluctuations?", *American Economic Review*, 89(1), 249-271.

German Council of Economic Experts (2001), "Annual Report 2001/2002", Verlag Metzler Poeschel, Stuttgart, 251-266.

Giannone, D., L. Reichlin, L. Sala (2002), "Tracking Greenspan: systematic and unsystematic monetary policy revisited", ECARES-ULB Working Paper, www.dynfactors.org.

Hall, P. (1992), "The Bootstrap and Edgeworth Expansion", Springer-Verlag, New York:

Hamilton, J. (1994), "Time series analysis", Princeton University Press, Princeton, New Jersey.

Heathcote, J., F. Perri (2000), "Financial globalization and real regionalization", NBER Working Paper 9292.

Imbs, J. (2004), "Trade, finance, specialization and synchronization", Review of Economics and Statistics, forthcoming in August.

IMF (1998), "World Economic Outlook - May 1998", 55-73.

IMF (2001a), "World Economic Outlook - October 2001", 65-79.

IMF (2001b), "Monetary and exchange rate policies of the Euro Area", Country Report 01/60.

Kalemli-Ozcan, S., B. E. Sørensen, O. Yosha (1999), "Risk sharing and industrial specialization: regional and international evidence", Joint Center for Poverty Research Working Paper, http://www.jcpr.org/wpfiles/sorensen.pdf.

Kapetanios, G., M. Marcellino (2003), "A comparison of estimation methods for dynamic factor models of large dimensions", Queen Mary University of London, Working Paper 489.

Kilian, L. (1998), "Small-Sample Confidence Intervals for Impulse Response Functions", *Review of Economics and Statistics*, 80(2), May 1998, 218-230.

Kose, M. A., C. Otrok, C. H. Whiteman (2003a), "Understanding the evolution of world business cycles", manuscript, http://www.imf.org/external/np/res/seminars/2002/global/preconf.htm.

Kose, M. A., C. Otrok, C. H. Whiteman (2003b), "International business cycles: world, region and country-specific factors", *The American Economic Review*, September 2003, 93(4).

Kose, M. A., E. S. Prasad, M. E. Terrones (2003a), "Volatility and comovement in a globalized world economy: an empirical exploration", IMF Working Paper WP/03/246.

Kose, M. A., E. S. Prasad, M. E. Terrones (2003b), "How does globalization affect the synchronization of business cycles?", *American Economic Association Papers and Proceedings*, May 2003, 93(2), 57-62.

Kose, M. A., K. Yi (2001), "International trade and business cycles: is vertical specialization the missing link?", *American Economic Association Papers and Proceedings*, 91(2), 371-375.

Lumsdaine, R. L., E. S. Prasad (2003), "Identifying the common component in international economic fluctuations", NBER Working Paper 5984.

Monfort, A., J. P. Renne, R. Rüffer, G. Vitale (2002), "Is economic activity in the G7 synchronised? Common shocks vs. spillover effects", Working Paper, http://www.cepr.org/meets/wkcn/1/1550/papers/

Norrbin, S. C., D. E. Schlagenhauf (1996), "The role of international factors in the business cycle: A multi-country study", *Journal of International Economics* 40, 85-104.

Otto G., G. Voss, L. Willard (2001), "Understanding OECD output correlations", Reserve Bank of Australia Research Discussion Paper 2001-05.

Peersman, G. (2003), "What caused the early millenium slowdown? Evidence based on vector autoregresssions", Working Paper, http://www.bundesbank.de/vo/download/konferenzen/kon030912_13.pdf.

Peersman, G., F. Smets (2001), "Are the effects of monetary policy in the Euro Area greater in recessions than in booms?", ECB Working Paper 52.

Prasad, E. S. (1999), "International trade and the business cycle", IMF Working Paper WP/99/56.

Rogoff, K. (1996), "The purchasing power parity puzzle", *Journal of Economic Literature*, XXXIV, June 1996, 647-668.

Sala, L. (2001), "Monetary transmission in the Euro Area: a factor model approach", ECARES-ULB Working Paper, www.dynfactors.org.

Smets, F., R. Wouters (2002), "An estimated stochastic dynamic general equilibrium model of the Euro area", ECB Working Paper 171.

Statistisches Bundesamt (2002), "Im Blickpunkt: Informationsgesellschaft", Verlag Metzler Poeschel, Stuttgart.

Stock, J. H., M. W. Watson (1998), "Diffusion indexes", NBER Working Paper 6702.

Stock, J. H., M. W. Watson (2002a), "Macroeconomic Forecasting using diffusion indexes", *Journal of Business & Economic Statistics,* April 2002, 20(2), 147-162.

Stock, J. H., M. W. Watson (2002b), "Has the business cycle changed and why?", NBER Working Paper 9859.

Stock, J. H., M. W. Watson (2003), "Understanding changes in international business cycle dynamics", NBER Working Paper 9127.

Uhlig, H. (2003a), "What moves real GNP?", manuscript, http://eabcn.org/agenda/programme0302.htm.

Uhlig, H. (2003b), "Do technology shocks lead to a fall in total hours worked?", manuscript, http://www.wiwi.hu-berlin.de/wpol/papers/uhlig_v4_tech_shocks.pdf.

Table 1: Data set

Group	# series (US/GER)	Source (US/GER)[1)]	Treatment[2)]
GDP[6)]	1/1	BEA/StaBu	2
Personal consumption[6)]	16/9	BEA/StaBu	2
Private investment[6) 8)]	16/11	BEA/StaBu	2
Government expenditure[6)]	1/2	BEA/StaBu	2
Employment, hours	21/9	BLS/StaBu, OECD	2[3)]
Industrial production	10/7	FRB/Buba	2
Capacity utilization	10/8	FRB/IFO	0 or 3
Productivity, unit labor costs	3/2	BLS/Buba, StaBu	2
Wages and salaries[7)]	7/7	BEA/StaBu	2
Disposable income, savings	3/3	BEA/StaBu	2[4)]
Prices	19/12	BLS, BEA/OECD, StaBu	2
Money, reserves, credits	7/8	FRB/Buba	2
Survey-based confidence	5/3	Conf. Board, ISM, FRB/EU, IFO	0 or 3
Interest rates[7)]	14/7	FRB, Buba	0
Stock prices	2/1	Datastream/Buba	2[5)]
Trade flows[9)]	6/12	BEA/StaBu	2
Export and import prices, terms of trade	7/7	BEA/StaBu	2
Exchange rates	1/1 (+1)	FRB/Buba	2
Capital flows	10/20	BEA/Buba	3
Current account balance	1/1	BEA/Buba	3
World commodity prices	4	Datastream	2
Total	296		

1) Abbreviations: Bureau of Economic Analysis (BEA), Bureau of Labor Statistics (BLS), Federal Reserve Board (FRB), European Commission (EU), Statistisches Bundesamt (StaBu), Buba (Deutsche Bundesbank), IFO Institute Munich (IFO)
2) 0: no transformation, 1: logarithm, 2: first difference of logarithm, 3: first difference
3) US unemployment: 1, US and GER unemployment rate: 0
4) US and GER saving rates: 0
5) US price earnings ratio: 0
6) Real
7) Nominal
8) Includes private inventory of the US and private and public inventory of GER
9) Total trade measures are volumes; GER trade with the US, the EU and the rest of the world are values.

Table 2: Forecast error variance of the common components explained by the first US principal component shock, median and 90% confidence interval[1)], 1975-2002, different horizons

	US variables			GER variables		
Variables	0-5 years	0-1 year	3-5 years	0-5 years	0-1 year	3-5 years
GDP[2)]	0,90 (0,79 - 0,96)	0,66 (0,41 - 0,86)	0,92 (0,78 - 0,97)	0,10 (0,01 - 0,31)	0,02 (0,00 - 0,10)	0,12 (0,00 - 0,35)
Private investment[2)]	0,79 (0,65 - 0,90)	0,58 (0,31 - 0,79)	0,80 (0,55 - 0,92)	0,09 (0,01 - 0,31)	0,02 (0,00 - 0,11)	0,11 (0,00 - 0,35)
Personal consumption[2)]	0,68 (0,44 - 0,81)	0,82 (0,67 - 0,90)	0,60 (0,32 - 0,79)	0,05 (0,01 - 0,22)	0,03 (0,00 - 0,16)	0,04 (0,00 - 0,26)
Employment	0,82 (0,70 - 0,90)	0,44 (0,17 - 0,71)	0,88 (0,74 - 0,95)	0,15 (0,03 - 0,40)	0,08 (0,01 - 0,32)	0,17 (0,01 - 0,45)
Productivity	0,16 (0,06 - 0,37)	0,45 (0,23 - 0,64)	0,06 (0,01 - 0,25)	0,09 (0,01 - 0,33)	0,07 (0,01 - 0,23)	0,06 (0,00 - 0,32)
Capacity utilization	0,30 (0,12 - 0,49)	0,16 (0,09 - 0,27)	0,30 (0,04 - 0,57)	0,32 (0,19 - 0,46)	0,24 (0,08 - 0,47)	0,41 (0,12 - 0,69)
Government expenditures[2)]	0,10 (0,00 - 0,35)	0,08 (0,00 - 0,26)	0,11 (0,00 - 0,39)	0,04 (0,00 - 0,20)	0,02 (0,00 - 0,11)	0,05 (0,00 - 0,23)
Consumer confidence	0,56 (0,32 - 0,74)	0,82 (0,63 - 0,91)	0,41 (0,13 - 0,68)	0,24 (0,05 - 0,48)	0,08 (0,02 - 0,22)	0,33 (0,06 - 0,61)
Business confidence	0,38 (0,25 - 0,54)	0,40 (0,25 - 0,59)	0,21 (0,03 - 0,47)	0,24 (0,13 - 0,38)	0,11 (0,03 - 0,27)	0,37 (0,08 - 0,65)
Consumer prices	0,15 (0,01 - 0,40)	0,35 (0,04 - 0,58)	0,10 (0,00 - 0,35)	0,44 (0,15 - 0,65)	0,39 (0,12 - 0,61)	0,45 (0,16 - 0,68)
Short-term interest rates[3)]	0,19 (0,03 - 0,42)	0,20 (0,02 - 0,46)	0,21 (0,01 - 0,55)	0,35 (0,11 - 0,56)	0,40 (0,12 - 0,63)	0,21 (0,02 - 0,44)
Long-term interest rates[3)]	0,13 (0,01 - 0,36)	0,10 (0,01 - 0,36)	0,19 (0,01 - 0,49)	0,35 (0,13 - 0,56)	0,37 (0,12 - 0,57)	0,20 (0,01 - 0,51)
M1[3)]	0,06 (0,01 - 0,29)	0,14 (0,00 - 0,38)	0,04 (0,00 - 0,28)	0,20 (0,02 - 0,48)	0,31 (0,07 - 0,59)	0,17 (0,01 - 0,47)
Stock prices	0,33 (0,09 - 0,57)	0,41 (0,14 - 0,61)	0,30 (0,05 - 0,58)	0,24 (0,05 - 0,62)	0,44 (0,14 - 0,64)	0,19 (0,02 - 0,61)
Wages[3)]	0,55 (0,25 - 0,76)	0,22 (0,02 - 0,55)	0,65 (0,31 - 0,83)	0,12 (0,02 - 0,38)	0,03 (0,00 - 0,19)	0,15 (0,01 - 0,44)
Exports[2)]						
Total	0,41 (0,12 - 0,62)	0,04 (0,01 - 0,17)	0,44 (0,13 - 0,70)	0,05 (0,01 - 0,22)	0,08 (0,00 - 0,27)	0,03 (0,00 - 0,24)
Goods	0,42 (0,13 - 0,63)	0,04 (0,01 - 0,21)	0,47 (0,13 - 0,71)	0,04 (0,00 - 0,19)	0,05 (0,00 - 0,21)	0,03 (0,00 - 0,22)
Services	0,20 (0,01 - 0,48)	0,03 (0,01 - 0,13)	0,22 (0,01 - 0,53)	0,17 (0,03 - 0,43)	0,30 (0,08 - 0,51)	0,10 (0,01 - 0,41)
Imports[2)]						
Total	0,47 (0,26 - 0,70)	0,37 (0,16 - 0,62)	0,40 (0,17 - 0,71)	0,14 (0,01 - 0,37)	0,02 (0,00 - 0,12)	0,16 (0,00 - 0,44)
Goods	0,44 (0,22 - 0,69)	0,36 (0,17 - 0,59)	0,37 (0,14 - 0,68)	0,16 (0,01 - 0,41)	0,03 (0,00 - 0,14)	0,19 (0,00 - 0,46)
Services	0,38 (0,09 - 0,68)	0,24 (0,03 - 0,60)	0,34 (0,06 - 0,72)	0,06 (0,01 - 0,20)	0,10 (0,01 - 0,30)	0,04 (0,00 - 0,18)
Terms of trade	0,08 (0,02 - 0,26)	0,24 (0,03 - 0,50)	0,05 (0,00 - 0,30)	0,12 (0,01 - 0,40)	0,18 (0,01 - 0,44)	0,10 (0,00 - 0,39)
Real effective exchange rate	0,15 (0,01 - 0,44)	0,08 (0,00 - 0,29)	0,15 (0,00 - 0,47)	0,16 (0,01 - 0,47)	0,08 (0,00 - 0,30)	0,17 (0,00 - 0,49)
Current account balance	0,15 (0,04 - 0,47)	0,23 (0,03 - 0,53)	0,08 (0,01 - 0,40)	0,10 (0,02 - 0,31)	0,10 (0,01 - 0,33)	0,10 (0,00 - 0,35)
Net capital outflows						
Total	0,05 (0,00 - 0,25)	0,02 (0,00 - 0,12)	0,05 (0,00 - 0,30)	0,28 (0,05 - 0,53)	0,08 (0,01 - 0,23)	0,33 (0,07 - 0,63)
Foreign direct investment	0,17 (0,02 - 0,39)	0,17 (0,03 - 0,36)	0,15 (0,01 - 0,39)	0,08 (0,01 - 0,28)	0,05 (0,00 - 0,15)	0,08 (0,00 - 0,33)
Securities	0,02 (0,00 - 0,14)	0,02 (0,00 - 0,07)	0,02 (0,00 - 0,18)	0,09 (0,01 - 0,33)	0,07 (0,01 - 0,18)	0,08 (0,00 - 0,34)
Credit banks	0,07 (0,00 - 0,33)	0,04 (0,00 - 0,20)	0,06 (0,00 - 0,38)	0,10 (0,01 - 0,40)	0,02 (0,00 - 0,12)	0,14 (0,00 - 0,50)
Credit non-banks	0,02 (0,00 - 0,15)	0,01 (0,00 - 0,08)	0,02 (0,00 - 0,19)	0,05 (0,00 - 0,28)	0,03 (0,00 - 0,23)	0,05 (0,00 - 0,32)
Net capital inflows						
Total	0,04 (0,00 - 0,22)	0,02 (0,00 - 0,13)	0,04 (0,00 - 0,24)	0,04 (0,01 - 0,20)	0,03 (0,00 - 0,13)	0,04 (0,00 - 0,25)
Foreign direct investment	0,08 (0,01 - 0,30)	0,02 (0,00 - 0,12)	0,09 (0,01 - 0,34)	0,06 (0,01 - 0,31)	0,06 (0,00 - 0,28)	0,05 (0,00 - 0,32)
Securities	0,04 (0,00 - 0,22)	0,03 (0,00 - 0,12)	0,04 (0,00 - 0,26)	0,05 (0,00 - 0,33)	0,06 (0,00 - 0,31)	0,05 (0,00 - 0,35)
Credit banks	0,06 (0,01 - 0,28)	0,03 (0,00 - 0,19)	0,06 (0,00 - 0,29)	0,09 (0,01 - 0,30)	0,02 (0,00 - 0,10)	0,12 (0,00 - 0,38)
Credit non-banks	0,05 (0,00 - 0,26)	0,03 (0,00 - 0,13)	0,05 (0,00 - 0,31)	0,09 (0,01 - 0,32)	0,03 (0,00 - 0,15)	0,13 (0,01 - 0,41)

1) For details on the construction of the confidence bands see Appendix B.

2) Real

3) Nominal

Table 2 cont.: Forecast error variance of the common components explained by the second US principal component shock, median and 90% confidence interval[1], 1975-2002, different horizons

	US variables			GER variables		
Variables	0-5 years	0-1 year	3-5 years	0-5 years	0-1 year	3-5 years
GDP[2]	0,07 (0,03 - 0,15)	0,32 (0,11 - 0,57)	0,05 (0,01 - 0,13)	0,06 (0,01 - 0,36)	0,14 (0,01 - 0,39)	0,04 (0,00 - 0,35)
Private investment[2]	0,09 (0,03 - 0,18)	0,33 (0,12 - 0,59)	0,05 (0,01 - 0,20)	0,06 (0,01 - 0,30)	0,13 (0,01 - 0,38)	0,03 (0,00 - 0,26)
Personal consumption[2]	0,15 (0,07 - 0,34)	0,06 (0,02 - 0,16)	0,18 (0,07 - 0,42)	0,22 (0,04 - 0,54)	0,13 (0,01 - 0,34)	0,23 (0,03 - 0,58)
Employment	0,07 (0,03 - 0,15)	0,43 (0,15 - 0,72)	0,01 (0,00 - 0,06)	0,11 (0,02 - 0,54)	0,19 (0,02 - 0,52)	0,07 (0,01 - 0,51)
Productivity	0,25 (0,07 - 0,47)	0,08 (0,03 - 0,19)	0,25 (0,04 - 0,53)	0,08 (0,03 - 0,26)	0,24 (0,07 - 0,45)	0,04 (0,00 - 0,30)
Capacity utilization	0,31 (0,17 - 0,43)	0,40 (0,18 - 0,60)	0,38 (0,13 - 0,67)	0,21 (0,09 - 0,39)	0,19 (0,06 - 0,38)	0,25 (0,05 - 0,53)
Government expenditures[2]	0,04 (0,00 - 0,26)	0,03 (0,00 - 0,16)	0,05 (0,00 - 0,29)	0,04 (0,00 - 0,24)	0,06 (0,01 - 0,22)	0,04 (0,00 - 0,27)
Consumer confidence	0,12 (0,04 - 0,32)	0,06 (0,02 - 0,17)	0,13 (0,03 - 0,41)	0,16 (0,05 - 0,32)	0,06 (0,01 - 0,32)	0,32 (0,05 - 0,62)
Business confidence	0,43 (0,26 - 0,56)	0,39 (0,23 - 0,52)	0,48 (0,18 - 0,77)	0,15 (0,05 - 0,31)	0,12 (0,03 - 0,34)	0,34 (0,09 - 0,64)
Consumer prices	0,19 (0,03 - 0,52)	0,22 (0,02 - 0,46)	0,15 (0,02 - 0,54)	0,05 (0,00 - 0,23)	0,02 (0,00 - 0,15)	0,06 (0,00 - 0,25)
Short-term interest rates[3]	0,38 (0,12 - 0,62)	0,32 (0,09 - 0,58)	0,26 (0,06 - 0,63)	0,20 (0,07 - 0,38)	0,09 (0,03 - 0,21)	0,44 (0,10 - 0,73)
Long-term interest rates[3]	0,26 (0,05 - 0,53)	0,18 (0,03 - 0,47)	0,34 (0,05 - 0,69)	0,15 (0,03 - 0,32)	0,05 (0,01 - 0,18)	0,40 (0,10 - 0,71)
M1[3]	0,06 (0,00 - 0,28)	0,05 (0,00 - 0,26)	0,05 (0,00 - 0,28)	0,40 (0,11 - 0,70)	0,20 (0,02 - 0,48)	0,44 (0,12 - 0,74)
Stock prices	0,05 (0,01 - 0,17)	0,04 (0,00 - 0,20)	0,04 (0,00 - 0,16)	0,06 (0,01 - 0,32)	0,07 (0,01 - 0,34)	0,06 (0,00 - 0,32)
Wages[3]	0,16 (0,04 - 0,45)	0,53 (0,15 - 0,81)	0,06 (0,00 - 0,29)	0,20 (0,02 - 0,58)	0,27 (0,03 - 0,53)	0,15 (0,01 - 0,60)
Exports[2]						
Total	0,10 (0,04 - 0,33)	0,56 (0,30 - 0,75)	0,03 (0,00 - 0,25)	0,33 (0,10 - 0,63)	0,35 (0,12 - 0,59)	0,28 (0,04 - 0,63)
Goods	0,11 (0,05 - 0,36)	0,61 (0,36 - 0,78)	0,03 (0,00 - 0,26)	0,34 (0,11 - 0,64)	0,41 (0,17 - 0,63)	0,29 (0,04 - 0,64)
Services	0,07 (0,01 - 0,27)	0,09 (0,00 - 0,32)	0,06 (0,00 - 0,31)	0,25 (0,05 - 0,51)	0,15 (0,01 - 0,40)	0,24 (0,03 - 0,55)
Imports[2]						
Total	0,08 (0,03 - 0,20)	0,33 (0,12 - 0,53)	0,04 (0,01 - 0,19)	0,08 (0,02 - 0,34)	0,21 (0,05 - 0,46)	0,04 (0,00 - 0,32)
Goods	0,08 (0,03 - 0,20)	0,29 (0,10 - 0,51)	0,04 (0,01 - 0,22)	0,07 (0,01 - 0,33)	0,18 (0,04 - 0,43)	0,03 (0,00 - 0,28)
Services	0,21 (0,03 - 0,53)	0,50 (0,12 - 0,76)	0,14 (0,00 - 0,46)	0,08 (0,02 - 0,36)	0,17 (0,02 - 0,39)	0,05 (0,01 - 0,31)
Terms of trade	0,08 (0,03 - 0,31)	0,19 (0,01 - 0,36)	0,05 (0,01 - 0,30)	0,29 (0,06 - 0,64)	0,39 (0,11 - 0,70)	0,26 (0,02 - 0,61)
Real effective exchange rate	0,23 (0,01 - 0,56)	0,26 (0,02 - 0,56)	0,22 (0,01 - 0,58)	0,21 (0,01 - 0,53)	0,26 (0,03 - 0,56)	0,21 (0,01 - 0,55)
Current account balance	0,23 (0,01 - 0,56)	0,26 (0,02 - 0,56)	0,22 (0,01 - 0,58)	0,07 (0,01 - 0,40)	0,04 (0,01 - 0,18)	0,06 (0,01 - 0,39)
Net capital outflows						
Total	0,03 (0,00 - 0,19)	0,03 (0,00 - 0,16)	0,03 (0,00 - 0,17)	0,04 (0,01 - 0,20)	0,09 (0,01 - 0,27)	0,03 (0,00 - 0,16)
Foreign direct investment	0,13 (0,01 - 0,37)	0,08 (0,00 - 0,26)	0,13 (0,01 - 0,39)	0,03 (0,00 - 0,22)	0,02 (0,00 - 0,10)	0,03 (0,00 - 0,26)
Securities	0,02 (0,00 - 0,15)	0,02 (0,00 - 0,09)	0,02 (0,00 - 0,17)	0,03 (0,00 - 0,15)	0,02 (0,00 - 0,11)	0,03 (0,00 - 0,18)
Credit banks	0,06 (0,01 - 0,20)	0,14 (0,01 - 0,36)	0,04 (0,00 - 0,23)	0,07 (0,02 - 0,33)	0,11 (0,02 - 0,31)	0,05 (0,01 - 0,27)
Credit non-banks	0,04 (0,00 - 0,21)	0,03 (0,00 - 0,14)	0,04 (0,00 - 0,23)	0,26 (0,05 - 0,54)	0,37 (0,13 - 0,55)	0,21 (0,02 - 0,53)
Net capital inflows						
Total	0,04 (0,00 - 0,23)	0,02 (0,00 - 0,14)	0,04 (0,00 - 0,27)	0,06 (0,01 - 0,18)	0,06 (0,01 - 0,22)	0,04 (0,00 - 0,20)
Foreign direct investment	0,03 (0,01 - 0,15)	0,04 (0,00 - 0,18)	0,02 (0,00 - 0,14)	0,04 (0,00 - 0,22)	0,08 (0,01 - 0,26)	0,03 (0,00 - 0,23)
Securities	0,02 (0,00 - 0,13)	0,02 (0,00 - 0,08)	0,02 (0,00 - 0,14)	0,11 (0,01 - 0,34)	0,24 (0,04 - 0,45)	0,07 (0,00 - 0,32)
Credit banks	0,10 (0,02 - 0,36)	0,28 (0,07 - 0,51)	0,04 (0,00 - 0,29)	0,09 (0,03 - 0,23)	0,18 (0,04 - 0,34)	0,04 (0,00 - 0,18)
Credit non-banks	0,07 (0,00 - 0,39)	0,04 (0,00 - 0,21)	0,08 (0,00 - 0,44)	0,36 (0,12 - 0,60)	0,47 (0,19 - 0,66)	0,27 (0,04 - 0,57)

[1] For details on the construction of the confidence bands see Appendix B.

[2] Real

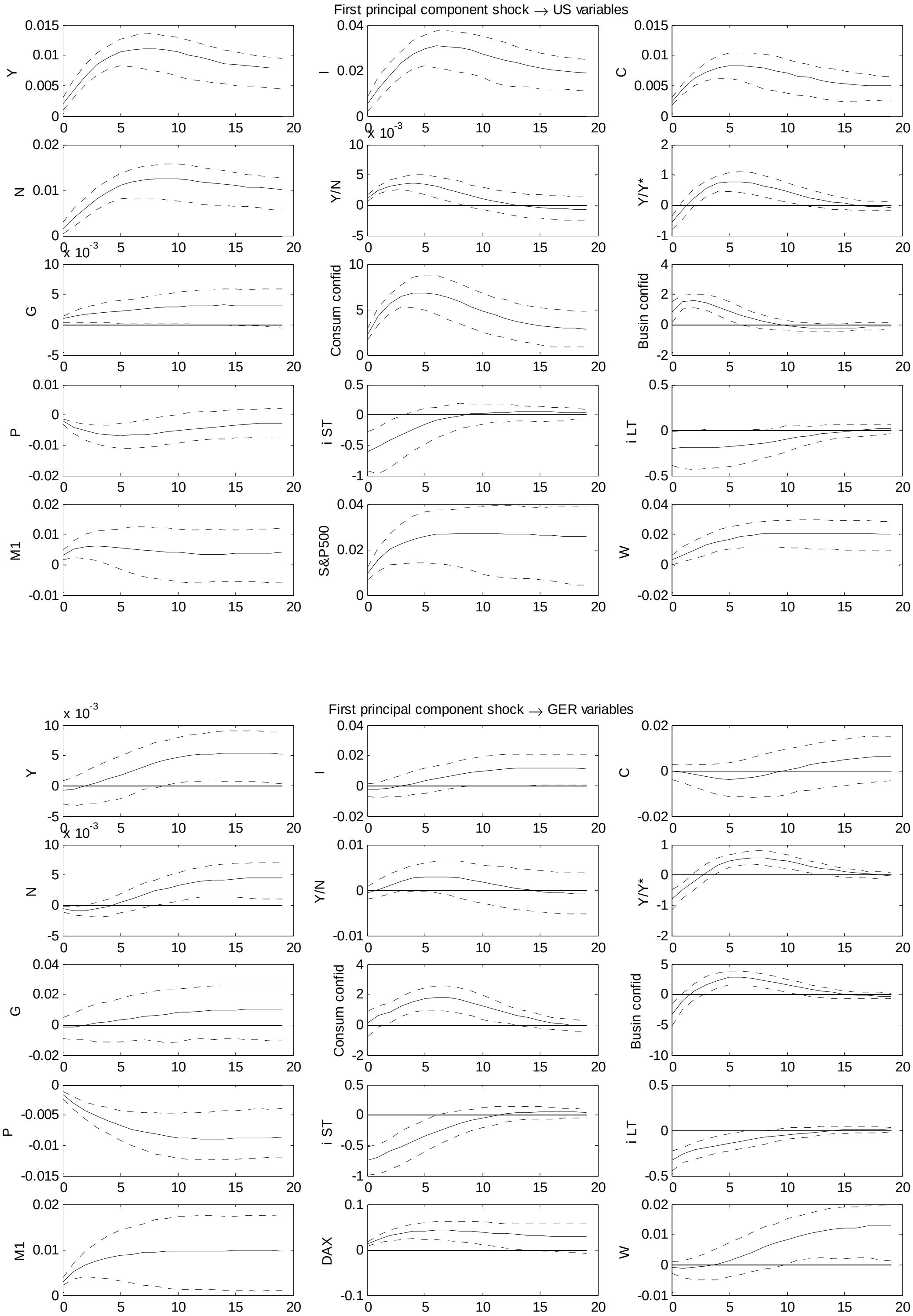
[3] Nominal

Table 3: Variance shares of the common components, 1975-2002[1)]

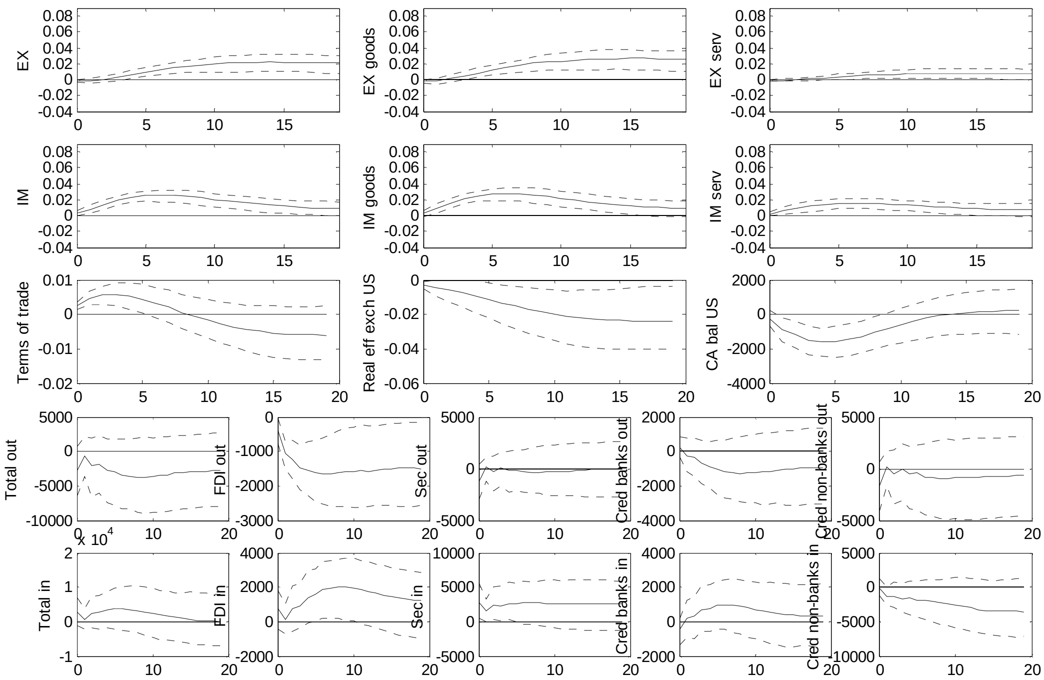
Variables[2)]	US	GER
GDP[3)]	0.70	0.77
Private investment[3)]	0.80	0.72
Personal consumption[3)]	0.64	0.75
Employment	0.85	0.71
Productivity	0.33	0.32
Capacity utilization	0.85	0.86
Government expenditures[3)]	0.14	0.30
Consumer confidence	0.29	0.65
Business confidence	0.82	0.81
Consumer prices	0.88	0.73
Short-term interest rates[4)]	0.88	0.86
Long-term interest rates[4)]	0.85	0.64
M1[4)]	0.60	0.36
Stock prices	0.08	0.13
Wages[4)]	0.71	0.40
Exports[3)]		
Total	0.40	0.51
Goods	0.39	0.52
Services	0.08	0.15
Imports[3)]		
Total	0.59	0.52
Goods	0.57	0.48
Services	0.27	0.16
Terms of trade	0.36	0.64
Real effective exchange rate	0.41	0.39
Current account balance	0.22	0.04
Net capital outflows		
Total	0.34	0.20
Foreign direct investment	0.12	0.10
Securities	0.47	0.35
Credit banks	0.06	0.06
Credit non-banks	0.26	0.13
Net capital inflows		
Total	0.39	0.13
Foreign direct investment	0.15	0.11
Securities	0.45	0.08
Credit banks	0.06	0.10
Credit non-banks	0.06	0.06

1) The covariance between the common component and the idiosyncratic component is approximately zero.
2) Stationary variables, that is, GDP refers to GDP growth etc. See also Table 1.
3) Real
4) Nominal

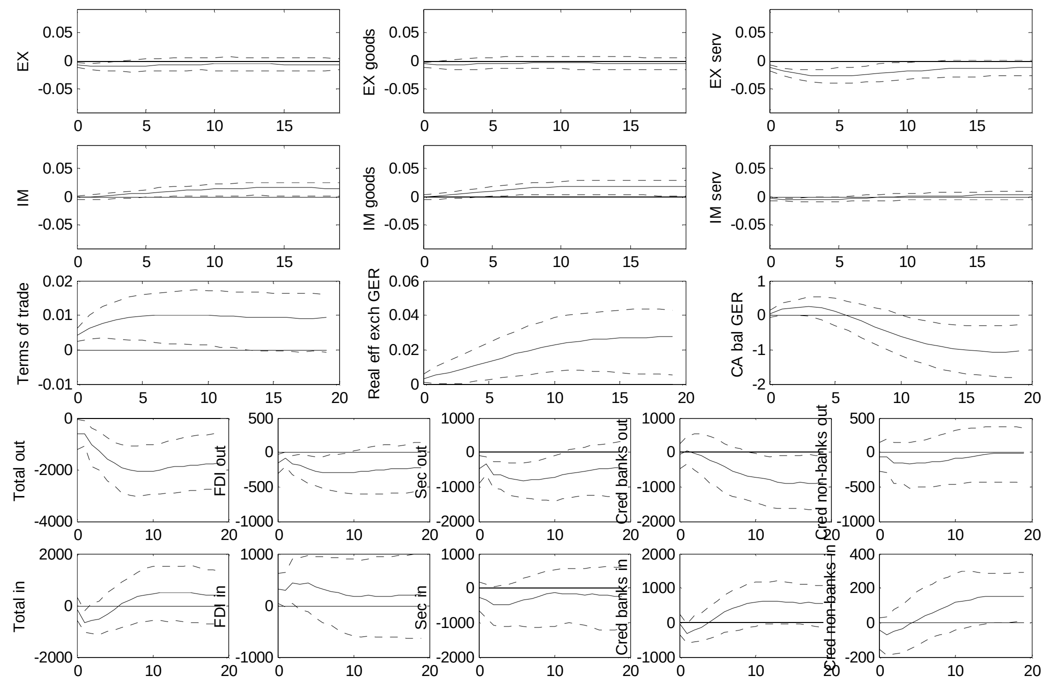
Figure 1: Impulse response functions to US shocks, 1975-2002



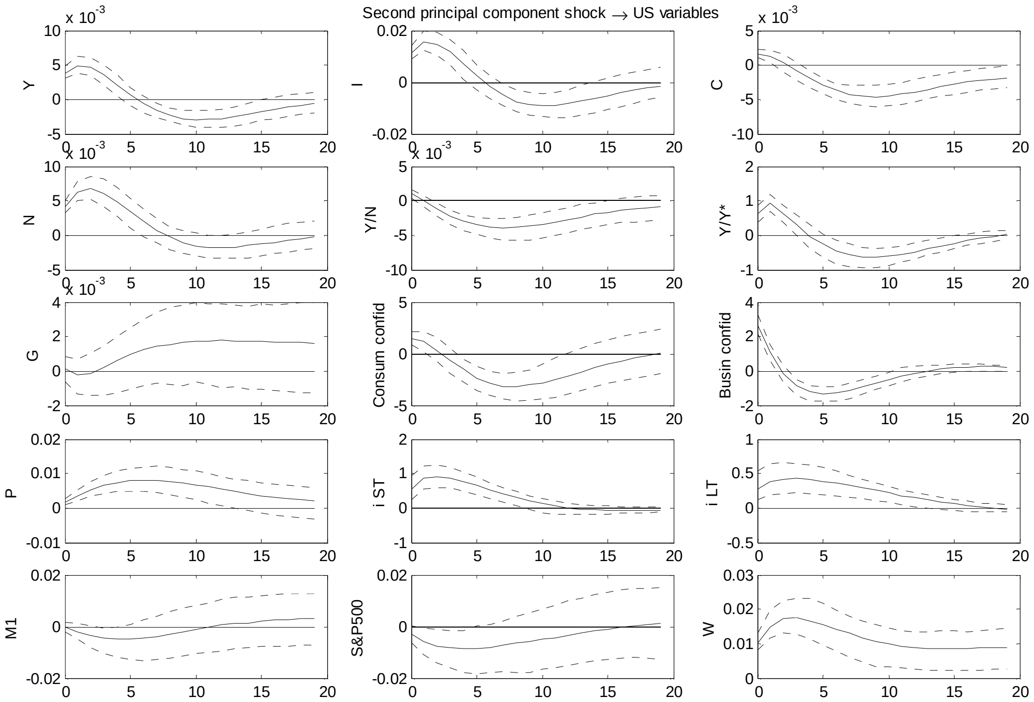
First principal component shock → US variables



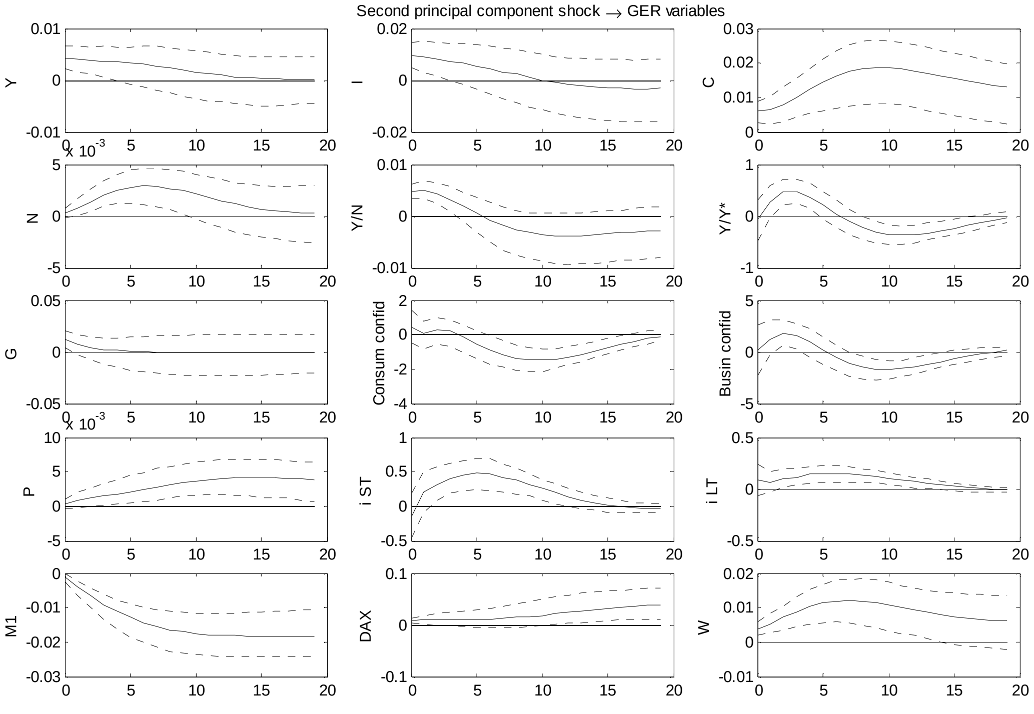
First principal component shock → GER variables



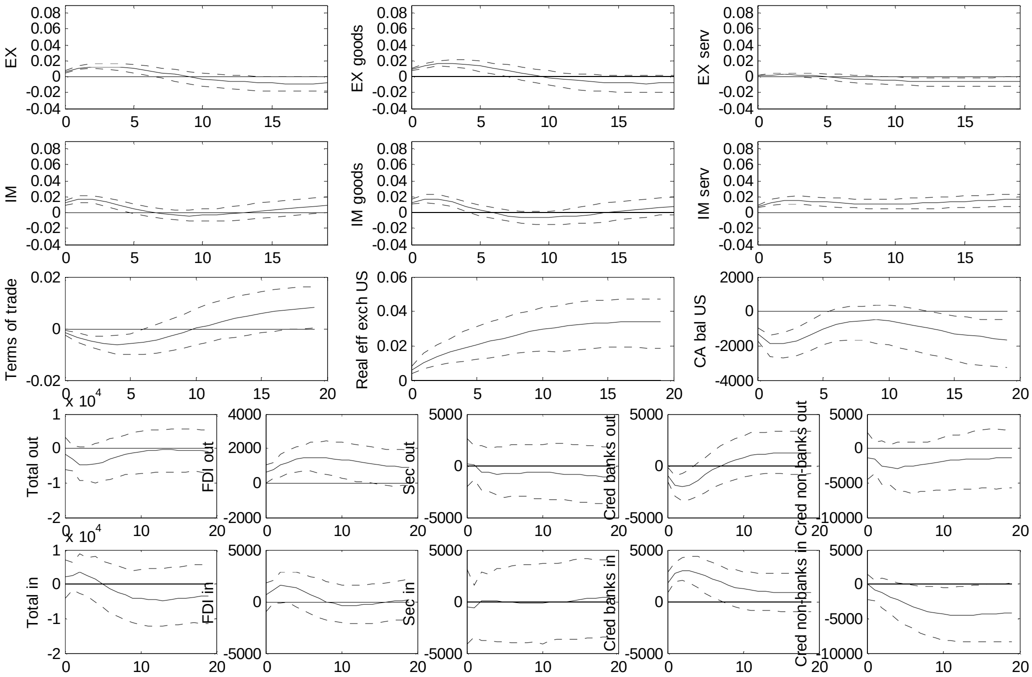
Second principal component shock → US variables



Second principal component shock → GER variables



Second principal component shock → US variables



Second principal component shock → GER variables

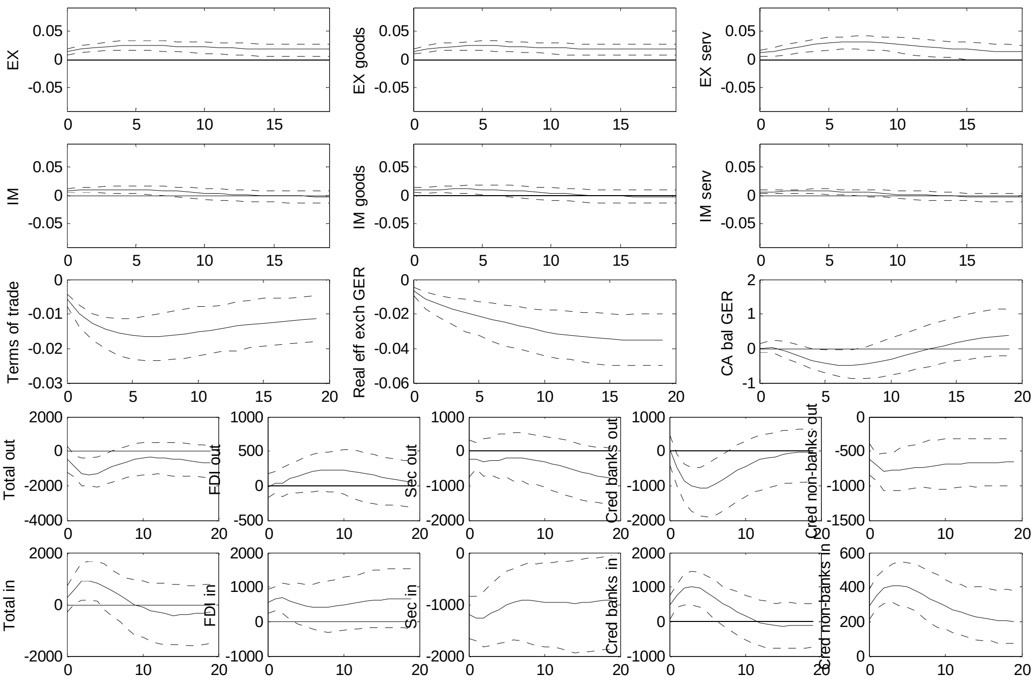


Figure 2: US shock series

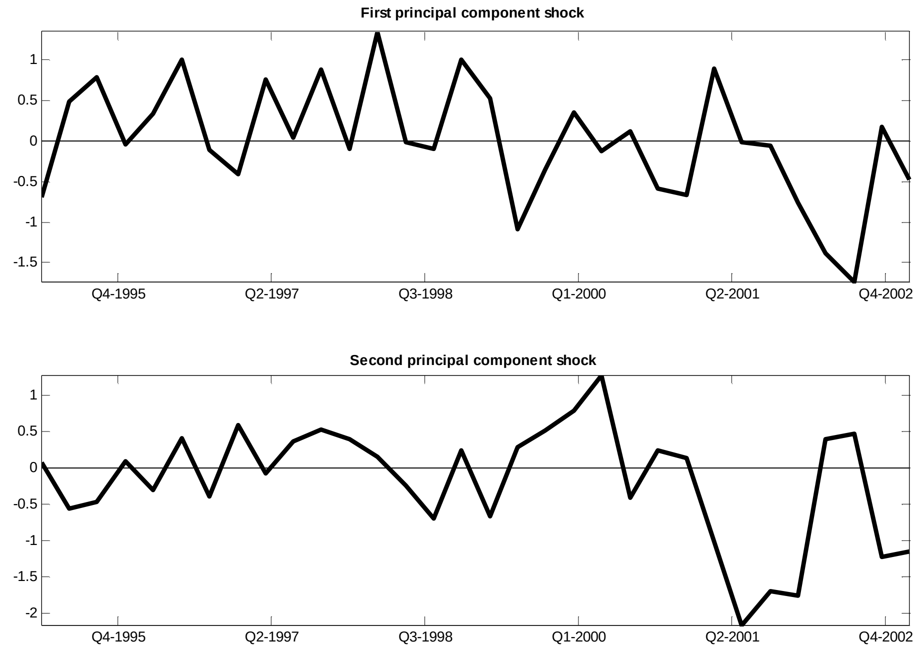
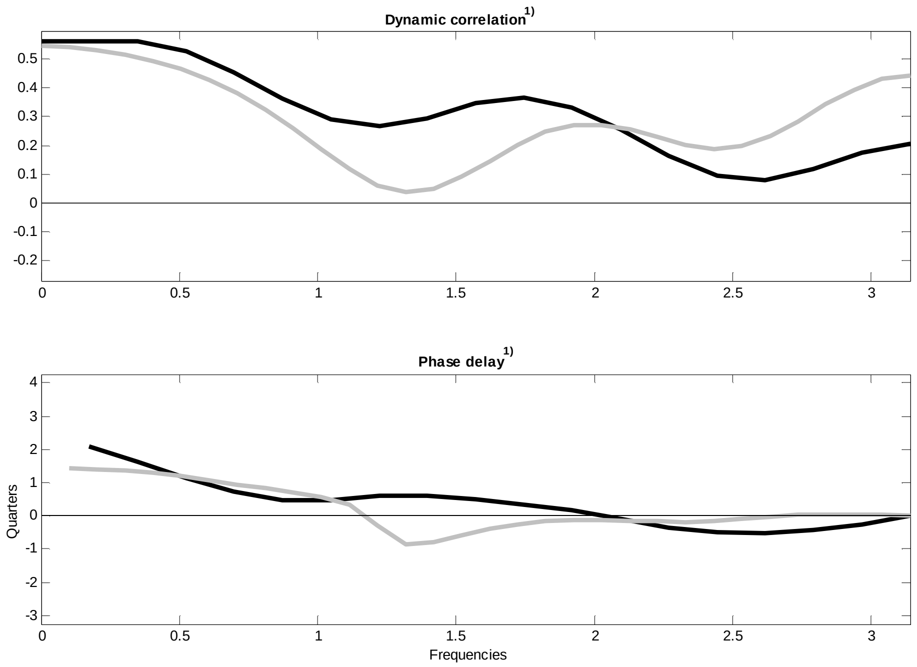
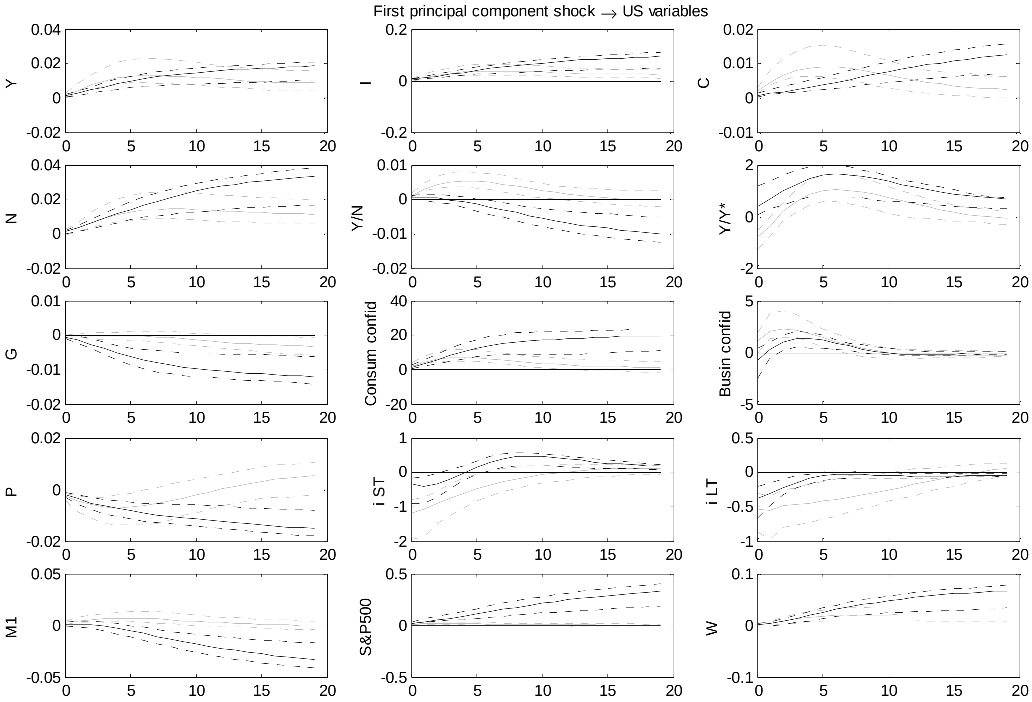


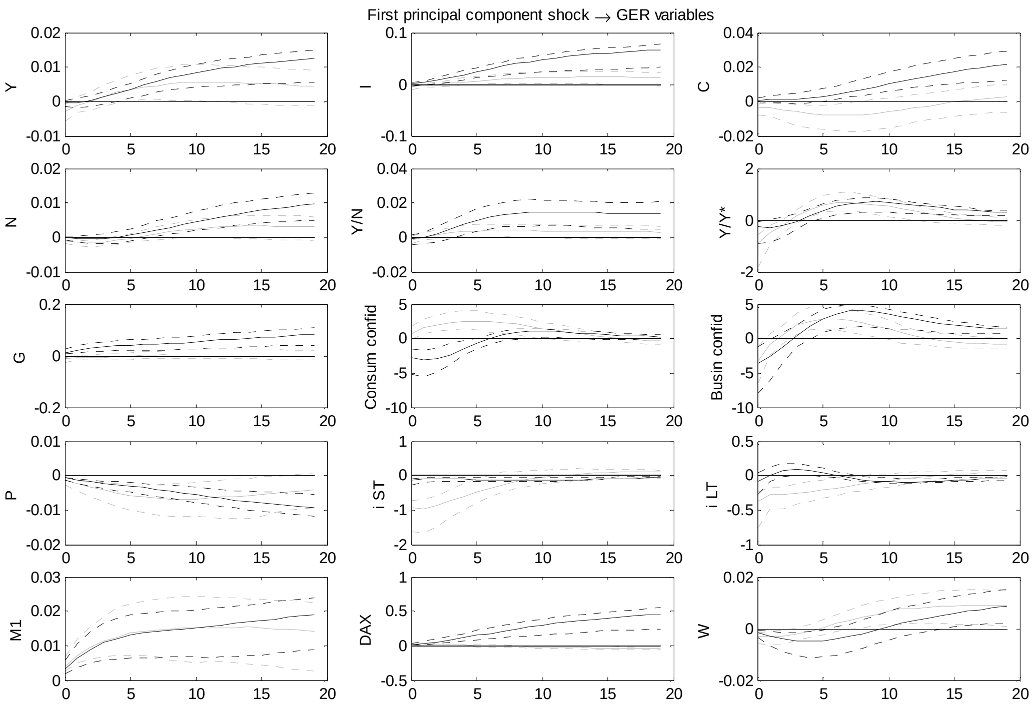
Figure 3: Frequency based measures for co-movement between GER and US GDP growth, 1975-1990 (gray) and 1994-2002 (black)



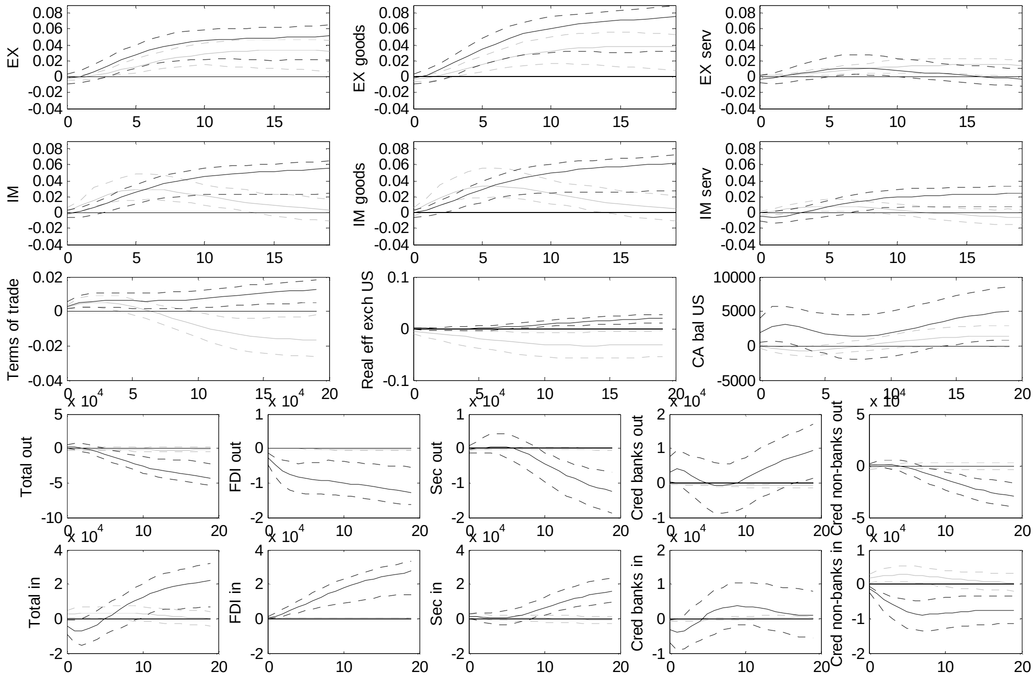
1) A description of the measures can be found in the text.

Figure 4: Impulse response functions to US shocks, 1975-1990 (gray) and 1994-2002 (black)

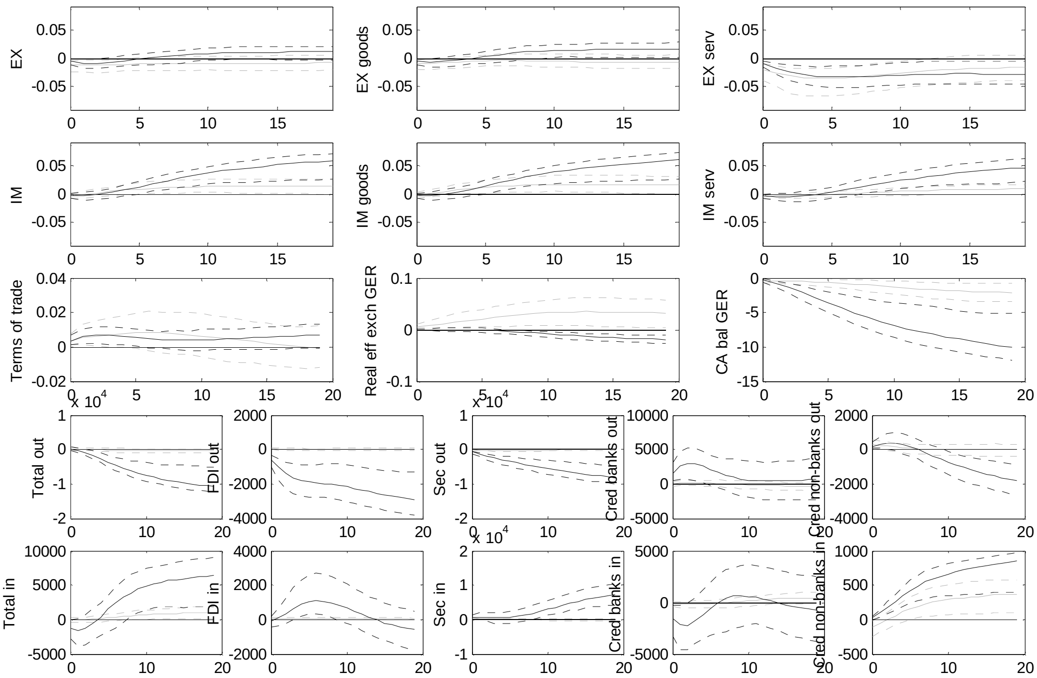




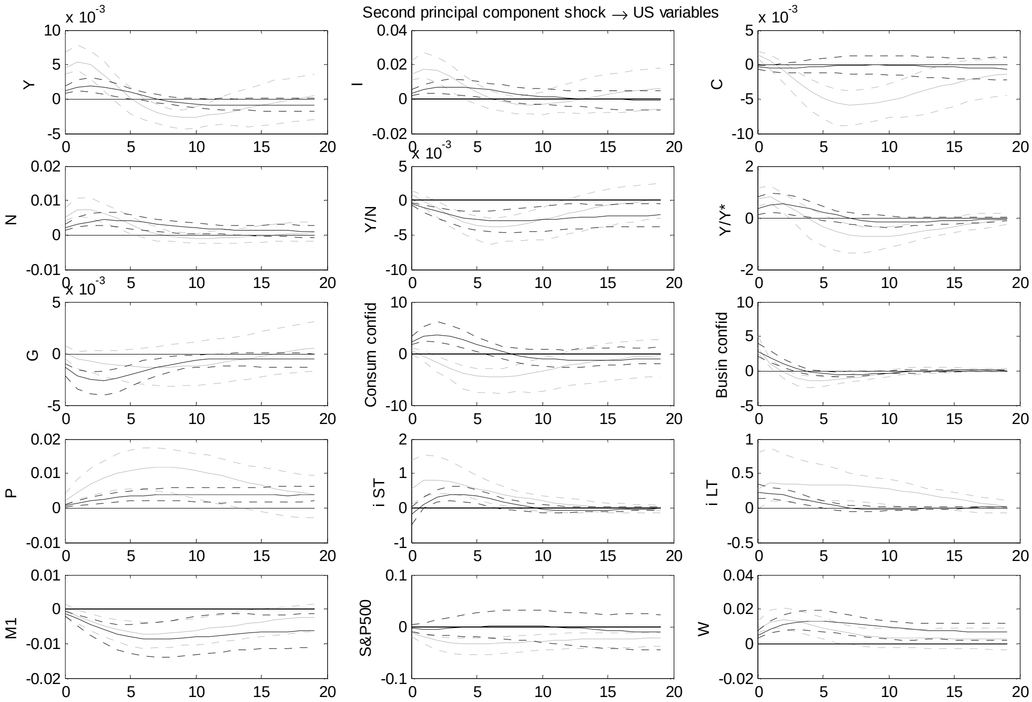
First principal component shock → US variables



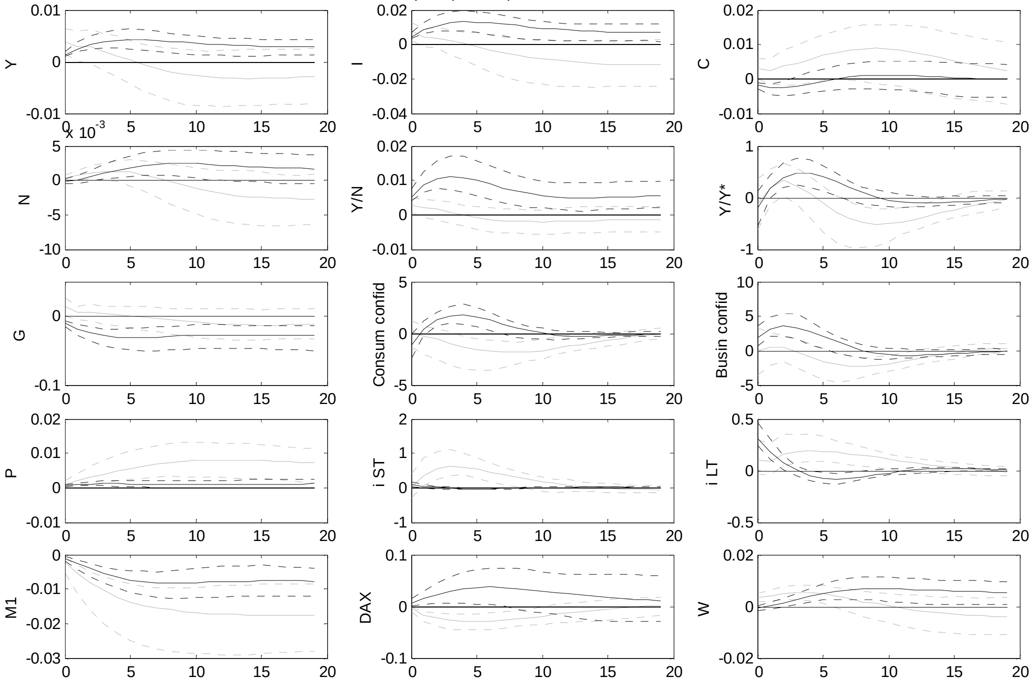
First principal component shock → GER variables



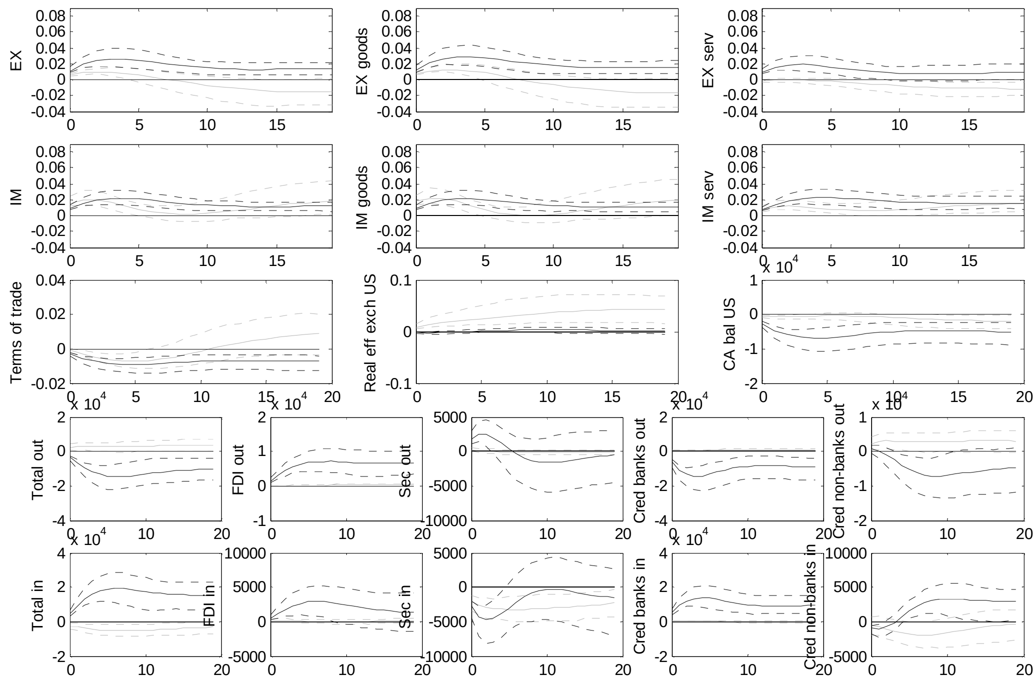
Second principal component shock → US variables



Second principal component shock → GER variables



Second principal component shock $\rightarrow$ US variables



Second principal component shock $\rightarrow$ GER variables

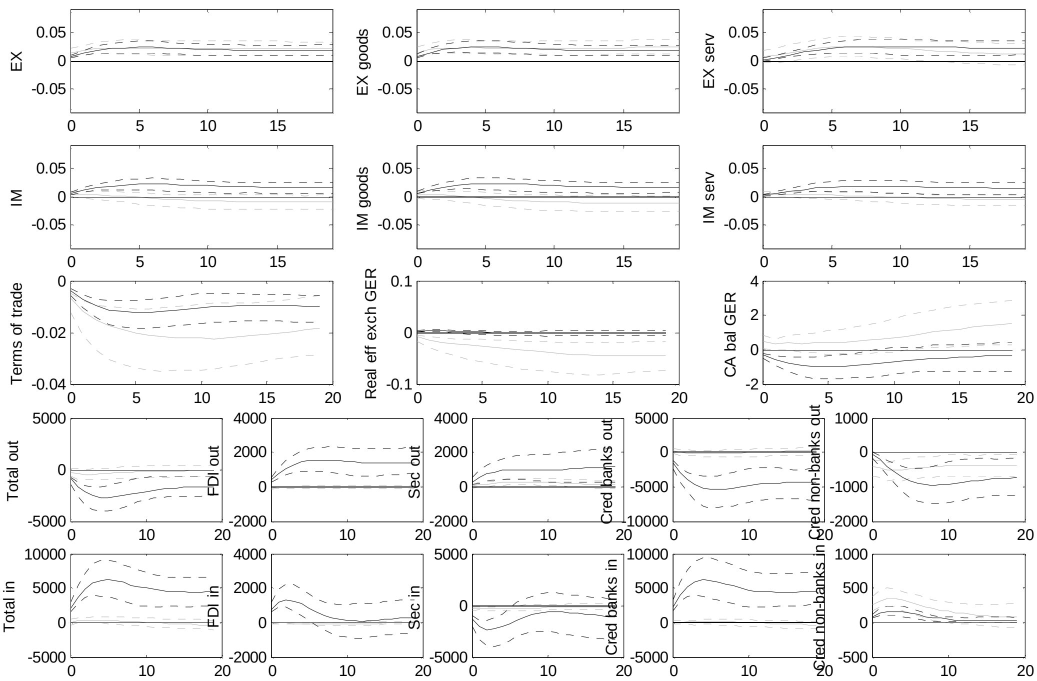
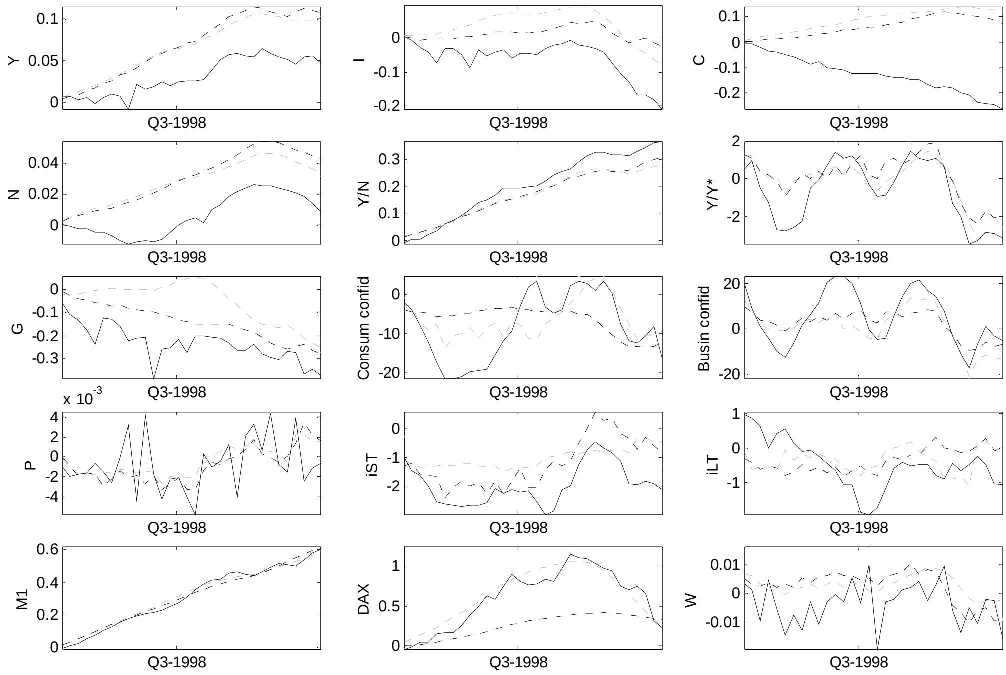
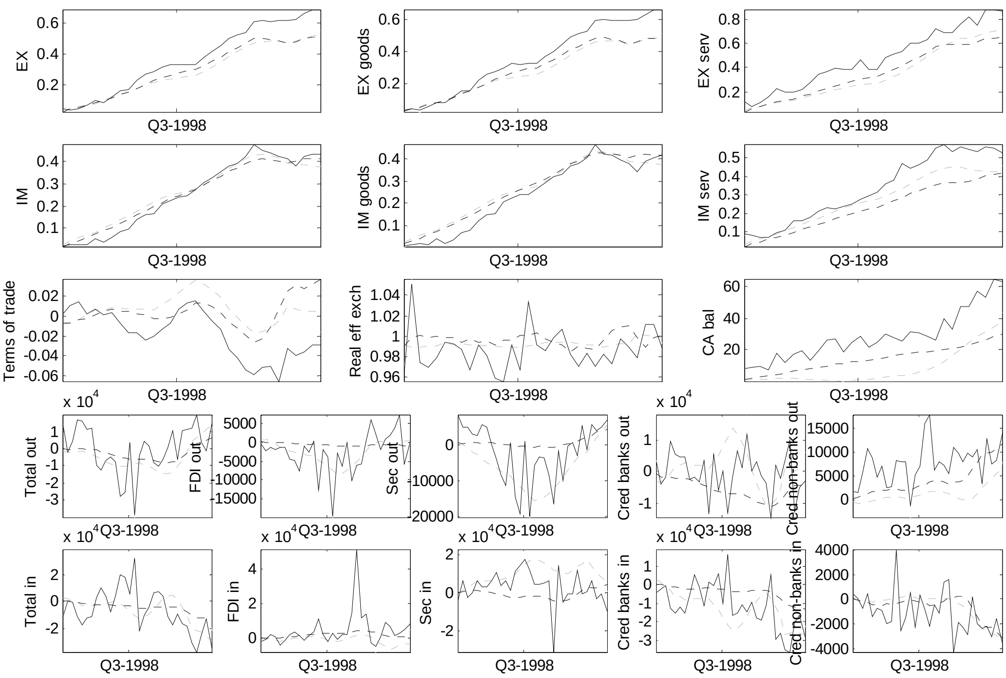


Figure 5: Contribution of US shocks to GER variables;
model based on 1975-1990 (gray), model based on 1994-2002 (black)





Series: solid, series if only driven by US shocks: dotted

The following Discussion Papers have been published since 2003:

Series 1: Studies of the Economic Research Centre

January	2003	Testing mean-variance efficiency in CAPM with possibly non-gaussian errors: an exact simulation-based approach	Marie-Claude Beaul Jean-Marie Dufour Lynda Khalaf
January	2003	Finite-sample distributions of self-normalized sums	Jeong-Ryeol Kim
January	2003	The stock return-inflation puzzle and the asymmetric causality in stock returns, inflation and real activity	Jeong-Ryeol Kim
February	2003	Multiple equilibrium overnight rates in a dynamic interbank market game	Jens Tapking
February	2003	A comparison of dynamic panel data estimators: Monte Carlo evidence and an application to the investment function	Andreas Behr
March	2003	A Vectorautoregressive Investment Model (VIM) And Monetary Policy Transmission: Panel Evidence From German Firms	Joerg Breitung Robert S. Chirinko Ulf von Kalckreuth
March	2003	The international integration of money markets in the central and east European accession countries: deviations from covered interest parity, capital controls and inefficien-Cies in the financial sector	Sabine Herrmann Axel Jochem
March	2003	The international integration of foreign exchange markets in the central and east European accession countries: speculative efficiency, transaction costs and exchange rate premiums	Sabine Herrmann Axel Jochem

March	2003	Determinants of German FDI: New Evidence from Micro-Data	Claudia Buch Jörn Kleinert Farid Toubal
March	2003	On the Stability of Different Financial Systems	Falko Fecht
April	2003	Determinants of German Foreign Direct Investment in Latin American and Asian Emerging Markets in the 1990s	Torsten Wezel
June	2003	Active monetary policy, passive fiscal policy and the value of public debt: some further monetarist arithmetic	Leopold von Thadden
June	2003	Bidder Behavior in Repo Auctions without Minimum Bid Rate: Evidence from the Bundesbank	Tobias Linzert Dieter Nautz Jörg Breitung
June	2003	Did the Bundesbank React to Stock Price Movements?	Martin T. Bohl Pierre L. Siklos Thomas Werner
15	2003	Money in a New-Keynesian model estimated with German data	Jana Kremer Giovanni Lombardo Thomas Werner
16	2003	Exact tests and confidence sets for the tail coefficient of α-stable distributions	Jean-Marie Dufour Jeong-Ryeol Kurz-Kim
17	2003	The Forecasting Performance of German Stock Option Densities	B R Craig, E Glatzer, J Keller, M Scheicher
18	2003	How wacky is the DAX? The changing structure of German stock market volatility	Jelena Stapf Thomas Werner

1	2004	Foreign Bank Entry into Emerging Economies: An Empirical Assessment of the Determinants and Risks Predicated on German FDI Data	Torsten Wezel
2	2004	Does Co-Financing by Multilateral Development Banks Increase "Risky" Direct Investment in Emerging Markets? – Evidence for German Banking FDI	Torsten Wezel
3	2004	Policy Instrument Choice and Non-Coordinated Monetary Policy in Interdependent Economies	Giovanni Lombardo Alan Sutherland
4	2004	Inflation Targeting Rules and Welfare in an Asymmetric Currency Area	Giovanni Lombardo
5	2004	FDI versus cross-border financial services: The globalisation of German banks	Claudia M. Buch Alexander Lipponer
6	2004	Clustering or competition? The foreign investment behaviour of German banks	Claudia M. Buch Alexander Lipponer
7	2004	PPP: a Disaggregated View	Christoph Fischer
8	2004	A rental-equivalence index for owner-occupied housing in West Germany 1985 to 1998	Claudia Kurz Johannes Hoffmann
9	2004	The Inventory Cycle of the German Economy	Thomas A. Knetsch
10	2004	Evaluating the German Inventory Cycle Using Data from the Ifo Business Survey	Thomas A. Knetsch
11	2004	Real-time data and business cycle analysis in Germany	Jörg Döpke
12	2004	Business Cycle Transmission from the US to Germany – a Structural Factor Approach	Sandra Eickmeier

Series 2: Banking and Financial Supervision

1	2003	Measuring the Discriminative Power of Rating Systems	B. Engelmann, E. Hayden, D. Tasche
2	2003	Credit Risk Factor Modeling and the Basel II IRB Approach	A. Hamerle, T. Liebig, D. Rösch
1	2004	Forecasting Credit Portfolio Risk	A. Hamerle, T. Liebig, H. Scheule

Visiting researcher at the Deutsche Bundesbank

The Deutsche Bundesbank in Frankfurt is looking for a visiting researcher. Visitors should prepare a research project during their stay at the Bundesbank. Candidates must hold a Ph D and be engaged in the field of either macroeconomics and monetary economics, financial markets or international economics. Proposed research projects should be from these fields. The visiting term will be from 3 to 6 months. Salary is commensurate with experience.

Applicants are requested to send a CV, copies of recent papers, letters of reference and a proposal for a research project to:

Deutsche Bundesbank
Personalabteilung
Wilhelm-Epstein-Str. 14

D - 60431 Frankfurt
GERMANY