IMF MULTI-COUNTRY REPORT

August 2013

GERMAN-CENTRAL EUROPEAN SUPPLY CHAIN— CLUSTER REPORT

IMF staff regularly produces papers covering multilateral issues and cross-country analyses. The following documents have been released and are included in this package:

- **Staff Report** on German-Central European Supply Chain—Cluster Report, prepared by IMF staff and completed on July 1, 2013 for the Executive Board's consideration on July 11, 2013.

- **First Background Note**—Trade Linkages

- **Second Background Note**—The Evolution of Financial Linkages

- **Third Background Note**—The Role of Fundamentals and Policies

The Executive Board met in an informal session, and no decisions were taken at this meeting.

The publication policy for staff reports and other documents allows for the deletion of market-sensitive information.

Copies of this report are available to the public from

International Monetary Fund • Publication Services
P.O. Box 92780 • Washington, D.C. 20090
Telephone: (202) 623-7430 • Telefax: (202) 623-7201
E-mail: publications@imf.org Internet: http://www.imf.org

**International Monetary Fund
Washington, D.C.**

INTERNATIONAL MONETARY FUND

July 1, 2013

GERMAN-CENTRAL EUROPEAN SUPPLY CHAIN— CLUSTER REPORT

EXECUTIVE SUMMARY

Since the 1990s a German-Central European supply chain (GCESC) has evolved, manufacturing goods for export to the rest of the world. Reflecting this, bilateral trade linkages between Germany and the Czech Republic, Hungary, Poland and the Slovak Republic (henceforth CE4) have expanded rapidly.

Supply chain production in CE4 countries has been supported by large inflows of FDI. FDI comprised a much larger share of overall capital inflows to the CE4 than to some comparator European countries. FDI was directed to the manufacturing sectors, in particular, motor vehicles and other transport equipment. Portfolio investment and cross-border bank flows were relatively less important.

Participation in the GCESC has led to technology transfers to CE4 countries and accelerated income convergence. Export growth in knowledge-intensive sectors has been particularly rapid in the CE4. The sophistication of domestic value added embodied in overall exports has also increased rapidly. Complementarities between supply chain activities and domestic production have led to greater synchronization of the business cycle among GCESC countries.

CE4 policymakers stressed the importance of safeguarding enhanced competitiveness in knowledge-intensive sectors. As unit labor cost differentials with Germany narrow, the CE4 countries may struggle to sustain their current role in the supply chain. In order to remain part of the GCESC—or branch out into more specialized export production activities, as some countries in Asia have done—the CE4 countries will need to continually upgrade labor force skills.

The growth of the supply chain has increased the exposure of Germany and the CE4 to final demand outside Europe, to an extent not captured by bilateral trade statistics. Spillovers from aggregate demand and policy actions in the rest of the world are now much larger than before. Conversely, German domestic demand spillovers to the CE4 remain relatively small. Much bilateral trade between Germany and the CE4 is in intermediate goods: final demand in Germany is not the main determinant of CE4 exports to Germany. Correspondingly, German fiscal policies to stimulate or contract domestic demand have a relatively limited impact on CE4 economies.

Balance sheet fundamentals in Germany are a key determinant of the magnitude of shock spillovers to CE4 countries and beyond. Currently, sound fundamentals act as a shock absorber; more leveraged balance sheets and greater sovereign risk in Germany would considerably magnify the regional impact of external shocks.

Approved By **Ranjit Teja**	Prepared by Shekhar Aiyar, Bartek Augustyniak, Christian Ebeke, Ehsan Ebrahimy, Selim Elekdag, Nir Klein, Subir Lall and Hongyan Zhao (all EUR) and Dirk Muir (RES).

CONTENTS

INTRODUCTION

1.   In recent decades supply chains—production spread across several countries within a particular region—have arisen in many different parts of the world. The distribution of the manufacturing process over more than one country, with different countries specializing in different stages of production, owes to both a favorable policy environment and technological developments. Global and regional trade agreements have resulted in significant tariff reduction and removal of non-trade barriers, while increased financial liberalization has encouraged foreign direct investment (FDI) supporting the offshoring of production. Technological developments have also played a vital role: falling transportation costs and improvements in communication technologies have significantly reduced the costs of information exchange and made it easier for firms to coordinate and monitor production in diverse locations.

2.   In Europe the German-Central European Supply Chain (GCESC) has expanded rapidly since the mid-1990s and assumed global importance. Large labor cost differentials together with geographical proximity and cultural similarities have led many German firms to shift large parts of their production to central European countries, most notably the Czech Republic, Hungary, Poland and Slovakia (CE4, hereafter) either by directly investing there or by purchasing intermediate inputs from local firms. The pattern is exemplified by the automobile industry, where increasing competition in both domestic and foreign markets has triggered a sustained process of outsourcing of manufacturing activities.

3.   This report examines the evolution and economic implications of the GCESC. Several questions of policy relevance are discussed. What have been the chief benefits of membership in the GCESC, and how should these best be safeguarded? Have vulnerabilities to external shocks risen as a result of the supply chain? Have demand or policy spillovers within the cluster become more important over time? To answer these questions, the study first documents the pattern of vertical trade integration in the GCESC, and the pattern of international capital flows supporting this integration. The benefits and costs of GCESC membership are then examined empirically along several dimensions. Model simulations are used to examine policy actions and spillovers.

THE EVOLUTION OF TRADE AND FINANCIAL LINKAGES

A. Trade Linkages

4.   The CE4's trade links with Germany have strengthened considerably since the mid-1990s, largely reflecting their increased integration into the GCESC. Bilateral trade with Germany grew much faster in CE4 countries than in other European countries (Figure 1). However, there is heterogeneity among the CE4 countries. In particular, Poland, which accounts for more than half of CE4 GDP, is a relatively less open economy than the others, and its trade with Germany has grown more slowly. Similarly the share of German value added embodied in CE4 exports expanded much more rapidly than in comparator countries. Apart from large unit labor cost differentials and

adequate labor skills to support supply chain activities, the CE4's integration into the GCESC reflects several bilateral advantages vis-à-vis Germany: geographic proximity, cultural similarities, and a similar sectoral structure. Rahman and Zhao (2013) compute an "industrial similarity index" relative to Germany, and show that the CE4 countries had strong similarities with Germany even before they integrated into the GCESC.

5. **The growth of the supply chain has substantially increased the exposure of both Germany and the CE4 to final demand outside Europe, to an extent not captured by bilateral**

Figure 1. Bilateral Trade with Germany

Sources: DOTS; IMF staff calculations based on the WIOT.
* Other Big Euro includes Austria, Belgium, France, Italy, and the Netherlands.
** Selected European Countries includes Greece, Ireland, Portugal, and Spain.
*** Other CEE includes BiH, Bulgaria, Croatia, Estonia, Latvia, Lithuania, Macedonia, Romania, Slovenia, and Ukraine.
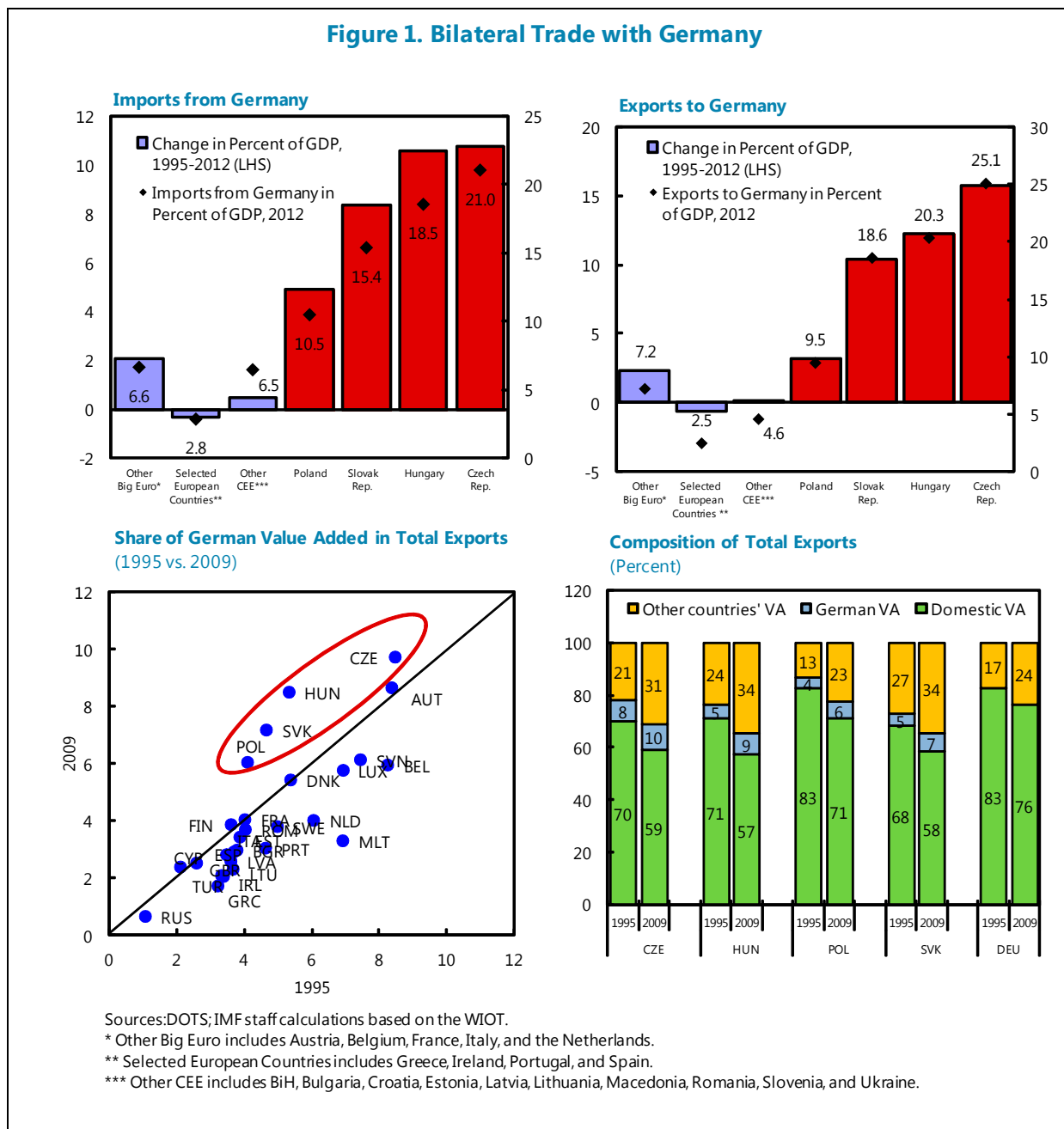
trade statistics. Conventional trade statistics tend to overestimate exposures within a supply chain due to the high prevalence of trade in intermediate goods. The recently released World Input-Output Table (WIOT) permits a detailed decomposition by origin of the value added (VA) embodied in total exports (Background Note 1). Figure 2 compares exposures to countries of final demand (from WIOTS) against more conventional gross exposures computed using the IMF's Direction of Trade statistics (DOTS). Germany's exposure to the EU under the WIOT (48 percent) is significantly below the implied exposure under DOTS (62 percent) while its exposure to the rest of the world is much higher (33 percent vs. 26 percent). Similarly, the CE4's exposure to Germany is significantly lower than implied by gross bilateral trade statistics; a substantial fraction of CE4 exports pass through Germany before export outside the EU.

Figure 2. Actual Exposure of the CE4 Countries Based on the Recipients' Final Demand, 2009
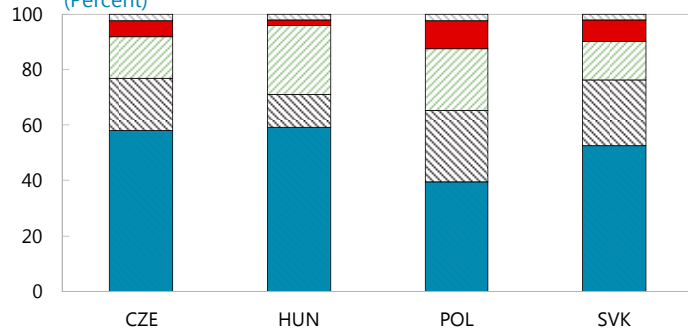(Percent)
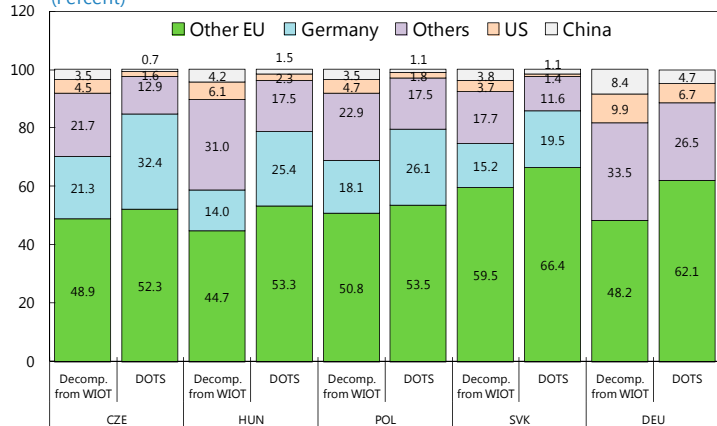
Source: IMF staff calculations based on the WIOT.

6.   CE4 exports grew most rapidly in knowledge-intensive sectors (Figure 3).[1] In Czech Rep., Hungary and Slovakia, these sectors—which include transport and electrical equipment, machinery and chemicals—contributed about 50-60 percent of total export growth in the period 1995-2009. In Poland, their contribution was somewhat lower (40 percent) but still the highest among sectors. Knowledge-intensive sectors also comprise the highest share in the countries' domestic VA exports (about 30-40 percent).

Figure 3. Sectoral Contribution to Exports Growth, 1995-2009
(Percent)

■ Knowledge-intensive manufacturing   ◩ Capital-intensive manufacturing
▨ Services   ■ Labor-intensive manufacturing
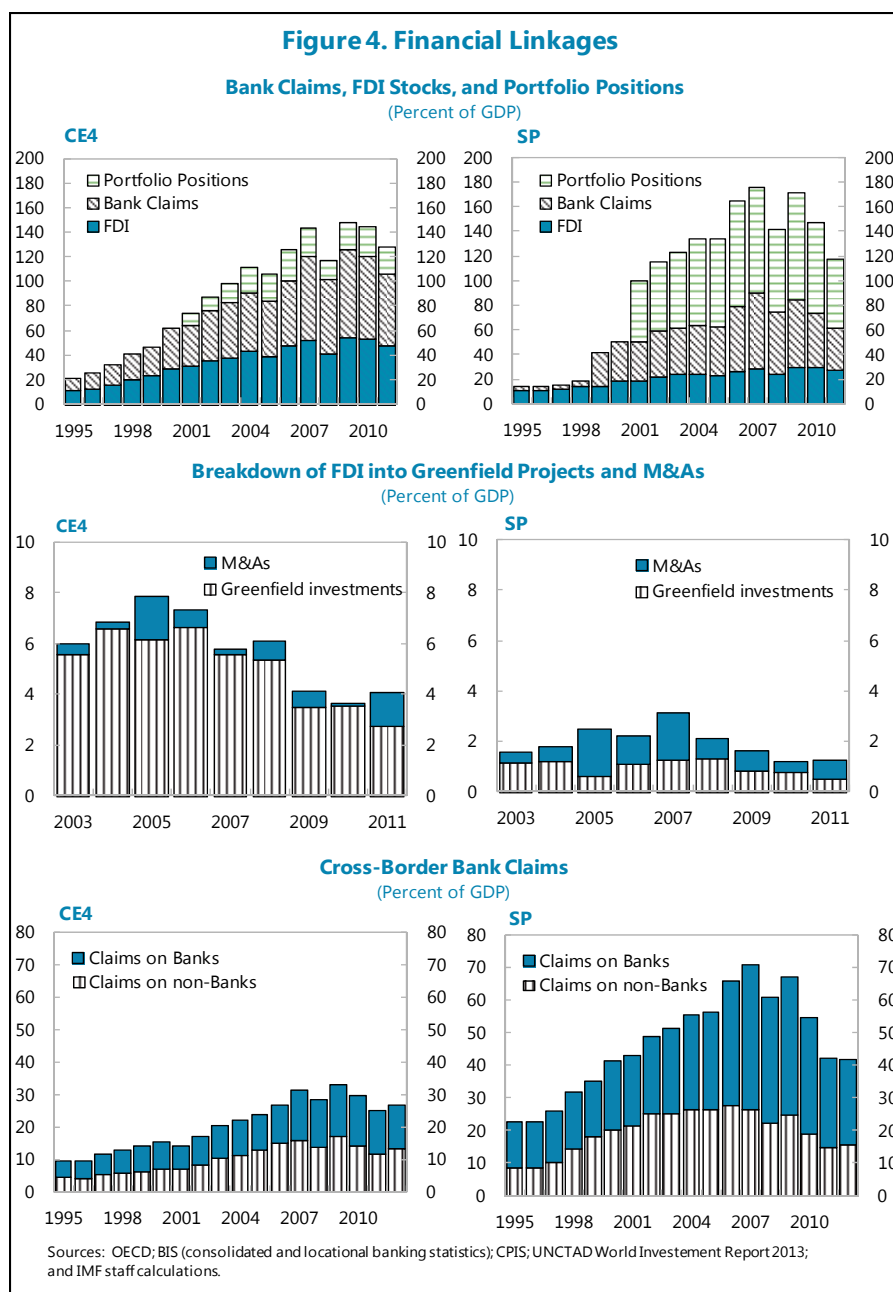▢ Primary and natural resources

Source: IMF staff calculations based on the WIOT.

---

[1] The various sectors are grouped into five main categories: primary and natural resources, services, labor-intensive manufacturing, capital-intensive manufacturing and knowledge-intensive manufacturing.

B.   Financial Linkages

7.   The evolution of the GCESC has been supported by large inflows of foreign direct investment (FDI) to CE4 countries. Figure 4 decomposes the stock of inward capital flows into FDI, portfolio flows and other (mainly bank) flows.[2] All stocks are scaled by GDP, and for reference purposes, a comparison is made against selected periphery (SP) countries—comprising Greece,

Figure 4. Financial Linkages

Bank Claims, FDI Stocks, and Portfolio Positions
(Percent of GDP)

CE4 — Portfolio Positions, Bank Claims, FDI (1995–2010)

SP — Portfolio Positions, Bank Claims, FDI (1995–2010)

Breakdown of FDI into Greenfield Projects and M&As
(Percent of GDP)

CE4 — M&As, Greenfield investments (2003–2011)

SP — M&As, Greenfield investments (2003–2011)

Cross-Border Bank Claims
(Percent of GDP)

CE4 — Claims on Banks, Claims on non-Banks (1995–2010)

SP — Claims on Banks, Claims on non-Banks (1995–2010)

Sources: OECD; BIS (consolidated and locational banking statistics); CPIS; UNCTAD World Investement Report 2013; and IMF staff calculations.

---

[2] The time series of stock positions is very similar to the evolution of balance of payments flows, but the former comprises a much richer data source for *bilateral* positions between, say, Germany and other countries.

Italy, Portugal and Spain—another group of European countries which globalized rapidly in the run-up to the 2007-08 crisis but have had very different recovery paths (Background Note 2). While FDI and bank flows were the main source of external financing for the CE4, portfolio and bank flows were the main types of external financing for the SP. The pattern of bilateral German claims on the CE4 and SP is broadly similar to the global exposures.

8. **Moreover, the FDI inflows into CE4 countries have largely financed greenfield investments (Figure 4).** Greenfield investment—as opposed to mergers and acquisitions (M&A) activity—is generally associated with an expansion in productive capacity and therefore growth. Moreover, it is a relatively stable source of external funding, and the least prone to sudden stops and reversals. Notably, much of the FDI directed to the CE4 countries was in the Motor Vehicles and Transport Equipment sectors (Background Note 2), supporting the offshoring of German passenger car production (Box, Background Note 1). 2009 marked the first year in which offshored production outstripped domestic German production of passenger cars.

9. **While foreign bank finance has played a large role in the CE4, *cross-border* bank flows have been less pronounced (albeit still important).** The CE4 countries have been reliant on foreign bank financing to roughly the same extent as the SP countries on a *consolidated* basis, which includes not just cross-border bank flows, but also local lending by resident foreign branches and subsidiaries. But cross-border bank flows to the CE4 countries have been far less pronounced than in the SP (Figure 4). In the run-up to the financial crisis, cross-border claims on the SP countries built-up to a much larger extent than in CE4 countries, and the corresponding deleveraging was also much sharper. Foreign bank lending to the CE4 contained a relatively larger share of local lending by resident banks, which tend to support their lending operations through local deposits and are thus more stable and less prone to sudden reversals. However, there are important differences between CE4 countries; in particular, the share of cross-border bank flows was much larger in Hungary (where the pattern more closely resembled the SP countries).
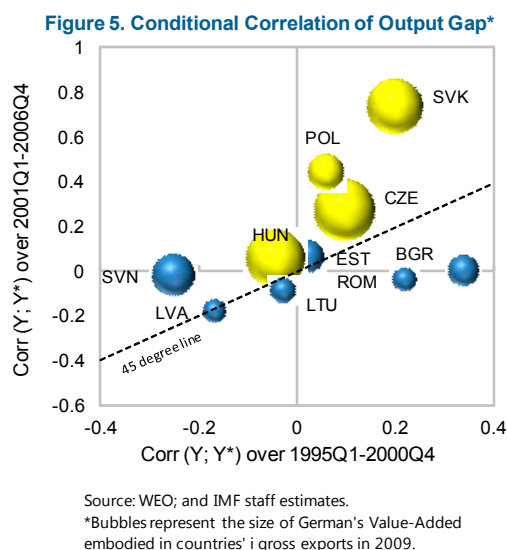
10. **Overall, therefore, it would appear that the external financial linkages supporting the GCESC countries have developed in a sustainable fashion over time**. The stock position indicates the predominance of FDI and lending by foreign-owned but locally resident banks. FDI is a relatively stable source of external funding, and holds up better during external crises, as documented by a well-established literature, most recently, Catao and Milesi-Ferretti (2013). FDI was directed to the manufacturing—and in particular, motor vehicles and other transport equipment—sectors, and a substantial amount of this FDI comprised greenfield investments. By way of contrast, the SP attracted a greater share of portfolio and cross-border banking flows, which—with the benefit of hindsight—exacerbated overheating pressures. In general, while FDI flows promoted durable growth in the CE4, non-FDI flows added to macroeconomic and financial imbalances across the SP.

MACROECONOMIC CONSEQUENCES AND POLICY IMPLICATIONS

A. Business Cycle Synchronization

11.   The business cycles of the CE4 countries have become more synchronized with Germany. The CE4 countries stand out in a ranking of the bilateral conditional correlation of output gaps against Germany.[3] The conditional correlation has increased over time for all the CE4 countries except Hungary (Figure 5), and this is associated with the size of German VA embodied in the countries' exports. For other CEE countries, the output synchronization seems to have diminished over the time. This result—that greater vertical trade integration with Germany contributes to closer business cycle co-movement—is supported by a more formal econometric analysis that attempts to account for endogeneity concerns (see Background Note 1).

Figure 5. Conditional Correlation of Output Gap*

Source: WEO; and IMF staff estimates.
*Bubbles represent the size of German's Value-Added embodied in countries' i gross exports in 2009.

B. Technology Transfers

12.   There is evidence that participation in the GCESC has led to considerable technology transfers to the CE4 countries. As documented in the previous section, export growth in knowledge-intensive sectors has been particularly rapid in the CE4 countries. Moreover, the share of these sectors in domestic value added exports has been increasing.

13.   Revealed Comparative Advantage (RCA) patterns for the CE4 countries have evolved in line with such technology transfers.[4] Table 1 provides RCA calculations in the manufacturing sectors for the CE4 countries, Germany and some comparator countries. The manufacturing sectors are grouped into labor-intensive, capital-intensive, and knowledge-intensive sectors. The RCA calculations show that with the exception of Poland, all other CE4 countries have largely "caught up" with Germany's comparative advantage in the knowledge-intensive manufacturing sectors, which

---

[3] The correlation of output gaps is computed using output gaps (for each country and Germany) purged from the effect of global economic conditions. The resulting output gaps therefore represent idiosyncratic shocks observed in each country. See Background Note 1 for further details.

[4] Traditionally, RCA is defined as the proportion of a sector's exports in a country's total gross exports relative to the average share of the same sector's exports in the world's total exports. A value higher than one indicates that the country has a comparative advantage in that particular sector. Here RCA is calculated on the basis of domestic VA, as in Rahman and Zhao (2013). See Background Note 1 for further details.

are a significant part of the German supply chain. While there has been a concomitant loss of comparative advantage in the labor and capital-intensive sectors, even in these sectors the RCA index remains greater than one (except in Hungary). These trends differ from those in some euro area periphery countries, which have lost their comparative advantage in the knowledge-intensive sectors (Ireland and Spain) or retain their comparative disadvantage (Greece and Portugal).

| Table 1. Revealed Comparative Advantage (RCA) in Manufacturing						
	Manufacturing 1995			Manufacturing 2009		
	Labor-intensive	Capital-intensive	Knowledge-intensive	Labor-intensive	Capital-intensive	Knowledge-intensive
Czech	1.29	1.30	0.56	1.01	1.16	1.18
Hungary	0.68	1.06	0.50	0.37	0.77	1.18
Poland	1.95	1.39	0.59	1.52	1.39	0.93
Slovakia	1.05	1.61	0.60	1.16	1.41	1.11
Germany	0.64	1.07	1.48	0.64	1.20	1.49
Portugal	3.42	0.94	0.57	2.08	1.43	0.60
Spain	0.93	1.21	1.04	0.97	1.29	0.98
Ireland	0.34	1.79	1.01	0.11	0.72	0.89
Greece	1.56	1.26	0.03	0.33	0.72	0.20
China	3.55	1.03	0.64	2.52	0.66	1.27
Source: Rahman and Zhao (2013).						

14.   Integration into the GCESC has greatly enhanced CE4 competitiveness in knowledge-intensive sectors. With the progression of income convergence and narrowing of unit labor cost differentials with Germany, the CE4 countries may struggle to sustain their current role in the supply chain and further benefit from the vertical specialization. In addition, other CEE economies have made substantial progress in removing impediments to trade and improving the business environment, increasing their attractiveness as new potential links in the GCESC. In order to remain part of the GCESC—or indeed, to branch out into more specialized export production activities of their own—the CE4 countries will likely need to continue investing in human capital and upgrading labor skills to cement their comparative advantage in the region. This would facilitate moving up the value chain, as countries in Asia, notably China, are doing.[5]

---

[5] IMF (2011) documents that China is moving beyond its earlier predominant role as a downstream assembler of manufactured products, and accounts for a burgeoning share of intermediate inputs into advanced countries' high technology exports.

C.   Spillovers to Domestic Production

15.   The increase in foreign value added in CE4 exports appears to have spurred domestic value added (DVA). While the shares of DVA in gross exports have broadly declined, they have increased significantly in nominal terms and as a percentage of GDP (Figure 6). The increase in domestic VA was positively correlated with the increase in foreign value added (FVA). Importantly, Rahman and Zhao (2013), who examine the relationship between foreign and domestic VA growth across 40 countries during 1995-2008, find econometric evidence that causality runs from growth in FVA to DVA.

Figure 6. The Change in Foreign and Domestic Value Added in Total Exports, 1995-2009
(Percent of GDP)
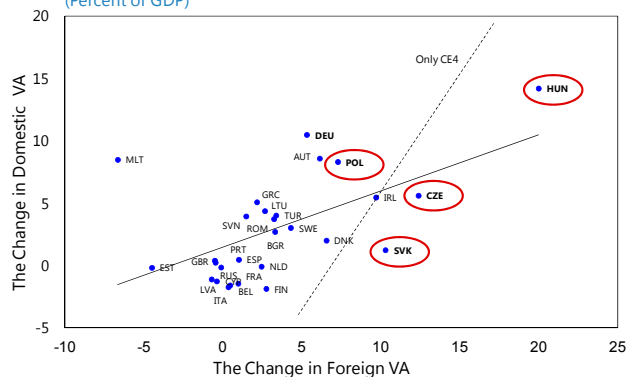
Source: IMF staff calculations based on the WIOT.

16.   Thus attracting FVA—as part of integrating into the vertical supply chain—complements rather than substitutes for domestic production. The existence of the supply chain creates demand for ancillary products and services in host economies. This contributes to an expansion of the production possibility frontier and spurs overall employment and growth. So policies aimed at improving an economy's attractiveness for the supply chain are unlikely to come at the expense of domestic industries; instead the latter in general benefit from positive spillovers from supply chain activities.

D.   Income Convergence

17.   There are several channels through which trade—and supply chains in particular—may foster growth and income convergence. Trade can stimulate productivity gains, especially if supported by investment that embodies technological transfers with spillovers to other sectors in the economy. It could also foster financial deepening. Moreover, trade can contribute to specialization in highly productive sectors, which could generate efficiency gains for the economy as a whole.

18.   The CE4 economies have generally grown more rapidly than can be explained simply by initial income, suggesting that membership in the GCESC accelerated income convergence. Figure 7 illustrates that over the last two decades income convergence was broadly prevalent in Europe. Greater technological catch-up, improved functioning of markets, greater market access, and better institutions have allowed

Figure 7. Income Convergence and the Role of Supply Chains
(Bubble size is proportional to the share of German foreign value added embodied in countries' exports as percentage of GDP in 2009)

$y = -7E-07x + 0.0374$
$R^2 = 0.28$
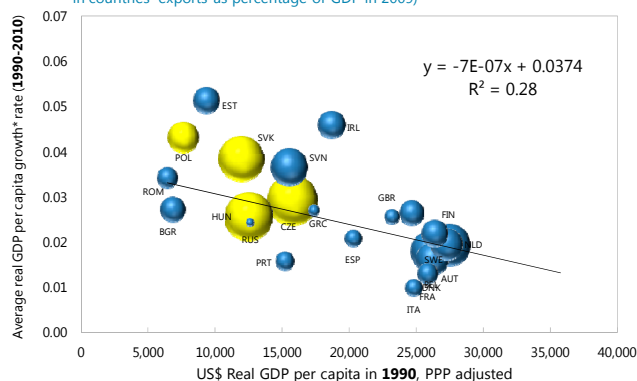
Sources: Penn World Table 7.1.; WIOT; IMF Staff estimates. (*) Instantaneous growth rate.

developing countries, mostly from the CEE region, to grow faster than richer economies. But the CE4 countries, with the exception of Hungary, lie above the regression line, implying that, controlling for initial income, they grew faster than average. The importance of the supply chain is confirmed using a more formal econometric approach, in which the beta convergence co-efficient is allowed to vary according to the amount of foreign VA in a country's exports (see Background Note 1 for further details). Exposure to External Shocks

19.   Greater trade openness has increased the vulnerability of both Germany and the individual CE4 countries to global shocks. A six-region version of the IMF's Global Integrated Monetary and Fiscal (GIMF) model is calibrated to capture the way in which the evolution of the GCESC has changed the transmission of shocks (Background Note 3). Each region exports and imports both final (consumption and investment) and intermediate goods; thus capturing the changing trade relationship between Germany, the CE4, and other key trading partners. Figure 8 summarizes the peak impact of a 1 percent aggregate demand (private consumption and investment) shock originating either in Germany, or in the non-European blocks of the model (Emerging Asia, the U.S., and remaining countries). This shock is motivated by the collapse of world trade during the global financial crisis of 2008-09. It shows the percent deviation of real GDP from the baseline in Germany and in the CE4 region.

Figure 8. Aggregate Demand Shock
(Real GDP, percent deviation from baseline)

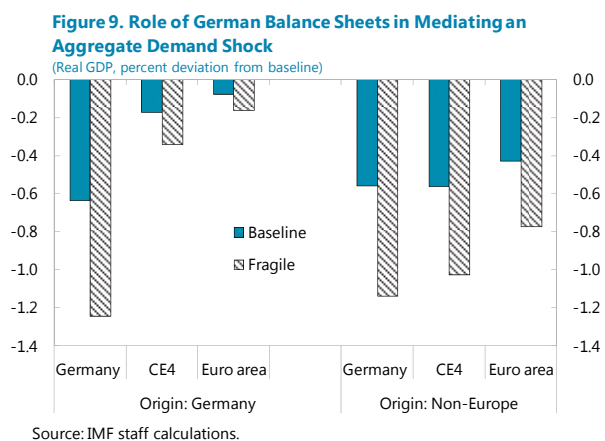Source: IMF staff calculations.
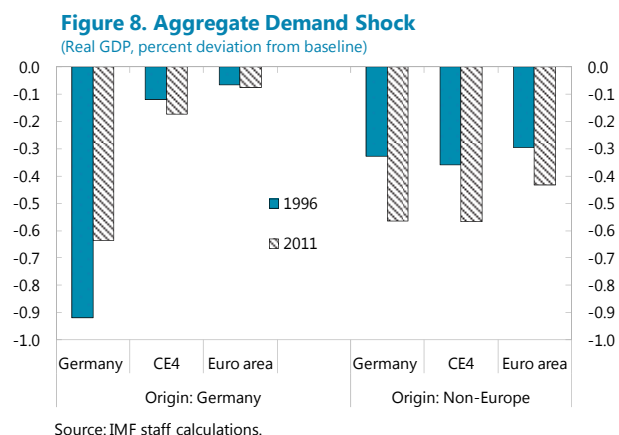
20.   German domestic demand spillovers to the CE4 have increased over time but remain relatively small, while greater openness has lessened the domestic impact of a pure domestic demand shock originating in Germany. The CE4 is only slightly more vulnerable to domestic demand shocks in Germany in 2011 than in 1996 (similar to other euro area countries), despite far more developed trade links. This is explained by the supply chain nature of the trade integration: final demand in Germany is *not* the main determinant of CE4 exports to Germany. Meanwhile, the impact on German GDP of an aggregate demand shock originating within Germany has *declined* substantially between 1996 and 2011. Germany's openness has greatly increased over the period, with the export-to-GDP ratio doubling from 24 percent to around 48 percent. Because Germany is more open in 2011, the economy is characterized by more "leakage", and therefore a lower domestic impact multiplier. Note that this simulation of an aggregate shock to domestic demand in Germany is virtually identical to modeling the impact of German *policy action*—for example fiscal contraction (or stimulus) —on the domestic economy and the CE4 countries. German fiscal policy has less domestic impact now than in the 1990s, due to greater openness, and the impact on the CE4 economies is relatively limited because of the nature of trade linkages. To a much larger extent than before, spillovers from German domestic demand are directed towards trade partners outside Europe, including emerging Asia.

21.   Because the GCESC has become more open, spillovers from the rest of the world are now much larger. In response to non-European demand shocks, real GDP in both Germany and the CE4 dips below baseline by considerably more in 2011 than in 1996. This is because both economies have become more open, and are thus more susceptible to fluctuations in global economic activity. The larger downturns are compounded by indirect effects because intra-European economic activity slows down, acting as an additional drag on growth. Also, the size of the "rest of the world" (especially emerging Asia) has increased disproportionately over time, and the impact of shocks originating here has increased correspondingly.[6] Again, simulating a shock to aggregate demand in the rest of the world is akin to considering co-ordinated *policy action* in the rest of the world. Thus a fully co-ordinated non-European fiscal action of a given magnitude (in percent of GDP) would have a much greater impact on both the German and CE4 economies than a purely German fiscal action of the same magnitude.

E.   The Importance of German Balance Sheets

22.   At present balance sheets in Germany are generally healthy. Low debt-to-GDP ratios prevail in the household, corporate and government sectors (Background Note 3). The country's safe haven status is reflected in the growing and persistent divergence in yields between Germany and other countries in the region.

23.   Model simulations suggest that fundamentals in Germany are an important determinant of the magnitude of shock spillovers to CE4 countries. To assess these linkages, the GIMF model was calibrated to an alternative scenario under which Germany has weaker household, corporate, and sovereign balance sheets (see Background Note 3 for details). As before an aggregate demand shock originating in either Germany or the rest of the world (non-European blocks) is shown in Figure 9. The negative impact on real GDP

Figure 9. Role of German Balance Sheets in Mediating an Aggregate Demand Shock
(Real GDP, percent deviation from baseline)

Source: IMF staff calculations.

triggered by the domestic shock is much larger when balance sheets are more fragile in Germany. A key reason is the stronger financial accelerator.[7] This makes the German economy much more

---

[6] Although not captured by the model, increasing exposure to the outside world has been accompanied by concentration risk in certain sectors such as automobiles. An external shock that had a large differential impact on the automobile sector (such as an energy shock), could have a disproportionately large impact on GCESC countries.

[7] Weaker corporate balance sheets, for example, would be associated with a larger increase in spreads, and a more severe decline in investment. The decline in economic activity would in turn further impair balance sheets, thereby triggering a vicious cycle.

sensitive to shocks, a situation which is further exacerbated by corporate credit spreads, the higher stock of government debt and greater share of liquidity constrained households. The larger economic contraction in German is also transmitted across borders, causing more pronounced declines in real GDP in CE4 countries and the rest of the euro area. This wider European slowdown then has feedback effects on the GCESC countries. Relatedly, sensitivity to global shocks in CE4 countries (and other euro area countries) increases very considerably under a scenario of fragile German balance sheets. The implication is that healthy German balance sheets have the characteristics of a public good: they generate positive spillovers that extend well beyond Germany, serving as a buffer against external shocks for the whole GCESC (and beyond).

KEY CONCLUSIONS

This section summarizes the key conclusions and policy dialogue with GCESC country authorities at a conference in Prague on June 14.

24.   Conventional trade statistics are a poor guide to bilateral export exposures for supply chain countries. A value added decomposition shows that CE4 countries' bilateral exposure to final demand in Germany is much less than that implied by the IMF's DOT statistics, and its exposure to the rest of the world much greater. For Germany, the exposure to European countries (including the CE4) is substantially lower, and exposure to non-European countries higher. *Authorities agreed that the value added decomposition was more useful in examining final exposures than bilateral trade statistics. More generally, for analytical purposes they saw merit in examining the consolidated external position of the supply chain countries vis-à-vis the rest of the world, since this would net out supply chain-related intermediate goods trade..*

25.   The evolution of the GCESC has been supported by large inflows of foreign direct investment (FDI) to CE4 countries. The pattern of capital inflows differs considerably from many other European comparators—such as SP countries—for whom FDI was less important and portfolio inflows more so. In the CE4 countries greenfield investment—which most directly expands productive capacity—comprised a much larger share of FDI than mergers and acquisitions. Much of the FDI directed to the CE4 countries was in the transport sector, consistent with the rapid offshoring of the German automobile industry. *The Hungarian authorities noted that FDI inflows to their country not only proved more stable during the global crisis, but tended to finance production, whereas portfolio inflows in the pre-crisis period created an unsustainable consumption boom. There was general acknowledgement that the GCESC had been accompanied by substantial FDI inflows, and that such inflows represented the "best" form of external financing.*

26.   While foreign bank finance has been important in the CE4, ***cross-border*** **bank flows have been less pronounced.** On a consolidated basis**,** foreign bank financing in the CE4 since 1995 has been at broadly comparable levels to SP countries. But this includes not just cross-border bank flows but also local lending by foreign-owned but domestically resident subsidiaries. The cross-border component—which tends to be the most prone to sudden stops and reversals—was much larger for the SP, whereas local lending, supported by local deposits, was more pronounced in the

CE4. *Participants felt that the distinction between cross-border and locally-supported foreign bank financing was a crucial one. Several authorities also noted that penetration by German banks in the CE4 countries was not commensurate with GCESC activities. They pointed to the "first-mover" advantage enjoyed by Austrian banks in the region, and observed that parent company rather than bank funding was used by at least some large supply chain companies.*

27.   Participation in the GCESC has led to considerable technology transfers to the CE4 countries. Export growth in knowledge-intensive sectors has been particularly rapid in the CE4 countries. The sophistication of domestic VA embodied in overall exports also appears to have increased rapidly. With the exception of Poland, all other CE4 countries have largely "caught up" with Germany's comparative advantage in knowledge-intensive manufacturing sectors. *There was a lively debate about whether export growth in knowledge intensive sectors – especially automobile production – really represented technology transfer and human capital development, or simply entailed low-skilled assembly jobs within a high tech industry. Publically available data are insufficiently granular to illuminate this distinction. CE4 participants emphasized that while overall the GCESC has undoubtedly created knowledge spillovers, there is heterogeneity across firms in terms of fostering skills. The Czech representatives pointed to Skoda (owned by Volkswagen) as a good example of a company that develops workers' technical skills: the firm has its own University. Skoda's Czech operations have evolved towards producing relatively high value added components. The company now owns subsidiary plants in countries such as China, India and Russia, where final assembly is undertaken for several markets. By contrast, other foreign-owned car plants in the Czech Republic specialize in downstream activities.*

28.   The increase in foreign value added in CE4 exports appears to have spurred domestic value added. The existence of the supply chain creates demand for ancillary products and services in host economies. This contributes to an expansion of the production possibility frontier and spurs overall employment and growth. The complementarity between supply chain activities and domestic production has led overall to greater synchronization of the business cycle among GCESC countries. *The German authorities in particular emphasized the importance of this finding. Production within a vertically specialized chain is not a "zero sum game". The potential gains in employment as a result of production spillovers should be kept in mind when considering labor market reforms or during negotiations between industry and labor unions.*

29.   Integration into the GCESC has accelerated income convergence. Within a sample of European countries, the CE4 economies have generally grown more rapidly over the last two decades than can be explained simply by initial income levels. This is consistent with the evidence regarding technology transfers, enhanced competitiveness in skill-intensive sectors, and positive spillovers from supply chain activities to domestic production. *The authorities agreed that GCESC investment and production activities had played a key role in fostering income convergence.*

30.   The issue of safeguarding enhanced competitiveness in knowledge-intensive sectors received considerable attention. With the progression of income convergence and narrowing of unit labor cost differentials with Germany, the CE4 countries may struggle to sustain their current role in the supply chain and further benefit from the vertical specialization. In order to remain part of

the GCESC—or indeed, to branch out into more specialized export production activities of their own—the CE4 countries will likely need to continue investing in human capital and upgrading labor skills to cement their comparative advantage in the region. The aspiration should be to move up the value chain, as countries in Asia, notably China, have done. *All the authorities agreed that it was important for downstream countries to gradually move towards more sophisticated activities, although the German authorities pointed out that there was no imminent threat to the position of CE4 countries in the value chain despite narrowing cost differentials. German business surveys show that the CE4 countries remain favored destinations of supply chain investment, due to their skilled labor forces and track record in the relevant industries. As noted above, the Czech authorities highlighted Skoda as a successful example of upstream evolution over time. Participants agreed on the importance of technical training to upgrade labor force skills, and felt that much could be learned from the German model of combining vocational education with business apprenticeships. The Czech authorities are considering a scheme offering tax breaks to companies that provide technical education. The Hungarian and Polish authorities pointed out that skills shortages were linked to the wider demographic problem of ageing populations, which will require policy action across several dimensions.*

31.   German domestic demand spillovers to the CE4 have increased over time but remain relatively small. This is explained by the supply chain nature of the trade integration: final demand in Germany is not the main determinant of CE4 exports to Germany. As a corollary, German fiscal policies to stimulate or contract domestic demand have a relatively limited impact on CE4 economies. Meanwhile, the impact on German GDP of an aggregate demand shock originating within Germany has *declined* substantially, due to Germany's increasing openness. *The Slovak authorities noted that there is potentially some tension between the findings of greater business cycle synchronization, and limited domestic demand spillovers from Germany to the CE4. The ensuing discussion clarified the difference between* domestic *demand spillovers from Germany (which are relatively small), and demand spillovers from Germany related to the production chain (which are large, but originate in countries to which goods are finally exported). The latter can increase business cycle synchronization between Germany and the CE4.*

32.   Because the GCESC countries have become more open, spillovers from the rest of the world are now much larger. In response to non-European demand shocks, real GDP in both Germany and the CE4 dips below baseline by considerably more in 2011 than in 1996. The larger downturns are compounded by indirect effects because intra-European economic activity slows down, acting as an additional drag on growth. A fully co-ordinated non-European fiscal action of a given magnitude (in percent of GDP) would have a much greater impact on both the German and CE4 economies than a purely German fiscal action of the same magnitude. *Authorities agreed that exposure to external shocks had increased substantially with the evolution of the GCESC, and that this represents a key policy challenge going forward. The Hungarian authorities furthermore pointed out that the small size of some of the CE4 countries relative to supply chain firms can be a concern in this context: Nokia's loss of market share after the financial crisis had a large impact on Hungary's exports. Participants agreed that diversification of export markets and product lines could help reduce vulnerability to external shocks. There was also a lively discussion on the merits of a flexible exchange*

rate in adjusting to external shocks. Polish, Hungarian and Czech authorities held that a flexible exchange rate provided an important buffer against volatile external demand. But the Slovak authorities argued that flexible exchange rates were not very helpful in 2008-09, against a background of collapsing external demand. They also noted that a fixed exchange rate reduces currency risk within the supply chain. *Slovakia has enjoyed vigorous growth in exports and GDP under the euro.*

33.   Balance sheet fundamentals in Germany are an important determinant of the magnitude of shock spillovers to CE4 countries. At present balance sheets in Germany are generally healthy. Low debt-to-GDP ratios prevail in the household, corporate and government sectors, and the country is regarded by investors as a safe haven. Simulations suggest more leveraged balance sheets and greater sovereign risk in Germany would considerably magnify the impact of external shocks. Thus healthy German balance sheets have the characteristics of a public good: they generate positive spillovers that extend well beyond Germany, serving as a buffer against external shocks for the whole GCESC (and beyond). *CE4 participants broadly agreed on the advantages of the supply chain being anchored by a country with strong fundamentals and low sovereign risk.*

INTERNATIONAL MONETARY FUND

July 1, 2013

GERMAN-CENTRAL EUROPEAN SUPPLY CHAIN—CLUSTER REPORT—FIRST BACKGROUND NOTE—TRADE LINKAGES

Prepared By B. Augustyniak, C. Ebeke, N. Klein and H. Zhao (All EUR)

CONTENTS

INTRODUCTION

1.   **Recent years have witnessed a rapid expansion in global and regional trade**. Since 1990, the world's export volumes have registered more than a threefold increase, considerably surpassing global GDP growth. In Europe, while export volumes expanded more moderately, their growth was nearly double that of real output (Figure 1). The rapid expansion of trade was driven by trade liberalization, reflected in significant reduction in tariff rates and removal of non-tariff trade barriers,[1] and increased fragmentation of production (also known as "vertical-specialization"), which resulted in much higher trade volumes of intermediate inputs.[2]

Figure 1. Trade Volumes and Output
(1990=100)

Source: World Economic Outlook
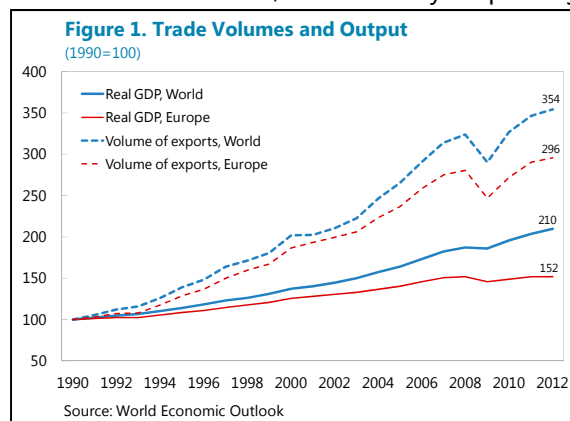
2.   **The increase in vertical specialization has emerged in response to challenges from increased competition and new opportunities from stronger globalization**. Firms have chosen to outsource or shift part of the production process to different locations to exploit efficiency gains, including from differences in wages, productivity, business laws, and taxation.[3] Vertical specialization has been driven by several factors, some related to the reduction of trade costs, including transportation and tariffs (Feenstra, 1997, Miroudot and Ragoussis, 2009), and improvements in communication technology (e.g. the internet), which significantly reduced the costs of information exchange and made it easier for firms to coordinate and monitor production in diverse locations (Hummels et al., 2001).[4] As documented in background paper #2, increased financial liberalization, which encouraged Foreign Direct Investment (FDI), and therefore allowed firms to shift production offshore more easily, also played an important role. Some studies, including Hummels et al. (1998), also suggest that the development of supply chains was in fact needed because goods production today requires more steps than in the past, therefore requiring multiple areas of specialization.

3.   **Vertical specialization has led to new trade patterns, in which advanced and emerging markets normally play different roles (Riad et al. 2012).** Advanced economies tend to be upstream in the supply chain using relatively limited foreign content in their exports, while emerging

---

[1] In Europe, for instance, the accession to the EU's single market was accompanied by elimination of impediments for internal movement of goods and services.

[2] Today, more than half of world manufactured imports are intermediates goods and more than 70 percent of world services imports are intermediates services (OECD, 2012).

[3] Numerous empirical studies, using different definitions, data sources and methodologies, find robust evidence of the growing importance of vertical integration. See Koopman et al. (2011) for an extensive literature survey.

[4] Miroudot and Ragoussis (2009), for instance, found that a reduction of 10 percent in distance-related trade costs is associated with an increase of 9 percent in vertical trade.

markets are normally located in the downstream segment of the production chain.[5] In Asia, for instance, Japanese companies have located a large part of the "downstream" production process in the automobile and electronic industries in South East Asian economies, including China, (Koopman et al., 2008),[6] while, in North America, US companies use plants in Mexico for manufactured goods assembly ("Maquiladoras", Hummels et al. 1998).

4.   In Europe, the emergence of vertical specialization has been particularly evident among German firms (Sinn, 2003, 2006). Proximity to Germany, cultural similarities, and relatively high labor costs differentials[7] have led many German firms to shift large parts of their production to central and eastern European (CEE) countries, most notably in the Czech Republic, Hungary, Poland and Slovakia (CE4, hereafter) either by directly investing there or by purchasing intermediate inputs from local firms.[8] This pattern is particularly evident in the automobile industry where increased competition in both domestic and foreign markets triggered a rapid process of international outsourcing of manufacturing activities (Box).

5.   Against this background, the primary objective of this chapter is to look at the CE4's integration into the supply chain with the aim of assessing the magnitude and effects of this process. In particular, the chapter focuses on the following main questions:

- To what extent have the CE4's bilateral trade links with Germany changed over time, and do they differ from the trends observed in other European countries?

- What is the CE4's role in the German-Central European Supply Chain (GCESC) and which are the main sectors that participate in the GCESC?

- How has integration into the GCESC affected the CE4 countries both individually and as a group?

6.   Evaluating recent trends in the CE4's trade linkages with Germany would shed light on the benefits and challenges of the integration process. While closer integration into the GCESC should lead to positive spillovers in terms of productivity gains (including from technology transfer) and external competitiveness, thereby engendering faster economic development and income

---

[5] Countries upstream normally produce the raw materials or intangibles involved at the beginning of the production process (e.g., research, design), while countries downstream do the assembly of processed products or specialize in customer services (OECD, 2012).

[6] Koopman et al. (2008) show that, on average, foreign companies contribute 80 percent or more of the VA embodied in Chinese exports of computers, and office telecom equipment.

[7] Sinn (2006) points to the excessive wages growth in Germany as one of the main factors for the fragmentation of production.

[8] According to a survey by Cologne Institute for Business Research (IW, 2002), by 2002, close to 60 percent of the SMEs with 1000-5000 employees had already established plants outside the old EU.

growth, it could in principle pose some challenges going forward. Higher concentration of trade could also imply that the CE4's dependency on the German economy has increased with ramifications for business cycle co-movement and vulnerabilities to shocks. Moreover, sustaining a country's role in the supply chain and continuing to derive the associated benefits could involve policy effort. Policies taken by the CE4 members should ultimately aim to safeguard the benefits of the GCESC while mitigating any risks related to greater exposure to the German economy.

7.   **This chapter is structured as follows:** The next section provides some stylized facts on recent trends in Germany's bilateral trade links with the CE4, and, in light of challenges related to the interpretation of trade statistics in the context of supply chains, it looks at a decomposition of exports into domestic and foreign value added (VA) and assesses how they have changed over time. This section also evaluates Germany's and the CE4's exposure to other countries based on their final consumption and compares it to the exposure under the commonly used gross bilateral trade statistics published in the IMF Direction of Trade Statistics (DOTS). The following section examines the effects of the GCESC on the CE4 countries, with a particular focus on technology transfer, business cycles synchronization, and income convergence. The final section provides concluding remarks.
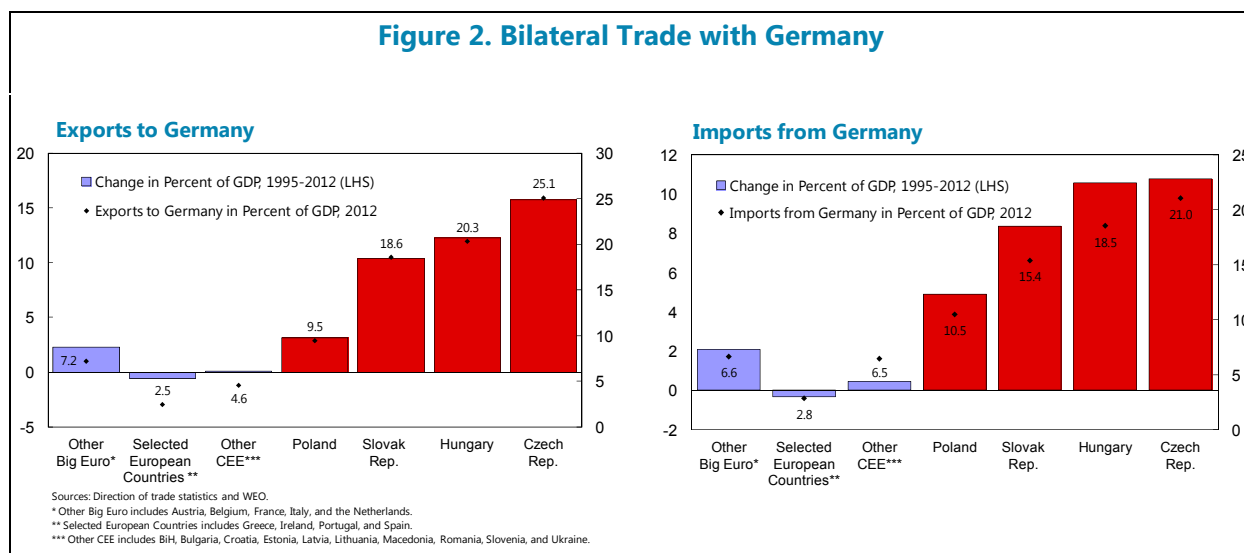
THE GERMAN-CENTRAL EUROPEAN SUPPLY CHAIN

A.   Trends in CE4 Trade Linkages with Germany

8.   **The CE4's trade links with Germany have strengthened considerably since the mid-1990s, largely reflecting their increased integration into the GCESC (Figure 2)**. Between 1995 and 2011, the CE4's imports from Germany grew by 8½ percent of GDP on average (cumulative basis), with Czech Republic leading the way (10½ percent of GDP), while exports to Germany increased sharply by nearly 10 percent of GDP on average. Consequently, Germany has become the main trading partner (with the largest export and imports as a share of GDP) of all the CE4 countries.

9.   **Compared with other countries, including CEE economies, the CE4 exhibits the strongest trade linkages with Germany**. The CE4's average imports from Germany stood in 2012 at 16 percent of GDP, which, apart from Austria–which traditionally has a high German import content–is well above other European countries. Similarly, the average of the CE4's exports to Germany in 2012 stood at 18 percent of GDP, behind only the Netherlands (22 percent of GDP). A closer look at the sectoral level suggests that knowledge-intensive sectors, particularly transport and electrical equipment, account for the CE4's largest bilateral trade with Germany. As documented in the next section, the increased links in these sectors have led to the transfer of technology, which in turn has translated to sizeable gains in terms of comparative advantage.

10.   **While trends are similar, the CE4 is not a homogenous group (Figure 2).** Poland's trade linkages with Germany (as a share of GDP) are significantly less than those in other CE4 countries, largely due to Poland's large GDP (Poland's GDP is about 54 percent of the CE4's GDP) and higher

share of domestic demand, which mechanically dampens the magnitude of the trade intensity with Germany as compared to other CE4 economies. In this regard, although Poland's openness has increased in recent years, it remains a relatively closed economy with the sum of overall imports and exports at 74 percent of GDP (compared to an average of 157 percent of GDP in rest of the CE4 countries).

Figure 2. Bilateral Trade with Germany

Exports to Germany

Change in Percent of GDP, 1995-2012 (LHS)
♦ Exports to Germany in Percent of GDP, 2012

7.2
2.5
4.6
9.5
18.6
20.3
25.1

Other Big Euro* | Selected European Countries ** | Other CEE*** | Poland | Slovak Rep. | Hungary | Czech Rep.

Imports from Germany

Change in Percent of GDP, 1995-2012 (LHS)
♦ Imports from Germany in Percent of GDP, 2012

6.6
2.8
6.5
10.5
15.4
18.5
21.0

Other Big Euro* | Selected European Countries** | Other CEE*** | Poland | Slovak Rep. | Hungary | Czech Rep.

Sources: Direction of trade statistics and WEO.
* Other Big Euro includes Austria, Belgium, France, Italy, and the Netherlands.
** Selected European Countries includes Greece, Ireland, Portugal, and Spain.
*** Other CEE includes BiH, Bulgaria, Croatia, Estonia, Latvia, Lithuania, Macedonia, Romania, Slovenia, and Ukraine.

11.   The importance of Germany as a major trading hub for the CE4 is illustrated in Figure 3. The thickness of the arrows represents the share of imports (exports) relative to recipient (exporter) GDP and the bubble size indicates the country's total imports (exports) to GDP. The charts clearly show that, among the major global players, Germany is the largest trading partner for the CE4. For Czech Rep, Hungary, and Slovakia, imports from Germany are between 15 to 21 percent of the countries' GDP while exports to Germany amount to 16 to 24 percent of GDP. For Poland, Germany's exports and imports shares are somewhat lower, due to Poland's higher GDP level and less dependence on external trade, yet with exports and imports at 10-11 percent of GDP, Germany remains Poland's major trading partner.

Figure 3. CE4's Bilateral Trade with Major Global Players

Imports to CE4
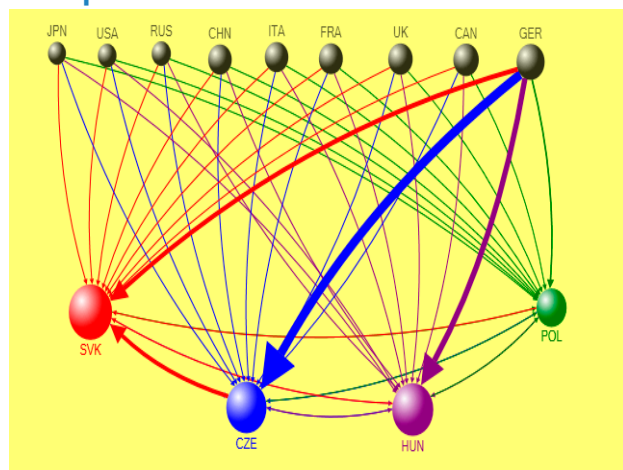
Exports from CE4
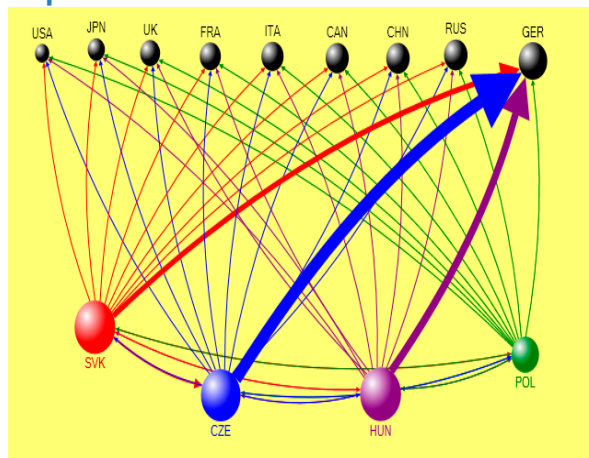
* Source: Direction of Trade statistics and WEO.

* The arrows point to the receiving country.
* Line thickness indicates imports (exports) values relative to recipient's (exporter) GDP.
* The bubble size is proportional to the country's total imports (exports) to GDP.

12.   The CE4's high degree of integration into the supply chain reflects a host of factors.
Beyond the geographic proximity to Germany, cultural similarities, and high unit labor cost
differentials,[9] the countries share a similar sectoral structure, which suggests that they have
adequate labor skills to support the GCESC.[10] In this context, Rahman and Zhao (2013) computed
the industrial similarity index relative to Germany. They showed that the CE4 countries had strong
similarities with Germany even before they integrated into the supply chain.

B. Shortcomings of Traditional Trade Statistics

**13.   Vertical specialization networks have created challenges for interpreting official trade
statistics.** Trade statistics are usually measured in gross terms, which include both intermediate and
final goods. In supply chain-related activities, particularly when imported intermediates are re-
exported after some processing, export figures tend to be inflated and do not adequately reflect the
countries' domestic VA, which matters most for domestic employment and economic growth.

---

[9] The average exchange rate-adjusted unit labor cost differential between the German manufacturing sector and that
in the CE4 during 1995-2009 ranged between 35 percent (Poland) and 58 percent (Hungary).

[10]Among others, these variables were found to have a significant contribution to the share foreign VA in countries'
exports. See Rahman and Zhao (2013).

14.   The shortcomings of trade statistics in supply chain-integrated countries are illustrated in the high and positive correlation of the CE4 countries' import from and exports to Germany (Figure 4). This is in contrast to much lower correlations for other countries vis-à-vis Germany. This may owe partly to high business cycles synchronization, but also suggests that a large part of the CE4's exports to Germany contains German intermediates, which were imported and then processed in the CE4 as part of the fragmented production process. The high correlation may also suggest that the share of the CE4's foreign VA in these products is relatively high.

Figure 4. Correlation between Exports and Imports from Germany (1995-2012)
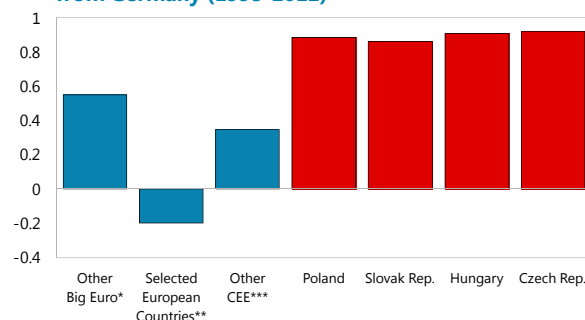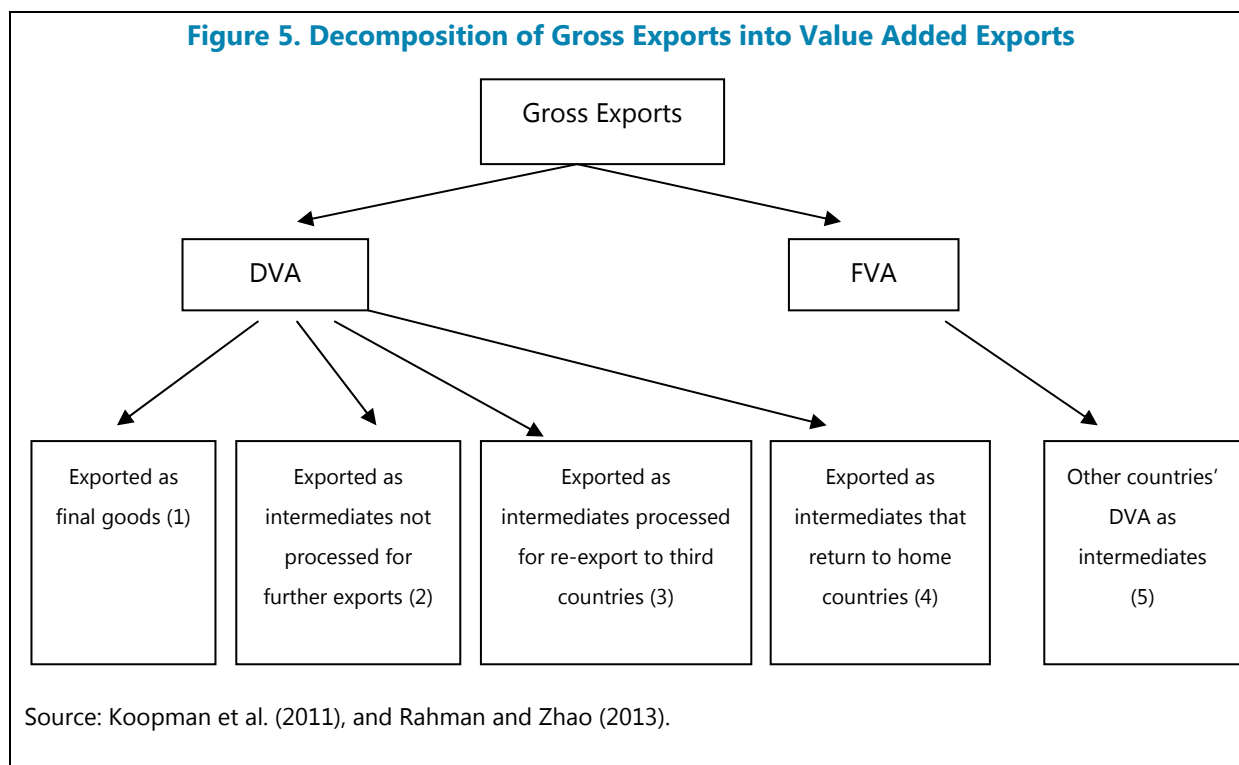

Sources: Direction of trade statistics and WEO.
* Other Big Euro includes Austria, Belgium, France, Italy, and the Netherlands.
** Selected European Countries includes Greece, Ireland, Portugal, and Spain.
*** Other CEE includes BiH, Bulgaria, Croatia, Estonia, Latvia, Lithuania, Macedonia, Romania, Slovenia, and Ukraine.

C.   Decomposition of Gross Exports into Domestic and Foreign Value Added

15.   To evaluate the CE4's role in the GCESC, we decompose gross exports into VA exports using the newly released World Input-Output Table (WIOT). We follow the Hummels et al. (2001) measure of vertical specialization by looking at the import content of production for exports. This measure was used in several studies, including Chen et al (2005), Johnson and Noguera (2012), Koopman et al. (2011), and more recently, in Rahman and Zhao (2013), and is different from the definition used in earlier studies such as Feenstra and Hanson (1996), which mainly focused on documenting trends in outsourcing, usually defined as the imported input shares of gross output or of material inputs.[11]

16.   The analysis builds on the conceptual framework developed by Koopman et al. (2011). It decomposes gross exports into five main categories depending on the location of VA and stage of production (Figure 5). These include: (1) domestic VA (DVA) in final goods, (2) DVA in intermediate goods not processed for further exports, (3) DVA in intermediate goods processed for exports to third countries, (4) DVA exported to another country but returns back to the original country for exports to a third country, and (5) foreign VA (FVA) used as input into exports.
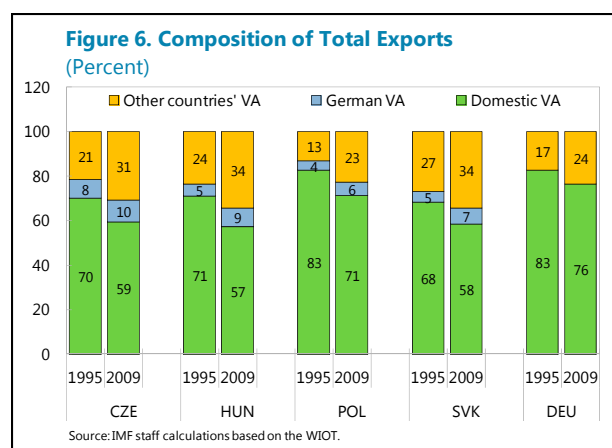
---

[11] The WIOT provides an annual time series for 1995-2009 for 35 sectors and covers forty countries, including all EU 27 countries and 13 other major advanced and emerging economies (see details in Annex 1).

Figure 5. Decomposition of Gross Exports into Value Added Exports

Gross Exports

DVA

FVA

Exported as final goods (1)

Exported as intermediates not processed for further exports (2)

Exported as intermediates processed for re-export to third countries (3)

Exported as intermediates that return to home countries (4)

Other countries' DVA as intermediates (5)

Source: Koopman et al. (2011), and Rahman and Zhao (2013).

17.   The decomposition of the five-category VA is computed for manufacturing and services exports respectively (Annex 2). Components (1)-(4) measure the value of exports that are created domestically. Components (1)-(2) reflect the countries' stand-alone exports, i.e. outside the supply chain, while components (3)-(5) indicate supply chain-related exports. These have two components: upstream (components (3)-(4)), which include DVA that is processed for further exports, and downstream (component (5)). A large share of FVA in total exports would generally indicate that a country is a downstream participant in the supply chain, usually specializing in processing and assembly functions.

D.   The Evolution of Domestic and Foreign Value Added Exports

18.   Over the last 15 years, the share of FVA in the exports of CE4 countries and Germany has increased considerably (Figure 6). Among the CE4 countries, Hungary registered the sharpest increase (14 percentage points) bringing the share of FVA in exports to the highest level (43 percent), while Poland, which continues to maintain a relatively high share of domestic value exports, registered the smallest increase in FVA. The share of German VA in the CE4's exports increased by about 2 percentage points, with the exception of

Figure 6. Composition of Total Exports
(Percent)

Legend: Other countries' VA | German VA | Domestic VA

	CZE		HUN		POL		SVK		DEU	
	1995	2009	1995	2009	1995	2009	1995	2009	1995	2009
Other countries' VA	21	31	24	34	13	23	27	34	17	24
German VA	8	10	5	9	4	6	5	7		
Domestic VA	70	59	71	57	83	71	68	58	83	76

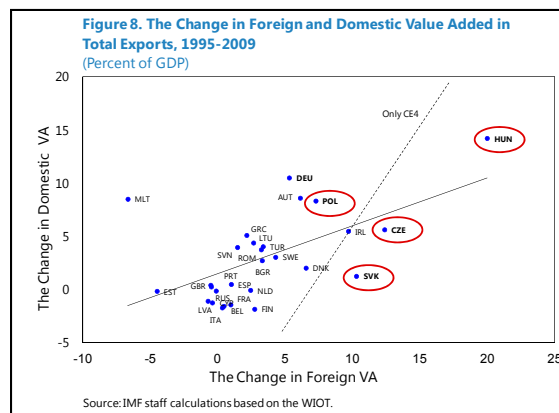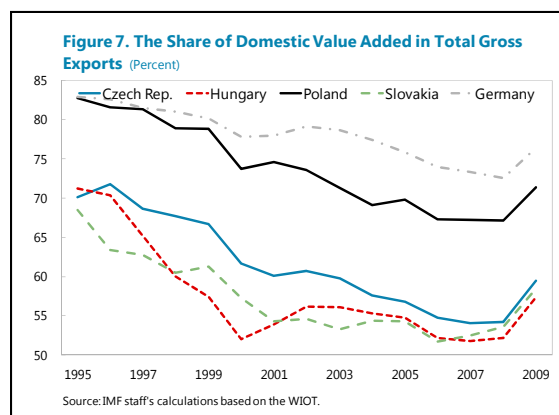Source: IMF staff calculations based on the WIOT.

Hungary (4 percentage points). Beyond higher German VA that is embodied in the CE4's exports, the increased integration into the GCESC has also led to:

- Higher intermediates from other countries (captured by "other countries' VA") to support the GCESC's related activities, and;

- Increased intermediates that are exported by the CE4 to Germany for further processing (Table 1).

Table 1. Supply Chain-Related Activities				
	Intermediates from DEU embodied in the CE4's exports (Percent of total CE4's exports)*		Intermediates from CE4 embodied in DEU's exports (Percent of total CE4's exports)*	
	1995	2009	1995	2009
CZE	8.45	9.75	5.53	5.82
HUN	5.31	8.52	3.09	3.77
POL	4.08	6.07	5.77	5.59
SVK	4.63	7.20	3.68	4.20

*The calculation of intermediates includes only the countries' domestic value added.

19. **The counterpart to the increasing share of FVA in exports is a substantial secular decline in the share of DVA (Figure 7).** A closer look at the evolution of the shares over time suggests that the lion's share of the decline in DVA occurred during the 1995-2002 period, while, during the "boom years" (2003-2008), it contracted only moderately until it reached a trough in 2008. In 2009, however, the share of DVA increased by about 4-5 percentage points on average, suggesting perhaps that supply chain-related activities were adversely affected by the global financial crisis, in part due to high exchange rate volatility, thus leading companies to consolidate their operations and perhaps switch back to domestic suppliers. This is consistent with the OECD's findings regarding the decline in the length of the value chains during 2008-09 (OECD, 2012).

Figure 7. The Share of Domestic Value Added in Total Gross Exports (Percent)
Source: IMF staff's calculations based on the WIOT.

Figure 8. The Change in Foreign and Domestic Value Added in Total Exports, 1995-2009 (Percent of GDP)
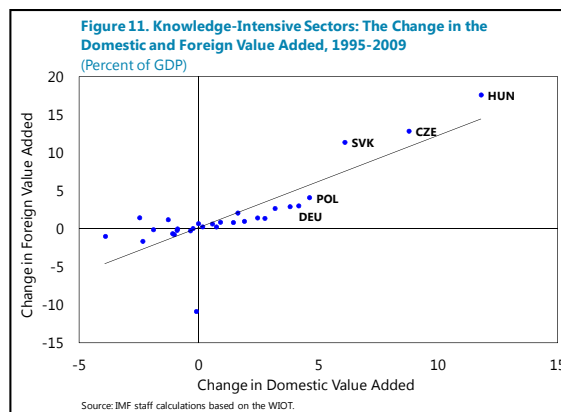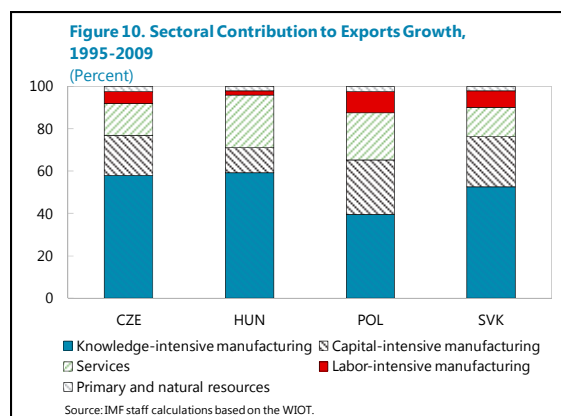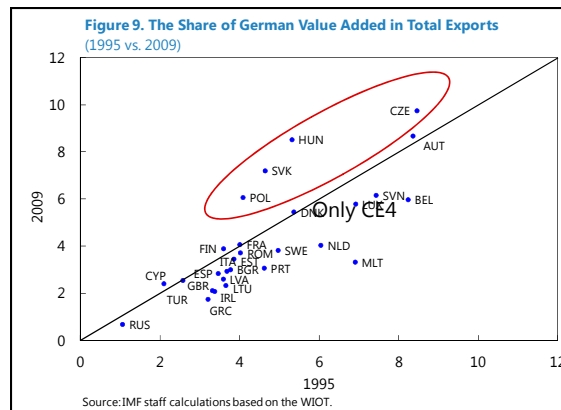Source: IMF staff calculations based on the WIOT.

20.   While the shares of DVA in gross exports have broadly declined, they have increased significantly in nominal terms and as a percentage of GDP (Figure 8). Between 1995-2009, Hungary, Germany, Poland, and Czech Rep., registered an increase of 14, 10½, 8 and 5½ percentage points of GDP, respectively, while Slovakia recorded the smallest increase (1 percentage point of GDP). The increase in domestic VA was positively correlated with the increase in FVA. In this regard, Rahman and Zhao (2013), who examine the relationship between foreign and domestic VA growth across 40 countries during 1995-2008, found a positive and significant link. Moreover, they find econometric evidence that causality runs from growth in FVA to DVA. In other words FVA is not a substitute to domestic VA but tends to complement the production process and spur overall employment and growth.

21.   The increase in FVA in the CE4 is related to the German VA increase in both nominal and relative terms. In this regard, the CE4 group stands out when comparing the share of the German VA to that in other European countries; they are the only countries that recorded a significant increase in German VA as a share of total exports (Figure 9).

22.   The sectoral decomposition shows that the knowledge-intensive sectors (transport and electrical equipment, machinery and chemicals) made the largest contribution to export growth in the period 1995-2009 (Figure 10).[12] In Czech Rep., Hungary and Slovakia, these sectors contributed about 50-60 percent of total exports growth, while, in Poland, their contribution was somewhat lower (40 percent) but still the highest compared to other sectors. At about 30-40 percent, the knowledge-intensive sectors also have the highest share in countries' domestic VA exports.

Figure 9. The Share of German Value Added in Total Exports
(1995 vs. 2009)
Source: IMF staff calculations based on the WIOT.

Figure 10. Sectoral Contribution to Exports Growth, 1995-2009
(Percent)

■ Knowledge-intensive manufacturing ◨ Capital-intensive manufacturing
▨ Services ■ Labor-intensive manufacturing
▨ Primary and natural resources
Source: IMF staff calculations based on the WIOT.

Figure 11. Knowledge-Intensive Sectors: The Change in the Domestic and Foreign Value Added, 1995-2009
(Percent of GDP)
Source: IMF staff calculations based on the WIOT.
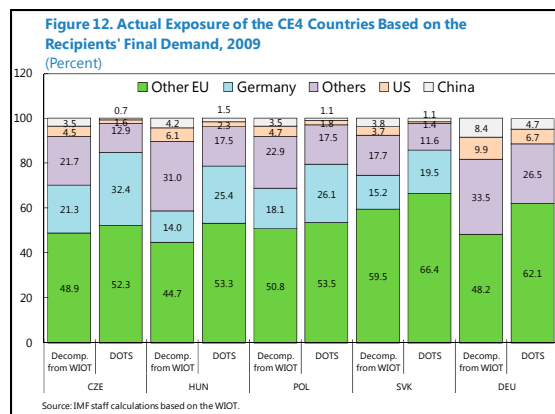
---

[12] The various sectors are grouped into five main categories: primary and natural resources, services, labor-intensive manufacturing, capital-intensive manufacturing and knowledge-intensive manufacturing (see annex 3 for detailed classification).

23.   Knowledge-intensive sectors in the CE4 stand out in terms of the cumulative increase in both DVA and FVA (since 1995). The increase, which is well beyond that in other European countries, is a clear indication of their strong integration into the GCESC (Figure 11). More importantly, the changes in domestic and foreign VA in knowledge-intensive sectors exhibit a strong positive correlation. In these sectors, Hungary recorded the sharpest increase in both domestic and foreign VA, with the latter largely reflecting German VA. While Czech Rep. and Slovakia also registered a considerable increase in both domestic and foreign VA, the increase in Poland and Germany was more moderate, in part reflecting their large GDP.

E.   Countries' Export Exposure Based on Final Demand

24.   The VA decomposition also allows revisiting countries' export exposure to other trading partners based on final demand rather than proximate demand. This pattern would generally differ from exposures computed using the Direction of Trade statistics (DOTS) on bilateral gross trade flows as, in the context of global supply chains, a significant part of the countries' exports can be in the form of intermediates that are processed and re-exported by a third economy.

25.   The countries' export exposure based on final demand underscore the strong presence of the GCESC (Figure 12). In particular, the comparison between the exposure under the WIOT and under the DOTS indicates that Germany's exposure to the EU under the WIOT (48 percent) is significantly below the implied exposure under the DOTS (62 percent) while its exposure to the rest of the world is much higher (33 percent vs. 26 percent). This is exactly what one would expect from vertical specialization activities under which Germany exports intermediates that are further processed in downstream facilities in the EU, including the CE4, and then re-exported directly or indirectly outside the EU to the rest of the world.

Figure 12. Actual Exposure of the CE4 Countries Based on the Recipients' Final Demand, 2009
(Percent)

Source: IMF staff calculations based on the WIOT.

26.   Similarly, the comparison indicates that the CE4's exposure to Germany is significantly lower than the implied exposure by the DOTS. This again suggests that part of the CE4's exports is passing through Germany before it is exported further outside the EU. And indeed, the comparison also shows that, under the WIOT, the exposure to the rest of the world is significantly higher than the exposure under the DOTS.
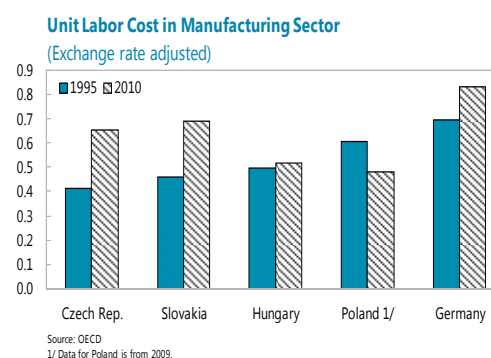
27.   The comparison underlines the challenges in assessing trade exposures. As illustrated, the DOTS figures can be misleading in capturing the countries' exposure to trading partners' final demand, particularly in the context of supply chains where a large part of the flows are in the form of intermediate goods that are used for the production of exports. This may have ramifications for the calibration of economic models that aim at evaluating countries' vulnerabilities to shocks in external demand.

Box 1. The Automobile Industry

The German automobile industry is one of the most prominent examples of supply chains in Europe. Germany has been a leading producer and exporter of passenger cars with a global market share of around 20 percent as of 2012. Offshore production, particularly in Czech Republic, Hungary, Poland and Slovakia (CE4), has become significant in recent years, with 2009 marking the first year when foreign production overtook domestic production. In this regard, while domestic production has remained relatively constant at around 5.5 million vehicles per year between 1992 and 2011, foreign production registered more than a threefold increase in the same period, reaching 7.1 million.

Germany: Production of Cars
(Millions)

Foreign production
Domestic production
Share of foreign production in total (RHS; pct.)

Source: VDA
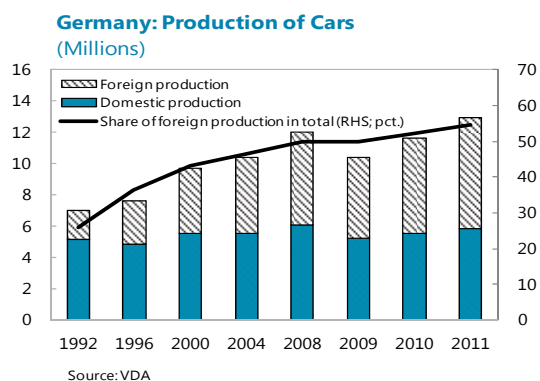
The shift in German automotive production towards the CE4 started in the mid-1990s and was a natural outcome of demand and supply forces. On the demand side, German automobile manufactures needed to respond to a more competitive environment in an increasingly globalized world, while on the supply side, the CE4 countries offered an attractive mix of characteristics whose appeal only strengthened after their accession to the EU in 2004. Geographic proximity, relatively low unit labor costs, the favorable tax environment, and a highly qualified workforce with a history of expertise in the automobile industry played an important role.[1][2]

Unit Labor Cost in Manufacturing Sector
(Exchange rate adjusted)

1995 2010

Czech Rep.   Slovakia   Hungary   Poland 1/   Germany

Source: OECD
1/ Data for Poland is from 2009.

With greater integration into the supply chain, the CE4's automotive sector has become an important part of their economic activity. Although moderating somewhat after the global financial crisis, the inflow of foreign direct investment (FDI) into this sector increased markedly from the mid-1990s, while the production of vehicles reached a peak of nearly 3 million in 2012. The latter has had an enormous impact on the CE4's export growth (Table), accounting for over half of the cumulative increase in exports since 1995 in all CE4 countries except Hungary (where the contribution was still very substantial). Employment in the automobile sector has increased somewhat, but given that the sector is highly capital- and knowledge-intensive, its overall impact on direct employment has been more limited.

---

[1] The corporate income tax rate in the CE4 is significantly lower than in Germany. In 2011, for instance, it was 19 percent in all CE-4 countries compared with 29 percent in Germany.

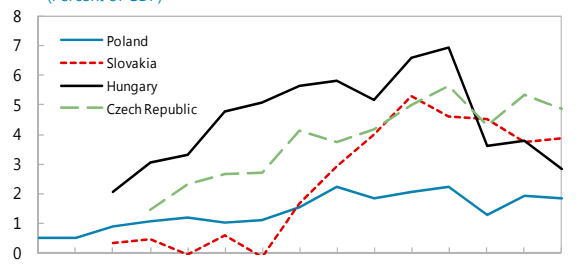[2] Czechoslovakia was one of the main car producers in the Soviet bloc.

Box 1. The Automobile Industry (Concluded)

CE4: Passenger Car Production and Registration
(Millions)
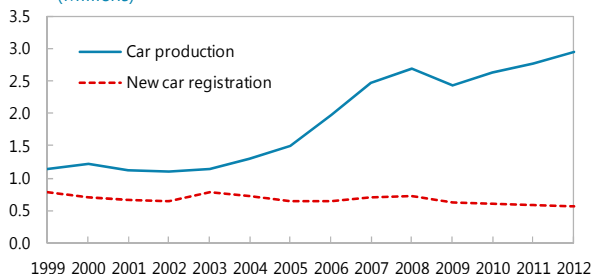
Sources: OICA; ACEA

FDI Inflow into Automotive Sector
(Percent of GDP)


Source: OECD

Automotive Sector: Some Stylized Facts

	2012 Passenger Car Production in multiple of 1999 level	Employment (ratio to manufacturing employment, 2010)	Share in Total Exports (2011)	Contribution to Exports Growth Since 1995* (percent)
Czech Rep.	3.4	11.7	17.1	50.7
Hungary	1.7	9.9	8.7	32.2
Poland	1.2	6.9	12.7	53.7
Slovakia	7.1	11.3	21.5	53.4
Germany	1.1	11.8	17.4	10.1

* Change in automobile exports between 1995-2011 relative to the 1995 total export level.

A decomposition of the automotive sector's gross exports based on the origins of the VA illustrates the increased integration of the CE4 countries with Germany. The share of German VA in total exports has increased in all the CE4 countries while the share of domestic VA declined by about 12 percentage points (on average) between 1995 and 2009. Despite the declining share of domestic value added in total exports, the automobile industry registered a significant increase in domestic value added in percent of GDP, exhibiting a positive and strong correlation with the increase in foreign VA in this sector.

Automotive Sector: Composition of Exports
(Percent)
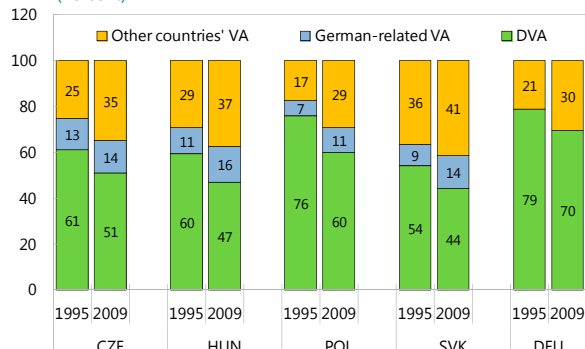
Source: IMF staff's calculations based on the WIOT.

Automobile sector: The Change in the Domestic and Foreign Value Added, 1995-2009
(Share of GDP)
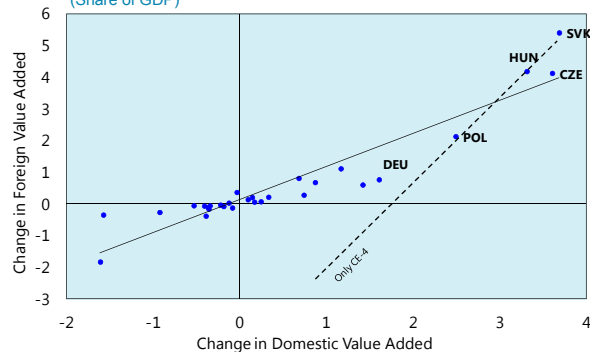
Source: IMF staff calculations based on the WIOT.

THE EFFECTS OF THE GERMAN-CENTRAL EUROPEAN SUPPLY CHAIN

The previous sections documented the evolution of the CE4's trade linkages with Germany and showed that their integration into the supply chain has increased dramatically since the mid-1990s. The literature suggests that increased trade linkages may affect economies across various dimensions. This section examines the possible effects in the context of technology transfer, business cycle synchronization, and income convergence.

A. Technology Transfer

28.   The CE4's increased integration into the supply chain, particularly in knowledge-intensive sectors, allowed them to enhance the technology content of their exports in general, and the sophistication of domestic VA embodied in overall exports in particular. Therefore, it is likely that these economies have gained greater technological capacity in recent years, in part because German firms have provided them with technology and know-how to ensure that the produced components are of high quality (Jabbour and Mucchielli, 2007, Pack and Saggi, 2001).

29.   A standard tool to evaluate whether the CE4 countries have increased their competitiveness, including through technology transfer, is by looking at the evolution of Revealed Comparative Advantage (RCA) over time.[13] Traditionally, RCA is defined as the proportion of a sector's exports in a country's total gross exports relative to the average share of the same sector's exports in the world's total exports. A value higher than one indicates that the country has a comparative advantage in that particular sector. Koopman et al. (2011) and Timmer et al. (2013) showed that such a computation can be misleading as, in the context of international production fragmentation, large part of the sectors' exports may contain imported intermediates. Therefore, as an alternative, the RCA in this subsection is calculated on the basis of domestic VA as in Rahman and Zhao (2013).

30.   Table 2 provides the RCA calculation for the CE4 countries, Germany and some comparable countries for the manufacturing sectors. As in the previous section, the manufacturing sectors are grouped to labor-intensive, capital-intensive, and knowledge-intensive (see annex 3 for details). The RCA calculations confirm that the CE4 countries have benefitted from increased integration into the supply chain. With the exception of Poland, all other CE4 countries have largely "caught up" with Germany's comparative advantage in the knowledge-intensive manufacturing sectors, which are a significant part of the GCESC. This may point to a technology

---

[13] The concept of RCA was first proposed by Balassa (1965) and since then was used as a useful technique in research in international trade.

transfer.[14] While there has been a concomitant loss of comparative advantage in the labor and capital-intensive sectors, even in these sectors the RCA index remains greater than one (except in Hungary). These trends differs from those in selected periphery (SP) euro-zone countries, which have lost their comparative advantage in the knowledge-intensive sectors (Ireland and Spain) or retain their comparative disadvantage (Greece and Portugal).

Table 2. Revealed Comparative Advantage (RCA) in Manufacturing						
	Manufacturing 1995			Manufacturing 2009		
	Labor-intensive	Capital-intensive	Knowledge-intensive	Labor-intensive	Capital-intensive	Knowledge-intensive
Czech	1.29	1.30	0.56	1.01	1.16	1.18
Hungary	0.68	1.06	0.50	0.37	0.77	1.18
Poland	1.95	1.39	0.59	1.52	1.39	0.93
Slovakia	1.05	1.61	0.60	1.16	1.41	1.11
Germany	0.64	1.07	1.48	0.64	1.20	1.49
Portugal	3.42	0.94	0.57	2.08	1.43	0.60
Spain	0.93	1.21	1.04	0.97	1.29	0.98
Ireland	0.34	1.79	1.01	0.11	0.72	0.89
Greece	1.56	1.26	0.03	0.33	0.72	0.20
China	3.55	1.03	0.64	2.52	0.66	1.27

31.   A high degree of integration into the supply chain has positioned CE4 countries as leaders in knowledge-intensive sectors. However, this new status poses challenges going forward. With the progression of income convergence and narrowing of unit labor cost differentials with Germany, the CE4 may face challenges in sustaining their current role in the GCESC and further benefiting from vertical specialization, particularly given that other CEE economies have made substantial progress in removing impediments to trade and business environment that increases their attractiveness as new potential links in the GCESC. As the region grows and develops, the CE4 should therefore continue investing in human capital and maintain high skilled labor to cement their comparative advantage in the region, and perhaps develop new supply chains in the CEE region where they can become "upstream" countries, following the Chinese example.[15]

---

[14] The concept of "knowledge-intensive" sectors is very broad and captures a wide range of activities. Due to lack of more disaggregated data, the analysis cannot determine where each of the CE4 countries is located in the supply chain and, by extension, whether the domestic value added is generated from high skilled activities.
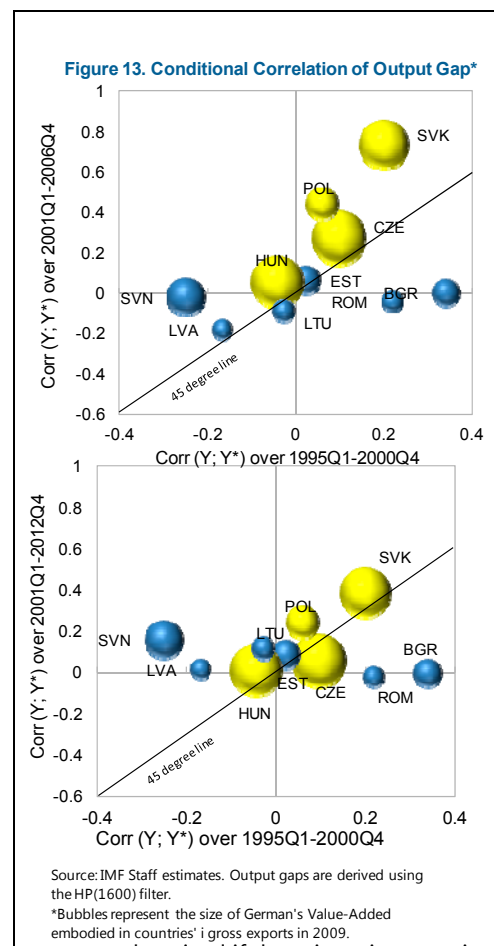
[15] In recent years China has moved up the production chain from being a giant assembly hub in the value chains of Japan and Korea to one of the main exporters of intermediates to advanced economies' high technology exports (Riad et al. 2012, IMF, 2011).

B.   Business Cycles Synchronization

32.   The link between trade integration and business cycles synchronization has been extensively analyzed in the literature. While a-priori the link between the two can be ambiguous, depending on the nature of trade and types of shocks affecting the economies,[16] empirical findings have generally found that higher trade integration contributes to increased cross country output correlations, especially among advanced economies (Frankel and Rose 1997, 1998; Clark and van Wincoop 2001; Imbs 2004; Calderon et al. 2007; and Inklaar et al. 2008, and Garcia-Herrero and Ruiz, 2008).

33.   The conditional correlations of output gaps in Germany and other CEE countries highlight the specificity of CE4 countries.[17] The correlations of the CE4's output gaps with Germany's output gap seems to have increased and this appears to be correlated with the size of the German VA embodied in the countries' exports, particularly when comparing the period 2001Q1-2006Q4 with 1995Q1-2000Q4. For other CEE countries, output synchronization seems to have diminished over time. The inclusion of the crisis period also shows an increase in the bilateral correlations of the CE4's output gaps with Germany's output gap, though the relationship has somewhat weakened.

34.   The impact of the CE4's increased integration into the supply chain on bilateral business cycle synchronization is also assessed through an empirical model.[18] The analysis broadly follows the standard literature on the determinants of international business cycle synchronization while complementing it in several ways.[19] First, the synchronization of business cycles is

Figure 13. Conditional Correlation of Output Gap*

Source: IMF Staff estimates. Output gaps are derived using the HP(1600) filter.
*Bubbles represent the size of German's Value-Added embodied in countries' i gross exports in 2009.

---

[16]Kose and Yi (2001), for instance, suggested that countries may become more synchronized if there is an increase in intra-industry trade and industry specific shocks are the main drivers of the business cycles. However, if inter-industry trade and industry shocks dominating, then the co-movement of output would decline.

[17] The correlation of output gaps has been computed using output gaps (for each country and Germany) after purging the effects of global economic conditions. The resulting output gap figures therefore represent idiosyncratic shocks observed in each country.

[18] See the model's specification in Annex 4.

[19] Our approach is similar to di Giovanni and Levchenko (2010) who examined the effects of vertical trade linkages on business cycle synchronization using industry-level data, and found that sector pairs that use each other as intermediates exhibit significantly higher elasticity of sectoral output growth co-movement with respect to trade.

measured in a time-varying way, which helps take advantage of the resulting panel data structure. Second, the analysis utilizes the exports' decomposition into domestic and foreign VA. Third, the econometric models control for other bilateral correlates of the synchronization of business cycles between Germany and each country. In this vein, financial linkages are accounted for through bilateral FDI flows and bank flows from Germany into each recipient economy.

35.   The analysis uses various measures of business cycle synchronization. First, for each country the synchronization is measured as the rolling correlation coefficient of the country's specific real output growth rate with Germany's growth rate over an overlapping 7- year window. The second method is similar, but differs by making use of output gaps instead of real GDP growth rates. Finally, the paper follows the recent contribution of Aghion and Marinescu (2008) to compute time-varying co-movements between countries' growth rates by using Local Gaussian Weighted Ordinary Least Squares (LGWOLS) estimates.[20]

36.   Our estimates broadly confirm that a higher level of vertical trade integration with Germany contributes to closer business cycle co-movement (Table 1A in Annex 4).[21] This result, which is consistent with recent evidence by di Giovanni and Levchenko (2010), holds regardless of the measure of output synchronization, and remains robust after accounting for potential endogeneity problems.[22] Moreover, the marginal effect of the vertical supply chain links with Germany is stronger in the case of CE4 countries compared to euro-zone countries and other sample countries, underscoring perhaps the exceptional magnitude and uniqueness of the CE4's trade linkages with Germany. Interestingly, while the impact of bilateral FDI flows is not significant, financial linkages in the form of bank flows are negatively associated with the co-movement of business cycles. This result is consistent with Garcia-Herrero and Ruiz (2008), who argued that financial integration allows easier transfer of resources between two economies, amplifying differences in business cycles.

---

[20] This method helps deal with the shortcomings of the rolling correlation method which can provide noisy estimates of the correlation coefficients, and suffers from data losses. In the LWOLS, all observations are used for each year, but those observations closest to the reference year are given greater weight.

[21] The paper also tried to separate the effects of downstream links from those of upstream links by controlling for the two variables in the model. It turned that only the downstream link (proxied by the share of foreign value-added embodied in countries' exports) was statistically significant.
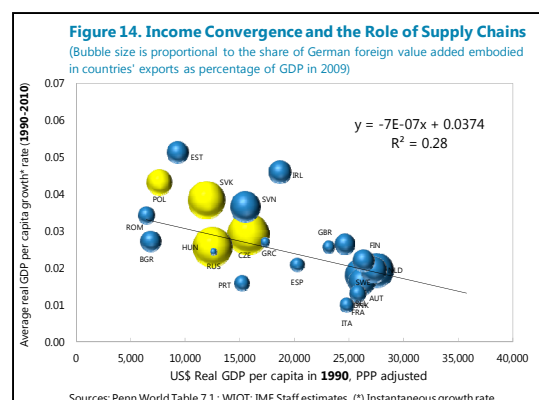
[22] Identification tests associated with the first-stage equation (instrumentation equations) do not reject the hypothesis that the selected instrumental variable is strongly correlated with the endogenous foreign value-added variables in all the models.

C. Income Convergence

37.   There are several arguments for why trade, and supply chains in particular, may contribute to higher long term growth and income convergence. Higher trade can stimulate productivity gains as it comes with investment that embodies technological transfers with spillovers to other sectors in the economy. It could also foster financial deepening and could contribute to economic diversification. Moreover, trade can contribute to specialization in highly productive sectors, which could generate efficiency gains for the economy as a whole. Saito et al. (2013), for instance, examined the relationship between output growth and VA exports (relative to GDP) and found that a country's output growth is associated with greater exporting and importing of VA, which suggests that trade contributes to growth possibly through productivity gains from both export and import competition. They also found that higher levels of VA exports relative to GDP are associated with higher growth.

38.   Income convergence in Europe is evident.
While improved functioning of markets, greater market access, and better institutions have allowed developing countries, mostly from the CEE region, to catch up in the past two decades, the data suggests that countries' degree of integration with the supply chain may also have contributed to income convergence. Indeed, apart from Hungary, the CE4 countries are broadly above the regression line, implying that, even controlling for their initial income, they grew faster than the average growth of other economies, perhaps reflecting the rapid increase of the value added in knowledge-intensive activities.[23]

Figure 14. Income Convergence and the Role of Supply Chains
(Bubble size is proportional to the share of German foreign value added embodied in countries' exports as percentage of GDP in 2009)

$$y = -7E\text{-}07x + 0.0374$$
$$R^2 = 0.28$$

Sources: Penn World Table 7.1.; WIOT; IMF Staff estimates. (*) Instantaneous growth rate.

39.   To evaluate more formally whether the CE4's increased trade linkages has also led to faster income growth we estimate an empirical model. The methodology applied follows the recent empirical literature, which has examined the factors shaping conditional beta-convergence of per capita income across countries by allowing the standard beta-convergence coefficient to vary according to the variable of interest.[24] The model, which is estimated through a standard cross-sectional growth equation, controls for standard determinants of long term growth, including the investment ratio, human capital, and macroeconomic policies and instability proxied by the inflation rate (See Annex 5 for details).

---

[23] This is also consistent with the theoretical framework of Hausman and Klinger (2007), who argue that economic development depends on a graduation from production of low-value goods to high-value goods (structural transformation).

[24] See for instance, Slaughter (2001) and Abiad et al. (2009).

40. **The estimation results are presented in Table 2A in the Annex.** Although the number of observations is relatively low, the results suggest statistically significant income convergence in the sample (the coefficient on initial real per capita income is negative and significantly different from zero) and a quicker convergence speed for countries with strong vertical trade linkages (the coefficient on the interaction term between initial income and the foreign value-added in countries' exports is also negative and significant). Interestingly, the share of foreign VA in countries' exports (as a share of GDP) was found to have a positive and significant effect on the countries' average GDP growth. This, together with the significance of its interaction with initial real per capita income, also suggests that the positive contribution of FVA to growth in recipient countries decreases with the level of economic development (proxied by initial per capita income). These results hold when potential endogeneity of the foreign VA is accounted for in IV estimations.[25]

---

[25] The results of the test of joint significance of the coefficients associated with initial income and its interaction with foreign value-added do not reject the hypothesis that the non-linearity is statistically significant. Identification tests associated with the first-stage equation (instrumentation equations) do not reject the hypothesis that the selected instrumental variable is strongly correlated with the endogenous foreign value-added variables in the models.

CONCLUDING REMARKS

41.   Trade linkages between Germany and the CE4 have strengthened significantly since the mid-1990s, well beyond those with other countries, including in the CEE region. This pattern largely reflects the increased integration of the CE4 into the supply chain: with German firms having relocated parts of the production process to these countries, taking advantage of their proximity to Germany, cultural similarities, and a low cost but highly skilled labor force. While trade links with Germany have increased in many sectors, they have increased prominently in knowledge-intensive sectors, particularly in the automotive industry, which has been a major contributor to the CE4's export growth in recent years.

42.   A decomposition of exports into domestic and foreign value added indeed suggests that foreign VA's share in total exports has increased significantly in recent years, reflecting the CE4's integration into the GCESC. Domestic VA registered a dramatic increase in both nominal terms and in percent of GDP, exhibiting a strong and positive link with the change in foreign VA. This indicates that the two are not substitutes but complement each other in the production process. A recent study by Rahman and Zhao (2013), which found that higher foreign VA contributes to higher domestic VA, also suggests that the increased integration of the CE4 in the GCESC has been a major contributor to economic activity in recent years.

43.   The GCESC plays an increasing role in intra-EU trade. The countries' export exposure based on final demand underscores the strong presence of the GCESC in the EU's trade: It shows that Germany's exposure to the EU is significantly below the implied exposure under the more conventional direction of trade statistics while its exposure to the rest of the world is much higher. This suggests that a large part of Germany's trade with the EU is in the form of intermediates that are being processed in downstream economies and then re-exported outside the EU.

44.   The GCESC has brought new opportunities and challenges for the CE4. The analysis indicates that the CE4 have rapidly gained comparative advantage in knowledge-intensive manufacturing sectors, suggesting a considerable technology transfer. While this has so far contributed to rapid export and GDP growth, it suggests that the CE4 may face challenges in maintaining their position in the GCESC, particularly given narrowing unit labor cost differentials and the fact that other CEE countries have made substantial progress in removing impediments to trade and becoming more attractive as potential members of the supply chain. In addition, the CE4's integration into the GCESC has fostered higher business cycle co-movement with Germany over time. The GCESC has also increased the exposure of member countries to the rest of the world. While this implies that the efficacy of domestic policies aimed at stabilizing economic activity may have weakened, the GCESC is anchored by Germany—a country with strong balance sheets and safe haven status—which could act as a source of stability in the face of external shocks (some evidence for this is provided by background paper #3).

References

Abiad, A., D. Leigh., and A. Mody. 2009. "Financial integration, capital mobility, and income convergence", Economic Policy, 24(58), pp. 241–305.

Aghion, P. and I. Marinescu. 2008. "Cyclical Budgetary Policy and Economic Growth: What Do We Learn from OECD Panel Data?", NBER Chapters, in: NBER Macroeconomics Annual 2007, Volume 22, pp. 251-278, National Bureau of Economic Research, Inc.

Balassa , B. 1965. "Trade Liberalization and 'Revealed' Comparative Advantage", Manchester School of Economic and Social Studies, Vol. 33, pp. 99-123.

Breda, E., R. Cappariello, and R. Zizza. 2008. "Vertical Specialization in Europe: Evidence from the Import Content of Exports" W*orking Paper, Bank of Italy*.

Calderon, C., A. Chong, and E. Stein. 2007. "Trade Intensity and Business Cycle Synchronization: Are Developing Countries Any Different?", Journal of International Economics, 71, 2–21.

Campa, J. and L.S. Goldberg, 1997, "The Evolving External Orientation of Manufacturing: A Profile of Four Countries," *Federal Reserve Bank of New York Economic Policy Review*, July, 53–81.

Cerqueira, P. A., and R., Martins. 2009. "Measuring the Determinants of Business Cycle Synchronization Using a Panel Approach*", Economics Letters*, 102(2), 106–108.

Chen, H., M. Kondratowicz, and K. Yi, 2005, "Vertical Specialization and Three Facts about U.S. International Trade," *North American Journal of Economics and Finance*, Vol. 16, pp. 35–59.

Clark, T.E., and E. van Wincoop. 2001. "Borders and Business Cycles", *Journal of International Economics* 55, 59–85.

di Giovanni, J., and A. Levchenko. 2010. "Putting the Parts Together: Trade, Vertical Linkages, and Business Cycle Comovement", *American Economic Journal: Macroeconomics*, American Economic Association, 2(2), 95-124.

Feenstra, R.C. and G.H. Hanson. 1996. "Foreign Investment, Outsourcing and Relative Wages," In: Feenstra, R.C., G.M. Grossman and D.A. Irwin, (Eds.), *The Political Economy of Trade Policy. Papers in Honor of Jagdish Bhagwati*. MIT Press, Cambridge, MA, pp. 89–127.

Feenstra, R.C. and G.H. Hanson. 1997, "Foreign Direct Investment and Relative Wages: Evidence from Mexico's Maquiladoras," *Journal of International Economics* 42, pp. 371–394.

Flood, R., and A.K. Rose. 2010. "Inflation Targeting and Business Cycle Synchronization", *Journal of International Money and Finance*, 29(4), 704–727.

Frankel, J.A., A.K. and Rose. 1997. "Is EMU More Justifiable Ex Post than Ex Ante?" *European Economic Review* 41, 753–760.

Frankel, J., and A.K. Rose. 1998. "The Endogeneity of the Optimum Currency Area Criteria", *The Economic Journal* 108, 1009–1025.

Fujita, M. and J. Thisse, 2006, "Globalization and the Evolution of the Supply Chain: Who Gains and Who Loses?" *International Economic Review*, Vol. 47, No. 3 pp. 811-836

Garcia-Herrero. A., and Ruiz. J.M. 2008. Do Trade and Financial Linkages Foster Business Cycle Synchronization in Small Economy", Economic Research Department Working Paper No. 0801, Bank of Spain.

Grossman, G., and E. Rossi-Hansberg. 2008. "Trading Tasks: A Simple Theory of Off-Shoring," *American Economic Review,* Vol. 98 (No. 5).

Hausmann, R., and B. Klinger. 2007. "The Structure of the Product Space and the Evolution of Comparative Advantage," CID Working Paper 146.

Helpman, E. 1987. "Imperfect Competition and International Trade: Evidence from Fourteen Industrial Countries", Journal of the Japanese and International Economics, Vol. 1, pp. 62-81.

Hummels. D., D. Rapoport., and K. Yi. 1998. "Vertical Specialization and the Changing Nature of World Trade", *FRBNY Economic Policy Review*, pp. 79-99.

Hummels, D., J. Ishiib, and K. Yi. 2001. "The Nature and Growth of Vertical Specialization in world Trade" *Journal of International Economics*, Vol. 54, pp. 75–96.

Imbs, J. 2004. "Trade, Finance, Specialization and Synchronization", *Review of Economics and Statistics*, 86(3), 723–734.

Inklaar, R., R. Jong-a-Pin R., and J. de Haan. 2008. "Trade and Business Cycle Synchronization in OECD Countries - a Re-examination", *European Economic Review*, 52(4), 646-666.

IMF. 2011. "Managing the Next Phase of Growth", Regional Economic Outlook, Asia and Pacific Department.

Jabbour, L., and J. Mucchielli. 2007. "Technology Transfer Through Vertical Linkages: The Case of the Spanish Manufacturing Industry", *Journal of Applied Economics,* Vol. 10, No. 1, pp. 115-136.

Johnson, R.C., and G. Noguera. 2012. "Fragmentation and Trade in Value Added over Four Decades", NBER Working Paper series 18186, Camebridge.

Kalemli-Ozcan, S., E. Papaioannou, and J.L Peydró. 2009. "Financial Regulation, Financial Globalization and the Synchronization of Economic Activity", NBER Working Papers 14887.

Koopman, R., Z. Wang, and S. Wei. 2008. "How Much of Chinese Export is Really Made in China? Assessing Domestic Value-Added When Processing Trade is Pervasive," *NBER Working Paper* 14109.

Koopman, R., W. Powers, Z. Wang and S. Wei. "Tracing Value-added in Global Production Chains", *NBER Working Paper No.* 16426.

Kose, A., and K. Yi. 2001. "International Trade and Business Cycles: Is Vertical Specialization the Missing Link?", *American Economic Review Papers and Proceedings,* Vol. 91, pp. 371-75.

Kose, M., E. Prasad, and M. Terrones. 2003. "How Does Globalization Affect the Synchronization of Business Cycles", *American Economic Review* 93, 57–62.

Miroudot, S., and A. Ragoussis. 2009. "Vertical Trade, Trade Costs and FDI", *OECD Trade Policy Working Paper* No. 89, OECD.

OECD. 2012. "Mapping Global Value Chains", TAD/TC/WP/RD (2012)9.

Pack, H., and K. Saggi. 2001. "Vertical Technology Transfer via International Outsourcing", *Journal of Development Economics* 65, No. 2:389-415.

Rahman. J., and T. Zhao. 2013. Export Performance in Europe: What Do We Know from Supply Links?" IMF working Paper 13/62, International Monetary Fund.

Riad, N., L. Errico., C. Henn., C. Saborowski., M. Saito., and J. Turunen., 2012, "Changing Patterns of Global Trade" Strategy, Policy and Review Department, International Monetary Fund.

Rose, A., and C. Engel. 2002. "Currency Unions and International Integration", *Journal of Money, Credit, and Banking*, 34, 1067–1089.

Saito. M., M. Ruta., and J. Turunen. 2013. "Trade Interconnectedness: The World with Global Value Chains*", IMF Policy Paper Series* No. XX, International Monetary Fund.

Schott, P. 2004. "Across-Product Versus Within-Product Specialization in International Trade", *Quarterly Journal of Economics*, Vol. 119, No. 2, pp. 647-678.

Sinn H.W. 2003. "Bazaar Economy" *IFO-Viewpoint*, No. 50.

----------. 2006. "The Pathological Export Boom and the Bazaar Effect—How to Solve the German Puzzle" *Cesifo Working paper*, No. 1708.

Slaughter, M. J. 2001. "Trade liberalization and per capita income convergence: a difference-in-differences analysis", *Journal of International Economics*, 55(1), pp. 203-228.

Timmer, M. 2012. "The World Input-Output Database (WIOD), Contents, Sources and Methods" *European Commission.*

Timmer. M., B. Los., R. Steher., and G. de Vries. 2013. "Fragmentation, Income and Jobs. An Analysis of European Competitiveness", paper prepared for the 57th Panel Meeting of Economic Policy, April 2013.

Yi, K. 2003. "Can Vertical Specialization Explain the Growth of World Trade?" *Journal of Political Economy*, Vol. 111, No. 1, pp. 52-102.

Annex 1. The World Input-Output Table

The World Input-Output Table used in our study is based on a newly released world Input-Output Table (WIOT) by Timmer et al. (2012). The database covers 27 EU countries and 13 other major countries in the world for the period 1995 to2009.[1] The 40 countries included in our world input-output table cover more than 85 percent of world GDP.

Differing from previous databases, the construction of WIOT relies on the national supply and use tables (SUTs) rather than input-output tables as its basic building blocks. Timmer and others (2012) argues that SUTs are a more natural starting point as they provide information on both products and (using and producing) industries.[2] Moreover, the input-output table is often constructed on the basis of an underlying SUT, requiring additional assumptions. Besides national SUTs, the construction of the WIOT also uses National Accounts time series data for industry output and final use, and bilateral international trade data in goods and services.

In the first step of the construction process, time-consistent output and final consumption series in the national accounts are used to benchmark national SUTs to ensure meaningful analysis over time.[3] In the second step, the national SUTs are combined with information from international trade statistics to construct so-called international SUTs. Basically, a split is made between use of products that were domestically produced and those that were imported. Finally, the international SUTs for each country are combined into a world input-output table.

For services trade, no standardized database on bilateral flows exists. These have been collected from various sources (including OECD, Eurostat, IMF and WTO), checked for consistency and integrated into a bilateral service trade database. As services trade is taken from the balance of payments statistics it is originally reported at Balance of Payments codes.

---

[1] Nevertheless to complete the WIOT and make it suitable for various modeling purposes, Timmer et al (2012) also added a region called the Rest of the World (RoW) that proxies for all other countries in the world. The RoW needs to be modeled due to a lack of detailed data on input-output structures. Production and consumption in the RoW is modeled based on totals for industry output and final use categories from the UN National Accounts, assuming an input-output structure equal to that of an average developing country. Imports from RoW are given as share of imports from RoW from trade data applied to the imports in the supply table. Hence, exports from the RoW are simply the imports by our set of countries not originating from the set of WIOT countries. Exports to RoW for each product and country from the set of WIOT countries are defined residually to ensure that exports summed over all destination countries is equal to total exports as given in the national supply and use tables (SUTs). This sometimes resulted in negative exports to the RoW. In those cases they added additional constraints to prevent negativity.

[2] A supply table provides information on products produced by each domestic industry and a use table indicates the use of each product by an industry or final user. In contrast, an input-output table is exclusively of the product or industry type.

[3] Typically, SUTs are only available for a limited set of years and once released by the national statistical institute revisions are rare. This compromises the consistency and comparability of these tables over time. By benchmarking the SUTs on consistent time series from the National Accounting System (NAS), tables can be linked over time in a meaningful way. In their database, for some countries full time-series of SUTs are available, but for other countries only some years are available.

Annex 2. Decomposition Methodology

Decomposing Gross Trade Statistics

We adopt the conceptual framework developed in Koopman and others (2011) to decompose the sources of VA in global production of tradables. The decomposition methods are summarized below.

Assume an *m*-country world, in which each country produces goods in *n* differentiated tradable sectors. The *m*-country production and trade system can be written as an Inter-County Input-Output model in the form of block partitioned matrix

$$(1) \quad \begin{bmatrix} X_1 \\ \vdots \\ X_m \end{bmatrix} = \begin{bmatrix} A_{11} & \cdots & A_{1m} \\ \vdots & \ddots & \vdots \\ A_{m1} & \cdots & A_{mm} \end{bmatrix} \begin{bmatrix} X_1 \\ \vdots \\ X_m \end{bmatrix} + \begin{bmatrix} Y_{11} + \dots Y_{1m} \\ \vdots \\ Y_{m1} + \dots Y_{mm} \end{bmatrix}$$

where X_m is the *n×1* gross output vector of country *m*, Y_{ij} is the *n×1* final demand vector that shows demand in country *j* for final goods produced in country *i*, and A_{ij} is the *n×n* IO coefficient matrix, giving intermediate use in country *j* of goods produced in country *i*.

Deriving the Leontief inverse matrix from equation (1) and pre-multiplying it with the final demand matrix, we get:

$$(2) \quad \begin{bmatrix} I - A_{11} & \cdots & -A_{1m} \\ \vdots & \ddots & \vdots \\ -A_{m1} & \cdots & I - A_{mm} \end{bmatrix}^{-1} \begin{bmatrix} Y_{11} & \cdots & Y_{1m} \\ \vdots & \ddots & \vdots \\ Y_{m1} & \cdots & Y_{mm} \end{bmatrix}$$

$$= \begin{bmatrix} B_{11} & \cdots & B_{1m} \\ \vdots & \ddots & \vdots \\ B_{m1} & \cdots & B_{mm} \end{bmatrix} \begin{bmatrix} Y_{11} & \cdots & Y_{1m} \\ \vdots & \ddots & \vdots \\ Y_{m1} & \cdots & Y_{mm} \end{bmatrix} = \begin{bmatrix} X_{11} & \cdots & X_{1m} \\ \vdots & \ddots & \vdots \\ X_{m1} & \cdots & X_{mm} \end{bmatrix}$$

where B_{ij} denotes the *n×n* block Leontief inverse matrix, which is the total requirement matrix giving the amount of gross output produced in country *i* required for a one-unit increase in final demand in country *j*. It follows that, X_{ji} is the output of country *j* used to produce goods eventually consumed in country *i*.

Regarding exports, let E_{ij} be the *n×1* vector of gross exports from *i* to *j*. Gross exports from *i* to *j* is divided into final good Y_{ij} and intermediates $A_{ij}X_j$. The intermediates are further divided into goods that are processed and consumed by country *j* ($A_{ij}X_{jj}$), goods that are processed and re-exported by *j* to third countries ($\sum_{k \neq i,j} A_{ij}X_{jk}$), and intermediate goods exported from *i* to *j* then processed and exported back to *j* $(A_{ij}X_{ji})$:

$$(3) \; E_{ij} = Y_{ij} + A_{ij}X_j = Y_{ij} + A_{ij}X_{jj} + \sum_{k \neq i,j} A_{ij}X_{jk} + A_{ij}X_{ji}$$

Equation (3) traces the *downstream* use of exports from country i to country j, however, it does not provide information on the *upstream* contribution from other countries to the exports of country i. Thus, we still need to compute the upstream VA of country i's exports in order to derive a complete picture of supply links and disaggregation of VA.

Formally, we define V_i to be the *1×n* direct VA coefficient vector. Each element of V_i gives the share of direct domestic VA in total output. This is equal to one minus the intermediate input share from all countries (including domestically produced intermediates):

$$(4) \; V_i = u\left(I - \sum_j A_{ji}\right)$$

Where, u is a 1×n unity vector.

Combining the VA coefficient vector with the partitioned Leontief inverse matrix provides information regarding the VA share. For example, each element in the 1×n vector $V_i B_{ii}$ gives the domestic VA share of a particular sector in country i. Similarly, the corresponding element in vector $V_j B_{ji}$ is the share of country j's VA in the same sector produced in country i.

Let E_{i*} be the total export from i, i.e. $E_{i*} = \sum_{j \neq i} E_{ij} = \sum_{j \neq i}(A_{ij}X_j + Y_{ij})$

The gross exports from country i can be divided into domestic VA export (DV_i) and foreign VA export $(FV)_i$.

$$(5) \; E_{i*} = DV_i + FV_i$$

Using the derived information on VA share, Koopman and others (2011) shows that:

$$(6) \; FV_i = \sum_{j \neq i} V_j B_{ji} E_{i*}$$

$$(7) \; DV_i = V_i B_{ii} E_{i*}$$

Combining the downstream use of export in equation (3) with the VA decomposition in equation (5), we can decompose gross exports into five VA categories (Figure 3):

$$(8) \; E_{i*} = DV_i + FV_i$$

$$= V_i B_{ii} \sum_{j \neq i} Y_{ij} + V_i B_{ii} \sum_{j \neq i} A_{ij}Y_{jj} + V_i B_{ii} \sum_{j \neq i} \sum_{k \neq i,j} A_{ij}X_{jk} + V_i B_{ii} \sum_{j \neq i} A_{ij}X_{ji} + FV_i$$

For country i, the terms in equation (8) correspond to the following, respectively:

(A: $V_i B_{ii} \sum_{j \neq i} Y_{ij}$): DV in the form of final goods and services consumed by the direct importer;

(B: $V_i B_{ii} \sum_{j \neq i} A_{ij} Y_{jj}$): DV in the form of intermediate inputs used by the direct importer to produce its domestically consumed products;

(C: $V_i B_{ii} \sum_{j \neq i} \sum_{k \neq i,j} A_{ij} X_{jk}$): DV in the form of intermediate exports used by the direct importer to produce goods for third countries

(D: $V_i B_{ii} \sum_{j \neq i} A_{ij} X_{ji}$): DV in the form of intermediate exports used by the direct importer to produce goods shipped back to source country;

(E: FV_i): VA by foreign countries embodied in country i's gross exports.

Measuring Vertical Integration

In previous literature, measures of vertical integration have been developed. Most of these proposed measures are easily taken to the data, specifically with the use of the input-output tables.

Earlier literature such as Feenstra and Hanson (1996 and 1999), Feenstra (1998), Campa and Goldberg (1997), use the share of imported intermediate input (in total input or in gross output) to measure the level of outsourcing. However, these measures fail to fully capture the supply links as countries are grouped either as producers in intermediate stages or as exporters of final goods while in reality the links are more complex.

Hummels and others (2001) suggest a measure of vertical specialization, focusing on those imported goods that are used as inputs to produce a country's exports. (Hummels and others, 2001) Their measure emphasizes the twin ideas that the production sequence of a good involves at least two countries, and that, during this sequencing, the good-in-process crosses at least two international borders. The same approach is followed in Chen and others (2005), European Central Bank (ECB, 2005a), Breda and others (2008), and Koopman and others (2010).

Following the more recent group of literature originated from Hummels and others (2001), we define vertical integration or supply links as occurring when two or more countries provide VA in a good's production sequence; at least one country must use imported inputs in its production process, and the resulting output must be exported.

Note that the notion of vertical integration is only sensible in at least a bilateral context. Thus, it has both an upstream side and a downstream side. The upstream supplier exports intermediate goods to a downstream producer who uses these intermediates to add value for further export. As an upstream supplier, a country's participation in the global production chain depends on its VA to

other countries' exports. As a downstream assembler, a country's participation in the global production chain depends on the foreign VA in its exports.

To evaluate this bilateral relation in supply links, we need to measure, for all country-pairs, the embedded foreign VA from one country in another country's export. Koopman and others (2011) has shown that the matrix of VA by source in gross exports (VAS_E) can be specified as:

$$VAS\_E = \begin{bmatrix} V_1 B_{11} E_{1*} & \cdots & V_1 B_{1m} E_{m*} \\ \vdots & \ddots & \vdots \\ V_m B_{m1} E_{1*} & \cdots & V_m B_{mm} E_{m*} \end{bmatrix}$$

The elements of this matrix provide VA by source in gross exports between each country pair. For example, the element $VAS\_E_{ij} = V_i B_{ij} E_{j*}$ gives country i's VA embodied in country j's export. Therefore, diagonal elements of VAS_E matrix correspond to the domestic VA in each country's exports. Off-diagonal elements give the foreign VA embodied in each country's exports.

To link this bilateral VA relation with the country-level decomposition of export, note that the sum of off-diagonal elements along a column is the measure of VA from foreign sources embodied in a particular country's gross exports, which is just equal to FV defined in equation (8). Here, we call it Downstream Participation (DP) and use it to measure a country's participation in global VA chain as a downstream producer:

$$DP_i = FV_i = \sum_{j \neq i} V_j B_{ji} E_{i*}$$

Similarly, the sum of off-diagonal elements along a row provides information on a country's VA embodied as intermediate inputs in all other countries' gross exports. It can be used to measure the country's participation in global VA chains as an upstream supplier. We call it Upstream Participation (UP):

$$UP_i = \sum_{j \neq i} V_i B_{ij} E_{j*}$$

Annex 3. Classification of Merchandise and Services Exports

Categories	Sector number	Sector name
Primary and Natural resources	1,2	Agriculture, Hunting, Forestry and Fishing
		Mining and Quarrying
labor-intensive manufacuring	4,5,6,16	Textiles and Textile Products
		Leather, Leather and Footwear
		Wood and Products of Wood and Cork
		Manufacturing, Nec; Recycling
capital-intensive manufacuring	3,7,8,10,11,12	Food, Beverages and Tobacco
		Pulp, Paper, Paper , Printing and Publishing
		Coke, Refined Petroleum and Nuclear Fuel
		Rubber and Plastics
		Other Non-Metallic Mineral
		Basic Metals and Fabricated Metal
knowledge-intensive manufacuring	9,13,14,15	Chemicals and Chemical Products
		Machinery, Nec
		Electrical and Optical Equipment
		Transport Equipment
labor-intensive service	18,19,20,21,22,26,35	Construction
		Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel
		Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles
		Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods
		Hotels and Restaurants
		Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
		Private Households with Employed Persons
capital-intensive service	17,23,24,25,27,29	Electricity, Gas and Water Supply
		Inland Transport
		Water Transport
		Air Transport
		Post and Telecommunications
		Real Estate Activities
knowledge-intensive service	28,30	Financial Intermediation
		Renting of M&Eq and Other Business Activities
health/education/public service	31,32,33,34	Public Admin and Defence; Compulsory Social Security
		Education
		Health and Social Work
		Other Community, Social and Personal Services

Annex 4. Business Cycle Synchronization

The model

More formally, the specification is the following:

$$\rho_{i,t} = \theta_1 fva_{i,t} + \mathbf{X}'_{i,t}\beta + u_i + \eta_t + \varepsilon_{i,t}, \quad [1]$$

where *fva* measures the ratio of the Germany's foreign VA embodied in each country's *i* exports normalized by country's *i* nominal GDP. Since the largest recipients of Germany's VA are the CE4 countries, the *fva* variable is already performing as a proxy for the CE4 group. The matrix **X** contains the other determinants of business cycle synchronization – mainly the variables capturing several dimensions of financial integration – such as bilateral FDI and Bank flows from Germany into each country *i*. Country and time fixed effects are controlled for to account for the effects of country specific and time-invariant factors and global common shocks.

To account for the specificity of CE4 countries and Eurozone countries, the model can re-written as:

$$\rho_{i,t} = \left(\theta_2 + \theta_3 CE_{4,i.} + \theta_4 EZ_{i,t}\right)fva_{i,t} + \gamma EZ_{i,t} + \mathbf{X}'_{i,t}\beta + u_i + \eta_t + \varepsilon_{i,t}, \quad [2]$$

where CE4 and EZ denote the dummy variable for CE4 and Eurozone countries, respectively. θ_2 measures the marginal impact of the GCESC when the given country is neither a CE4 or member of the Eurozone. $\theta_2 + \theta_3$ is the effect of the GCESC on CE4 whereas $\theta_2 + \theta_4$ gives the impact on Eurozone countries.[1]

Sample

The sample consists of 29 countries (advanced and emerging markets) observed over the period 1995-2009. The Germany's value-added embodied in countries' exports are computed using the methodology proposed by Koopman et al. (2011) based on the World Input Output Table (WIOT) and nominal dollar values are normalized by each country's GDP. Data on the export decomposition based on the WIOT are available from 1995 to 2009 at an annual frequency. Bilateral FDI and bank flows are drawn from the OECD Stat and the Bank for International Settlements (BIS) databases, respectively. Each financial flow is also normalized by nominal GDP. In the case of specifications using the rolling correlation coefficients over overlapping 7-year sub-periods, the control variables are measured as country-specific rolling averages of the variables whereas in the case of the model using the time-varying synchronization coefficient based on the Aghion and Marinescu (2008) methodology, variables are taken as they are (i.e. at an annual frequency) since the methodology does not require computing sub-periods.

---

[1] The CE4 dummy is not introduced additively because it is time-invariant and thus fully absorbed by the country fixed effects.

Annex Table 1. Business Cycles Synchronization and Its Determinants

	OLS	IV [a]	OLS	OLS	IV [a]	OLS	OLS	IV [a]	OLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable: Correlation of:	Real growth rates			Output gaps			Real growth rates (Aghion and Marinescu, 2008)		
Germany VA in country i exports (as percentage of GDP)	5.816**	68.05***	-11.22	9.628***	51.13***	-11.03*	19.13***	33.40***	-4.742
	(2.485)	(3.781)	(-1.624)	(4.699)	(3.569)	(-1.872)	(11.27)	(8.703)	(-1.011)
Germany VA * CE4 dummy			16.16**			20.12***			24.77***
			(2.292)			(3.344)			(5.181)
Germany VA * Eurozone dummy			7.580**			4.969*			3.745
			(2.532)			(1.946)			(1.290)
Eurozone dummy			-0.399***			-0.452***			-0.315***
			(-4.123)			(-5.474)			(-4.055)
Germany's bilateral FDI flows (as percentage of GDP)	0.0189	0.0536	0.0158	-0.00509	0.0152	-0.0205	0.00528	0.0163	0.000284
	(0.431)	(0.877)	(0.357)	(-0.133)	(0.313)	(-0.545)	(0.368)	(1.146)	(0.0210)
Germany's bank bilateral flows (as percentage of GDP)	-0.00578**	-0.00998	-0.00335	-0.0102***	0.00318	-0.00626***	-0.00287	-0.00272	6.18e-05
	(-2.131)	(-1.463)	(-1.203)	(-4.317)	(0.585)	(-2.633)	(-1.632)	(-1.387)	(0.0339)
Global Financial crisis dummy	0.372***	0.0512	0.443***	0.732***	0.0249	0.824***	0.793***	0.339***	0.793***
	(4.048)	(0.712)	(4.807)	(9.094)	(0.435)	(10.48)	(11.68)	(4.611)	(11.84)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-stat of the first-stage instrumentation equation of foreign value-added		36.07			36.07			126.52	
Observations	493	261	493	493	261	493	435	377	435
R-squared	0.379	0.351	0.406	0.514	0.311	0.559	0.614	0.412	0.659
Number of countries	29	29	29	29	29	29	29	29	29

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Annex 5. Income Convergence

The model

The econometric model is a standard cross-sectional growth equation where the initial per capita income is included additively and in interaction with the total foreign value-added embodied in each country exports (and normalized by GDP). The existence of a beta-convergence is tested by estimating a negative regression coefficient associated with the initial per capita income. The model controls for standard determinants of long term growth: investment ratio, human capital, and macroeconomic policies and instability proxied by the inflation rate. The foreign value-added in exports is also accounted for in the specifications.

The baseline takes the following form:

$$g_i = -\beta \ln Y_{i,1995} + \phi_1 fva_i + \mathbf{X}_i'\Gamma + \varepsilon_i, \qquad [1]$$

where g is the average annual growth rate in each country i, $Y_{i,1995}$ is the real initial per capita in 1995, fva is the within-country average of the total foreign value-added embodied in each country's i exports (scaled by GDP), and $\mathbf{X}$ is the matrix of standard determinants of growth rate: investment ratio, human capital, and inflation rate, both measured as averages over 1995-2009. $-\beta$ measures the convergence effect which suggests that growth is affected by diminishing returns as countries starting with low initial income should growth faster than others.

The model [1] can be amended to account for the contribution of the foreign value-added to the speed of income convergence by allowing the coefficient β to be conditional on the size of the foreign value-added. The proposed specification which follows previous works on the estimation of non-linearities in income convergence process (Slaughter, 2001; Abiad et al., 2009) is as follows:

$$g_i = -\left(\beta_1 + \beta_2 fva_i\right) \ln Y_{i,1995} + \phi_1 fva_i + \mathbf{X}_i'\Gamma + \varepsilon_i, \qquad [2]$$

where β_1, and β_2 are strictly positive.

Sample and data

All the variables are drawn from Penn World table 7.1., except the inflation rate (World Development Indicators) and the value-added trade export series which are computed by the authors using the WIOT. All the variables are computed as averages over 1995-2009, except for the initial income variable which is measured at the beginning of the period in 1995.

Annex Table 2. Supply Chains and Income Convergence

Dependent variable: Average real per capita GDP growth	OLS	OLS	IV [a]	IV [b]
Period: 1995-2009	(1)	(2)	(3)	(4)
Initial real per capita income (in 1995, log)	-0.0244***	-0.0217***	-0.0243***	-0.0212***
	(-5.565)	(-4.632)	(-6.061)	(-5.077)
Initial income * Foreign value-added in exports		-0.0262*		-0.0267**
		(-2.007)		(-1.974)
Foreign value-added in exports (over GDP)	0.0567***	0.328**	0.0552***	0.328**
	(6.619)	(2.413)	(6.213)	(2.365)
Investment ratio	0.0689	0.0743	0.0688	0.0740
	(1.222)	(1.291)	(1.342)	(1.446)
Years of schooling in the tertiary	0.0343***	0.0329***	0.0342***	0.0324***
	(5.155)	(4.986)	(5.545)	(5.551)
ln (100+inflation rate)	-0.0158	-0.0141	-0.0158	-0.0140
	(-0.589)	(-0.543)	(-0.646)	(-0.609)
Intercept	0.294*	0.257	0.293*	0.254*
	(1.781)	(1.614)	(1.947)	(1.809)
First-stage identification tests				
F-stat of the instrumentation equation of foreign value-added			80.79	461.50
F-stat of the instrumentation equation of foreign value-added*Initial income				396.80
P-value of the joint significance of initial income coefficients			0.000	0.000
Observations	34	34	34	34
R-squared	0.661	0.684	0.661	0.683

Robust t-statistics in parentheses. [a] The foreign value-added embodied in cou

*** p<0.01, ** p<0.05, * p<0.1

INTERNATIONAL MONETARY FUND

July 1, 2013

GERMAN-CENTRAL EUROPEAN SUPPLY CHAIN CLUSTER REPORT—SECOND BACKGROUND NOTE— THE EVOLUTION OF FINANCIAL LINKAGES

Prepared By B. Augustyniak, C. Ebeke, E. Ebrahimy and S. Elekdag [All EUR]

CONTENTS

INTRODUCTION

1.   A vibrant supply chain has flourished in central Europe. With Germany serving as the anchor, deeper integration has taken place with the Czech Republic, Hungary, Poland, and Slovakia (henceforth the CE4). This economic entity will be referred to henceforth as the German-Central European Supply Chain (GCESC). This paper complements Augustyniak and others (2013a) and is motivated by the conjecture that the increasing vertical integration of production would have a counterpart in the flow of capital across the GCESC.

2.   This paper is framed by the following questions: How have financial linkages evolved over time and across the region? What were the main trends before and after the collapse of Lehman Brothers which was a turning point in the global financial crisis? In contrast to the rest of the region, what type of flows—FDI (foreign direct investment), banking, or portfolio—were most relevant for the CE4? What sectors were these flows primarily directed to? The goal of the paper is to address these questions by presenting some key stylized facts and highlighting their main policy implications.

3.   In contrast to financial flows, stock positions are available on a bilateral or sectoral basis and serve as the cornerstone of the analysis. Indeed, stock positions (from the international investment position) can be used to try to link financial flows between the CE4 and Germany. Financial stock positions can be decomposed into FDI positions, portfolio positions, and banking claims. Unfortunately, there does not seem to be cross-country consistent data capturing bilateral intra-company loans and trade credit. Such financial flows are likely to be especially important in the context of deepening vertical integration. Another advantage of stock positions is that they are also available on a sectoral basis. In what follows, the CE4 will be contrasted with selected periphery (SP) countries (Greece, Italy, Portugal, and Spain), in part motivated by the divergent nature of their post-Lehman recoveries. That said, a rigorous cross-country analysis of recessions and recoveries is beyond the scope of this study.

4.   This paper uncovers two main results, the first of which underscores the role of FDI in the CE4:

- FDI stock positions (as a percent of GDP) in the CE4 are nearly twice as large as those in the SP. Moreover, the difference of FDI stocks from Germany is even more pronounced when the CE4 and the SP are contrasted.

- A larger share of CE4 FDI was directed toward greenfield projects. In addition, CE4 FDI positions were higher within certain manufacturing sectors—for example, the motor vehicles and other transport equipment sectors—in contrast to the SP.

- These FDI inflows—including those from Germany—are important because, consistent with the establishment of the supply chain, they seem to have been used to expand productive capacity

in the CE4. In addition, because FDI is a more stable source of external financing, it is less sensitive to fluctuations in global risk aversion and therefore capital flight.

5.   The second main result focuses on bank claims, where in contrast to the CE4, the share of cross-border bank claims is substantially greater in the SP. The instability of cross-border bank lending (particularly for the SP) was highlighted during the Global Recession of 2008-09, and has been documented in the literature. In fact, while bank claims on the CE4 actually increased over the 2006-11 period, in the SP the stock decreased by about a third.

6.   The types of external financing matter for growth and financial stability. It seems that financial integration between the CE4 and Germany evolved in a more durable manner owing to the relative predominance of FDI flows linked with the GCESC, and therefore promoted financial resilience and sustainable economic activity. In contrast—and admittedly with hindsight—large portfolio and cross-border bank inflows into the SP were symptoms of overheating and macroeconomic and financial instability.

7.   In this context, FDI inflows—including from Germany—are likely to have generated beneficial medium-term spillovers to the CE4. As discussed in Augustyniak and others (2013a), there is evidence that the evolution of the GCESC was associated with technology transfers: the rapid expansion of CE4 exports was largely driven by the knowledge-intensive sectors, which was likely financed and thereby supported by a relatively greater share of FDI, including from Germany.[1]

8.   The remainder of the paper is structured as follows: The next section discusses the main results of the paper. To ensure a smoother narrative, details regarding the data sources used and references to the literature are interspersed throughout this section. The final section concludes by summarizing the main results and underscoring the key policy implications.

RESULTS

9.   The evolution of net capital inflows to the CE4 and to the SP has differed noticeably. Using readily available balance of payments statistics, net capital inflows are scaled by GDP and contrasted across the region.[2] Figure 1 depicts some interesting patterns and reveals that while FDI was the predominant inflow into the CE4, portfolio and other (bank) flows were the main types of external financing for the SP. While net FDI inflows to the CE4 were on a general downtrend for

---

[1] In the most general terms, this paper could be thought of making a contribution to the long literature debating the impact of finance on growth which could be dated as far back to at least Schumpeter (1911). While it could be that data severely limits the ability to draw firm conclusions, when the findings of this paper are combined with those in Augustyniak and others (2013a), it seems that the GCESC is mostly about real integration. This echoes the thoughts of Robinson (1952), who claims that where enterprise leads, finance follows.

[2] Net capital inflows and GDP were extracted from the IMF's World Economic Outlook (WEO) database, but are also readily available from other sources.

most of the last decade, in contrast to the SP, these inflows were nonetheless positive. Moreover, there was a spike in net other (bank) inflows during 2007 and 2008, subsequently followed by a sharp decline in 2009. Although net portfolio inflows picked up for the CE4 starting in 2009, this type of financing was quite large for the SP until 2009.
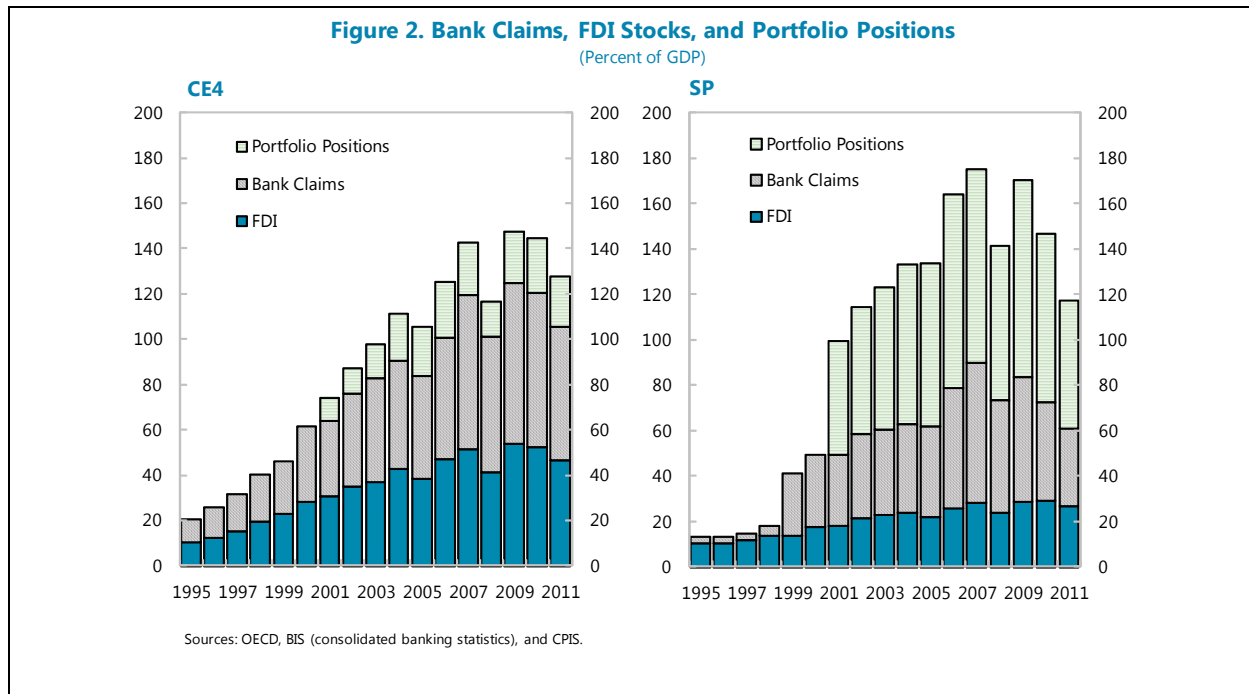

Figure 1. Net Capital Inflows
(Percent of GDP)

Source: WEO.
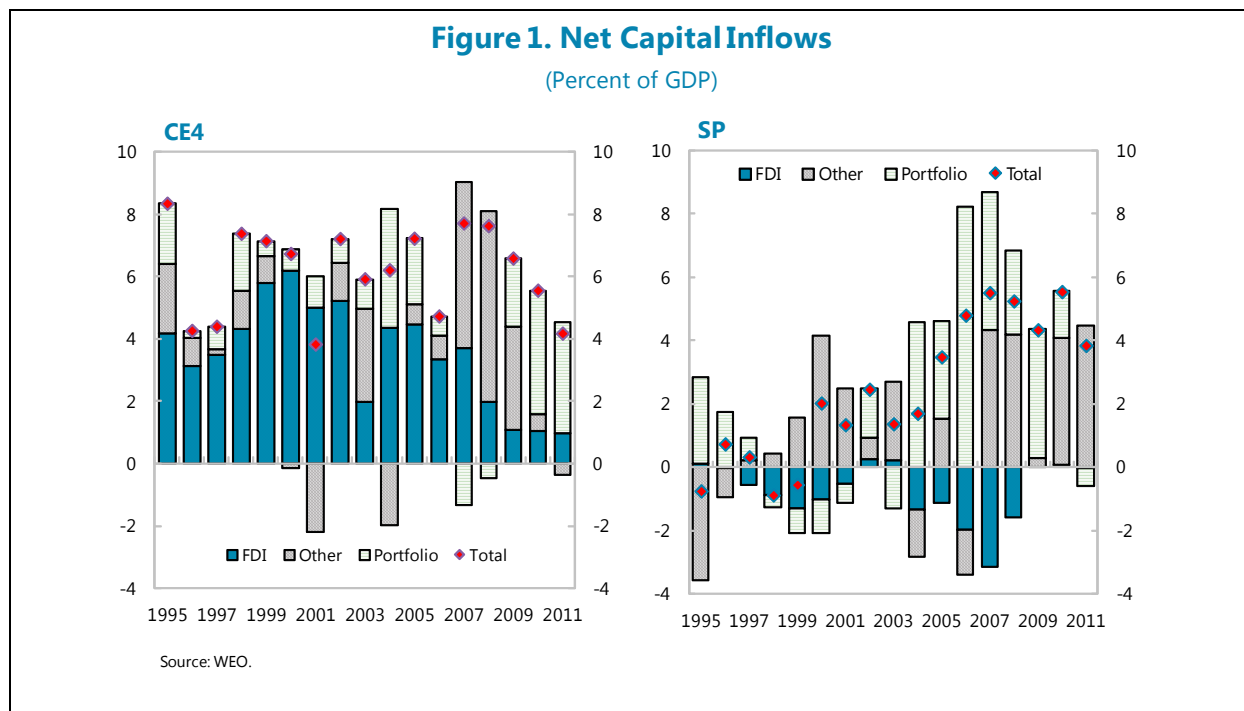
10.   While the stock of FDI is large for the CE4, in the SP, we see larger portfolio positions. Figure 2 aggregates (inward) FDI positions (from OECD databases), portfolio positions (from the IMF CPIS database), and banking claims (from the BIS, consolidated banking statistics).[3] Notice that analyzing global stock positions reveals a similar narrative to that based on the examination of net capital inflows. Specifically, when scaled by GDP, while the stock of FDI is large for the CE4, we see higher portfolio positions in the SP (with the caveat that the IMF's CPIS database starts in 2001). It should also be noted that these differences would be even larger if the stocks were in U.S. dollars, rather than as a percent of GDP. Indeed, in U.S. dollars (in, for example, 2007), GDP in the SP is about five times as large of the GDP of the CE4. As discussed in the Appendix, notice that the pattern of financial positions in other Central and Eastern countries seems to be closer to the CE4.
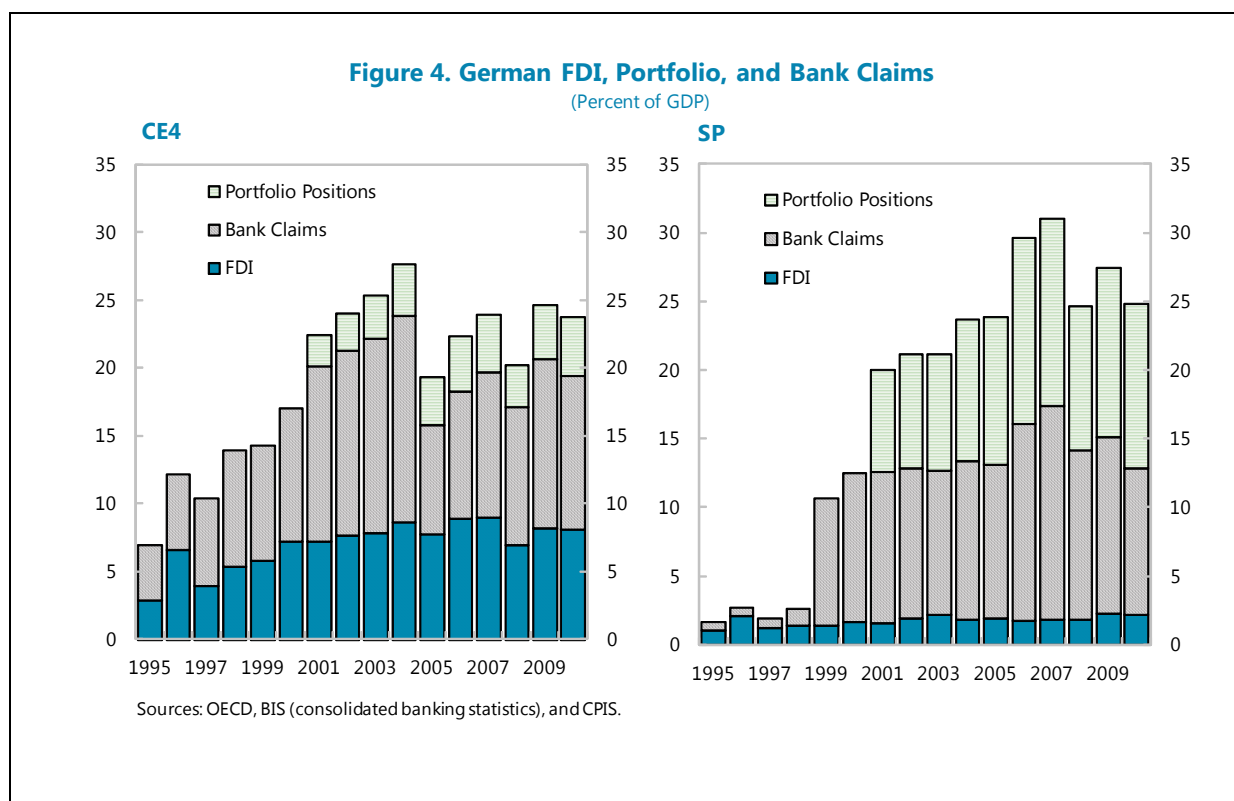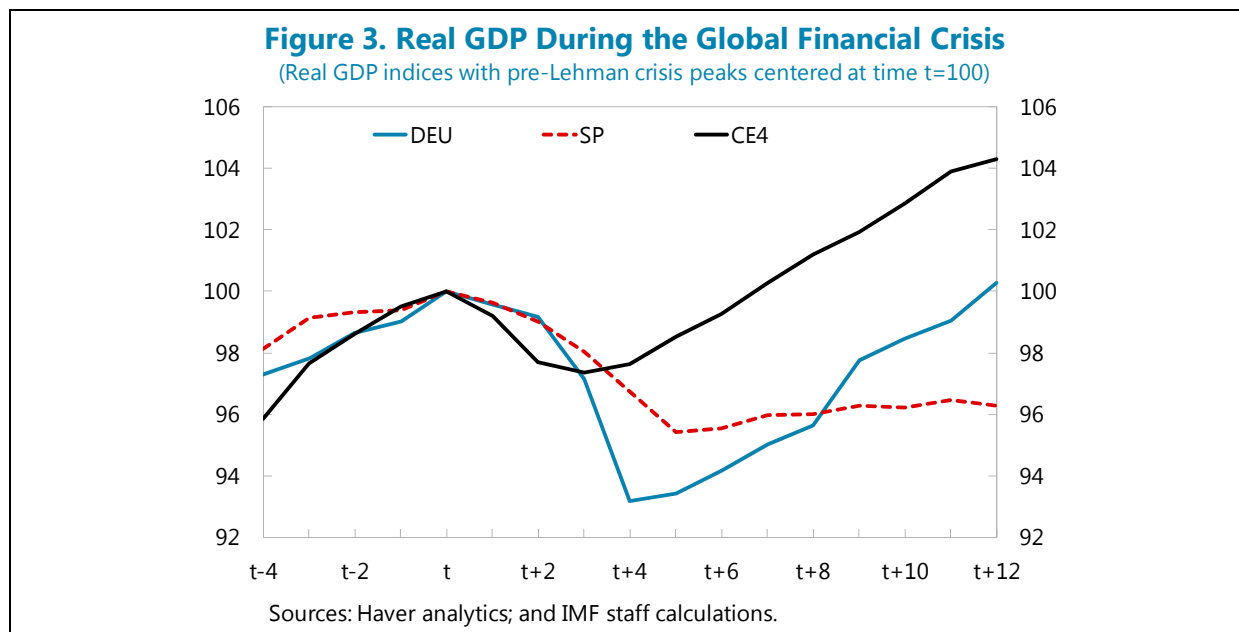
11.   In what follows, the CE4 will be contrasted with the SP, in part motivated by the divergent nature of the post-Lehman recoveries. Indeed, as displayed in Figure 3, the peak-to-trough decline in output for the CE4 was around –2½ percent. More interesting, while the post-

---

[3] These three components, along with derivative positions and the stock of reserve assets amount to the international investment position. For BIS consolidated data, structural breaks exist for some countries as discussed in Cerutti (2013).

Lehman contraction in GDP was –4½ for the SP, it was even harsher for Germany, with the recession bottoming out around –6¾ percent below the peak, in part reflecting the combination of Germany's economic openness and the severity of the collapse in global trade in the aftermath of the Lehman Brothers bankruptcy. This said, a cross-country analysis of recessions and recovers is beyond the scope of this study. Before continuing, it is worth noting bilateral flows are not available—in part because they are intermediated via international financial centers—and therefore stock positions are examined with the advantage that they reveal bilateral or sectoral exposures, but not both, as discussed further below.

Figure 2. Bank Claims, FDI Stocks, and Portfolio Positions
(Percent of GDP)

Sources: OECD, BIS (consolidated banking statistics), and CPIS.

Figure 3. Real GDP During the Global Financial Crisis
(Real GDP indices with pre-Lehman crisis peaks centered at time t=100)

Sources: Haver analytics; and IMF staff calculations.

.

Figure 4. German FDI, Portfolio, and Bank Claims
(Percent of GDP)

CE4

SP

Sources: OECD, BIS (consolidated banking statistics), and CPIS.

12. **The pattern of German claims on the CE4 and the SP is broadly similar to the global exposures, but with some notable nuances.** First, as shown in Figure 4, Germany has sizeable claims on the CE4 and on the SP. Second, CE4 FDI stocks from Germany are substantially larger
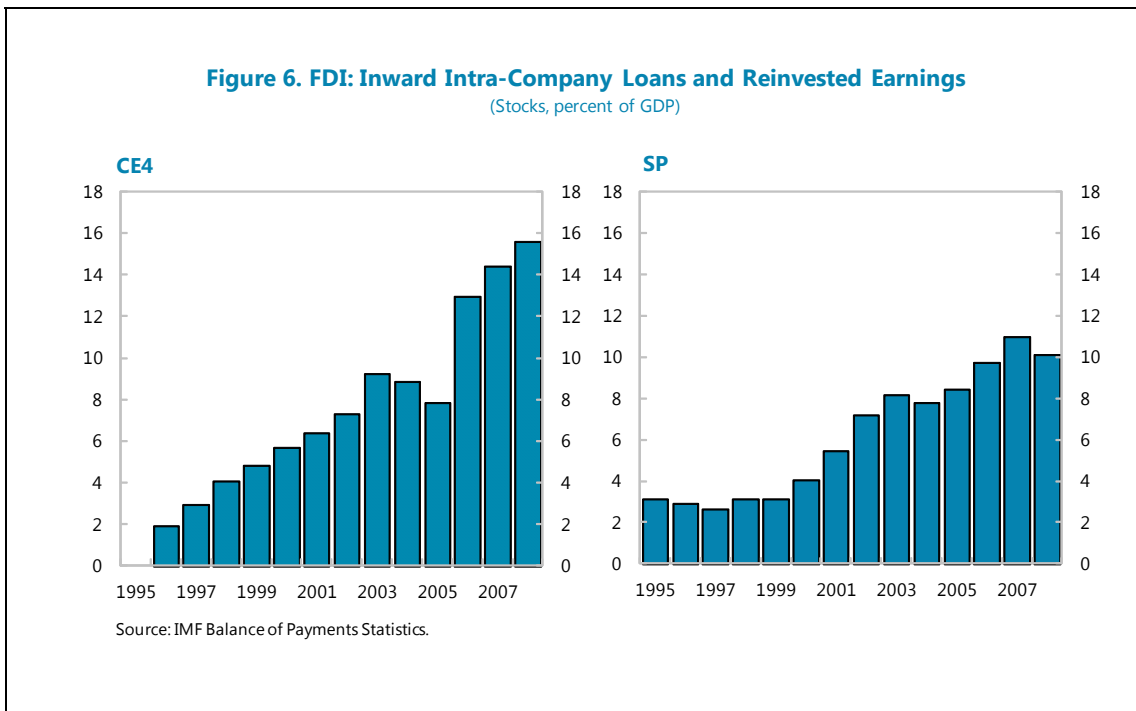
relative to the SP. Third, while banking claims are broadly similar, Germany's portfolio claims on the SP are much larger relative to those on the CE4. While not shown here (see Appendix), other Central and Eastern European countries display patterns closers to the CE4, but with stock positions around one third of the levels discussed above.

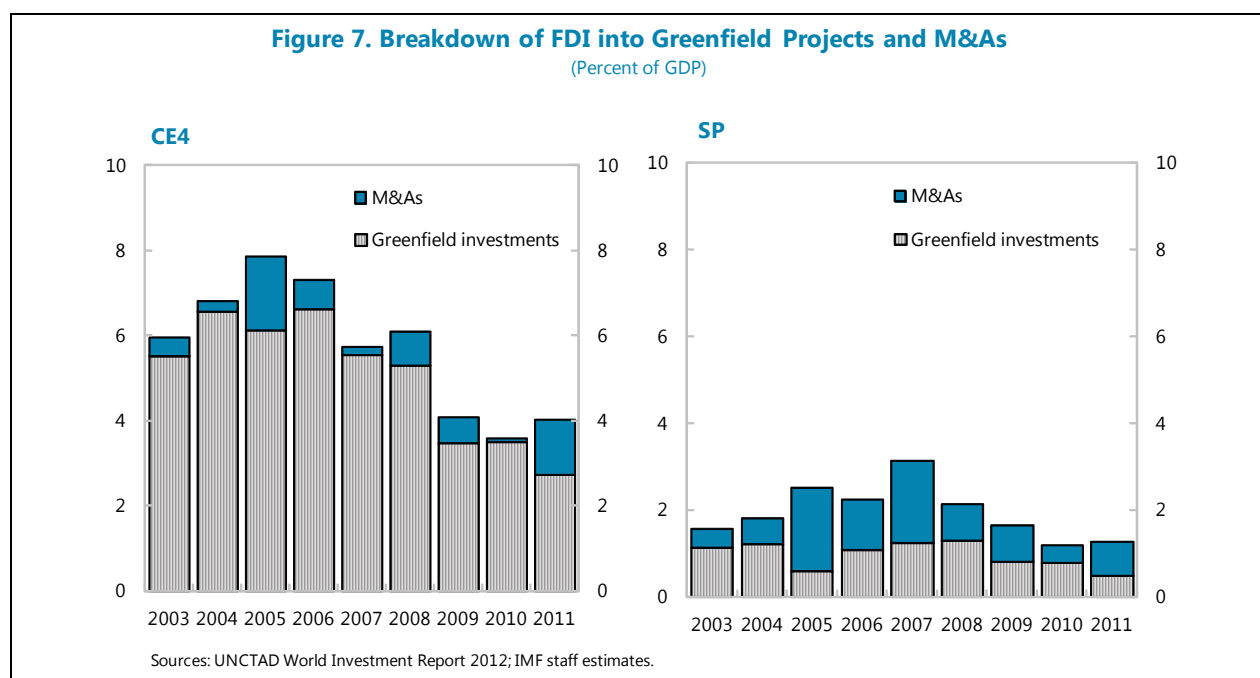## A. The Evolution of FDI Stock Positions

13.   FDI stock positions as a percent of GDP in the CE4 are nearly twice as large as those in the SP. As shown in Figure 5, CE4 FDI stocks were on a sharp uptrend with a peak in 2009 amounting to 54 percent of GDP. While the stock of FDI in 1995 was similar for the SP, the increase over time was more gradual. More interestingly, note that despite the global financial crisis of 2008-09, the stock of FDI was relatively stable which is consistent with the established literature (see, for example, Cardarelli and others, 2009, and more recently, Catão and Milesi-Ferretti, 2013). In this context, while FDI promotes financial resilience, it also fosters technology transfers, innovation, competition, efficiency, employment, and overall economic growth

Figure 5. FDI Stocks
(Percent of GDP)

Source: OECD.
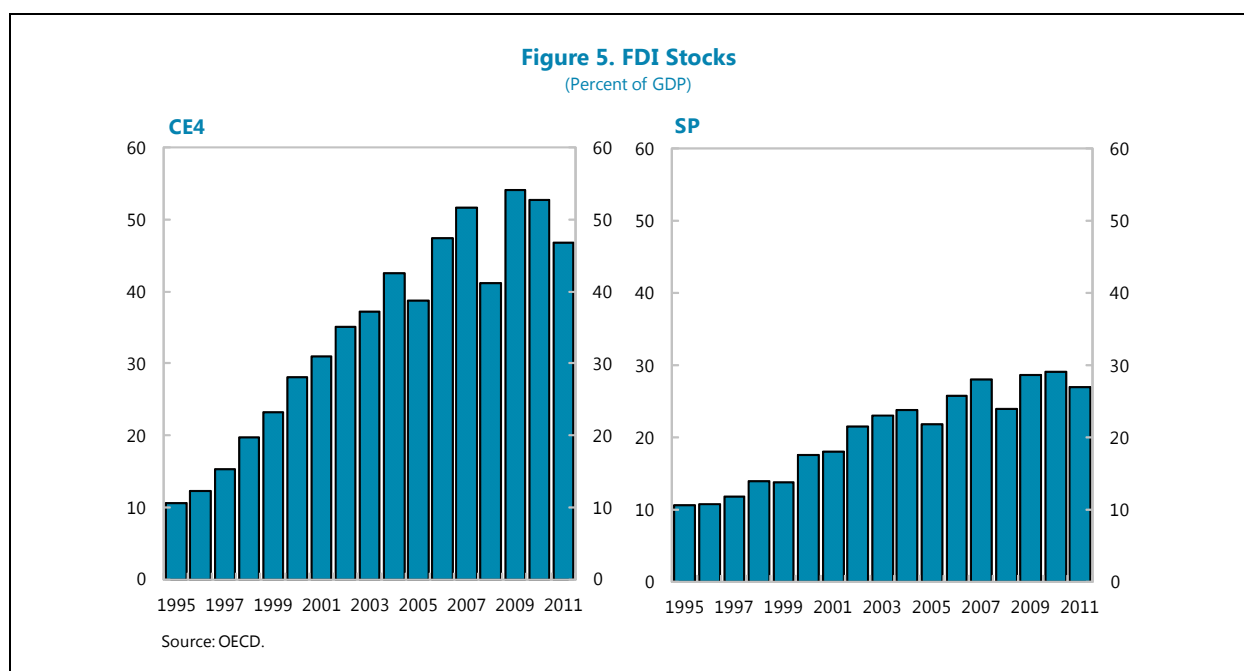
14.   The stock of intra-company loans and reinvested earnings as a share of GDP is larger in the CE4 than in the SP. The stock of FDI can be decomposed into three components: (i) Equity capital (purchase of shares of an enterprise in a foreign country, with a 10 percent participation threshold), (ii) Reinvested earnings (the part of an affiliate's earnings accruing to the foreign investor that is reinvested in that enterprise), and (iii) Intra-company loans (or intra-company debt transactions refer to short- or long-term borrowing and lending of funds between direct investors—parent enterprises—and affiliate enterprises). In this context, as displayed in Figure 6, the higher stock of intra-company loans and reinvested earnings (as a percent of GDP) in the CE4 may reflect ongoing relationships which are likely to be more stable, and less sensitive to changes in global risk aversion.

Figure 6. FDI: Inward Intra-Company Loans and Reinvested Earnings
(Stocks, percent of GDP)

CE4

SP

Source: IMF Balance of Payments Statistics.

15.   More importantly, CE4 FDI stocks are characterized by a larger share of greenfield investments. Based on net sales of assets, FDI can be decomposed into greenfield investments and those related to mergers and acquisitions (M&A). As put into sharp relief by Figure 7, not only is FDI as a share of GDP higher in the CE4 countries than in the SP, but the share of greenfield FDI is also substantially higher. Greenfield investment is generally regarded as preferable to other sources of funding for at least two reasons. First, it is generally associated with an expansion in productive capacity and therefore growth. Second, it is a more stable source of funding, and less prone to sudden reversals (capital flight).

Figure 7. Breakdown of FDI into Greenfield Projects and M&As
(Percent of GDP)

Sources: UNCTAD World Investment Report 2012; IMF staff estimates.

16.   A larger share of CE4 FDI was channeled to certain manufacturing sectors that are at the core of the GCESC. As discussed in Augustyniak and others (2013a), the German automotive sector is a well-known example of a thriving supply chain within Europe. In particular, Germany continues to be a leading global producer of passenger cars. However, offshore production of German passenger cars, particularly in the CE4, has become significant in recent years, with 2009 marking the first year when domestic production was overtaken by foreign production. Indeed, as shown in Figure 8, relative to the SP, the stock of CE4 FDI directed to the motor vehicles and other transport equipment sectors was at least twice as large as the stock in the SP. In particular, as a share of total, while the stock of inward FDI channeled toward motor vehicles and other transport equipment sectors hovered around 2½ percent for the SP, the average over 2005–10 was around 7 percent for the CE4. Therefore, along with attracting a greater amount of FDI as a percent of GDP as discussed above, a larger share of CE4 FDI was allocated to sectors which played a prominent role in the GCESC, which likely helped underpin stable and durable longer-term growth in the CE4.

Figure 8. FDI Stocks: The Motor Vehicles and the Transport Equipment Sectors

Percent of GDP

Percent of Total FDI
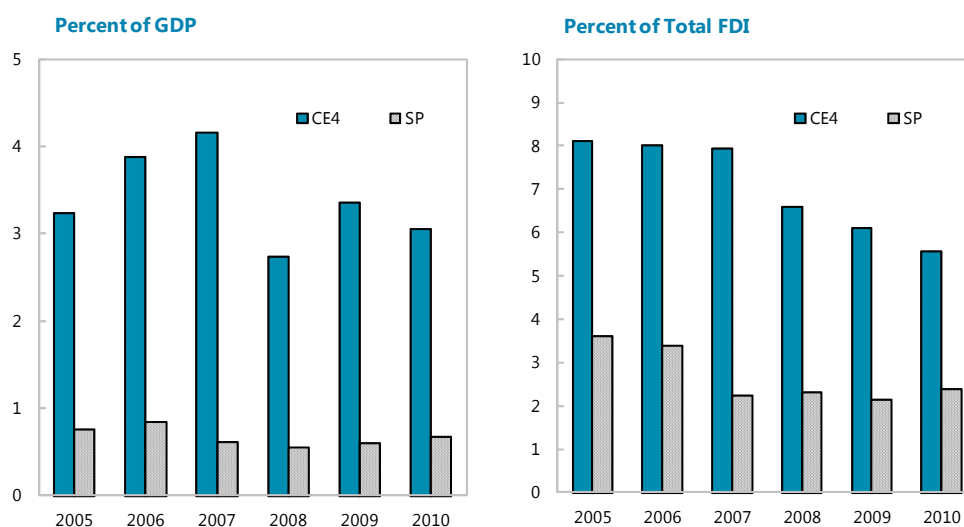
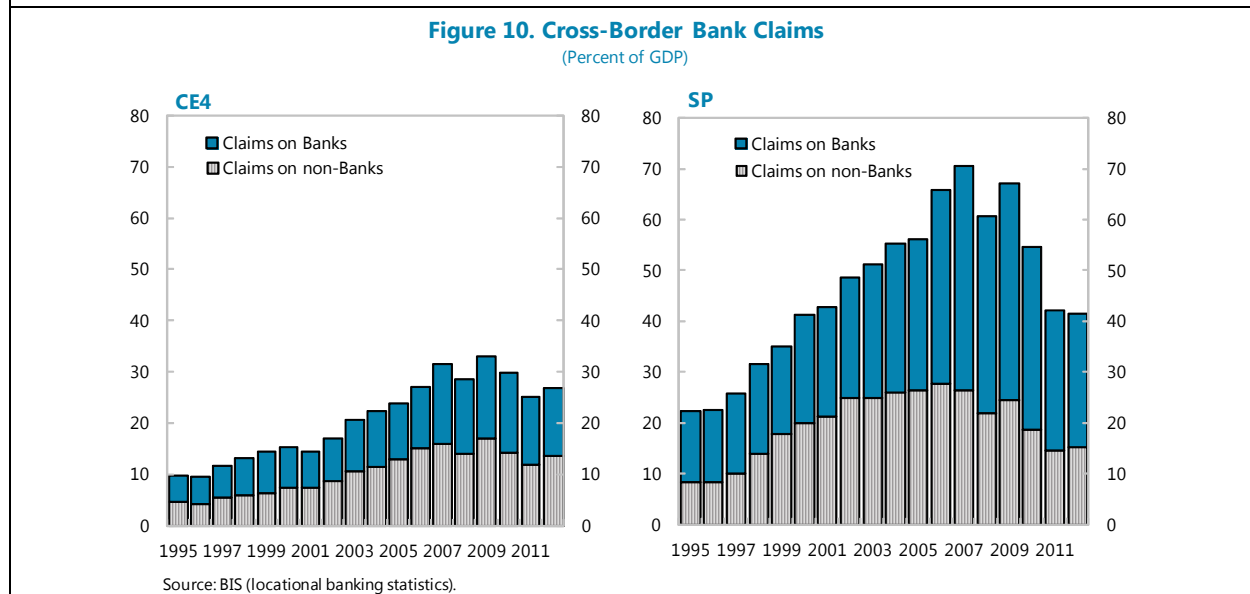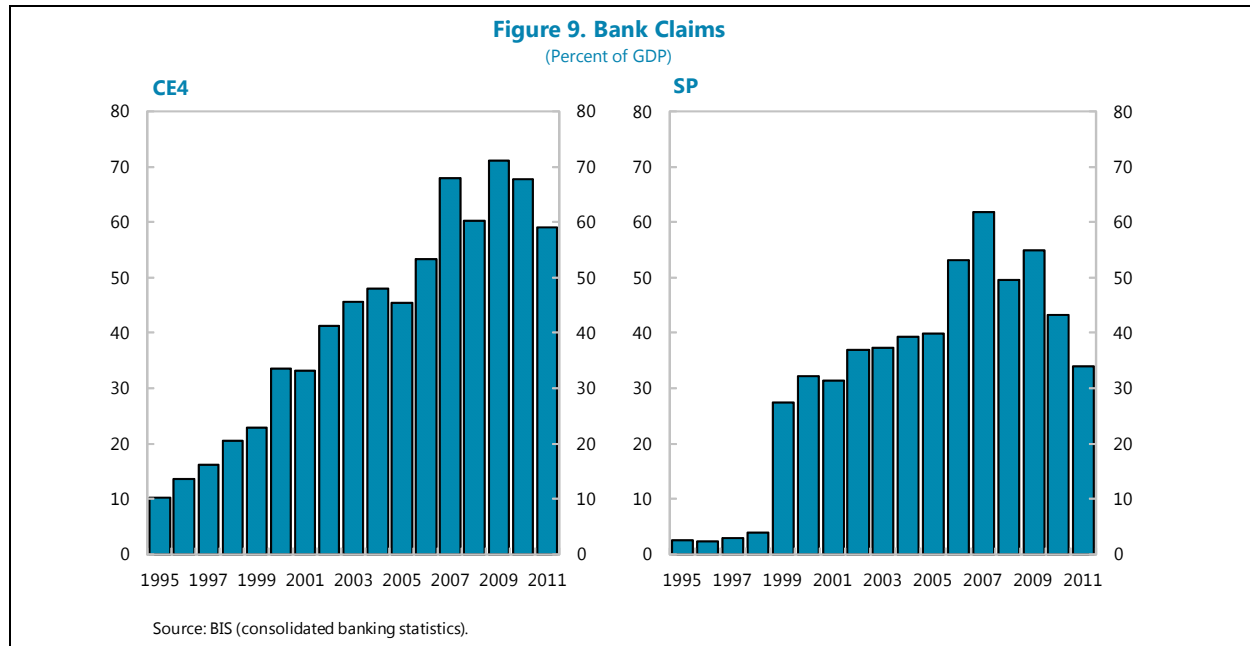Sources: OECD; and IMF staff calculations.

B.   The Evolution of Bank Claims

17.   As share of GDP, the post-1999 pattern of bank claims across the CE4 and the SP is broadly similar. As shown in Figure 9, while the pace varied, after a gradual uptrend, bank claims as a share of GDP (using consolidated BIS statistics) peaks at around 71 percent and 62 percent for the CE4 and the SP, respectively. While higher bank claims in the CE4 relative to the SP seems somewhat counterintuitive, recall that these stock are scaled by GDP. If U.S. dollar amounts were used, bank claims on the SP would be substantially larger than for the CE4. It is also worthwhile to note that in 2011, while CE4 bank claims hovered around 60 percent of GDP, those in the SP declined quite markedly, and have settled at half of the pre-crisis peak.

18.   More critically, cross-border bank claims on the SP were larger as compared to the CE4. Instead of the BIS consolidated claims used above, Figure 10 displays bank claims based on locational statistics. While consolidated banking statistics are structured by the nationality of reporting banks and are reported on a worldwide consolidated basis, the locational banking statistics focus on cross-border banking claims.[4] In contrast to the CE4, notice the sharp upward

---

[4] The locational banking statistics are structured by the residency of banking offices and capture the activity of all internationally active banking offices in the country regardless of the nationality of the parent bank. Banks record their positions on an unconsolidated basis, including those vis-à-vis their own offices in other countries. More intuitively, consolidated statistics include both cross-border bank flows, and local lending by resident foreign branches and subsidiaries.
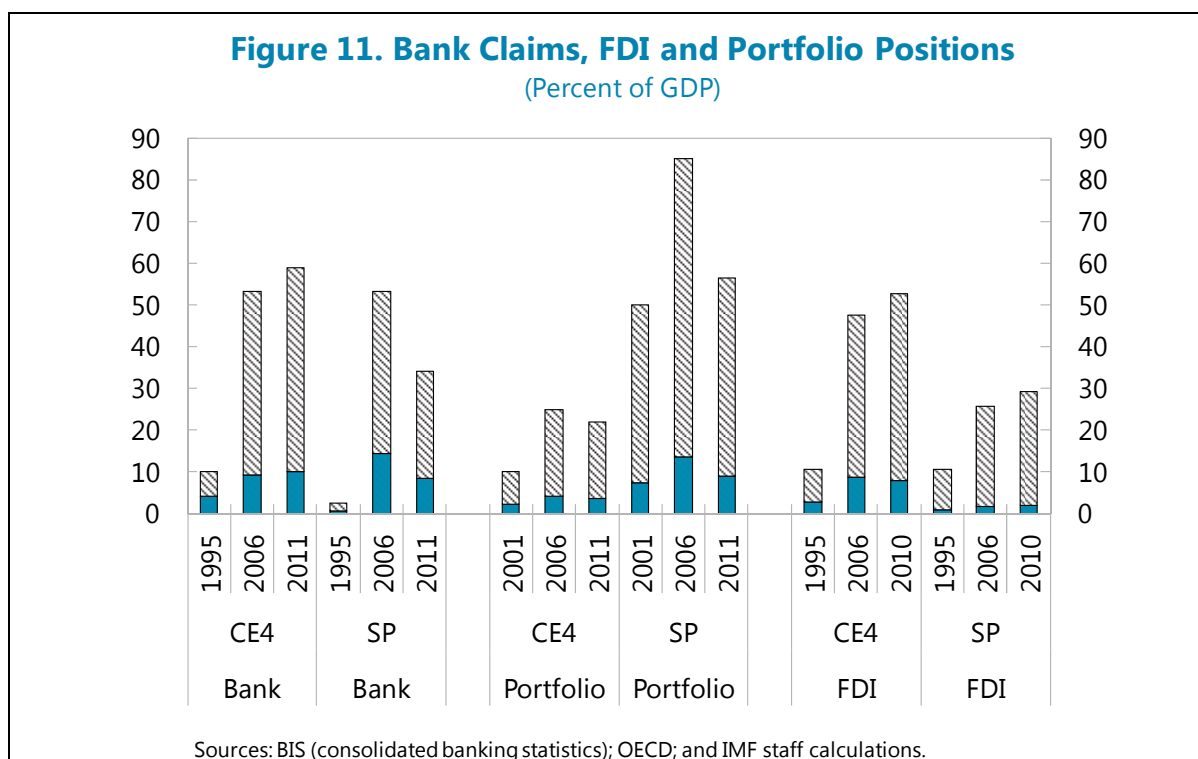
trend in cross-border claims on the SP, with a pre-crisis peak of 70 percent in 2007.[5] While CE4 cross-border claims were quite stable as a share of GDP throughout the 2007-2012 period, for the SP, there is evidence of an abrupt deleveraging process as the stocks in 2012 were around half of the 2007 levels. Echoing the results in the literature (including Cardarelli and others, 2009; IMF, 2007; IMF, 2011), cross-border banking claims are the least stable form of external financing, and a sharp reversal in these types of flows is usually associated with slower growth and financial instability.

Figure 9. Bank Claims
(Percent of GDP)

Source: BIS (consolidated banking statistics).

Figure 10. Cross-Border Bank Claims
(Percent of GDP)

Source: BIS (locational banking statistics).

---

[5] While not shown, there are important differences between CE4 countries; in particular, the share of cross-border bank flows was much larger in Hungary (where the pattern more closely resembled the SP countries).
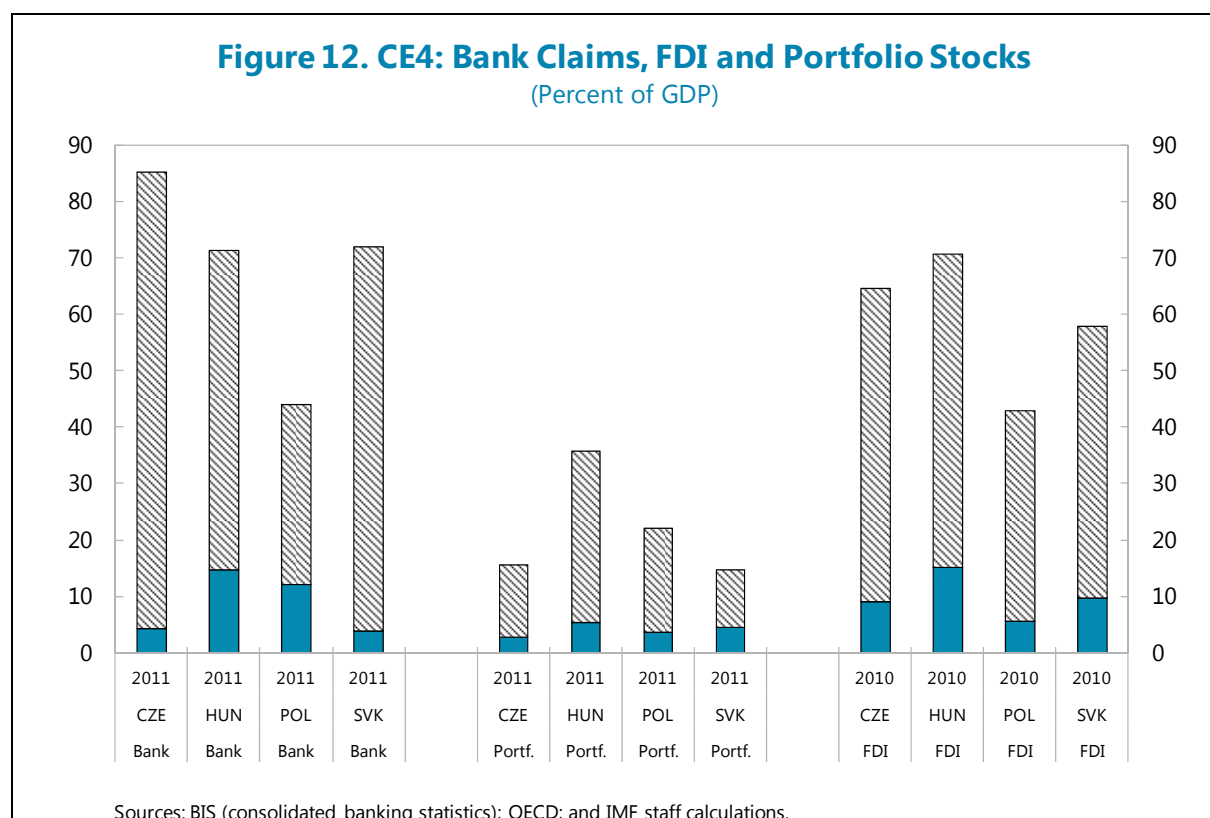
C. German FDI Facilitated Beneficial Medium-Term Spillovers to the CE4

19.   **It will be useful to take stock of the results presented thus far.** Figure 11 summarizes a considerable amount of information and serves to highlight some of the key findings. It displays FDI and portfolio positions and banking claims, including the share of German exposures as a percent of recipients' GDP, that is, for the CE4 or the SP.[6] To emphasize how patterns have changed over time, it presents a beginning of sample value (1995, but in the case of portfolio positions, 2001 owing to the data available from the IMF's CPIS database), a pre-crisis level (2006), and an end-of-period stock position (2011). Several points are worth emphasizing: First, notice the outstanding portfolio stock positions in the SP (both from a global and German perspective). Second, FDI stocks are larger in the CE4, again hinting at the GCESC relationship. In contrast, while banking claims are broadly similar, recall the important cross-border banking claim differences across the CE4 and the SP. Fourth, while FDI stock increased across regions, portfolio positions decreased after the global financial crisis, especially for the SP. Fifth, and relatedly, while bank claims increased in the CE4, they displayed a pronounced decline for the SP after the Lehman crisis.

Figure 11. Bank Claims, FDI and Portfolio Positions
(Percent of GDP)

Sources: BIS (consolidated banking statistics); OECD; and IMF staff calculations.

---

[6] Ideally, to get a sense of cross-border exposures, BIS locational statistics would have been used (as discussed in the context of Figure 10), however, because these are not available on a bilateral basis, banking claims using consolidated BIS statistics are used (as in Figure 9, for example).

Figure 12. CE4: Bank Claims, FDI and Portfolio Stocks
(Percent of GDP)

Sources: BIS (consolidated banking statistics); OECD; and IMF staff calculations.

20.   Taken together, there is evidence to suggest that financial integration between the CE4 and Germany evolved in a more durable manner owing to the relative predominance of FDI which was most likely associated with the GCESC. In contrast to the SP, both global and German FDI exposures were larger in the CE4. FDI seems to have been directed to the manufacturing—and in particular, motor vehicles and other transport equipment—sectors, and a substantial amount of this FDI comprised greenfield investments. However, the SP attracted a greater share of portfolio and cross-border banking flows, which—with the benefit of hindsight—exacerbated overheating pressures. In general, while FDI flows promoted durable growth in the CE4, non-FDI flows added to macroeconomic and financial imbalances across the SP.

21.   Differences within the CE4 should be recognized. Figure 12 presents a snapshot of the banking, FDI, and portfolio positions for the Czech Republic, Hungary, Poland, and Slovakia, individually. In terms of FDI positions and banking claims, the lower stocks of Poland positions as a share of GDP is a good example of why differences within the CE4 are important to bear in mind. Poland is the largest member of the CE4, and accounts for over 50 percent of its GDP. Therefore even if Poland attracts a larger amount of FDI in U.S. dollars, this may not come across fully when the data is scaled by GDP. Note also, that as a share of GDP, while Hungary has the largest FDI position, it has the greatest share stock of portfolio investment, and sizeable banking claims relative to the other CE4 countries.

CONCLUDING REMARKS

22.   As a counterpart to increasing trade integration in the context of the GCESC, this paper examines key financial developments that have evolved in parallel.

23.   Two key results emerge, with the first highlighting the importance of FDI for the CE4. The stock of FDI in the CE4 as a share of GDP—particularly from Germany—is substantially greater than in the SP, and a larger share was directed toward greenfield investments. In addition, CE4 FDI positions were higher in the manufacturing—especially the motor vehicles and other transport equipment—sectors in contrast to the SP.

24.   The second main result is that while foreign bank financing played a substantial role in the CE4, *cross-border* bank flows have been less pronounced (albeit still important). The instability of cross-border bank lending has been documented in several studies, and highlighted during the Lehman crisis when these flows reversed abruptly.

25.   In sum, it seems that German FDI flows helped in the transmission of beneficial medium-term spillovers to the CE4. There is evidence that the faster pace of income convergence in the CE4 was associated with the rapid expansion of exports from knowledge-intensive sectors Augustyniak and others (2013a). This supports the notion that German FDI not only provided vital funding, but was likely associated with technology transfers which promoted the development of the GCESC in particular, but durable longer-term growth more generally.

References

Augustyniak, B., C. Ebeke, N. Klein, and H. Zhao, 2013a, "The Germany-CE4 Supply Chain: Trade Linkages," *forthcoming, IMF Working Paper*, International Monetary Fund.

Calvo, G.A., 1998, "Capital Flows and Capital-Market Crises: The Simple Economics of Sudden Stops," *Journal of Applied Economics*, Vol. 1, No. 1, pp. 35-54

Cardarelli, R., S. Elekdag, and M.A. Kose, 2009, "Capital Inflows: Macroeconomic Implications and Policy Responses," IMF Working Paper 09/40.

Cardarelli, R., S. Elekdag, and M.A. Kose, 2009, "Capital Inflows: Macroeconomic Implications and Policy Responses," IMF Working Paper 09/40.

Catão, L., and G-M. Milesi-Ferretti, 2013, "External Liabilities and Crises," IMF Working Paper 13/113.

Cerutti, E., 2013, "Banks' Foreign Credit Exposures and Borrowers' Rollover Risks Measurement, Evolution and Determinants," IMF Working Paper 13/9.

International Monetary Fund, 2007, "Managing Large Capital Inflows" World Economic Outlook, Chapter 3, October.

International Monetary Fund, 2011, "International Capital Flows: Reliable or Fickle?" World Economic Outlook, Chapter 4, April.

Appendix: OCEE: Bank Claims, FDI Stocks, and Portfolio Positions

As shown in the figure below, the other Central and Eastern European countries (OCEE: comprising Bulgaria, Croatia, Estonia, Latvia, Lithuania, Romania, Slovenia, and the Ukraine) display patterns closers to the CE4, but with lower stock positions.

Appendix Figure. Bank Claims, FDI Stocks, and Portfolio Positions
(Percent of GDP)
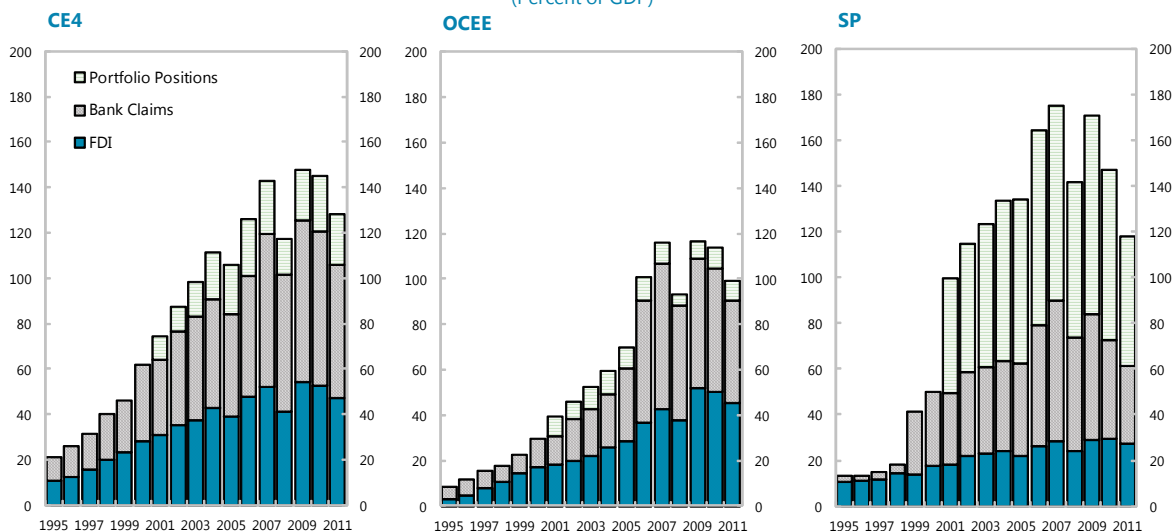
Sources: OECD; BIS (consolidated banking statistics); and CPIS.

INTERNATIONAL MONETARY FUND

July 1, 2013

GERMAN-CENTRAL EUROPREAN SUPPLY CHAIN CLUSTER REPORT—THIRD BACKGROUND NOTE—THE ROLE OF FUNDAMENTALS AND POLICIES

Approved By
[EUR Department]

Prepared By S. Elekdag (EUR) and D. Muir (RES)

CONTENTS

INTRODUCTION

1.   **A dynamic supply chain is thriving in the center of Europe.** As discussed in Augustyniak and others (2013a), geographic proximity, cultural similarities, and labor cost differentials are factors which have led many German firms to shift large parts of their production to the Czech Republic, Hungary, Poland, and Slovakia (hereafter, the CE4). The deepening economic integration between Germany and the CE4 has been associated with the development of a vibrant supply chain, and will henceforth be referred to as the German-Central European Supply Chain (GCESC).

2.   **Motivated by these developments, this paper comprises two parts, focusing on two broad questions:**

- The first part concentrates on the implications of greater economic interconnectedness owing to the establishment of the supply chain. How has deeper supply chain integration affected the nature of spillovers over time stemming from various global and regional shocks? What role is there for policies?

- The second part of the paper highlights how German fundamentals can affect spillovers to the supply chain. Along with its central position in the supply chain—in part owing to its safe haven status and robust balance sheets—does Germany act as an anchor of stability by helping the region better cope with external shocks?

3.   **This paper provides quantitative answers to these questions using model-based simulations**. In particular, policy implications are gleaned from counterfactual simulations generated using the IMF's GIMF model, which is a multi-country dynamic stochastic general equilibrium model (Kumhof and others, 2010). A six-region version of the model is utilized, comprising (i) Germany, (ii) CE4, (iii) the euro area excluding Germany, (iv) the United States, (v) an emerging Asia block, and (vi) the rest of the world, with the CE4 (the Czech Republic, Hungary, Poland, and Slovakia) taken together as a region. While the CE4 is taken as a single entity, in reality differences across these four countries should be recognized. For example, despite having the largest GDP, Poland is also the least open CE4 economy. Nevertheless, the six-region version of the model is appropriately calibrated to capture, for example, the changing strength and nature of trade linkages across the GCESC. Then, simulations trace out the transmission of global and regional shocks on real GDP under various model calibrations underpinning the policy implications of the paper.

4.   **The model-based simulations yield several policy implications, and can be summarized as follows:**

- **German fiscal stimulus is likely to have a relatively small impact on the CE4**—and more broadly, to the rest of the euro area. As a reflection of strengthening trade linkages, German spillovers to the CE4—including those related to fiscal policy—have increased over time, but

remain relatively limited. This is explained by the supply chain nature of trade integration: final demand in Germany is not necessarily the main determinant of CE4 exports to Germany.

- **Germany and the CE4 are now more exposed to global shocks**, as a result of greater trade openness, as Germany and the CE4 have integrated with the world, as well as with each other.

- **Germany plays the role of a regional anchor of stability**, however, by better absorbing shocks from other trading partners instead of amplifying their transmission across the GCESC, owing to its strong fundamentals—including sound balance sheets and its safe haven status.

- **More generally, sound balance sheets have positive benefits domestically and in terms of spillovers**. With more fragile balance sheets, domestic shocks result in lower growth both at home and abroad. Therefore strengthening household, corporate, and sovereign balance sheets is important for countries and their trading partners—especially those with even tighter trade links owing to a supply chain arrangement.

5.   **The remainder of the paper is structured as follows:** The next section provides an overview of the IMF's GIMF model and its calibration. Section III focuses on the main results of the paper and comprises two parts. The first part assesses the implications of deepening trade integration in the context of the GCESC, while the second part concentrates on illustrative counterfactual scenarios which highlight the role of balance sheets in amplifying the impact of growth shocks and the attendant spillovers. The final section concludes by summarizing the main results and underscoring the key policy implications.

MODEL

6.   **The main policy implications of the paper are derived from simulations using the IMF's Global Integrated Monetary and Fiscal (GIMF) model**. This section comprises two parts, with the first providing an overview of GIMF, with further details relegated to the Appendix. The idea is to provide enough intuition to understand the gist of the simulations, while leaving most of the details to Kumhof and others (2010) and Andersen and others (2013). The second part of this section provides a summary of the parameterization of GIMF, primarily focusing on the calibration of the trade matrix and key balance sheet indicators.

A.   Overview

7.   **GIMF is a multi-region dynamic stochastic general equilibrium (DSGE) model with optimizing behavior by agents**. As shown in Figure 1, GIMF has several sectors with multiple optimizing agents. Households have finite planning horizons, and some are liquidity constrained, generating non-Ricardian features which imply non-neutrality in spending- and revenue-based fiscal measures, making GIMF suitable to analyze fiscal policy issues. Firms are owned domestically, and

employ capital and labor to produce tradable and nontradable intermediate goods. An annual version of the model is used, which significantly reduces the computation burden the simulations require.[1]

8.   Weaker balance sheets can magnify the domestic impact of shocks, but also amplify the spillovers across borders. The health of household, corporate, and sovereign balance sheets matter in GIMF, in part, owing to incomplete asset markets. In particular, there is a financial sector a la Bernanke, Gertler and Gilchrist (1999), which incorporates a procyclical financial accelerator, with the cost of external finance facing firms rising with their indebtedness. Greater corporate leverage implies a more procyclical external finance premium, and therefore a more powerful financial accelerator. In this way, shocks can drive up the real cost of investment quite rapidly, resulting in a sharp contraction of economic activity.[2]

9.   Fiscal and monetary policies play an important role in economic stabilization. This is because of finite planning horizons, liquidity-constrained households, and other real and nominal frictions. For example, government debt is only held domestically, as nominal, non-contingent, one-period bonds denominated in domestic currency. The only assets traded internationally are nominal, non-contingent, one-period bonds denominated in U.S. dollars that can be issued by the U.S. government and by private agents in any region. Equity is not traded in domestic financial markets; instead, households receive lump-sum dividend payments.

---

[1] This version of GIMF abstracts from oil prices, but could be added along the lines of Elekdag and others (2008) to investigate the implications of terms of trade shocks on the GCESC.

[2] For further details on the financial accelerator mechanism—especially in the context of small open economies—see Elekdag and others (2006) and Elekdag and Tchakarov (2007) and the reference therein.

Figure 1. A Two-Country Representation of the GIMF Model
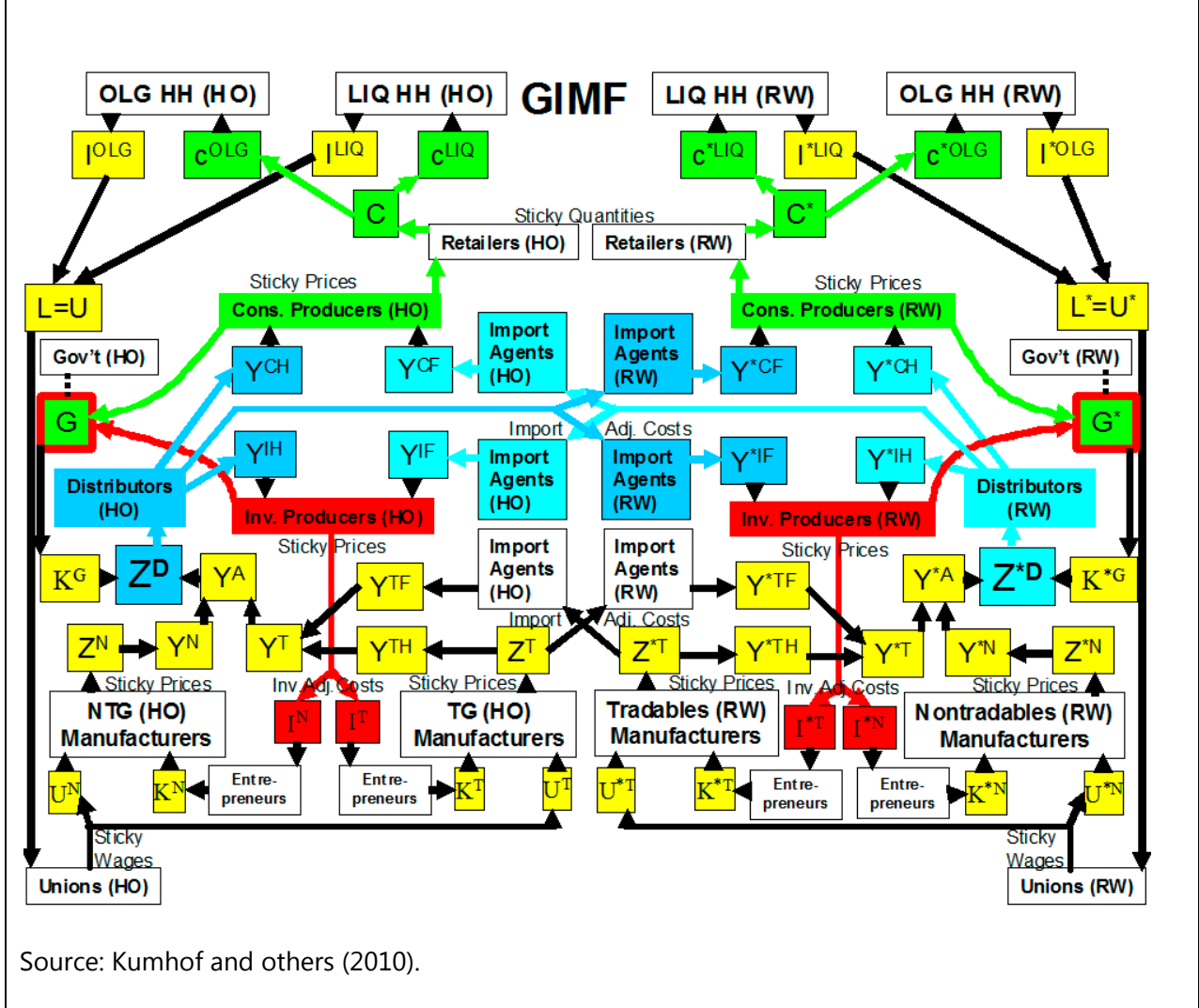
Source: Kumhof and others (2010).

B. Calibration

10.   A six-region version of GIMF is utilized. These regions are (i) Germany, (ii) CE4, (iii) the euro area excluding Germany, (iv) the United State, (v) an emerging Asia block, and (vi) the rest of the world, where the CE4 (the Czech Republic, Hungary, Poland, and Slovakia) would be taken together as a region. While the CE4 is taken as a single entity, in reality differences across these four countries should be recognized. For example, despite having the largest GDP, Poland is also the least open CE4 economy.

11.   The model is calibrated to realistically account for the changes in the trade ties across the GCESC. Each region in GIMF exports and imports both final (consumption and investment) and intermediate goods. In this way, the changing trade relationship between Germany, the CE4, and other key trading partners can be appropriately captured in the model. Relative prices, including exchange rates, are also modeled, and in part, influenced by policies.

12.   The strength and nature of the trade channel linking the GCESC has changed over time. A summary of GIMF's trade matrix is shown in Table 1. It compares the state of trade linkages in 1996 with that in 2011 (the benchmark calibration), and highlights a few interesting developments.

- First, exports as a share of GDP has increased in Germany and in the CE4. In other words, both regions have become much open, and therefore integrated with the global economy.

- Second, exports to each other have increased dramatically. Note the rapid growth of CE4 exports to Germany from 1996 to 2011.

- Third, and relatedly, as a reflection of deeper regional trade integration, intermediate exports across the GCESC have increased substantially.[3] The growth in intra-supply chain trade owing to the exchange of intermediate goods implies that final demand in Germany is not necessarily the main determinant of CE4 exports to Germany. This insight will be crucial when interpreting how spillovers across the region have evolved over time.

13.   An alternative calibration is used to assess the role of sound German balance sheets. In order to gauge the implicit stabilization benefits to the GCESC owing to strong German fundamentals—including sound balance sheets and its safe haven status—an illustrative scenario is developed which simulates the German economy with more fragile balance sheets as discussed below. Specifically, households are calibrated to be more liquidity constrained, corporate more leveraged, and the government more indebted along the lines of regional economies with less robust fundamentals. Weaker corporate balance sheets, for example, strengthen the financial accelerator mechanism as discussed above, and thereby make the economy more sensitive to shocks. At the same time, a loss of Germany's safe haven status is assumed, and given the backdrop of more fragile balance sheets, implies higher sovereign yields, in turn, raising those in the corporate sector.

Table 1. Summary of the Trade Matrix: 1996 versus 2011
(Exports in percent of nominal GDP unless otherwise stated)

	1996		2011	
	CE4	Germany	CE4	Germany
Total exports	30.1	24.3	52.8	47.7
to CE4		1.4		4.5
to Germany	8.4		16.6	
Final goods	21.4	17.8	38.9	35.0
to CE4		0.9		2.8
to Germany	6.0		11.2	
Intermediate goods	8.7	6.5	13.9	12.3
to CE4		0.5		1.6
to Germany	2.4		5.4	
Size (In percent of world GDP)	0.9	8.0	1.4	5.1

Sources: IMF Direction of Trade Statistics; United Nations ComTrade; and authors' calculations.

---

[3] While not shown, in 2011, Germany exports a substantial amount of intermediate goods to the rest of the euro area (5.3 percentage points of GDP). It should be noted however, that these goods are not necessarily associated with a vertical integration, while the intermediate exported to the CE4 most likely are closely related to the GCESC as emphasized in Augustyniak and others (2013a).

RESULTS

14.   This section presents the main results of the paper and comprises two parts: The first part concentrates on the implications of the evolving strength and nature of the trade channel linking the GCESC with each other, and with its main trading partners. It gauges how German spillovers to the CE4, and to the rest of the euro area, have changed over time. The second part assesses the extent to which, owing to its strong fundamentals—including sound balance sheets and its safe haven status—Germany plays the role of a regional anchor of stability by better absorbing shocks from other trading partners instead of amplifying their transmission across the GCESC.

A.   Spillovers: How Has the Supply Chain Changed Them?

Aggregate Demand Shocks

15.   Spillovers associated with aggregate demand shocks vary across regions and have changed over time. Figure 2 shows the peak impact to a 1 percent aggregate demand (private consumption and investment) shock originating either in Germany, or the non-European blocks of the model (Emerging Asia, the U.S., and remaining countries). This shock is motivated by the collapse of world trade during the global financial crisis of 2008-09. It shows the percent deviation of real GDP from baseline in Germany and in the CE4 region. The shocks are simulated using the trade matrix calibrated to match trade flows occurring in 1996 or 2011. In sum, a regional (German) or global (non-European blocks) aggregated demand shock is simulated under two calibrations of the trade matrix.[4]

Figure 2. Aggregate Demand Shock
(Real GDP, percent deviation from baseline)

Source: IMF staff calculations.

---
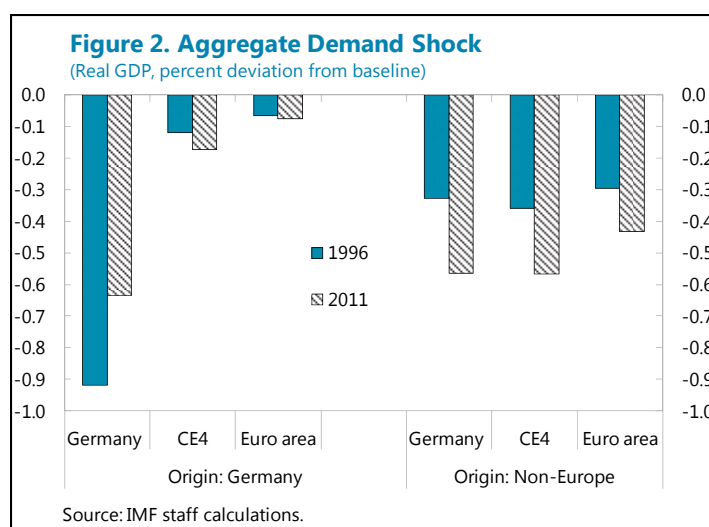
[4] The appendix briefly discusses a canonical supply shock, that is, a disturbance to total factor productivity.

16.   An aggregate demand shock of similar magnitude yields a smaller contraction in German output in 2011 relative to 1996. To be clear, what is under consideration is the domestic impact of an aggregate demand shock on real GDP originating in Germany. One factor behind this result is that German openness has increased over the period spanning 1996 to 2011; indeed, over this period, the export-to-GDP ratio has risen to around 48 percent from 24 percent (Table 1). Because Germany is more open in 2011, the economy is characterized by more "leakage" and therefore a lower impact multiplier. At the same time, the demand shock brings about a slowdown which puts downward pressure on inflation, and is therefore characterized by a depreciation of the real effective exchange rate. In 2011, a smaller change in relative prices is associated with a larger increase in net exports, and thereby helps stabilize GDP to a greater extent.

17.   German spillovers to the CE4, while still relatively small, have increased over time. In terms of spillovers, notice the larger impact on CE4 real GDP owing to an aggregate demand shock originating in Germany in 2011 as contrasted to 1996. A key determinant driving this result is greater economic integration owing to the supply chain. While greater integration strengthened the trade channel to an extent, spillovers are still limited because greater intra-supply chain trade occurred to a large degree through the exchange of intermediate goods. This implies that final demand in Germany is not necessarily the main determinant of CE4 exports to Germany.

18.   German spillovers to the rest of the euro area remain quite negligible. The transmission of German aggregate demand shocks to the rest of the euro area are small, and have not changed over time because of two reasons: First, the extent of trade between Germany and the rest of the euro area has not increased as much as it has between members of the GCESC. Second, while the CE4 is small in terms of economic size relative to German, the rest of the euro area is much larger. Therefore, the impact of a German shock is much smaller as a share of GDP in the rest of the euro area.

19.   Because the GCESC has become more open, spillovers from the rest of the world are now much larger. For non-European demand shocks (which with a modest exaggeration could be termed "the rest of the world"), real GDP in both Germany and the CE4 dips below baseline by more in 2011 than in 1996. This is because both economies have become more open, and are thus more susceptible to fluctuations in global economic activity (Table 1). The larger downturns are compounded by indirect effects because intra-European economic activity slows down, and thus acts as an additional drag on growth.

20.   More generally, spillovers to the CE4 from the rest of the world are greater than those from Germany. Given deepening regional integration one would expected that German shocks would have a larger impact on the CE4 (and the rest of the euro area more broadly) relative to shocks from the rest of the world. However, as highlighted in Figure 2, this is not the case. The differing impacts of the shocks originating in either Germany or the rest of the world are especially pronounced in 2011. There are three principal reasons underpinning these differences:

- First, and most importantly, while Germany accounts for five percent of global GDP in 2011, the rest of the world makes up about 80 percent of worldwide output. Because the rest of the world

is economically larger, its impact on global GDP will be proportionate, and bring about a deeper recession.

- Second, and as discussed above, Germany, the CE4, and the rest of the euro area are now much more open economies, and thereby more sensitive to global business cycle fluctuations.

- Third, and relatedly, as noted above, deeper regional integration in the context of the GCESC was characterized by a substantial increase in the trade of intermediate goods. This implies that a greater share of CE4 exports is now dependent on final demand in the rest of the world relative to Germany—another reason why the CE4 is more exposed to global growth shocks.[5]
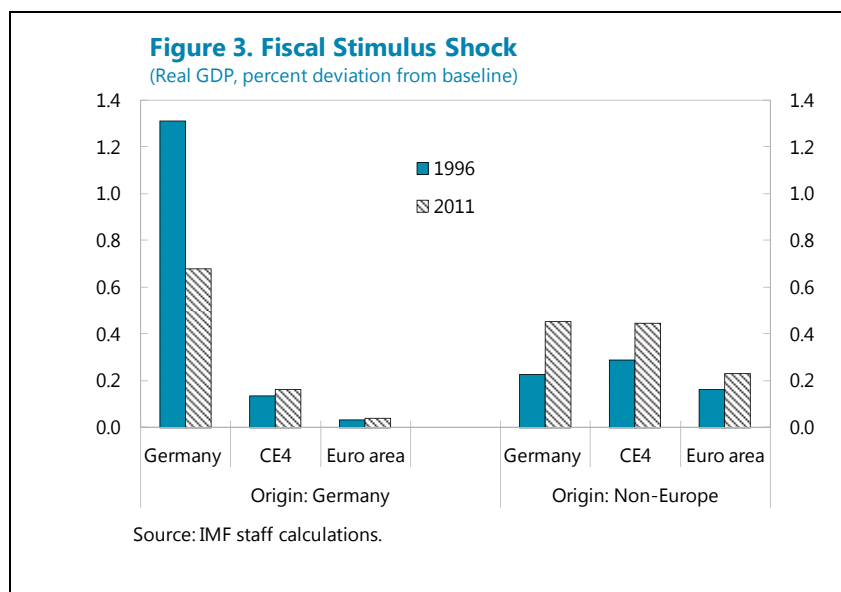
21. **In sum, greater trade openness has increased the economies of Germany and the individual CE4 countries to global shocks**. In fact, for Germany, when measured in terms of final demand (by explicitly accounting for domestic value added content of exports), while the European Union is still its largest trading partner, exposures to China and the U.S. are larger than what gross trade statistics suggest as noted in Augustyniak and others (2013a). While growth in Germany and the CE4 is likely to have benefitted from closer trade ties to these relatively faster growing regions, the GCESC countries have also become more sensitive to global trade downturns as witnessed by the experience of 2008/09.[6]

Fiscal Stimulus Shocks

22. **Given its implications for policy, fiscal stimulus shocks are considered**. As before, shocks originating in Germany or the non-European regions (Emerging Asia, the U.S., and remaining countries) are considered for two separate calibrations of the trade matrix (1996 or 2011). The fiscal policy shock under consideration is a debt-financed two-year 1 percentage point increase in government consumption set to stimulate domestic demand. In other words, this is another type of aggregate demand shock, and so would have similar properties to the shock discussed above (Figure 2).

---

[5] As emphasized by Augustyniak and others (2013a), using value added exports suggests that even a greater share of CE4 final demand is coming from the rest of the world in contrast to Germany.

[6] Although not modeled in GIMF, increasing exposure to the outside world has been accompanied by concentration risk in certain sectors such as automobiles. An external shock that had a large differential impact on the automobile sector (such as an energy shock), could have a disproportionately large impact on GCESC countries.

Figure 3. Fiscal Stimulus Shock
(Real GDP, percent deviation from baseline)

Source: IMF staff calculations.

23.   The growth impact of a domestic fiscal stimulus has changed over time. While an increase in domestic government consumption used to raise real GDP above baseline by about 1.3 percent in 1996, in 2011 the impact has declined to a deviation from baseline of around 0.7 percent. As before, because of the increased openness of the German economy, the economy overall, is subject to a greater degree of leakage.[7]
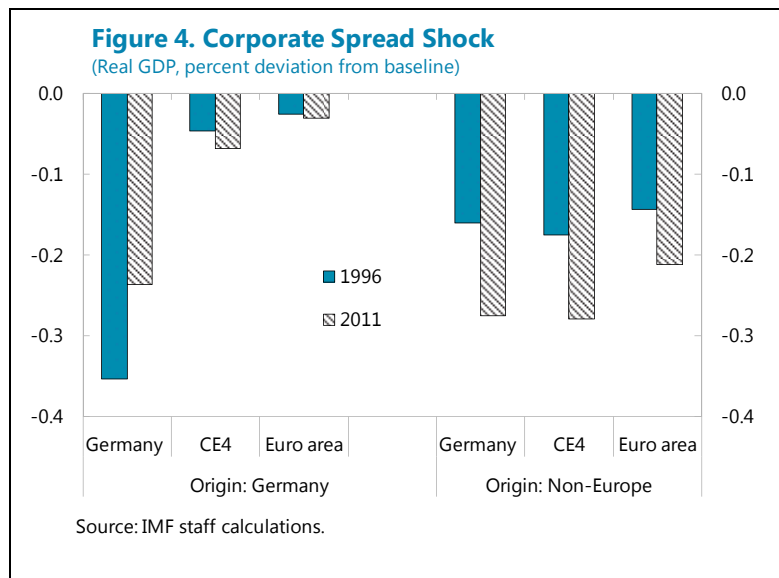
24.   German fiscal stimulus is associated with small spillovers. While rising over time, the increase in German government consumption appears to have a relatively small impact on the CE4 and the rest of the euro area. As shown in Figure 3, the simulations suggest that the maximum impact of the fiscal stimulus on the CE4 results in a real GDP deviation from baseline of about 0.13 percent and 0.16 percent in 1996 and 2011, respectively.

25.   Limited fiscal spillovers stemming from a German stimulus is a key policy implication of this paper. As highlighted above, small fiscal spillovers are explained by the supply chain nature of the regional trade integration: final demand in Germany is not main determinant of CE4 exports to Germany. This finding is in line with other studies, including Ivanova and Weber (2011), and echoes those presented in Kumhof and others (2010), and Vitek (2012). As noted in Ivanova and Weber (2011) and underscored here, despite greater regional integration, trade links are weak for countries that are relatively small compared to Germany (for example, Greece, Portugal), while the countries with relatively stronger trade ties (including Italy and Spain) are also the ones that closer to Germany in economic size. However, as before, because the members of GCESC are more open, they are more sensitive to a concerted global fiscal stimulus, that is, a simultaneous increase in government spending by the non-European regions as shown in the right-hand side of the figure.

---

[7] The sectoral (that is, traded versus nontraded) composition of government spending in the scenarios has not changed.

Financial Shocks

26.   Financial shocks are broadly similar to the aggregate demand shocks discussed above, with the exception that their impacts on real GDP tends to linger. The shock under consideration in Figure 4 is a 100 basis point exogenous increase in the corporate external finance (risk) premium. Higher spreads bring about a contraction in aggregate demand as higher borrowing rates increase the opportunity cost of investment and thereby suppress capital expenditures by firms. In turn, weaker economic activity impairs corporate balance sheets, increases their risk profile and triggers an endogenous increase in the external finance premium. The extent to which this reduces investment depends, in part, on the degree of corporate leverage, and thus determines the strength of the financial accelerator mechanism. While not obvious from the summary bar charts, even though this shock is similar to that to aggregate demand, the effects on GDP are more protracted as the shocks requires an adjustment of corporate balance sheets, that is, a process of deleveraging. Weaker corporate balance sheets—owing to higher debt ratios, for example—can amplify shocks by an even greater extent, and for much longer, and therefore even seemingly small shocks can bring about a disproportionate contraction in output.


Figure 4. Corporate Spread Shock
(Real GDP, percent deviation from baseline)

Source: IMF staff calculations.

Summary

27.   The results thus far could be recapped as follows: As a reflection of evolving nature of trade linkages, owing to an important degree to the establishment of the GCESC, spillovers from Germany to the CE4, have increased over time, but are still quite small. The limited fiscal spillovers are explained by the supply chain nature of the regional trade integration: final demand in Germany is not main determinant of CE4 exports to Germany. This result has important policy implications. For example, fiscal stimulus in Germany is likely to have a relatively small impact on the CE4—and more broadly, to the rest of the euro area. Greater trade openness in both Germany and the CE4 implies greater exposure of the GCESC to global shocks.

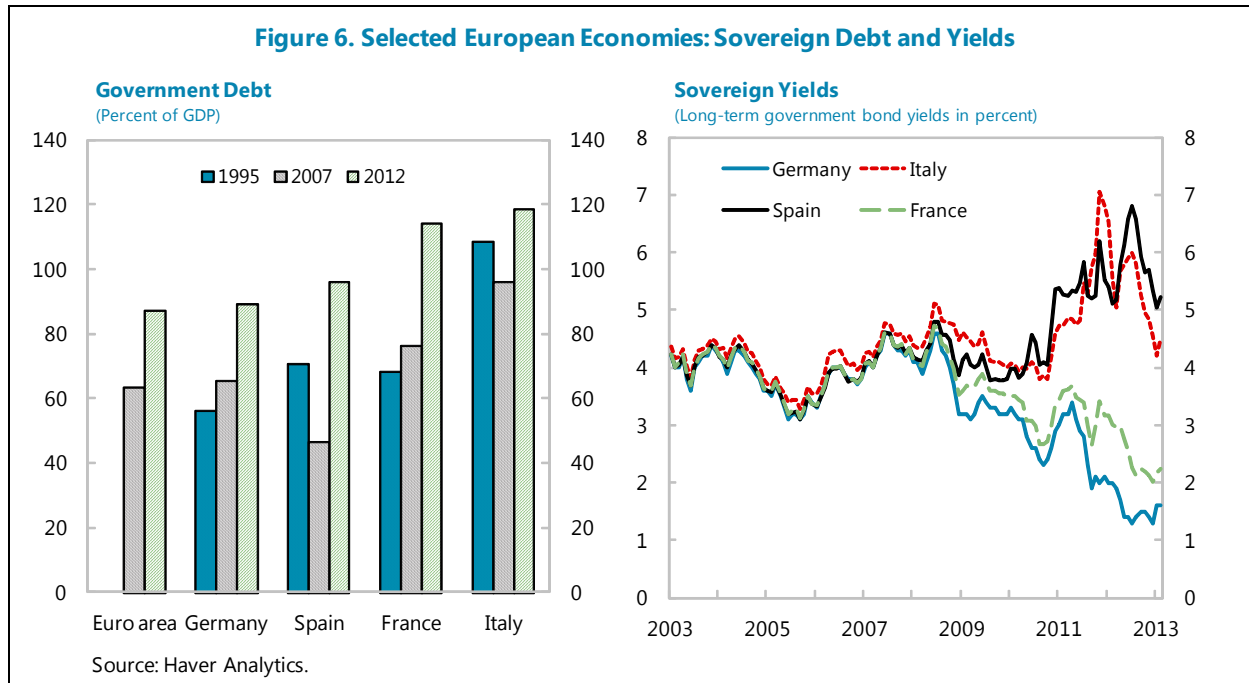## B.   Spillovers: What if German Balance Sheets Were More Fragile?

28.   The main goal of this subsection is to highlight how German fundamentals can affect spillovers to the supply chain. The question to be addressed is as follows: Along with its central position in the supply chain—in part owing to its safe haven status and robust balance sheets—does Germany act as an anchor of stability by helping the region better cope with external shocks? It will therefore be useful to first take stock of key German fundamentals, including its balance sheets.

29.   The German economy's balance sheets appear to be generally healthy. As a measure of balance sheet soundness—which is certainty not exhaustive or necessarily comprehensive—consider the debt-to-GDP ratio across sectors as shown in Figure 5. The balance sheets of the German non-financial corporate sector and especially households appear robust. At the same time, Germany's safe haven status supports the relative soundness of its public sector balance sheet (Figure 6). In fact, while the debt-to-GDP ratio in Germany increased after the global financial crisis, currently it is still lower than other large European economies. At the same time, the growing and persistent divergence in sovereign spreads between Germany and other economies in the region is noteworthy (and roughly around 500 basis points). This dynamic has been associated with the steep uptrend in household and corporate lending spreads for some large economies in the region (Figure 7), and clearly are a drag on consumption and investment growth.
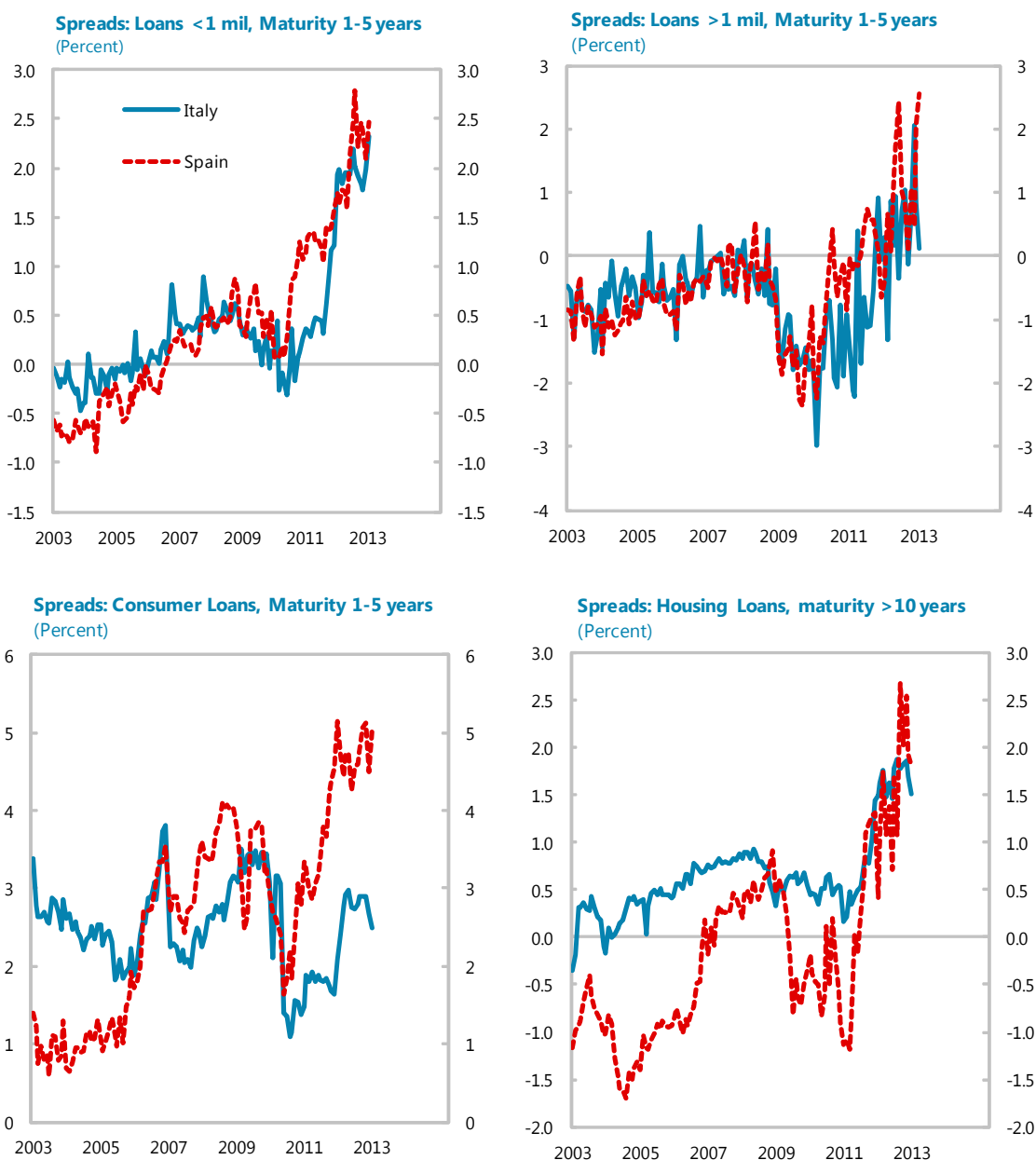
Figure 5. The Role of Balance Sheets: Debt-to-GDP Ratios Across Sectors
(Percent of GDP)

Source: OECD
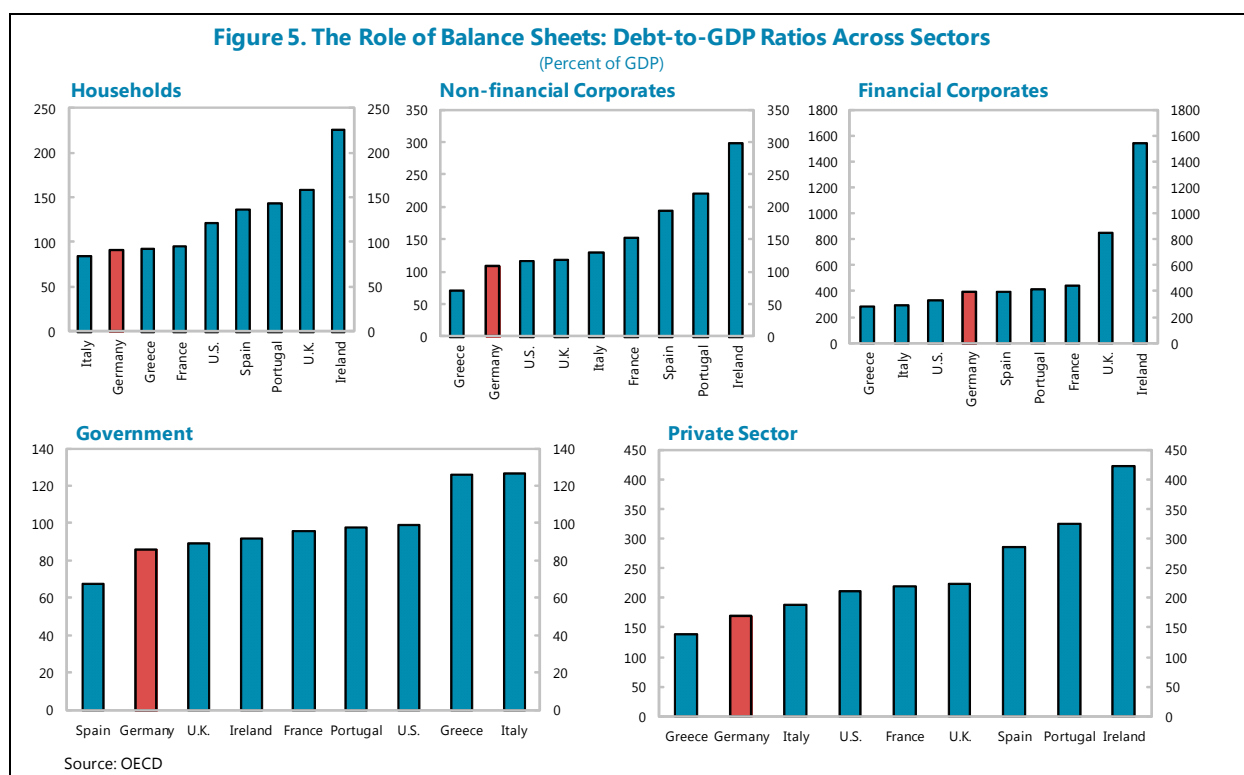
30.   An illustrative scenario is developed which simulates a German economy with more fragile balance sheets. An alternative calibration of the model is considered with weaker German household, corporate, and sovereign balance sheets. For example, the sovereign debt-to-GDP ratio is increased by 30 percentage points to match the indebtedness of large European economies. Similarly, corporate leverage ratios are also increased to match higher level prevailing in the region. At the same time, the share of liquidity constrained households is also raised to replicate economies with less efficient capital markets (which may reflect heightened financial stress or, for example, overextended household balance sheets). This illustrative scenario also assumes a loss of Germany's safe haven status, implying higher sovereign yields, and an attendant increase in corporate borrowing rates. Specifically, corporate spreads are assumed to increase by about 350 basis points, of which 150 basis points is transitory and 200 basis points more persistent owing to a structurally different economy (which is no longer a safe haven).
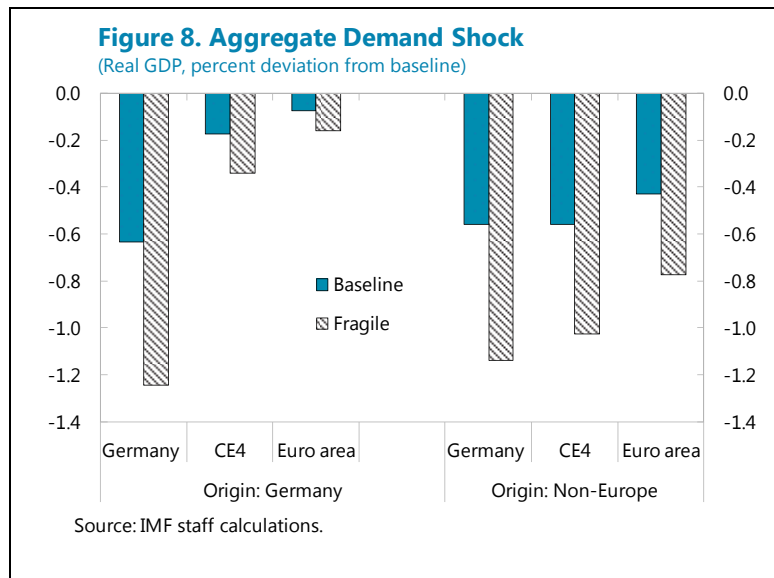
Figure 6. Selected European Economies: Sovereign Debt and Yields

Government Debt
(Percent of GDP)

Sovereign Yields
(Long-term government bond yields in percent)

Source: Haver Analytics.

Figure 7. Lending Spreads in Italy and Spain Relative to Germany

Spreads: Loans <1 mil, Maturity 1-5 years
(Percent)

Spreads: Loans >1 mil, Maturity 1-5 years
(Percent)

Spreads: Consumer Loans, Maturity 1-5 years
(Percent)

Spreads: Housing Loans, maturity >10 years
(Percent)

Sources: Haver Analytics; and IMF staff calculations.

31.   The simulations suggest that Germany plays the role of a regional anchor of stability. As before an aggregate demand shock originating in either Germany or the rest of the world (non-European blocks) is simulated as shown in Figure 8. The negative impact on real GDP triggered by the domestic shock is much larger when balance sheets are more fragile in Germany. As discussed above, one cause is because of a stronger financial accelerator mechanism. The loss of safe haven

status which was assumed to raise sovereign and thereby corporate yields is compounded by higher corporate leverage ratios, making the German economy much more sensitive to shocks, which is further exacerbated by elevated corporate credit spreads (increased external finance premium), a higher stock of government debt, and a greater share of liquidity constrained households. The larger economic contraction in German is also transmitted across borders as evident by more pronounced declines in real GDP in the CE4 and the rest of the euro area.[8] In turn, this wider European slowdown then has feedback effects on the GCESC countries.

Figure 8. Aggregate Demand Shock
(Real GDP, percent deviation from baseline)
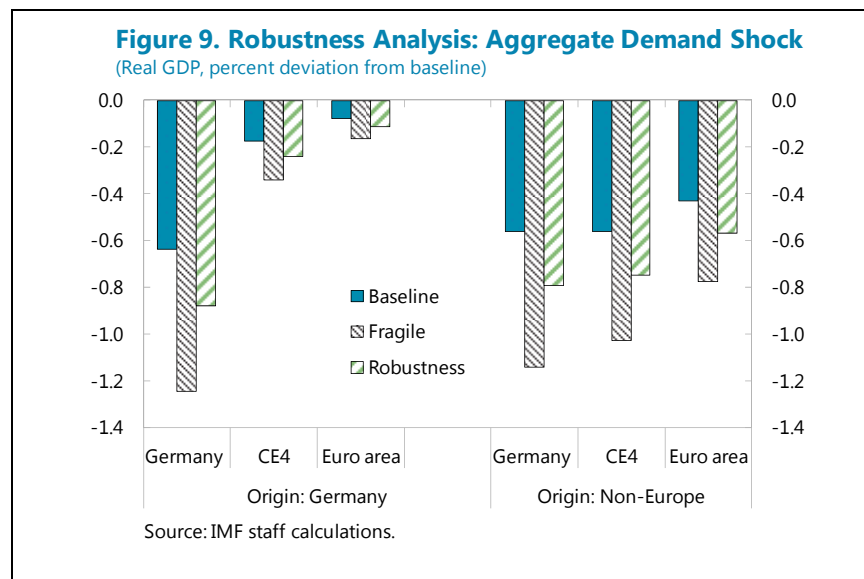
Source: IMF staff calculations.

32.   When German fundamentals are weaker, global shocks are associated with larger regional spillovers. This is because Germany is the largest economy in the euro area, and at the same time, very open to trade. In fact, the German economy is about 30 percent greater than the second largest economy in the euro area, and while Germany's openness is around 98 percent (exports plus imports as a percent of GDP), the average ratio for the next three largest economies (France, Italy, and Spain) is around 60 percent. Therefore, a German economy with more fragile balance sheets is less able to absorb global shocks, and in turn, may actually amply the transmission of the shocks across borders (especially to its closest trading partners).

33.   These findings are robust to alternative calibrations. While the alternative calibration which underpins the illustrative scenario just discussed is guided by empirical facts, it nonetheless involved an element of judgment. Therefore, the degree of balance sheet fragility in Germany is decreased to assess to sensitivity of this simulation. For example, the temporary increase in corporate spreads is now only 100 basis points, rather than 150 basis points. In the end, the main

---

[8] While note modeled explicitly, shocks could be further amplified owing to confidence effects, thereby further depressing aggregate demand.

message here is qualitative rather than quantitative: with weaker balance sheets, the simulated German economy's resilience is compromised.

Figure 9. Robustness Analysis: Aggregate Demand Shock
(Real GDP, percent deviation from baseline)

Source: IMF staff calculations.

Summary

34.   These results can be summed up as follows: Germany plays the role of a regional anchor of stability by better absorbing shocks from other trading partners instead of amplifying their transmission across the CE4 and the rest of the euro area, more generally, owing to its sound balance sheets and its safe haven status. At the same time, sound balance sheets have positive benefits domestically and in terms of spillovers.

CONCLUDING REMARKS

35.   This paper investigates aggregate demand and policy spillovers in the context of the GCESC. The GCESC has changed the strength and nature of the trade channel across member countries. Because stronger trade linkages have been built to an important extent through the exchange of intermediate goods, German spillovers to the CE4, while having increased over time, remain fairly limited. This has important policy implications. For example, regarding fiscal policy, this paper finds that German stimulus is likely to have a relatively small impact on the CE4—and more broadly, to the rest of the euro area. This is explained by the supply chain nature of trade integration: final demand in Germany is not necessarily the main determinant of CE4 exports to Germany.

36.   Germany and the CE4 have integrated with the world, as well as with each other. As a result of greater trade openness, Germany and the CE4 are now more exposed to global shocks. However, owing to its strong fundamentals—including sound balance sheets and its safe haven

status—Germany plays the role of a regional anchor of stability by better absorbing shocks from other trading partners instead of amplifying their transmission across the GCESC.

37.   More generally, sound balance sheets have positive benefits domestically and in terms of spillovers. With more fragile balance sheets, domestic shocks result in lower growth both at home and abroad. Therefore strengthening household, corporate, and sovereign balance sheets is important for countries and their trading partners—and likely even more so in the context of a supply chain arrangement.
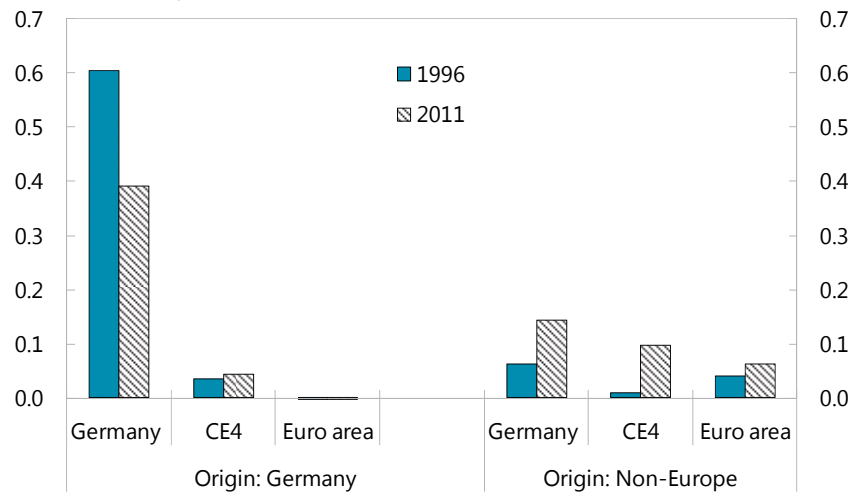
References

Anderson, D., B. Hunt, M. Kortelainen, M. Kumhof, D. Laxton, D. Muir, S. Mursula, and S. Snudden, 2013, "Getting to Know GIMF: The Simulation Properties of the Global Integrated Monetary and Fiscal Model," IMF Working Paper 13/55.

Augustyniak, B., C. Ebeke, N. Klein, and H. Zhao, 2013a, "The Germany-CE4 Supply Chain: Trade Linkages," *forthcoming, IMF Working Paper*, International Monetary Fund.

Augustyniak, B., C. Ebeke, E. Ebrahimy, and S. Elekdag, 2013b, "The Germany-CE4 Supply Chain: The Evolution of Financial Linkages," *forthcoming, IMF Working Paper*, International Monetary Fund.

Elekdag, S., A. Justiniano, and I. Tchakarov, 2006, "An Estimated Small Open Economy Model of the Financial Accelerator," *IMF Staff Papers*, Vol. 53, No. 2, pp. 219-41.

Elekdag, S., and I. Tchakarov, 2007, "Balance Sheets, Exchange Rate Policy, and Welfare," *Journal of Economic Dynamics and Control*, Vol. 31, pp. 3986-4015.

Elekdag, S., R. Lalonde, D. Laxton, and P. Pesenti, 2008, "Oil Price Movements and the Global Economy: A Model-Based Assessment," *IMF Staff Papers*, Vol. 55, No. 2, pp. 297-311.

Ivanova, A. and S. Weber, 2011, "Do Fiscal Spillovers Matter?" IMF Working Paper 11/211.

Kumhof, D., D. Laxton, D. Muir, and S. Mursula, 2010, "The Global Integrated Monetary Fiscal Model (GIMF)—Theoretical Structure," IMF Working Paper 10/34.

Vitek, F., 2012, "Policy Analysis and Forecasting in the World Economy: A Panel Unobserved Components Approach," forthcoming IMF Working Paper.

Appendix 1. The Impact of Persistent Productivity Shocks

While simulated productivity shocks are minimally transmitted across borders, Germany generates beneficial medium-term spillovers to the region. As discussed in Augustyniak and others (2013a), in the context of the GCESC, there is evidence that income convergence in these for countries was higher than the average pace. Higher growth in these countries was associated with technology transfers as the rapid expansion of CE4 exports were largely driven by the knowledge-intensive sectors and financed by a relatively greater share of FDI inflows from Germany. However, as shown in the figure below, models like GIMF (which are stationary around stochastic or deterministic trends) find it challenging to capture medium- and longer-term dynamics associated with knowledge transfers and income convergence.

Appendix Figure. Persistent Productivity Shock
(Real GDP, percent deviation from baseline)

Source: IMF staff calculations.