Is Germany's Influence on Austria Waning? Synchronization and Transmission of Cyclical Shocks

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This study analyzes the connection between business cycle fluctuations in Germany and Austria as well as the transmission of German shocks to Austria. Compared to Austria's links with other countries, the ties between Austria and Germany have loosened in relative terms in recent years; in terms of gross domestic product (GDP), however, a strong and steady increase has been recorded. Static and dynamic correlation measures point to a consistently high level of co-movement between Austria and Germany. While the Austrian economy lagged behind the German economy by one quarter in the 1970s, it now leads the German economy by one quarter. The Austrian economy's reaction to German shocks equals 0.4 times the German reaction. Monetary policy shocks are transmitted with the greatest impact, while supply and demand shocks trigger a far less pronounced reaction in Austria. Over time, monetary policy shocks have gained slightly in importance, while German demand shocks have become less important. On average across shocks, the transmission effect shows a marginal weakening. The relative importance of Germany and the international environment in explaining the forecast error for Austrian GDP has increased somewhat over time, whereas the domestic contribution to the forecast error has declined. On the whole, it is not possible to identify a decline in Germany's importance for the Austrian economy.

JEL classification: C32, E32, F41
Keywords: business-cycle, synchronization, vector autoregression, shock-identification, transmission.

1 Introduction

As a small and open economy, Austria is characterized by strong links with Germany, its largest neighbor. The ties between the two countries are the result of their geographical proximity, their common language, a number of cultural and institutional similarities as well as a turbulent common history. Germany has always had a major influence on Austria's economic development. Since the collapse of the communist regimes in the Central and Eastern European countries (CEECs), however, the importance of these countries for the Austrian economy has surged.

Against this backdrop, the question arises as to whether these developments have weakened Germany's influence on the development of the Austrian economy. Various aspects of the business cycle linkages between Austria and Germany have been analyzed in the relevant literature. Brandner and Neusser (1992) examine correlations between Austria and Germany based on a number of macroeconomic variables. They find a high contemporaneous correlation for GDP and investment but only a low one for private consumption. Winckler (1993) focuses on the orientation of Austrian economic policy toward Germany as a cause for the high level of co-movement, emphasizing the role of the social partners in wage negotiations as well as the role of Austria's hard currency policy. Hochreiter and Winckler (1995) examine sector-specific shocks in Germany and Austria from 1973 to 1989, finding no evidence of an increase in symmetry between the two countries. Cheung and Westermann (1999) analyze Austria's relations with Germany using an error correction model and come to the conclusion that a stable long-term relationship exists between Austrian and German industrial production.

Refereed by: Thomas Url, WIFO.

The International Monetary Fund (IMF) examined Austria's links with Germany and with the CEECs in a descriptive study (Epstein and Tzanninis, 2005), which identifies a marginal decrease in the correlation between Austrian and German GDP and attributes this development to the increasing relevance of the CEECs.

The purpose of this study is to examine empirically the influence of the German economy on business cycle fluctuations in Austria. We address this research question in several steps: Section 2 provides an introductory overview of the most important international business cycle links. Section 3 then describes the economic relations between Austria and Germany, addressing trade flows and direct investment in detail. In section 4, we proceed to examine the connection between business cycle fluctuations in Austria and its main trading partners. In addition to examining static correlations, we also evaluate frequency-domain measures. Section 5, the main part of the study, deals with the question of how strongly German structural shocks are propagated to Austria. For this purpose, we first identify supply and demand shocks as well as monetary policy shocks using a vector autoregression (VAR) model for Germany. In a second step, we determine the effects of these shocks on Austria during two periods (1972 to 1989 and 1990 to 2005). In section 6, we analyze the aggregate effects of global, German and Austrian shocks on GDP growth in Austria. Section 7 summarizes the results and draws a number of relevant conclusions.

2 Stable International Synchronization, Weakened Global Shocks

Business cycle fluctuations in Germany and Austria are heavily influenced by global and regional trends in addition to country-specific characteristics. For this reason, this section presents a brief overview of essential facts on the development of international synchronization in cyclical fluctuations.

2.1 Decreasing Volatility of Global Shocks

The volatility of business cycle fluctuations in industrialized nations has decreased substantially over time. Stock and Watson (2003a) show that the standard deviation of GDP growth in industrialized nations has declined by an average of one third since the 1960s. More than half of this development can be attributed to weaker global shocks, while improvements in monetary policy explain only a small part of the decline in volatility. Structural economic changes such as the increasing share of services and improved inventory management techniques have also contributed to the decline (OECD, 2002). An examination of demand components reveals that lower levels of volatility in inventory changes and in private consumption are the main factors responsible for the lower degree of fluctuations (Dalsgaard et al., 2002).

2.2 Globalization Boosts International Linkages

Over the last few decades, barriers to trade and capital controls have gradually been dismantled, and this has brought about an enormous increase in international trade links as well as highly integrated financial markets. Rapid advances in telecommunica-

tions technologies have, inter alia, created a situation in which intangible factors such as confidence spill over to other countries more quickly. However, the effects of these developments on the co-movement of economies are theoretically ambiguous. On the one hand, stronger international trade links reinforce the transmission of demand shocks. Deregulation as well as technological innovations have made it easier for companies to hedge risks and to gain access to financing. Moreover, consumers also have more ways of smoothing their consumption. On the other hand, if intensified foreign trade is a result of interindustry specialization, it will bring about higher levels of specialization and thus also asymmetric reactions to sectoral shocks. Integrated financial markets may bring about a concentration of capital flows to countries with high productivity growth, thus reducing synchronization.[1]

2.3 Stable Synchronization among Industrialized Nations over Time

On the whole, the sharp increase in international links would justify expectations of higher co-movement in international business cycle fluctuations. A large body of empirical literature deals with this question.[2] A majority of empirical studies find the effect of increasing trade links on synchronization to be positive (Frankel and Rose, 1998). The available empirical evidence indicates that strong growth in financial flows also reinforces synchronization (Imbs, 2004).

The results of empirical studies which examine the development of synchronization between industrialized nations over time are ambiguous, however, as they are sensitive with regard to method, country selection, the length of observation periods, etc. However, most of the literature finds evidence of a more or less unchanged synchronization between industrialized nations (except in the early 1990s[3]). The apparent paradox of stable synchronization coupled with intensified trade and financial flows can be explained by a decreasing volatility of global shocks, which has caused country-specific shocks to gain in relative importance.

Synchronization among countries in the euro area increased in the 1990s, while Anglo-American countries (U.S.A., Canada, United Kingdom) followed their own pattern of economic development.[4] Efforts to fulfill the criteria set forth in the Maastricht Treaty to create a monetary union accounted for a major part of the increase in synchronization between euro area countries. This reduced the individual countries' freedom to generate country-specific fiscal shocks.

Table 1 provides an overview of the determinants of synchronization. The strength of global shocks has a positive effect on synchronization,

[1] *Imbs (2004) provides an overview of the effects of financial market integration on synchronization.*

[2] *Dalsgaard et al. (2002), Doyle and Faust (2002), Helbling and Bayoumi (2003), IMF (2001), OECD (2002), Stock and Watson (2003a, 2003b), etc. A highly compact overview can be found in Kose (2004).*

[3] *At that time, German reunification and the bursting of the Japanese real estate bubble constituted two important country-specific shocks.*

[4] *Empirical examinations of G-7 countries distinguish between an Anglo-American cluster (U.S.A., Canada, United Kingdom) and a continental European cluster (Germany, France, Italy), while the Japanese economy shows an entirely independent pattern (Helbling and Bayoumi, 2003; Stock and Watson, 2003b).*

Table 1

Changes in the Synchronization of Cyclical Fluctuations over Time:
Results from Empirical Literature

	Effect on synchronization	Change over time	Effect on synchronization over time
Global shocks	Positive	Decreasing	Decreasing
Country-specific shocks	Negative	Decreasing	Increasing
Transmission of shocks between countries	Theoretically ambiguous, empirically positive	Increasing	Increasing
Synchronization	Unchanged among G-7 countries, stronger among euro area countries, weaker between industrialized nations and developing countries		

Source: Authors' depiction of literature cited.

i.e. stronger global shocks lead to a higher synchronization of cyclical fluctuations. As the strength of global shocks has decreased over time, synchronization has gone down. Conversely, a decrease in the amplitude of country-specific shocks will bring about an increase in synchronization. According to the empirical literature, the stronger transmission of cyclical fluctuations caused by stronger links between countries also enhances synchronization. As these links have intensified dramatically over time, a synchronizing effect can be observed. Overall, the three factors shown above have left the level of synchronization among industrialized nations largely unchanged.

3 Economic Relations between Austria and Germany Intensify Continuously despite Austria's Stronger Orientation toward Eastern Europe

In line with the global trend, Austria has also seen a sharp increase in international trade and financial flows over the last three decades. This section provides a brief overview of the most significant developments in Austria with special attention to its links with Germany and the CEECs.

3.1 Trade: European Integration and Vertical Specialization Intensify Trade Links

3.1.1 Strong Increase in Overall Foreign Trade

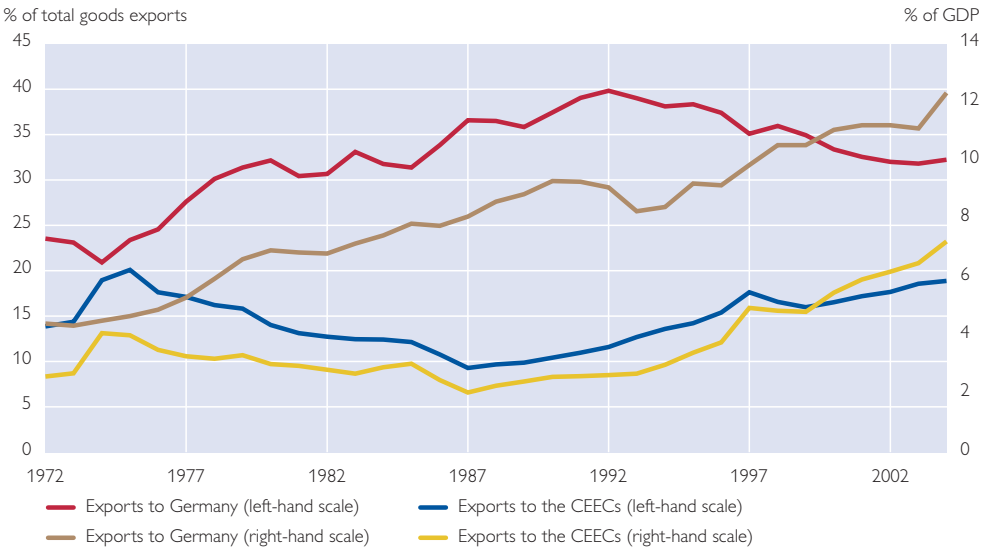
Austria's foreign trade links have intensified dramatically in recent years. Measured as the total of imports and exports, trade grew almost twice as fast as economic output (measured in terms of GDP) between 1972 and 2004. Goods exports in particular have developed dynamically (2.2 times faster than GDP). In that period, Austria's trade share (i.e. the total of imports and exports expressed as a percentage of GDP) rose from just under 60% to almost 100%. In addition to the global dismantling of trade barriers as well as reduced transport and communication costs, Austria's accession to the European Union (EU) – and subsequently to monetary union – and developments in the CEECs are responsible for this change.

3.1.2 Changes in the Regional Export Structure

The regional distribution of Austria's trade flows has changed dramatically over time. Germany's share in Austria's total goods exports rose from a

Chart 1

Austrian Goods Exports to Germany and the CEECs



Source: Statistics Austria.

low of 21% in 1974 to 40% in 1992.[5] Since that time, this share has declined, not least owing to the collapse of the communist regime in the CEECs and their reorientation with regard to external trade. In absolute terms, however, Germany's role is constantly expanding. Expressed as a percentage of GDP, goods exports to Germany have increased steadily, from 4% of GDP at the beginning of the period under review to 12% in 2004. The percentage of Austrian exports to the CEECs has shown the opposite development. A temporary increase in the early 1970s – when, at first, the CEECs were not as heavily affected by the oil crisis – was followed by a continuous decline in the ensuing years. On the one hand, Austrian economic policy pursued deeper integration into the EU, and on the other hand the indebtedness of the CEECs went up dramatically. It was not until the Eastern European economies opened up that trade relations began to show clear signs of revival. In 2004, the CEECs' share in Austrian goods exports reached the level attained in 1975.

3.1.3 Changes in Sectoral Export Structure Caused by Intraindustry Trade and Cross-Border Production

In addition to its regional structure, the sectoral structure of Austria's trade in goods has also shifted considerably over time. On the one hand, Austria has seen a sharp increase in intraindustry trade. Measured by the Grubel-Lloyd index, the share of intraindustry trade in overall trade with Germany rose from 47% in 1972 to

[5] *Unfortunately, longer time series (broken down by region) are not available for trade in services. However, since 1992 services exports have developed less dynamically than goods exports. While services exports to Germany equaled almost two thirds of goods exports in 1992, this ratio had dropped below 50% by 2004. Austria's overall services exports amounted to 33% of total goods exports in 2004.*

Table 2

Austrian Trade in Goods by Selected Regions

	EU-15	Germany	CEECs[1]	Italy	U.S.A.	Switzerland	Total
Exports (% of total exports)							
1972	57.9	**23.6**	13.9	9.6	4.5	11.5	100.0
1990	67.9	**37.4**	10.4	9.8	3.2	6.9	100.0
2004	59.1	**32.2**	18.9	8.6	5.9	4.9	100.0
Exports (% of GDP)							
1972	10.8	**4.4**	2.6	1.8	0.8	2.2	18.7
1990	16.9	**9.3**	2.6	2.4	0.8	1.7	24.8
2004	22.6	**12.3**	7.2	3.3	2.3	1.9	38.2
Imports (% of total imports)							
1972	70.4	**42.6**	8.8	7.2	3.2	7.3	100.0
1990	71.1	**44.0**	6.8	9.1	3.6	4.3	100.0
2004	66.5	**43.0**	15.1	6.8	3.2	3.1	100.0
Imports (% of GDP)							
1972	17.7	**10.7**	2.2	1.8	0.8	1.8	25.1
1990	21.1	**13.0**	2.0	2.7	1.1	1.3	29.7
2004	25.8	**16.6**	5.8	2.7	1.3	1.2	38.8

Source: OeNB, authors' calculations.

[1] *Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russia, Serbia and Montenegro, Slovakia, Slovenia and Ukraine.*

79% in 2004.[6] A large share of intraindustry trade is characteristic of trade relations between highly developed industrialized nations which have similar production structures and enjoy economies of scale in production; it leads to an increase in synchronization.

At the same time, the phenomenon of vertical integration due to cross-border production chains has become far more important in recent years. Hummels et al. (2001) show that from the 1970s to the 1990s alone, the extent of vertical integration in the countries belonging to the Organisation for Economic Co-operation and Development (OECD) increased by one-third; today, vertical integration is responsible for more than 20% of all OECD exports. The most prominent example in economic relations between Germany and Austria is the increasing integration of the Austrian automotive supply industry into German automobile manufacturing, which manifests itself clearly in the higher share of machines and vehicles in overall exports to Germany, which grew from 26% in 1972 to 46% in 2004. In the same period, the opposite development was recorded in the share of semi-finished and finished goods (which decreased from 39% to 21%) as well as raw materials (which dropped from 9% to 2%).

In parallel to the rise in the importance of exports for the Austrian economy, increasing vertical integration caused a sharp uptrend in imports as well. This movement led to a decline in the domestic value added per unit of exports. Between 1976

[6] *The Grubel-Lloyd index measures the share of intraindustry trade (IIT) as follows:* $IIT=1-\sum_i|X_i-M_i|/\sum_i(X_i+M_i)$, *where* X_i *and* M_i *refer to goods exports and imports for sector i. The Grubel-Lloyd index was calculated at the SITC two-digit level.*

Table 3

Value Added Generated by Goods Exports in Austria

	Multipliers from input-output tables (primary effects only)	Value added	
		Induced by overall exports	Induced by exports to Germany
		% of GDP	
1976	0.73	14.5	3.6
1983	0.69	14.9	4.9
1990	0.69	17.2	6.4
1995	0.69	16.5	6.3
2000	0.63	20.8	6.9

Source: Authors' calculations based on the input-output tables for 1976, 1983, 1990, 1995 and 2000.

and 2000, the primary value added multiplier slipped from 0.73 to 0.63 (table 3). However, as exports to Germany have gone up sharply in relation to GDP, their importance for the Austrian economy has also increased – despite declining value added effects and regional shifts. The primary value added generated by goods exported to Germany[7] has nearly doubled since the mid-1970s (1976: 3.6% of GDP; 2000: 6.9% of GDP; see table 3).

3.2 Internationalization of Financial Flows

In recent years, financial market integration has progressed even more rapidly than the internationalization of trade flows. Limited data availability makes it rather difficult to analyze international capital flows to and from Austria prior to 1990; however, such an analysis would not be particularly useful in the first place, as the Austrian capital market was not fully opened up until the 1980s.

The most striking development since 1990 can be found in inward and outward FDI, the levels of which have risen from 3%, respectively 7%, of GDP to more than 20% each. With a share of 40%, Germany plays a dominant role in Austria's inward FDI, while – after their highly dynamic development in recent years – the CEECs carry similar weight in outward FDI. Comparably high growth rates were also recorded in inward and outward portfolio investment, for which data broken down by region are not available, however.

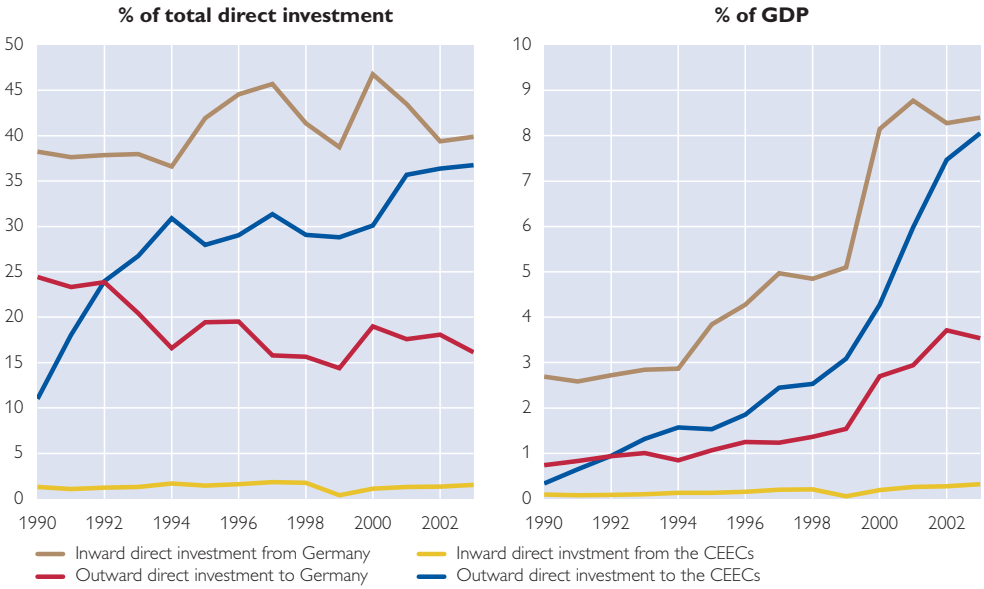
4 High and Stable Synchronization of Cyclical Fluctuations in Germany and Austria

This section examines the degree of synchronization between the Austrian and German economies. Chart 3 provides a first indication of the high level of co-movement between the two economies, while in many phases the U.S. economy shows an entirely different pattern of development. In the 1970s and early 1980s, when the world economy was hit hardest by global shocks (first and

[7] *Primary value added denotes the value added generated in the export sector and all sectors supplying intermediate goods. It does not include secondary effects due to increasing consumption induced by additional incomes. Moreover, value added effects caused by services exports are not reflected in the results shown in table 3. A rough calculation based on secondary effects estimated at one-third of primary effects as well as services exports to the tune of 33% of goods exports (2004) shows that the overall (primary and secondary) effects of goods and services exports to Germany account for approximately 12% of Austrian GDP. Thus, Austria's overall exports generate some 37% of GDP.*

Chart 2

Austrian FDI vis-à-vis Germany and the CEECs



Source: OeNB.

second oil price shock, sharp global interest rate hikes, the Volcker disinflation period, debt crisis), all three economies showed similar developments. The only apparent exception was the recession of 1978 in Austria, which was a budget and current account crisis triggered by an "Austro-Keynesian" economic policy stance that was adopted after the first oil price shock. In the first half of the 1980s, the U.S.A. enjoyed high growth rates (induced by U.S. President Reagan's policy of tax cuts cou-

Table 4

Austrian FDI Stocks

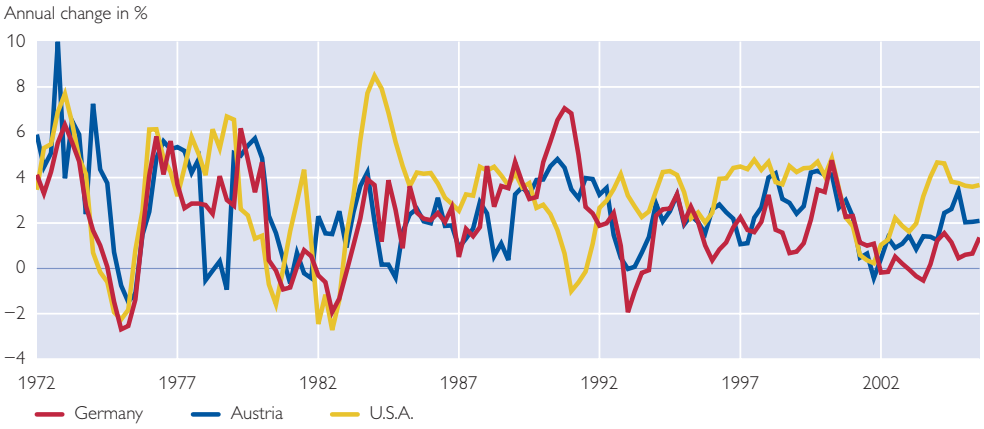
	1990	1995	2000	2003
	% of total outward (inward) FDI			
Inward FDI from Germany	38.2	41.9	46.8	39.9
Outward FDI to Germany	24.4	19.4	19.0	16.1
Inward FDI from the CEECs[1]	1.3	1.4	1.1	1.5
Outward FDI to the CEECs[1]	11.0	28.0	30.1	36.8
	% of Austrian GDP			
Inward FDI from Germany	2.7	3.8	8.1	8.4
Outward FDI to Germany	0.7	1.1	2.7	3.5
Inward FDI from the CEECs[1]	0.1	0.1	0.2	0.3
Outward FDI to the CEECs[1]	0.3	1.5	4.3	8.1
	Total FDI			
Outward FDI (EUR million)	3,683	8,674	26,674	44,308
Outward FDI (% of GDP)	3.0	5.5	14.2	21.9
Inward FDI (EUR million)	8,513	14,458	32,704	42,632
Inward FDI (% of GDP)	7.0	9.2	17.4	21.1

Source: OeNB, authors' calculations.

[1] *Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Republic of Moldova, Macedonia, Poland, Romania, Russia, Serbia and Montenegro, Slovakia, Slovenia and Ukraine.*

Chart 3

Growth in Real GDP in Austria, Germany and the U.S.A.



Source: Statistics Austria, Bureau of Economic Analysis, Eurostat.

pled with higher defense spending), whereas growth in Germany and Austria was substantially weaker. In the 1980s, Austria went through two crises triggered by domestic factors, specifically by budget consolidation measures and the crisis in the state industries. Starting in 1990, the German and Austrian economies became increasingly decoupled from the U.S. economy. While the situation in Europe was influenced by German reunification and the resulting recession in 1993, the U.S.A. saw strong growth (after a recession in 1991) thanks to high productivity growth throughout the rest of the 1990s. The global recession which emanated from the U.S.A. in the year 2000 also produced an economic slump in Germany and Austria, although it did not affect Austria as severely as it did Germany.

Several measures are used to depict the degree of synchronization between Austrian cyclical fluctuations and those of its main trading partners. These measures are calculated for two periods (1972 to 1989 and 1990 to 2005) and for "rolling windows."

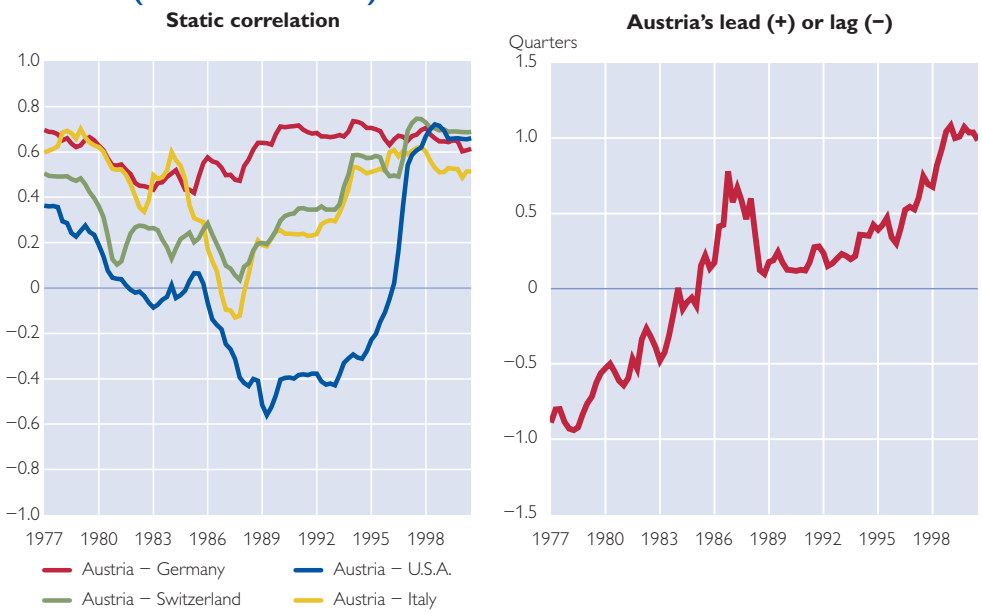
The left-hand panel in chart 4 shows the static correlations in real GDP growth (year on year) between Austria and its main trading partners Germany, Italy, the U.S.A. and Switzerland. These correlations were calculated for ten-year centered rolling windows. Calculations reveal a persistently high correlation between Austria and Germany which only weakened slightly in the 1980s as a consequence of two domestically triggered lapses in growth.[8] Austria's correlation with other countries is characterized by the fact that – starting from a high level during the phase of global shocks – it weakened steadily or even became negative, then increased again in recent years.[9]

[8] *The correlations were also calculated with deviations from a Hodrick-Prescott filtered trend and for quarterly growth rates. The results for the trend deviations are very similar to those for annual growth rates, while – due to high volatility – the results for quarterly growth rates hardly reveal any connections.*

[9] *Helbling and Bayoumi (2003) attribute the decline in the correlation between EU countries and the U.S.A. in the early 1990s to country-specific shocks with unchanged transmission strength, while all other business cycle developments are put down to global shocks.*

Chart 4

Static and Dynamic Relationship between Austria and Its Main Trading Partners (Real GDP Growth)



Source: OeNB.

In addition to examining the strength of contemporaneous correlation, this study addresses the question of whether German and Austrian business cycle fluctuations occur contemporaneously or whether there is a time lag between them. For this purpose, we calculated correlations for various leads and lags in two periods (1972 to 1989 and 1990 to 2005). Table 5 shows the maximum correlation along with the lead/lag for which it was found. This shows that the Austrian and German economies developed contemporaneously in the first period, while the maximum correlation found in the second period points to a one-quarter lead on the part the Austrian economy. This result can be refined further using spectral analysis methods, the fundamentals of which are discussed in box 1.

The right-hand panel in chart 4 shows the delay of the Austrian economy relative to Germany for ten-year rolling windows. A positive delay indicates a lead, while a negative delay points to a lag in the Austrian economy. The panel clearly shows that Austria's fluctuations have consistently shifted forward in relation to Germany's fluctuations. Whereas in the 1970s a lag of 1 quarter was recorded, the Austrian economy currently leads the German economy by 1 quarter. The overall shift thus amounts to 2 quarters. Observed across the two periods mentioned above, the shift is less pronounced (−0.8 to +0.6 quarters; see table 5). However, this result does not justify the conclusion that Austria's business cycle has become decoupled from its German counterpart. One reason for Austria's increasing lead may be the dramatic increase in the significance of the automotive supply industry as an upstream stage of production. While the delay vis-à-vis Germany turns out to be highly stable over time, the delay vis-à-vis other trading partners shows erratic fluctuations in

Box 1

Spectral Analytic Measures of Synchronization between Two Series

Co-movement between two time series has traditionally been analyzed in the time domain, i.e. by analyzing correlations. Apart from that method, spectral analysis techniques also offer an attractive means of analyzing co-movement for various frequencies (e.g. Croux et al., 2001). The idea behind this technique is that stationary time series can be composed of oscillations in various frequencies. For the purpose of bivariate spectral analysis, the auto-covariance matrix of series x and y up to a certain number of leads and lags is transformed into spectral density matrices by means of a Fourier analysis. The diagonal elements of the spectral density matrix $F_{\{x_t y_t\}}(\omega)$ *describe the spectrum of the two time series for frequency* ω*, while the off-diagonal elements describe the co-spectrum. The co-spectrum* $f_{xy}(\omega) = c_{xy}(\omega) + iq_{xy}(\omega)$ *is a complex number and can thus be decomposed into a real part* $c_{xy}(\omega)$ *and an imaginary part* $iq_{xy}(\omega)$*. A number of meaningful measures can be derived from the co-spectrum. The dynamic coherence measure* $C_{xy}(\omega) = |f_{xy}(\omega)| / \sqrt{f_x(\omega) f_y(\omega)}$ *is the frequency domain's counterpart to the static correlation and describes the correlation between two series for a certain frequency. However, it does not contain any information on the relative position of the two series, which means that a temporal shift in one of the two series leaves coherence unchanged. The delay* $d_{xy}(\omega) = -\tan^{-1}\left(q_{xy}(\omega)/c_{xy}(\omega)\right)/\omega$ *indicates the number of periods (in this case quarters) by which time series x leads, or lags behind, time series y. If the delay is greater than zero, then series x leads series y. In this study, these measures are analyzed for the business cycle frequencies with a duration of 1½ to 8 years.*

some cases, thus it was not depicted. This stems from the fact that the co-spectrum has no informative power in cases of weak correlation.

Table 5 also shows the results of the Granger causality test, which is used to test whether a variable which is delayed by one or more periods has predictive power for another variable. If this is the case, Granger causality is found (Hamilton, 1994). The null hypothesis to be tested in this context is that Granger causality is not present. The p-values are shown in table 5. If these values are lower than the critical value (e.g. 10%), then the null hypothesis can be rejected. The results show that Germany's GDP growth only exhibits Granger causality for Austrian GDP growth in the first period, but not in the second period. This confirms the results regarding delay, which indicate that Germany's lead in the first period turned into a lag in the second. In no case should the lack of Granger causality in the second period be taken as an indication of a decoupling of the Austrian economy from the German economy. For the U.S.A., a stable lead is also only found in the first period. For Switzerland, the null hypothesis cannot be rejected for both periods, while Granger causality is found in both periods in the case of Italy.

5 Influence of German Shocks on Austria Halved despite Nearly Unchanged Transmission

The high level of co-movement between the two business cycles can be caused by international shocks as well as by the transmission of specific German shocks to Austria. However, the descriptive analyses carried out in section 4 do not justify conclusions as to potential causes of the high degree of synchronization. In section 5, we therefore analyze the transmission of specific German shocks to the Austrian economy. Using a VAR model,

Table 5

Co-Movement of Austria's Economy with Its Main Trading Partners

	Static correlation			Dynamic coherence[2]	Delay[3] (Quarters)	Granger causality[4] (p-values)
	Contemporaneous	Maximum[1]				
Germany						
1972 to 1989	0.60	0.60	(0)	0.66	−0.75	0.01
1990 to 2005	0.72	0.75	(1)	0.76	0.63	0.80
1972 to 2005	0.62	0.62	(0)	0.68	0.43	0.00
U.S.A.						
1972 to 1989	0.23	0.33	(−2)	0.27	−1.67	0.05
1990 to 2005	0.13	0.22	(−4)	0.13	−1.21	0.54
1972 to 2005	0.21	0.30	(−2)	0.24	−0.56	0.02
Switzerland						
1972 to 1989	0.38	0.43	(1)	0.44	0.91	0.76
1990 to 2005	0.58	0.58	(0)	0.61	−0.30	0.27
1972 to 2005	0.42	0.44	(1)	0.47	0.22	0.98
Italy						
1972 to 1989	0.56	0.56	(0)	0.62	−0.15	0.02
1990 to 2005	0.54	0.54	(−1)	0.59	−0.14	0.09
1972 to 2005	0.54	0.54	(0)	0.59	0.42	0.00

Source: Authors' calculations.

[1] *The figures in parentheses indicate the number of leads (+) or lags (−) exhibited by Austria in relation to country i (in quarters) for which the maximum correlation was found.*
[2] *For business cycle frequencies (i.e. from 6 to 32 quarters).*
[3] *+(−): Austria leads (lags) country i.*
[4] *Null hypothesis: Country i exhibits no Granger causality for Austria (tested for one lag).*

we identify three structural shocks for Germany (supply shock, demand shock, monetary policy shock) and examine their transmission to Austria as well as any potential changes over time.

5.1 VAR Model

A model for estimating the strength of the transmission of specific German shocks to Austria has to fulfill multiple requirements: It has to capture explicitly the dynamic relationships between central macroeconomic variables in the two economies, sufficiently test the influence of the international environment and enable the identification of German shocks.

The VAR model used here satisfies these requirements. To keep the model as simple as possible and to ensure the proper identification of German shocks, the following simplifying assumptions were made: The Austrian economy has no effect on Germany. The transmission of German effects to Austria via other countries is not explicitly modeled. Austria and Germany exert no influence on the international environment. The model consists of one country block for Germany and one for Austria. These country blocks comprise one variable each for the level of real activity, inflation and monetary policy. These variables are depicted by real GDP, the Harmonized Index of Consumer Prices (HICP) and the three-month interest rate.[10] Growth in U.S. GDP (year on year) and in the HWWA Commodity Price Index

[10] *The time series ($(1-L^4)$ for GDP, $(1-L^4)(1-L)$ for the HICP and $(1-L^4)$ for the interest rate) were differentiated in such a way that the transformed time series are stationary.*

(first difference of the inflation rate) was used as a proxy for the international environment. The data are available on a quarterly basis. The observation period starts in the first quarter of 1972 and ends with the third quarter of 2005, thus focusing on the time after the collapse of the Bretton Woods system in 1971.

To examine the change in transmission from Germany to Austria over time, the model was estimated for two periods.[11] The reunification of Germany was chosen as a logical point in time to separate these periods. The first period thus comprises the years 1972 to 1989, while the second period covers 1990 to 2005 (up to the third quarter). As the Austrian schilling was in effect pegged to the Deutsche mark as from 1979, Austria basically had no independent monetary policy from that point onward. No notable differences in the development of three-month interest rates in Germany and Austria can be observed after 1981. As a result, the model was estimated without Austrian interest rates for the second period. The lag length in the models (one quarter) was calculated using Akaike's and Schwarz's information criteria. The identification of structural shocks in Germany is described in box 2.

Chart 5 shows the three structural shock series determined for Germany along with the growth rate in Germany's real GDP. The volatility of monetary policy shocks[12] declined substantially over the observation period. The highest volatility was observed at the beginning of the 1970s (after the collapse of the Bretton Woods system and the ensuing reorientation of Germany's monetary policy) and in the early 1980s (the Volcker disinflation period). In line with the relevant literature (Christiano et al., 1999), the explanatory power of monetary policy shocks is generally low for changes in aggregate output and inflation (each under 10% measured in terms of their contribution to forecast error variance).

In contrast, more than 50% of changes in aggregate output are explained by demand shocks, which especially reflect developments in fiscal policy. The special economic development observed in the German economy after reunification and the fiscal policy countermeasures taken after the two oil price shocks were identified as demand shocks. Interestingly enough, demand shocks cannot explain the weakness in growth between 2001 and 2004. After a negative monetary policy shock in 2001, a series of negative supply shocks (stock market collapse, strong exchange rate fluctuations, oil price hikes) were primarily responsible for the low level of growth in that period. Supply shocks mainly refer to shocks which influence prices, wages and other production costs. In this analysis, technological innovations do not play a decisive role in the definition of supply shocks. Supply shocks explain most of the variation in infla-

[11] *To ensure that the German shocks identified in both periods are equivalent in qualitative terms, the structure of the German VAR block was held constant for both periods and identical rotations were selected for both periods (see box 2). This implies that the coefficient matrices* $\boldsymbol{A}_{DD}$ *and* $\boldsymbol{B}_{D}$ *(box 2) are the same for both periods and that the German block in the VAR model can be estimated for the entire period (from 1972 to 2005) and not separately for the two subperiods.*

[12] *In addition to data problems and the changing expectations of private economic actors, changes in the monetary policy strategy are the main cause of monetary policy shocks (Christiano et al., 1999).*

Box 2

Identification of Shocks in Germany

In its reduced form, the VAR model is given by the following equation:

$$\begin{bmatrix} x_t^A \\ x_t^D \end{bmatrix} = \begin{bmatrix} A_{AA}(L) & A_{AD}(L) \\ 0 & A_{DD}(L) \end{bmatrix} \begin{bmatrix} x_{t-1}^A \\ x_{t-1}^D \end{bmatrix} + \begin{bmatrix} B_A(L) \\ B_D(L) \end{bmatrix} y_t + \begin{bmatrix} \varepsilon_t^A \\ \varepsilon_t^D \end{bmatrix}$$

*where x_t^A, and x_t^D denote the vectors of the endogenous variables (for Austria and Germany). Vector y_t contains the exogenous variables. Matrices **A** and **B** contain the coefficients for the endogenous and exogenous variables, and (L) stands for the lag operator. The coefficients of the Austrian variables in the German block were restricted to 0. ε_t^A and ε_t^D represent the residuals.*

To employ the model estimated in this way to simulate the transmission of structural shocks in Germany to Austria, it is first necessary to identify these shocks. As the reduced form alone does not suffice to identify the structural model, it is necessary to use suitable restrictions for this purpose. In the identification scheme used in this study, restrictions derived from economic theory are imposed on the impulse response functions.[1] A German supply and demand shock as well as a monetary policy shock are identified. These shocks must satisfy the following restrictions: In a supply shock, the reactions of GDP and inflation as well as those of GDP and interest rates have to be negatively correlated. In a demand shock, the reactions of GDP and inflation as well as those of GDP and interest rates have to be positively correlated. The monetary policy shock is identified by a positive correlation between GDP and inflation as well as by a negative correlation between GDP and interest rates. The sign restrictions can be derived from a number of theoretical models, which is a major advantage of the method selected. They are just as consistent with the standard textbook aggregate-demand aggregate-supply framework as with more advanced Dynamic Stochastic General Equilibrium (DSGE) models in the style of Smets and Wouters (2002).

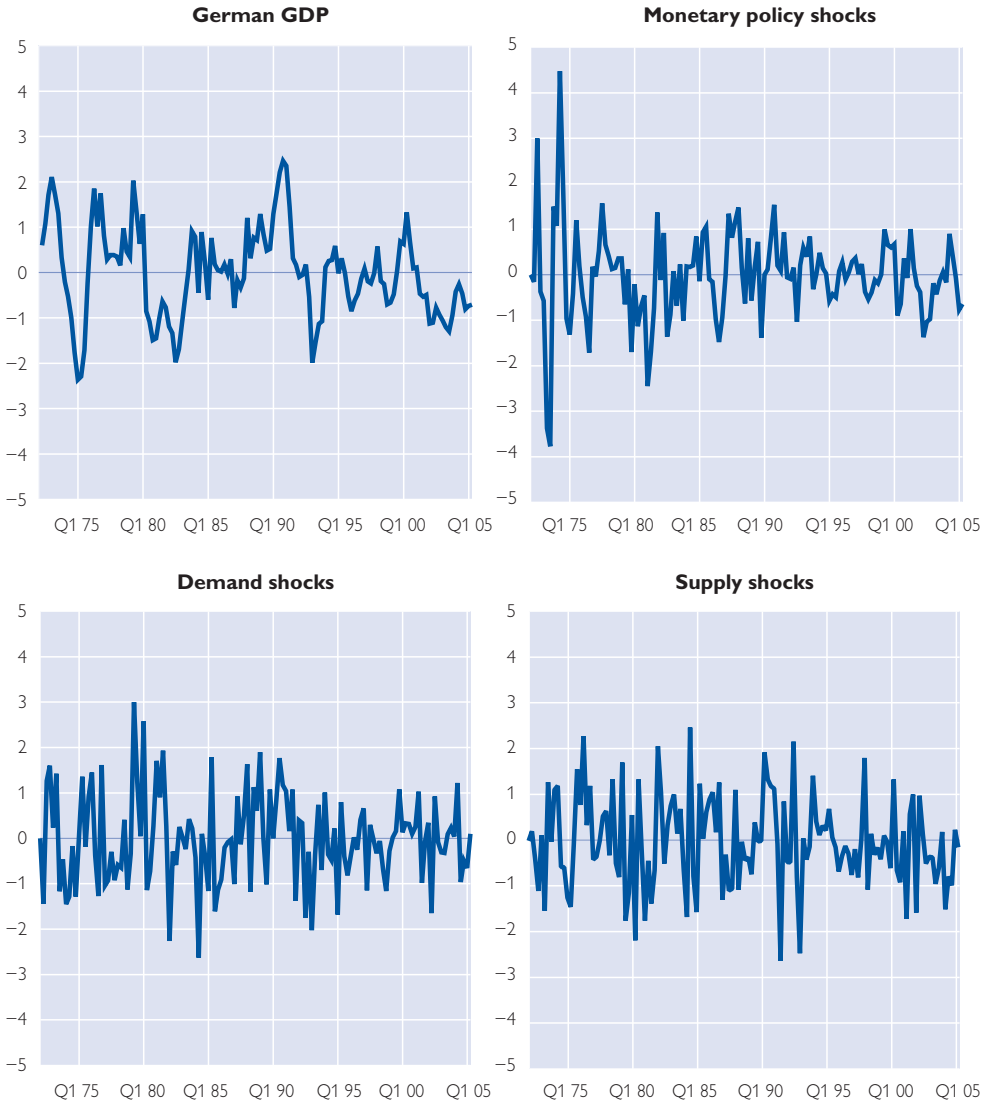
To implement the identification scheme, the German residuals are first decomposed into orthogonal shocks using an eigenvalue decomposition. At first, these residuals do not allow an economic interpretation and are only identified clearly as a whole, but not for each individual shock. Therefore, through multiplication by an orthonormal rotation matrix they can be rotated as desired in the space defined by the eigenvectors. When $N = 3$ German series, this gives us three $(= N*(N-1)/2)$ rotation axes around which the shocks can be rotated. Each rotation axis is subdivided into 15 steps, yielding a total of $15^3 = 3{,}375$ different rotations. For each of these rotations, we now check whether the restrictions mentioned above are satisfied. A detailed technical description of this method can be found in Fenz and Schneider (2006) as well as Canova (2005) and Uhlig (2005). By applying this method, we arrive at a total of 182 valid rotations, which are sorted in descending order based on the total covariance for the imposed restrictions. Starting with the first valid rotation, the rotation to be finally used was selected on the basis of visual inspections of the impulse response functions and the German shock series.

[1] *This identification scheme was first introduced in the literature in Canova (2005) as well as Canova and de Nicoló (2003). The relevant literature also provides a number of additional identification schemes in which the restrictions usually apply to the contemporaneous link between the shocks. The most common schemes are the Cholesky decomposition introduced by Sims (1980) as well as the theory-based formulation of linear relationships between unobservable shocks and the classification of shocks as transitory and permanent according to their effects. For an overview of various identification schemes, see Uhlig (2005).*

Chart 5

Historical Development of GDP Growth and Structural Shocks in Germany

Annual change in %; standardized values



Source: Authors' calculations.

tion and capture just over one-third of the variation in aggregate output.

5.2 Strong Transmission of German Shocks to Austria

Using the VAR model, we can now examine the transmission of German shocks to Austria. In this context, three questions are of particular interest: First, how strongly do specific shocks in Germany affect the Austrian economy relative to the German economy? Second, are there differences between the various types of shocks in terms of transmission strength? Third, has transmission changed over time? To answer these questions, the model's impulse response functions were calculated over 40 quarters for the three structural shocks in Germany. To determine the strength of Austria's reaction compared to Germany's, the cumulative impulse response functions for Aus-

tria after a ten-year period are divided by the corresponding German results.

Table 6 provides an overview of the results, which show that the transmission of German shocks to Austria is indeed strong. The reaction of Austria's GDP to an average shock in Germany is 0.44 times the reaction of German GDP.[13] Between the first and the second period, transmission weakened slightly from 0.46 to 0.42.[14]

The various shocks are transmitted to Austria to varying degrees, with monetary policy shocks showing the strongest transmission, as they trigger a reaction in Austria which, on average, is 0.83 times the reaction in Germany. This appears plausible because, during the long periods of identical monetary policy, such shocks were transmitted to Austria directly and not indirectly via the Germany economy. Between the first and second period, an increase in the transmission strength of the monetary policy shock could be observed. This can be attributed to two causes: First, Austria had its own monetary policy until the Austrian schilling was practically pegged to the Deutsche mark in 1979. Second, the effect of monetary policy shocks may have been reinforced by the beginning of monetary union in 1999 if these shocks are similar across euro area countries. A supply shock in Germany has a substantially weaker effect (0.36) on Austria than a monetary policy shock. This effect remains almost unchanged over time. The weakest transmission was found in the case of a demand shock. Supply shocks such as wage or technology shocks are likely to have more direct effects than a demand shock, which only makes its way to Austria through German import demand. The transmission of demand shocks weakened the most, specifically from 0.36 to 0.21. The reason for this development might lie in the changing effects of German fiscal shocks, which are among the most important sources of demand shocks in Germany. Whereas fiscal shocks only took effect in West Germany in the first period, massive investments and transfers to the east German Länder have been recorded since reunification. These shocks affected the Austrian economy to a lesser extent than the previous fiscal shocks.

In addition to the strength of transmission, the amplitude of German shocks also plays a decisive role in their effects on business cycle fluctuations in Austria. The standard deviation of German shocks declined by an average of one-third (table 7). The decline (by more than half) in the volatility of monetary policy shocks is especially pronounced, while the decrease in the volatility of supply shocks (–11%) and demand shocks (–30%) was substantially lower. This is an international phenomenon which has also been observed in other countries. Stock and Watson (2003a) also find an average decrease in volatility

[13] *The strength of transmission was defined as the cumulative reaction of Austria's GDP to a certain shock in Germany after ten years in relation to the effects on German GDP. The reaction to an "average" shock in Germany was determined by averaging the cumulative Austrian impulse responses across the three shocks and dividing the result by the corresponding value for Germany. After a maximum of three years, none of the three shocks still had a significant influence on German or Austrian GDP.*

[14] *Most of the impulse response functions are very similar for a majority of the 182 valid rotations (box 2). Averaging across these rotations yields a mean transmission of German shocks to Austria of 0.41 (from 1972 to 1990) and 0.38 (from 1991 to 2005). In the selected rotation (table 6), a very similar reaction pattern emerges with values of 0.46 and 0.42.*

Table 6

Strength of Transmission of German Structural Shocks to Austria[1]

	Supply	Demand	Monetary policy	Average
1972 to 1989	0.37	0.36	0.77	0.46
1990 to 2005	0.35	0.21	0.89	0.42
1972 to 2005	0.36	0.28	0.83	0.44
1990 to 2005/1972 to 1989	0.95	0.58	1.16	0.91

Source: Authors' calculations.

[1] *Cumulative effects on the level of Austrian output after ten years in relation to the corresponding effects in Germany.*

Table 7

Influence of German Structural Shocks on Business Cycle Fluctuations in Austria

	Supply	Demand	Monetary policy	Average
Standard deviation of German structural shocks, 1990 to 2005 compared to 1972 to 1989				
	0.89	0.70	0.45	0.66
Strength of transmission, 1990 to 2005 compared to 1972 to 1989				
	0.95	0.58	1.16	0.91
Influence of German structural shocks, 1990 to 2005 compared to 1972 to 1989				
	0.84	0.41	0.52	0.61

Source: Authors' calculations.

Table 8

Forecast Error Variance Decomposition for Austrian GDP Growth

	Global shocks	German shocks	Austrian shocks
	1972 to 1989		
Contemporaneous	0.00	0.11	0.89
After 1 year	0.19	0.23	0.58
After 3 years	0.23	0.26	0.52
After 10 years	0.23	0.26	0.51
	1990 to 2005		
Contemporaneous	0.04	0.14	0.81
After 1 year	0.19	0.27	0.54
After 3 years	0.28	0.28	0.44
After 10 years	0.29	0.28	0.43

Source: Authors' calculations.

by approximately one-third in industrialized nations (see section 2).

If both effects (the decreased volatility of German shocks and the slightly weakened transmission) are considered together, then the decline in the influence of German shocks on the Austrian economy comes to about 40%. This is primarily attributable to the influence of demand shocks and monetary policy shocks, which weakened by approximately half, whereas the influence of German supply shocks weakened only slightly.

6 Domestic Shocks Losing Importance

Now that the previous sections have shown that declining volatility caused the absolute importance of German shocks for business cycle fluctuations in Austria to decline by 40% between

the two periods under review, the next question is that of the relative importance of international, German and Austrian shocks. As documented in numerous studies, the decline in business cycle fluctuations is a global phenomenon (see section 2.1). Therefore, one can conjecture that the relative reduction in the importance of German shocks is far lower (if it exists at all).

In order to answer the above question, a slightly modified version of the model was estimated and an alternative identification scheme was applied.[15] The eight shocks obtained in this manner were divided into three groups (international, German and Austrian shocks). The significance of the shocks is depicted in the form of a forecast error variance decomposition for Austrian GDP. Using the variance decomposition, it is possible to show which share of variance in the forecast error is explained by the respective shock for a certain forecasting horizon.

In the short term, the bulk of the forecast error is explained by domestic shocks, whereas German and international shocks hardly play a role. As the forecasting horizon is lengthened, however, the share of domestic shocks falls to approximately half, and the relevance of German and international shocks increases.

Between the first and the second period, a decrease of 8 percentage points (to 43%) in the significance of domestic shocks can be observed. Most of this decline is explained by the stronger influence of global shocks, but Germany's influence also increases, albeit only slightly. Given Austria's increasing international trade links, the result appears to be plausible.

7 Summary and Conclusions

The processes of globalization in general and of European integration in particular have brought about a sharp increase in cross-border flows of goods, capital and information for European economies. The integration of the CEECs in particular has been highly significant for Austria. Against this backdrop, this study examines the connection between business cycle fluctuations in Germany and Austria as well as the transmission of German shocks to Austria.

A descriptive presentation of the trade and financial flows between Austria and Germany shows that Austria's links with Germany have lost significance in relative terms. In terms of GDP, however, a continuous increase can be observed. Exports to Germany are responsible for approximately 12% of Austria's GDP growth. Static and dynamic correlation measures show a high and stable degree of co-movement between the Austrian and German economies which clearly exceeds Austria's synchronization

[15] *Not least because of the required processing power, using the method described in section 5 to simultaneously identify seven or eight shocks is not possible. To answer the important question of the relative importance of global, German and Austrian shocks nevertheless, section 6 uses a Cholesky decomposition, which does not allow an immediate economic interpretation of the shocks owing to its atheoretical approach. Based on the assumptions that Austria's influence on Germany and the world economy as well as Germany's influence on the world economy are negligible, it is still possible to generate a sufficiently accurate estimate of the relative importance of global, German and Austrian shocks for economic fluctuations in Austria. In contrast to section 5, the two proxy variables for the international environment are now treated not as exogenous but as endogenous variables. The residuals in this model are orthogonalized using a Cholesky decomposition, ranking the international variables first and then the German and the Austrian variables. This sequence reflects our assumptions regarding contemporaneous causalities between the variables.*

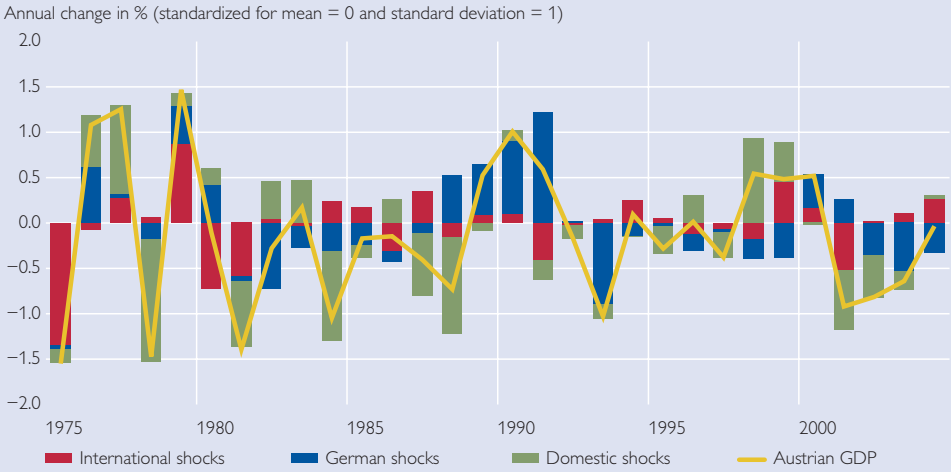
Box 3

Decomposition of Business Cycle Fluctuations in Austrian GDP Growth

Chart 6 shows the historical decomposition of Austria's GDP growth into international, German and Austrian shocks. For this purpose, the model was estimated over the entire observation period. The shocks were determined by applying a Cholesky decomposition to the residuals. The contribution of a shock at time t comprises the contemporaneous influence at time t as well as the delayed influence of the shock in all previous periods.

Chart 6

Decomposition of Business Cycle Fluctuations in Austrian GDP Growth



Source: Authors' calculations.

The first oil price shock in 1973–1974 triggered the recession of 1975. In 1976 and 1977, growth was supported by means of expansionary fiscal policies. This resulted in a budget deficit and – as a result of Austria's hard currency policy – a current account deficit, which then required a partial change of the monetary and fiscal policy course. Consolidation measures led to a recession in 1978 and are clearly visible as a domestic shock in chart 6. The early 1980s were characterized by negative international shocks (the second oil crisis in 1979–1980, high inflation rates, global interest rate increases). In the 1980s, the Austrian economy was hit by a number of negative domestic shocks linked to budget consolidation and the crisis in nationalized industries. At the end of the 1980s, positive shocks in Germany played an increasingly important role. The special economic development in post-reunification Germany was also carrying the Austrian economy in the early 1990s. The recession of 1993 must also be viewed in this context. The economic downturn that emanated from the U.S.A. in 2001 was further reinforced by domestic shocks, which were reflected in consumption and investment slumps. Since end-2002 and up to the end of the observation period, the German economy had a persistent dampening effect on Austrian economic growth.

with other important trading partners. The most important change observed is related to the timing of business cycle fluctuations in these two countries. While the Austrian economy lagged behind the German business cycle fluctuations by approximately 1 quarter in the 1970s, it now leads the German economy by 1 quarter.

The strength of the transmission of German shocks to Austria was examined using a VAR model for the periods from 1972 to 1989 and from 1990 to 2005. For this purpose, specific German supply and demand shocks as well as monetary policy shocks were identified. The results indicate the strong transmission of German business cycle fluctuations to Austria. On average, a positive German shock that amounts to 1% of GDP leads to an increase of 0.4% in Austria's GDP. German monetary policy shocks are transmitted with the greatest impact, while supply and demand shocks trigger a far less pronounced reaction in Austria. A comparison of the two periods shows that monetary policy shocks are now transmitted more strongly, whereas the transmission of German demand shocks has weakened. On average across the shocks, however, transmission has only weakened slightly. The average strength of German shocks lessened by one-third in the second period and thus entailed a decline of close to 40% in the amplitude of Austrian business cycle fluctuations caused by German shocks, despite the fact that the strength of transmission remained nearly unchanged.

An analysis of the relative importance of international, German and Austrian shocks for Austrian business cycle fluctuations based on forecast error variance decomposition shows a relative increase in the importance of international and – albeit to a lesser extent – German shocks, which now each explain just over one-fourth of fluctuations in Austrian growth. By contrast, the relative importance of domestic shocks has decreased to less than half.

To summarize the specific results of this study, no decline in Germany's influence on business cycle fluctuations in Austria can be observed. Instead, the increasing level of internationalization has actually weakened the impact of domestic shocks. This trend points to the decreasing leeway for active economic stabilization in national economic policy as well as to the need for stronger economic policy coordination at the international level.

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