Spillover Effects of Germany's Final Demand on Southern Europe

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We calibrate a closed multi-country input-output model with data from the World Input-Output Database to predict spillover effects of Germany's final demand on GDP, employment, and the trade balance in Southern European countries. Spillover effects are found to be small. Germany alone is unable to make a significant contribution to the external adjustment process in the European South. A coordinated asymmetric expansion might help.

Keywords: euro area, macroeconomic imbalances, external adjustment, input-output analysis, global value chains, spillover effects

JEL codes: F14: Empirical Studies of Trade; F32: Current Account Adjustment, Short-Term Capital Movements; F42: International Policy Coordination and Transmission; F47: Forecasting and Simulation: Models and Applications; C67: Input-Output Models

1. Introduction

The euro area witnessed the emergence of large internal current account imbalances in the period leading up to the Great Recession. Euro member states such as Greece, Ireland, and Spain recorded relatively high growth rates, high inflation rates, and external deficits, while other countries, most prominently Germany, recorded low growth, low inflation, and external surpluses. Largely as a result of the expenditure collapse during the crisis, many of the former deficit countries today record small current account surpluses, but whether these can be maintained if and when growth picks up remains an open question (Tressel

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et al., 2014). A sustainable rebalancing process, it is frequently argued, requires the surplus countries to stimulate domestic expenditure and inflate wages and prices, and the deficit countries to moderate expenditure and deflate. There is no consensus about what is a just or economically sensible distribution of the burden of adjustment between surplus and deficit countries. In practice, deficit countries are stifled by debt; they often face financing constraints and are forced to adjust, whereas surplus countries hesitate to do so. Adjustment is "compulsory for the debtor and voluntary for the creditor" (Keynes in Joshi and Skidelsky, 2010, p.174). In this article we take as given that surplus countries should contribute to the rebalancing process, and we ask how much they can help to ease the burden of adjustment of deficit countries. We predict the size of *spillover effects* of Germany's final demand on GDP, employment, and the trade balance in deficit countries.

Reports by international institutions routinely emphasize the positive spillover effects of Germany's final demand on its trading partners in the euro area (e.g. IMF, 2015a; EC, 2015). The Bundesbank however argues that Germany can contribute little to stimulate economic activity in Southern Europe (Bundesbank, 2010). As Germany trades with a large number of countries, each bilateral trade flow is fairly small. A German expenditure boom, according to this argument, would diffuse in many directions and consequently the final effect on income and employment in individual countries in Southern Europe would be small.

To illustrate, the ratio of bilateral imports of goods and services by Germany from Spain (M_{ESP}^{DEU}) to German final demand (A^{DEU}) varied between 0.7 and 1.3 percent over 1991-2014. For the purpose of a preliminary guess, we treat this ratio as a parameter $m = M_{ESP}^{DEU}/A^{DEU}$ and we assume that it is higher than historically observed: $m = 0.02$, i.e. two cent of every euro spent by German residents on final goods and services are spent on Spanish goods and services. Given this parameter, if Germany's final demand were to increase by one percent over the level in 2014 (by 27 billion euro), Spain's exports to Germany would rise by 549 million euro, which amounts to 0.05 percent of Spain's GDP in 2014.[1]

This guess ignores obvious repercussions. On the one hand, Spain's GDP would rise by less than 0.05 percent because the additional production of Spanish exports would require imported intermediate goods, and the factor income generated by additional production would induce an increase in Spanish imports for consumption purposes. On the other hand, Spain's GDP would rise by more than 0.05 percent because the German expenditure boom would generate income and expenditure in third countries that trade with Spain and would import products from Spain, and a Keynesian multiplier process would increase consumption expenditure in Spain, Germany, and third countries. In short, the prediction of spillover effects calls for the use of an economic model that, at the very least, captures multiplier effects and global value chains.

The input-output model is well suited to this task. The model, which represents a country's industrial structure in a matrix of inter-industry flows of intermediate goods,

[1] Appendix C lists the data sources.

can be used to predict the effects of an exogenous shock to final demand on income and employment (e.g. Leontief, 1986; Miller and Blair, 2009). A multi-country input-output model takes into account not only the structural relations between domestic industries but also the structural relations between industries in different countries. With sufficient information on the inter-industry flows of intermediate and final goods within and across countries, it can be used to predict spillover effects, that is, the response of economic variables in one country triggered by an exogenous increase in final demand in another country.

EC (2012) uses the input-output model to predict spillover effects of Germany's final demand on the trade balances of individual countries in the euro area. Ederer and Reschenhofer (2016) use it to analyze the historical evolution of trade balances in the euro area from 1995 to 2011, and to predict the spillover effects of hypothetical final demand shocks in Germany on certain country groups (e.g. Western and Southern Europe). These studies are based on the *open* input-output model that treats final demand as entirely exogenous. In this article we use the *closed* input-output model that endogenizes the consumption expenditure of households. The endogenous increase in consumption expenditure in response to higher household income represents an *induced effect* that is missing from the open model and that strengthens the effects of final demand shocks. We go beyond those earlier studies and explore the temporal stability of the Leontief inverse and Germany's final demand composition in order to assess the extent to which the results derived from historical data generalize to today.

Our predictions complement existing ones derived from Dynamic Stochastic General Equilibrium (DSGE) models (In't Veld, 2013; Elekdag and Muir, 2014; IMF, 2015b). DSGE models are grounded in theory; they incorporate a wide range of behavioral details and emphasize forward-looking decision making by rational agents. The typical DSGE model relates aggregate quantities to one another (e.g. aggregate consumption) and has to be content with taking broad country groups as the unit of analysis (e.g. six regions of the world economy). The input-output model is grounded in data; the main advantage is the use of country-specific information on a low level of aggregation. While the ultimate goal of this article is the prediction of *aggregate* spillover effects by country, the unit of analysis is the industry and the structural relations are calibrated using disaggregated data. The World Input-Output Database (Timmer et al., 2015), the main data source of this article, facilitates the calibration of input-output models with 41 countries and 35 industries per country.[2]

We are concerned with problems of external adjustment in the euro area and we report results for the EA11, nonetheless the predicted spillover effects depend on the entire structure of the world economy.[3] The spillover effect of Germany's final demand on Spain's GDP, for instance, includes the direct, indirect, and induced demand for Spanish goods

[2]The WIOD covers 40 countries and includes a model for the rest of the world, so there are no black holes and the database accounts for global production.

[3]The EA11 is made up of the early euro member states minus tiny and exceptional Luxembourg: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain.

and services by producers and end-users in Spain, Germany, and the rest of the world.

Our main finding suggests that if Germany's final demand were to increase by one percent, France, Italy, Spain, and Portugal's GDP would grow by 0.05 to 0.06 percent, the unemployment rate would be reduced by 0.05 to 0.07 percentage points, and the trade balance would improve by approximately 0.03 percentage points. These spillover effects are small relative to those found for Germany's neighbors (e.g. Austria's GDP would increase by 0.16 percent), and they are small in absolute terms. In order to raise GDP in the European South by one percent, assuming no change in the structure of the world economy, the exogenous increase in Germany's final demand would need to be 20 percent. Our predictions are more than 50 percent higher than those reported in previous input-output studies; the endogenous increase in household consumption explains the difference.

We conclude that Germany alone is unable to make a significant contribution to the external adjustment process in the European South. A coordinated expansion in the euro area (and possibly beyond) might be necessary to restore growth and create jobs without undermining rebalancing efforts in the European South.

This article is structured as follows. Section 2 explains input-output analysis to the reader who is not familiar with the method; appendix A presents the input-output model using matrix algebra and states the formula for spillover effects. Section 3 describes the main data source, and section 4 presents the results. A thorough discussion of the results and policy conclusions can be found in sections 5 and 6. Appendix B explores the temporal stability of the results.

2. Method: A Closed Multi-Country Input-Output Model

The input-output model treats final demand as exogenous. It can be used to investigate to what extent changes in final demand, given the structural relations between industries, generate changes in other economic variables such as income and employment. This is known as *impact analysis*.[4]

The input-output model assumes that industries use inputs in *fixed proportions in the double sense*. The industries are assumed to use all inputs in fixed proportion to output (constant returns to scale), and they use all inputs in fixed proportion to each other (no factor substitution). In other words, the *technical coefficients*, which determine the quantities of inputs that are necessary to produce one unit of output, are fixed. The input-output model furthermore assumes that additional supply is always able to meet the exogenous increase in final demand – the economy operates below full capacity.

If the final demand for cars were to increase by 100 euro, how much would gross output/income/employment in all industries increase in order to meet the new demand? If the car industry did not use any inputs (if the technical coefficients of this industry were zero), 100 euro worth of additional production in the car industry would be sufficient to

[4] Miller and Blair (2009) describe the use of input-output models for impact analysis in greater detail. Appendix A states the input-output model mathematically.

satisfy the increase in final demand for cars. This is the *direct effect* of the final demand shock. But the car industry does use inputs from itself and from other industries, and the technical coefficients are not zero. The *indirect effect* represents a change in output/income/employment in industries that supply goods and services to the car industry. The increased output/income/employment in the rubber and plastics industry resulting from higher production in the car industry is an indirect effect of the change in the final demand for cars.

The *open* input-output model considers only direct and indirect effects. The *closed* input-output model recognizes that final demand is not entirely exogenous. Basic consumption theory predicts that higher household income causes higher consumption spending. A final demand shock will initiate additional production; additional production will require more labor input; the higher demand for labor services will increase labor income; and this will increase the amounts spent by households on consumption. In input-output economics, the endogenization of household consumption is known as closing the model with respect to households (imagine adding industry-specific Keynesian consumption functions to the input-output model). The *total effect* of an exogenous increase in final demand is composed of the direct, the indirect, and the *induced* effect. The induced effect represents the change in output/income/employment that arises from households spending the increased labor income earned in the car industry and in supporting industries.

The closed input-output model treats the household sector as if it was an industry. The labor input requirements, which are given by wages and salaries in proportion to industry output, are treated as technical coefficients. The more labor-intensive is production, the higher is the fraction of income that turns into additional consumption spending, and the larger will be the induced effect. The consumption coefficients, which are given by household consumption spending on industry output in proportion to total household income, are treated as technical coefficients. The input-output model "freezes" household consumption behavior and regards it as part of the economy's structure. The Keynesian consumption functions are industry-specific in the sense that the labor input requirements and consumption coefficients are industry-specific.

The multi-country input-output model represents an extension of the single-region model that does not alter the basic ideas in any way. A multi-country model that has two countries and two industries per country can be thought of as a single-region model that has four industries. Germany's final demand falls in part on the output of domestic industries, and in part on the output of foreign industries. If Germany's final demand increases, there are direct effects on output/income/employment in domestic and foreign industries. There are also indirect and induced effects in Germany and abroad as a result of increased intermediate goods demand by producers and increased consumption demand by households. The *spillover effect* of Germany's final demand on Spain measures the increase in Spanish output/income/employment that arises as a result of direct, indirect, and induced effects in the world as a whole. In other words, Germany's final demand shock triggers demand for Spanish intermediate goods by producers in Germany, Spain, and the rest of the world as well as demand for Spanish final goods by end-users in Germany, Spain, and the rest of the world.

3. Data: The World Input-Output Database

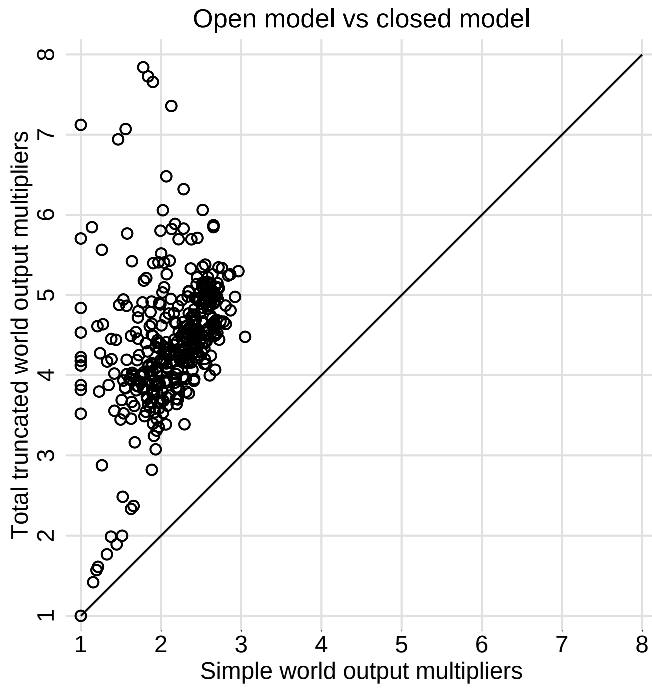
The data requirement of a closed multi-country input-output model is vast. The WIOD makes available World-Input-Output-Tables (WIOT) for $n = 35$ industries and $m = 41$ regions (40 countries and a model for the rest of the world) from 1995-2011 (Timmer et al., 2015). These tables report the flows of goods and services from industries to intermediate and final users, broken down by country of origin and by country of destination. The flows are measured in basic prices in current U.S. dollars. The tables assign values to all elements of the gross output vector $\mathbf{x}$ and the inter-industry flow matrix $\mathbf{Z}$. Given the data, we can compute the technical coefficient matrix $\mathbf{A}$ and the Leontief inverse $\mathbf{L}$.

The final demand columns of the WIOT are composed of final consumption expenditure, gross fixed capital formation, and changes in inventories. We disregard inventories. Final consumption expenditure is the sum of expenditure by households, non-profit organizations serving households (NPISH), and government. We aggregate households and NPISH and obtain $m = 41$ private consumption vectors $\mathbf{c}^r$. The final demand vector of country r is defined as the sum over the demand categories $\mathbf{f}^r = \mathbf{c}^r + \mathbf{g}^r + \mathbf{k}^r$, where $\mathbf{g}^r$ is the public consumption vector of country r, and $\mathbf{k}^r$ is the investment vector. Given the data, we can compute the total final demand of country r (f^r) and the demand composition vectors ($\mathbf{sf}^r$, $\mathbf{sc}^r$, $\mathbf{sg}^r$, $\mathbf{sk}^r$).

The WIOD provides auxiliary variables in the Socio-Economic Accounts (SEA). We use employment by industry, measured in persons engaged in production, for the employment vector $\mathbf{e}$; value added by industry, measured in basic prices in current national currency units, for value added vector $\mathbf{v}$; and labor compensation by industry, measured in current national currency units, for the labor input vectors $\mathbf{w}^s$. We convert domestic-currency values into dollars using the WIOD-provided market exchange rates. Given the data, we can compute the technical coefficients matrix of the closed model $\bar{\mathbf{A}}$ and the truncated Leontief inverse of the closed model $\bar{\mathbf{L}}$.[5]

The predicted spillover effects are based on the latest available data, which is from 2009. The WIOTs provide observations through 2011, but some of the auxiliary variables in the SEA that are necessary to close the model are only available until 2009. In the appendix we use values from 1995 to 2009 to explore the temporal stability of the results.

[5] Observations on labor compensation by industry in the rest of the world (ROW) are missing in the SEA. To close the model we have to impute the missing values: we assume that labor compensation per euro of output in each industry in the ROW is equal to the mean of emerging economies outside the European Union (Brazil, China, India, Indonesia, Mexiko and Turkey). The imputation is good insofar as the mean economic structure in these countries approximates the economic structure in the ROW. Regardless of whether we impute the minimum, the maximum, or the mean, the results for EA11 countries hardly change. The 40 countries that are included in the database make up 85 percent of world GDP in 2008 (at market exchange rates), so the WIOD does account for the vast majority of global value added and labor income, and the ROW is relatively small. Moreover, the trade ties between the EA11 and the ROW are relatively weak.



Notes: Each circle represents a particular industry in a particular country. The sample consists of 385 industry-country pairs (11 countries, 35 industries per country). The simple world output multipliers are derived from the open model and are computed according to equation 4; the total truncated world output multipliers are derived from the closed model and are computed according to equation 5. The mean of the simple multipliers is 2.2 (median 2.1), and the mean of the total multipliers 4.4 (median 4.4).

Figure 1: Closed model vs open model: A comparison of world output multipliers

4. Results

4.1. Closed Model vs Open Model

The closed model endogenizes the response of household consumption to increased income. Therefore the effects of equal-size final demand shocks on economic activity at home and abroad are larger in the closed model than in the open model. To assess the influence on the results, figure 1 compares the total truncated world output multipliers to the simple world output multipliers. Each circle in the scatter plot represents a particular industry in a particular country. If the total multipliers were exactly equal to the simple multipliers, all points would be located on the black diagonal line, but in fact they are located above and to the left of the diagonal line. On average the total multipliers are twice as large as the simple multipliers. Closing the model matters a lot.

The mean of the total multipliers in this 11-country sample is 4.4. If one additional euro were spent on the output of the average industry in the average EA11 country, gross output in the world as a whole (in all industries and all countries) would increase by 4.4 euro. Note that these are *gross* output multipliers which involve double-counting: the output of some industry i that is used as input in another industry j is included in the value of gross output of both industries. Ultimately we are interested in the effects of final demand shocks on value added, employment, and the trade balance – the subjects of the following sections.

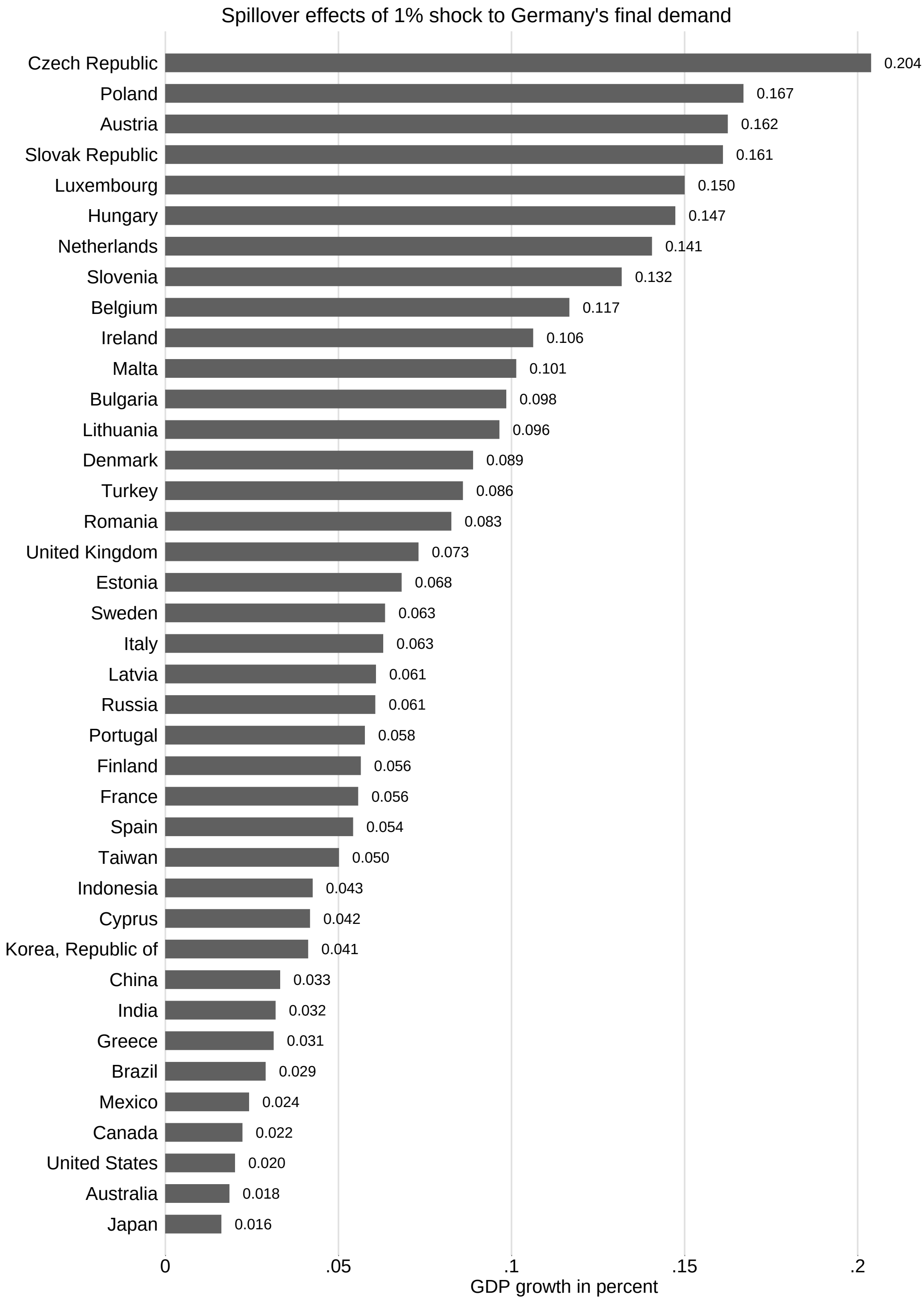
4.2. Spillover Effects of Germany's Final Demand

Figure 2 shows the spillover effects on GDP of a one-percent shock to Germany's final demand. To get a sense of relative magnitudes across the world, the figure shows the effect on all countries that are included in the WIOD (other than Germany itself and the rest of the world). The three countries that would benefit the most from a German demand boom are the Czech Republic, Poland, and Austria – countries that share a border with Germany. If Germany's final demand were to increase by one percent, the Czech Republic's GDP would grow by 0.2 percent. Note that spillover effects are relatively large for some emerging economies in Eastern Europe that are well integrated into German supply chains. The three countries that would benefit the least from a German demand boom are Japan, Australia, and the United States. These are large economies, and Germany is just one trading partner of many.

From now on we focus on the countries that make up the EA11. Figure 3 shows the spillover effects of a one-percent shock to Germany's final demand on GDP, employment, and the trade balance in the EA11. The countries are sorted by the size of the spillover effect on GDP. The correlation across the types of spillover effects is high: Greece records the smallest effect on employment and the smallest effect on the trade balance; Austria records the largest employment effect and the largest trade balance effect. The correlation is not perfect, e.g. the effect on Ireland's GDP is disproportionally larger than the effect on Ireland's unemployment rate.

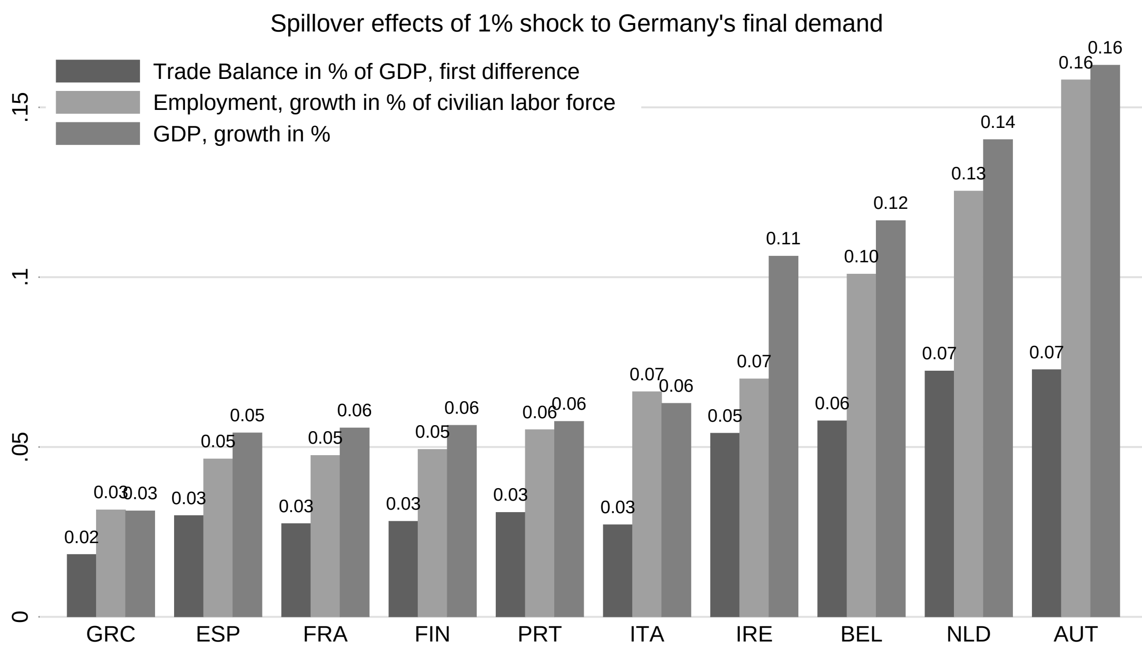
The EA11 countries that would benefit the most from a German demand shock are Austria, the Netherlands, and Belgium – three neighbors. If Germany's final demand were to increase by one percent, Austria's GDP would grow by 0.16 percent, the unemployment rate would be reduced by 0.16 percentage points, and the trade balance would improve by 0.07 percentage points. The spillover effect on Spain's GDP happens to be equal to the preliminary guess described in the introduction (0.05 percent). The countries that would benefit the least from a German demand shock are Greece, Spain, and France. If Germany's final demand were to increase by one percent, Greek GDP would grow by 0.03 percent, the unemployment rate would be reduced by 0.03 percentage points, and the trade balance would improve by 0.02 percentage points.

Overall we regard the magnitude of spillover effects as small. A 20-percent stimulus to Germany's final demand, assuming no change in the structure of the world economy, would raise the GDP in the South by approximately one percent. Former deficit countries in the EA11 cannot expect to benefit much from a German demand boom in terms of growth and



Notes: The spillover effects are computed according to equation 9 and are expressed as a percent growth rate ($\triangle v^s / v^s \cdot 100$).

Figure 2: Spillover effects on GDP of a one-percent shock to Germany's final demand, full sample



Notes: The trade balance effect is the first difference of the trade balance measured in percent of GDP ($\triangle TB$). The employment effect is expressed in percent of the civilian labor force – under the assumption that the labor force remains constant, it represents a percentage point reduction in the unemployment rate ($\triangle e^s/CLF^s \cdot 100$). The GDP effect is expressed as a percent growth rate ($\triangle v^s/v^s \cdot 100$).

Figure 3: Spillover effects of a one-percent shock to Germany's final demand, EA11

external adjustment.

How do these predictions compare to others in the literature? Ederer and Reschenhofer (2016) use the WIOD for the calibration of an open input-output model to execute an impact analysis. The model predicts that a 50-percent exogenous increase in final demand in Germany would eliminate the German trade surplus; the spillover effects of this German demand boom on GDP in Western and Southern Europe would amount to no more than one or two percent (Western and Southern Europe are understood as Belgium, Finland, France, Luxemburg, Cyprus, Greece, Spain, Ireland, Italy, and Portugal). Recall that the input-output model assumes constant returns to scale in production, so predictions can be compared simply by scaling up or down the hypothetical final demand shocks (the effects increase in proportion to the shocks). The closed model predicts that a 50-percent exogenous increase in Germany's final demand would lead to 2.4 percent higher GDP in Spain, 2.8 percent higher GDP in France, and 3.2 percent higher GDP in Italy. Our predictions are more than 50 percent higher than Ederer and Reschenhofer's.

EC (2012) use the open input-output model to predict the effects of a one-percent increase in Germany's final demand on the trade balances in other euro area countries. The study finds the trade balance of Spain, Italy and Portugal would improve by about 0.02 percentage points (the corresponding value for Greece is smaller). We find that the same shock would improve the trade balance of these countries by approximately 0.03 percentage points. While the spillover effects on GDP and employment are necessarily larger in the closed model, the spillover effects on the trade balance could in principle go either way. The induced response of household consumption in trading partner economies increases the revenue side of the trade balance through additional exports, while the induced response of domestic household consumption increases imports. The net effect is theoretically ambiguous; the data reveal that it is positive.

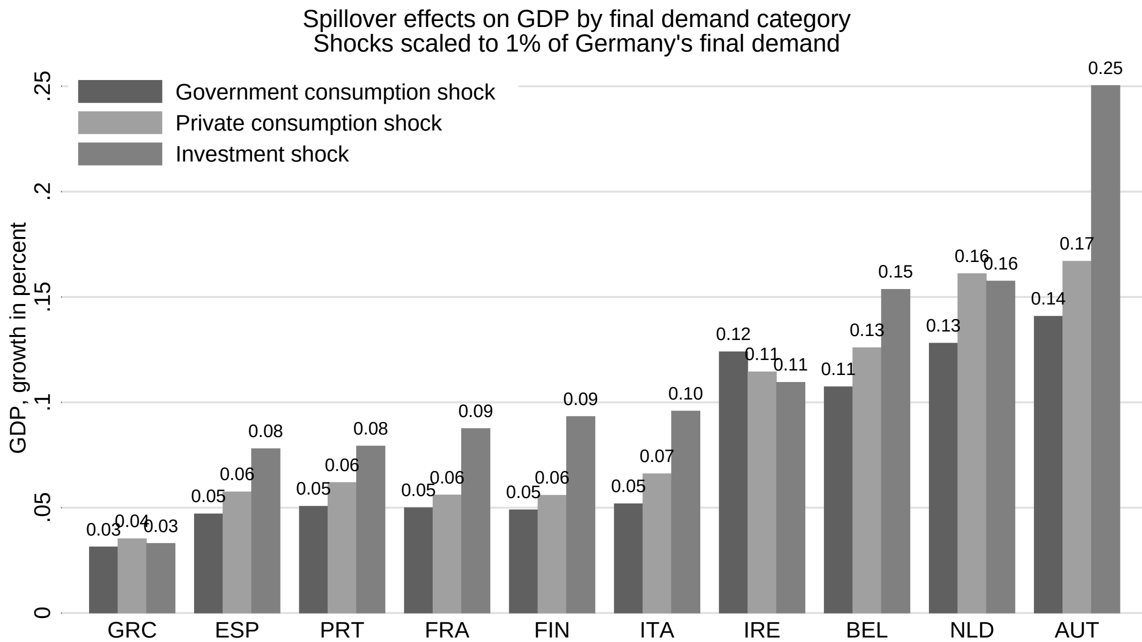
4.3. Spillover Effects by Final Demand Category

Figure 4 shows the spillover effects on GDP of equal-size final demand shocks broken down by final demand category.[6] The shocks are scaled to one percent of final demand ($0.01 \cdot f^r$), so the size of the spillover effects varies only because the composition of demand varies across final demand categories.

Germany's investment expenditure tends to generate the largest spillover effects, and government expenditure the smallest (Ireland, Netherlands, Greece represent exceptions to this rule). This finding mirrors a robust pattern that stretches across time and space: in general the import propensity is highest for investment expenditure, lowest for government expenditure, and consumption expenditure falls in between (Kennedy and Thirlwall, 1979; Bussière et al., 2013). Hence it is no surprise that the demand category which tends to induce the largest quantity of imports generates the greatest spillover effects.

While investment-induced spillover effects are relatively larger than final demand-induced

[6] We report only the spillover effects on GDP. The employment and trade balance effects bear no surprises.



Notes: The chart shows the spillover effects on GDP of equal-size German demand shocks computed according to equation 11. The shocks are scaled to one percent of Germany's final demand.

Figure 4: Spillover effects on GDP by final demand category, EA11

spillover effects, they remain small for countries in Southern Europe. This is true in particular for Greece. If Germany's investment expenditure were to increase by one percent of final demand, Greece's GDP would grow by merely 0.03 percent. The investment-induced spillover effects on Spain, Portugal, France, and Italy are larger, but they remain below 0.1 percent. Italy records the largest investment-induced spillover effect among the Southern European countries. The spillover effect on Austria is exceptionally large. If Germany's investment expenditure were to increase by one percent of final demand, Austria's GDP would grow by 0.25 percent.

How do these predictions compare to others in the literature? A comparison with predictions derived from DSGE models is not straightforward, because input-output models are static (the shocks are permanent) and DSGE models are dynamic (the shocks can be temporary or permanent, and the effects typically stretch over multiple periods). IMF (2015b) uses the IMF's Global Integrated Monetary and Fiscal Model (GIMF) to predict the spillover effects of an increase in German consumption demand. The GIMF model is calibrated to represent six regions of the world economy, one of which comprises Greece, Ireland, Italy, Portugal, and Spain (EA5). As consumption demand is an endogenous variable in the model, the study predicts the implications of shocks to i) the German wage markup and ii) a German consumer preference parameter. The wage markup shock leads to lower aggregate demand in Germany and lower GDP in the EA5. The preference parameter shock, scaled so as to generate a two-percent temporary increase in German consumption demand, leads at its peak to about 0.1 percent higher GDP in the EA5, but only if monetary policy is accommodative (i.e. if the nominal policy rate is constant). According to the input-output model a two-percent private consumption shock would lead to 0.04 percent higher GDP in Greece and 0.08 percent higher GDP in Italy.[7] The predictions for France, Spain, and Portugal fall into the range spanned by these two countries. The input-output model reveals the differences across countries, and the aggregation of countries into groups conceals this heterogeneity. In terms of magnitude, these spillover effects amount to only 40 to 80 percent of what the GIMF model predicts for the EA5 as a whole.

Elekdag and Muir (2014) use the same six-region GIMF model to investigate the spillover effects of shocks to Germany's public investment. If monetary policy is accommodative, a two-year debt-financed public investment shock, scaled to one percent of GDP per year, raises the EA5's GDP by 0.2 percent relative to the baseline scenario. For lack of data on the composition of investment, the input-output model cannot simulate a public investment shock. The results summarized in figure 4 are based on an exogenous increase in total investment expenditure (public and private), and they are scaled to one percent of Germany's final demand. If we double the size of our shock to approximate a one-percent-of-GDP shock stretched over two years and otherwise ignore the incommensurabilities, the GIMF's prediction and our prediction are roughly the same.

[7] One percent of final demand is equivalent to about 1.7 percent of private consumption (the share of private consumption in Germany's final demand is 57 percent). Multiplication of the numbers in figure 4 by 1.15 gives the results of a two-percent shock to private consumption in Germany.

In't Veld (2013) uses the QUEST model, the macroeconomic model of the European Commission's Directorate-General for Economic and Financial Affairs, to predict the spillover effects of fiscal consolidation and fiscal expansion under crisis conditions (liquidity-constrained households and zero lower bound). The model considers seven countries separately (Germany, France, Italy, Spain, Ireland, Portugal, and Greece) and treats the rest of the euro area as one aggregate block. If Germany in concert with a few small euro area countries would increase public investment expenditure by one percent of GDP per year for two years, France, Italy, Spain, Ireland, Portugal, and Greece's GDP would grow by 0.2 to 0.3 percent. It can be observed that the QUEST model yields predictions that are slightly larger than those derived from the input-output model and the GIMF model. In part this difference can be attributed to the fact that not only Germany is assumed to increase public investment, but a few small countries do so as well.

DSGE models incorporate a number of mechanisms that are absent from input-output models. One might expect that a robust expansion of the German economy exercises upward pressure on domestic wages and prices; as Germany loses price competitiveness and Southern Europe gains price competitiveness, exports from Southern Europe should increase to some extent and imports by Southern Europe should decrease to some extent. The predicted spillover effects on GDP, employment, and the trade balance should be greater in models that do incorporate such realignment of competitive positions. The actual strength of this *price competitiveness channel* remains elusive; in DSGE models it is regulated by the choice of the elasticity of substitution, a parameter.[8]

The evidence does not support the notion that the divergence in unit labor costs observed over the period 1999-2007 has caused a competitiveness problem in the European South (Gaulier and Vicard, 2012; Storm and Naastepad, 2015a; Storm and Naastepad, 2015b; Schröder, 2015).[9] If indeed the unit labor cost divergence did not seriously harm the South's export performance, it stands to reason that the price competitiveness channel is rather weak, and a reversal of the divergence might not bring about the desired improvement in international competitiveness in the South.

The simulations by researchers at the IMF and the European Commission assume that monetary policy is accommodative: the tightening that would follow an increase in demand and inflation in normal times does not occur at the zero lower bound, therefore the nominal policy rate remains constant, and the real rate declines. In the model economy the lower real rate tends to stimulate domestic demand all across the euro area and, moreover, it induces a depreciation of the euro that stimulates foreign demand for euro area products. While the actual strength of this *monetary policy channel* is difficult to ascertain, in the model economy it is a major driver of Germany's final demand spillovers; without it, the

[8] We are not aware of DSGE studies that present, as a sensitivity test, the results of variations in the elasticity of substitution. For recent econometric estimates of trade elasticities, see e.g. Christodoulopoulou and Tkačevs (2015) and Imbs and Mejean (2015).

[9] Debt-fueled domestic-demand booms and the non-trade components of the balance of payments (income flows and transfer payments) played an important role in the evolution of current account balances (Holinski et al., 2012; Kang and Shambaugh, 2013; Kang and Shambaugh, 2016).

spillovers might be negligible, or even negative in the short run.

The price competitiveness channel and the monetary policy channel would be reflected in the input-output model as both changes in the technical coefficients and changes in the final demand composition. The constant-coefficient input-output model yields broadly similar predictions as DSGE models, but the underlying mechanisms are different. Propagation in the input-output model is predicated on multipliers that reflect endogenous intermediate input demand by producers and endogenous final goods demand by households at constant prices and below full capacity. In DSGE models the labor supply function acts as a (flexible) supply constraint; the spillover effects do not result from multipliers in the manner of Leontief and Keynes, but from behavioral change in the form of relative price-induced expenditure-switching and, most importantly, from the interest-elasticity of domestic expenditure.

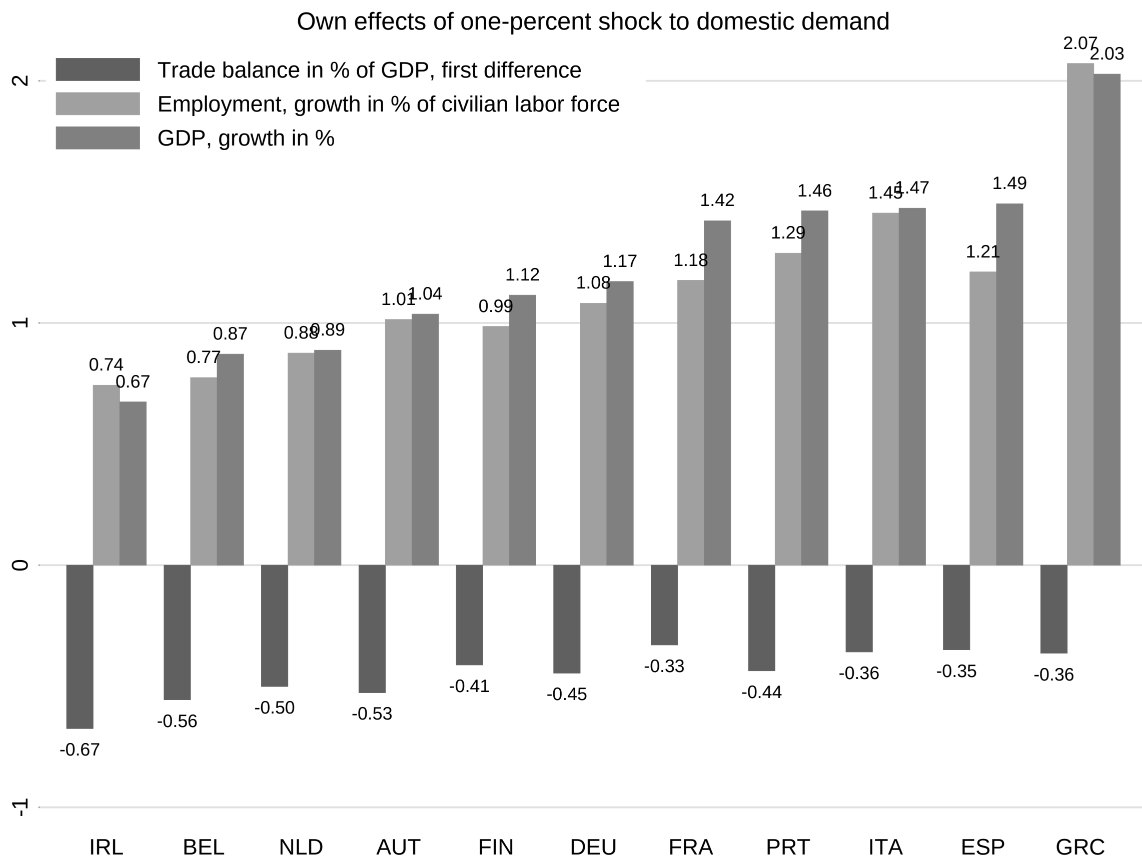
4.4. Own Effects

Figure 5 shows the effects on the domestic economy of a one-percent shock to domestic demand for each country of the EA11. Greece, once again, stands out. If final demand in Greece were to increase by one percent, assuming no change in the structure of the world economy, the country's GDP would grow by two percent. A revival of domestic sources of demand in Greece would have the greatest effects on employment and among the least adverse effects on the trade balance. Final demand shocks in the rest of the EA11 would generate significantly less growth; in Ireland, Belgium, and Netherlands, a one-percent final demand shock would raise GDP by less than one percent.

Recall that the open-economy multiplier of a Keynesian textbook model decreases in the propensity to import. In highly open economies like Ireland, Belgium, and Netherlands it is obviously more difficult to boost employment through domestic sources of demand and, even if successful, the trade balance would deteriorate significantly. In closed economies like Greece, there is greater potential for stimulating the economy through domestic sources of demand. The downside is that any compression of domestic sources of demand will tend to be more contractionary – one reason among many why austerity policies might have been more contractionary in Greece than elsewhere.[10]

Compare the own effects and the spillover effects of Germany's final demand. A ten-percent increase in GDP in Spain could be brought about by either a 6.7-percent exogenous increase in Spain's final demand, or a 185-percent exogenous increase in Germany's final demand. The spillover effects of Germany's final demand pale in comparison with own effects.

[10] "The [adjustment program for Greece] initially assumed a multiplier of only 0.5 despite staff's recognition that Greece's relatively closed economy and lack of an exchange rate tool would concentrate the fiscal shock" (IMF, 2013, p.21).



Notes: The countries are sorted by the size of the effect on GDP. The trade balance effect is the first difference of the trade balance measured in percent of GDP ($\triangle TB$). The employment effect is expressed in percent of the civilian labor force – under the assumption that the labor force remains constant, it represents a percentage point reduction in the unemployment rate ($\triangle e^s/CLF^s \cdot 100$). The GDP effect is expressed as a percent growth rate ($\triangle v^s/v^s \cdot 100$).

Figure 5: Domestic effects of one-percent shock to domestic demand

5. Discussion

From 1995 to 2007, Germany's final demand increased from 1883 to 2330 billion euros, which gives an average annual growth rate of 1.9 percent, or a cumulative growth rate of 24 percent. Spain's final demand increased from 462 to 1142 billion euros, which gives an average annual growth rate of 7.8 percent, or a cumulative growth rate of 147 percent. The annual growth difference is 5.9 percent and the cumulative growth difference is 123 percent. Given the scale of this demand divergence, the hypothetical one-percent shocks that underpin our spillover effects are tiny. Since the input-output model assumes constant returns to scale, the predicted effects of 10-percent final demand shocks will be precisely 10 times as large. In order to raise GDP in the European South by one percent, assuming no change in the structure of the world economy, the exogenous increase in final demand in Germany would need to be 20 percent. The public investment programs that are being discussed in Germany do not come anywhere near that number. The European Commission, for instance, gauges Germany's annual infrastructure investment backlog with one-half to one percent of GDP and criticizes that "planned measures fall short of the requirements to tackle the investment backlog in public infrastructure. If fully implemented, these measures would amount to about EUR 10 billion or 0.3 percent of GDP" (EC, 2015, p.30). Even if the German government was committed to an expansionary policy stance, a large increase in final demand could not be engineered overnight and, in any case, the prospect of one-percent higher GDP does not really justify a swing towards growth optimism in the European South.

The larger is the assumed exogenous increase in final demand, the more dynamic will be the model economy and the less credible will be the assumption of a fixed economic structure and fixed final demand composition. Economies of scale, relative price changes, domestic production bottlenecks that require foreign sourcing – the list of factors that could change the model's parameters is long. That being said, the predicted spillover effects are relatively stable over the period 1995-2009 even as producers changed their sourcing pattern and end-users changed their consumption pattern (see appendix B). In spite of sharp differences in the macroeconomic performance across euro member states, which was reflected in the observed divergence in domestic demand and the divergence in unit labor costs; in spite of the process of Eastern enlargement and the associated foreign direct investment flows and the re-organization of supply chains; in spite of the rise of China as the world's assembly line; the spillover effects of Germany's final demand on the European South remained remarkably stable. The prospect of behavioral and structural change, which is ignored by the input-output model, therefore does not alter our conclusion that spillover effects are bound to be small.

It is relatively easy to overestimate the importance of foreign demand for a country's growth performance. To this end one only needs to relate a country's exports of goods and services, a *gross* flow, to GDP, a *value added* flow; then it might appear as if export growth could make a considerable contribution to GDP growth. As soon as intermediate goods demand and supply-chain trade are taken into account, as is done by the input-output method, the said overestimation becomes significantly harder to sustain. Note that the foreign value added content of gross exports in the EA11 ranges from 24 percent in Greece to 45 percent in Ireland (Stehrer, 2013).

The next fact to appreciate is that in spite of the increased interdependence of economies and the presence of global value chains, a country's final demand first and foremost generates income in the domestic economy. Garbellini et al. (2014) split a country's GDP into the share that is activated by domestic final demand and the share that is activated by foreign final demand. In France, domestic sources of demand still account for 82 percent of domestic income; in Spain this number is 85 percent; in Italy 82 percent; and in Germany 71 percent. In other words, less than a fifth of the GDP in the European South depends on foreign sources of demand.[11] The lesson that we draw from these numbers is that any export-led growth strategy is forced to rely on rapid growth in what remains a small fraction of domestic income. Since all trading partners jointly account for this foreign demand-generated income, the contribution of any single trading partner is bound to be smaller still.

Matters will be somewhat different in small countries that trade a lot with a large neighboring economy, e.g. Austria/Germany, Ireland/UK. Suppose the dominant trading partner were to experience final demand growth rates comparable to those recorded in Ireland, Greece, and Spain before the crisis (upwards of five percent annually in real terms). The spillovers from this strong boom in the dominant trading partner could be expected to exert a significant influence on the evolution of the domestic economy. If *all* trading partners *simultaneously* were to go through *rapid* expansions, the spillover effects would no doubt be considerable. It is however rarely the case, absent macroeconomic policy coordination, that all trading partners are growing at such high rates; in reality some trading partners are expanding while others are stagnating, and final demand in the *average* trading partner is growing at some *average* rate but not at the pre-crisis rates observed in Ireland, Greece, and Spain. Without a coordinated expansion, it is unlikely that foreign demand will make a significant contribution to economic activity in the European South.

A closed economy like Greece can hardly benefit from foreign demand spillovers, because too few economic activities depend on exports. Exporting industries are larger in Italy, France, Spain, and Portugal, but even a relatively open economy like Germany can experience a combination of strong export growth and weak macroeconomic performance – it did so from the mid-1990s until the mid-2000s. Germany's unemployment rate peaked at 11.2 percent in 2005, well after the large trade surplus had emerged. The export growth rates were higher than in comparable high-income countries, but Germany, then called the "sick man of Europe", recorded relatively low growth and high unemployment. The lesson is that it is difficult to overestimate the importance of domestic sources of demand for a

[11] Ederer and Reschenhofer (2016, p.6) present the same statistic. Note also that the share of imported intermediates in global manufacturing output is only 16 percent; the share of imported intermediates in global production of goods and services is eight percent (Baldwin and Lopez-Gonzalez, 2014). In this sense "global manufacturing is not very internationalized" and "world production is not very globalized" (Baldwin and Lopez-Gonzalez, 2014, pp.10-11).

country's growth and employment performance. Germany's performance was poor then because domestic demand was weak. Growth will resume in the European South if and when domestic demand picks up.

A revival of domestic sources of demand in the European South would certainly worsen the region's external balance, although the relative closedness of the economies would work in their favor (figure 5 shows that in the EA11 the least adverse effects of a domestic expansion on the trade balance are found in the European South). It is evident that *expenditure-switching polices* are in principle desirable, for they would relax the external constraint and make room for an expansion of domestic demand. Consider, though, the arsenal of expenditure-switching policies as discussed by Harry Johnson (1958): currency devaluation, internal devaluation, trade subsidies, tariffs, and quantitative restrictions on imports. The Treaty of Rome rules out tariffs and quantitative import restrictions as well as any measures that have equivalent effects. Europe's common competition policy largely rules out state subsidies, and euro membership eliminates the option of currency devaluation. The only expenditure-switching policy that remains at the disposal of national governments in the euro area is internal devaluation. Whether and to what extent internal devaluation might raise export competitiveness is an open question, which cannot be discussed here.[12] The elected governments in the European South face a trade-off between the objective of promoting domestic employment and objective of improving the external balance, and the restrictions placed upon the macroeconomic policy toolkit certainly do not alleviate this trade-off.

A coordinated expansion in the euro area would contribute to both policy objectives. The relatively strong trade ties between the Southern European countries would help to contain adverse trade balance effects – to a non-negligible extent the Southern economies could invigorate one other. If the constraint was accepted that the trade balances in the South must not deteriorate, the stimulus in the North would have to be considerably larger than in the South. Given the dispersion of trade flows (the euro area countries have significant trade ties with countries outside the currency area), the coalition that agrees to pursue expansionary policies would have to include as many countries as possible.[13]

Any policy that could help spur innovation and encourage the development of new industries in the European South would support the rebalancing process. A revival of industrial

[12] To assess the prospect of internal devaluation, O'Rourke and Taylor (2013) turn to the examination of the historical record of the gold standard, and they conclude that there was less need for external adjustment in the first place, and when it was required, adjustment was achieved through other channels, including the devaluation of the exchange rate in peripheral countries. Shambaugh (2012) turns to more recent history and finds only three episodes that qualify as internal devaluation in a low-inflation environment, all associated with a severe contraction and high unemployment. It remains unclear to what degree these current account reversals can be attributed to relative price adjustment or simply to a compression of import demand. The internal devaluation strategy has few successful precursors, if any. Schröder (2015) finds that there is no correlation between unit labor cost growth and expenditure switching in the euro area in the period 1999-2007; he argues that reforms that aim at a reversal of the unit labor cost divergence should not be regarded as expenditure-switching policies.

[13] We explore various scenarios in a forthcoming companion article.

policy may have the capacity to raise economic growth and promote exports in the long run (Aghion et al., 2011; Aiginger, 2013; Rodrik, 2014; Mazzucato et al., 2015). The design and implementation of industrial policy raises a set of issues that is largely independent of the short-run external adjustment problems discussed here. In general any country, whether in surplus or deficit, strives to support innovative firms and develop new industries.

6. Conclusion

We find that the spillover effects of Germany's final demand on countries in Southern Europe are small in absolute and relative terms. If a German demand boom were to materialize, France, Greece, Italy, Spain, and Portugal would not benefit much in terms of growth and external adjustment. The real beneficiaries would be small neighbors (e.g. Austria and Luxembourg) and emerging economies in Eastern Europe that are well integrated into German supply chains (e.g. Czech Republic and Poland). The results lend support to the notion that Germany is largely unable to stimulate economic activity in Southern Europe (Bundesbank, 2010). The positive spillovers emphasized by international institutions (e.g. IMF, 2015a; EC, 2015) hardly constitute a remedy to the external adjustment problems in the European South.

Gross export statistics give a misleading picture of the importance of foreign demand. Even at the current stage of European integration and in spite of the presence of global value chains, the contribution of foreign demand to domestic income and employment in the European South remains rather small. The contribution of Germany's final demand is smaller still, for Germany is merely one trading partner among many. Income and employment in the European South largely depend on the state of domestic demand. Growth in the region will therefore resume only if domestic sources of demand can be ignited.

Rebalancing in accordance with the European Commission's Macroeconomic Imbalance Procedure relies on relatively modest fiscal action in Germany and other surplus countries aimed at stimulating domestic investment, while growth in the European South is supposed to come from the positive spillover effects thereof, and from the implementation of particular structural reforms in labor and product markets (e.g. EC, 2015). Given that the spillover effects are small and the alleged benefits of structural reforms certainly do not include a short-run expansion of domestic demand, the European policy stance that emerged out of the Macroeconomic Imbalance Procedure squarely places the South on a path to further stagnation. The governments in the South might want to reconsider the use of macroeconomic policies that aim at a revival of domestic demand. The introduction of a "Golden Rule of Public Investment" (Musgrave, 1939; Musgrave, 1959), which would exclude net public investment expenditure from balanced-budget rules, represents one possible escape route from the complex web of national and European procedures that constrain fiscal policy (Feigl and Truger, 2015; Truger, 2015). The spillovers from a simultaneous expansion in the North and the strong trade ties among the Southern European economies would at least help to contain the adverse trade balance effects.

It is quite possible that the pursuit of Germany's *domestic* policy objectives calls for the adoption of expansionary policies, but questions about the desirability of such policies, their type and design, are beyond the scope of this article, which was concerned with the spillover effects of Germany's final demand.[14]

[14] Private and public investment in Germany is weak, and it has been so for a long time (EC, 2015; BMWi, 2015). The German economy is healthy in comparison with crisis-ridden countries in Southern Europe, but economic growth is low by own historical standards. As of January 2016, 6.7 percent of the labor force (2.9 million persons) is unemployed, and 8.3 percent is under-employed (3.7 million persons) according to the national employment agency's definition of under-employment, and these numbers do not include refugees nor persons in subsidized short-time work nor discouraged persons who left the labor force. The fact that German officials and their advisors make reference to a "tight labor market and closed output gap" (IMF, 2015a, p.13) shows that definitions of full employment and potential output are fairly elastic and do change over time. Recall that in the 1960s and early 1970s the unemployment rate routinely fell below one percent.

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A. The Closed Multi-Country Input-Output Model

This section introduces our notation for the multi-country input-output model and describes how the model translates exogenous increases in final demand of country r into effects on GDP, employment, and the trade balance of country s.[15] The accounting equation $\mathbf{x} = \mathbf{Z}\,\mathbf{i} + \mathbf{f}$ summarizes the relation between the gross output vector $\mathbf{x}$, the multi-country inter-industry flow matrix $\mathbf{Z}$, and the world final demand vector $\mathbf{f}$. All vectors are column vectors. Let $i = 1, 2, ..., n$ index industries and $r = 1, 2, ..., m$ countries. The gross output vector $\mathbf{x}$ and the world final demand vector $\mathbf{f}$ have length $n \cdot m$. The inter-industry flow matrix $\mathbf{Z}$ has the dimension $n \cdot m \times n \cdot m$ (in the WIOD $n = 35$ and $m = 41$, so that $n \cdot m = 1435$). $\mathbf{i}$ denotes a column vector of ones with the appropriate length.

To illustrate with $m = 3$ countries, the equation system in expanded form is

$$\mathbf{x} = \underbrace{\begin{bmatrix} \mathbf{x}^1 \\ \mathbf{x}^2 \\ \mathbf{x}^3 \end{bmatrix}}_{n\cdot 3\times 1} = \underbrace{\begin{bmatrix} \mathbf{Z}^{11} & \mathbf{Z}^{12} & \mathbf{Z}^{13} \\ \mathbf{Z}^{21} & \mathbf{Z}^{22} & \mathbf{Z}^{23} \\ \mathbf{Z}^{31} & \mathbf{Z}^{32} & \mathbf{Z}^{33} \end{bmatrix}}_{n\cdot 3\times n\cdot 3} \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix} + \underbrace{\begin{bmatrix} \mathbf{f}^{11} \\ \mathbf{f}^{21} \\ \mathbf{f}^{31} \end{bmatrix} + \begin{bmatrix} \mathbf{f}^{12} \\ \mathbf{f}^{22} \\ \mathbf{f}^{32} \end{bmatrix} + \begin{bmatrix} \mathbf{f}^{13} \\ \mathbf{f}^{23} \\ \mathbf{f}^{33} \end{bmatrix}}_{n\cdot 3\times 1} = \mathbf{Z}\,\mathbf{i} + \mathbf{f}, \tag{1}$$

where $\mathbf{x}^1$ is the gross output vector of country 1, $\mathbf{f}^{11}$ are the purchases of final goods by end-users in country 1 from producers in country 1, $\mathbf{f}^{12}$ are the purchases of final goods by end-users in country 2 from producers in country 1, $\mathbf{Z}^{11}$ are the purchases of inputs by industries in country 1 from producers in country 1, $\mathbf{Z}^{12}$ are the purchases of inputs by industries in country 2 from producers in country 1, and so forth.

The multi-country input coefficient matrix is defined as $\mathbf{A} = \mathbf{Z}\,\hat{\mathbf{x}}^{-1}$. The hat denotes a diagonal matrix and the superscript -1 denotes the inverse of a matrix. Hence $\hat{\mathbf{x}}^{-1}$ is a diagonal matrix with the inverted elements of the gross output vector on the main diagonal and zeros elsewhere. The input coefficient matrix $\mathbf{A}$, the Leontief inverse $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$, and the identity matrix $\mathbf{I}$ have the dimension $n \cdot m \times n \cdot m$. The Leontief inverse converts final demands into gross output requirements: $\mathbf{x} = \mathbf{L}\,\mathbf{f}$. In the three-country example, the expanded form is

$$\mathbf{x} = \underbrace{\begin{bmatrix} \mathbf{x}^1 \\ \mathbf{x}^2 \\ \mathbf{x}^3 \end{bmatrix}}_{n\cdot 3\times 1} = \underbrace{\begin{bmatrix} \mathbf{L}^{11} & \mathbf{L}^{12} & \mathbf{L}^{13} \\ \mathbf{L}^{21} & \mathbf{L}^{22} & \mathbf{L}^{23} \\ \mathbf{L}^{31} & \mathbf{L}^{32} & \mathbf{L}^{33} \end{bmatrix}}_{n\cdot 3\times n\cdot 3} \underbrace{\begin{bmatrix} \mathbf{f}^1 + \mathbf{f}^2 + \mathbf{f}^3 \end{bmatrix}}_{n\cdot 3\times 1} = \mathbf{L}\,\mathbf{f}. \tag{2}$$

The world final demand vector $\mathbf{f}$ is the sum over the country final demand vectors, that is, $\mathbf{f} = \sum_{r=1}^{m} \mathbf{f}^r$, or

$$\mathbf{f} = \begin{bmatrix} \mathbf{f}^{11} \\ \mathbf{f}^{21} \\ \mathbf{f}^{31} \end{bmatrix} + \begin{bmatrix} \mathbf{f}^{12} \\ \mathbf{f}^{22} \\ \mathbf{f}^{32} \end{bmatrix} + \begin{bmatrix} \mathbf{f}^{13} \\ \mathbf{f}^{23} \\ \mathbf{f}^{33} \end{bmatrix} = \mathbf{f}^1 + \mathbf{f}^2 + \mathbf{f}^3. \tag{3}$$

[15] The MATLAB code, which documents every step from reading the source data to computing the results, is available from the authors upon request.

A.1. Multipliers

The column sums of the Leontief inverse give *simple world output multipliers*: the total value of production in all industries and all countries that is directly and indirectly necessary to meet one euro of additional final demand for the output of industry i in country r. In a multi-country model with n industries and m countries, there are $n \cdot m$ simple world output multipliers. These are collected in the row vector

$$\mathbf{m}^{simple}(o) = \mathbf{i}' \, \mathbf{L}. \tag{4}$$

The closed model gives rise to *total truncated world output multipliers*: the value of production in all industries and all countries that is directly and indirectly necessary to meet one euro additional final demand for output of industry i in country r, plus the value of production in all industries and all countries that is necessary to supply the output for the induced increase in household consumption. The $n \cdot m$ total truncated world output multipliers are collected in the row vector

$$\mathbf{m}(o) = \mathbf{i}' \, \bar{\mathbf{L}}. \tag{5}$$

$\bar{\mathbf{L}}$ is the *truncated* Leontief inverse of the closed model (see section A.3). In order to assess to what extent closing the model changes the results, we compare the simple to the total world output multipliers in section 4.2.

Income and employment multipliers follow naturally from the gross output multipliers. Following Dietzenbacher (2005), a generic definition of multipliers is

$$\mathbf{m}(\cdot) = \mathbf{m}' \, \hat{\mathbf{x}}^{-1} \, \bar{\mathbf{L}}, \tag{6}$$

If the multiplier vector $\mathbf{m}$ is set to be the gross output vector $\mathbf{x}$, the equation defines a vector of world gross output multipliers. $\mathbf{m} = \mathbf{v}$ gives world income multipliers, and $\mathbf{m} = \mathbf{e}$ world employment multipliers. The elements of $\mathbf{v}$ represent value added by industry, and the elements of $\mathbf{e}$ represent employment by industry. Both vectors have length $n \cdot m$. The terms income, value added, and GDP will be used interchangeably.

Traditional multipliers ask what happens if final demand for the output of industry i in country r increases by one euro; they measure the total effect of a final demand shock of one euro. *Growth-equalized* multipliers ask what happens if final demand for the output of industry i in country r increases by one percent; they measure the total effect of a one-percent final demand shock (Gray et al., 1979). The row vector

$$\tilde{\mathbf{m}}(\cdot) = \mathbf{m}' \, \hat{\mathbf{x}}^{-1} \, \bar{\mathbf{L}} \, \hat{\mathbf{f}} \cdot 0.01 \tag{7}$$

collects *growth-equalized total truncated world output/income/employment multipliers* ($\mathbf{m} = \mathbf{x}$ for gross output multipliers, $\mathbf{m} = \mathbf{v}$ for income multipliers, and $\mathbf{m} = \mathbf{e}$ for employment multipliers). We shorten the unwieldy name and drop the words “total” and “truncated” henceforth.

We are interested not so much in the effects of an increase in world final demand, but rather in the effects of an increase in final demand of a single country, Germany. The vector $\mathbf{f}^r$, which represents the final demands of country r, replaces $\mathbf{f}$ in equation 7. We are interested not so much in the effects on output, income, and employment in the world as a whole, but rather in the effects on these variables in a single country s. The row vector

$$\tilde{\mathbf{m}}^{sr}(\cdot) = (\mathbf{m}^s)' \ (\hat{\mathbf{x}}^s)^{-1} \ \bar{\mathbf{L}}^{s\cdot} \ \hat{\mathbf{f}}^r \cdot 0.01 \tag{8}$$

collects *growth-equalized inter-country output/income/employment multipliers*. If $s = r$, the equation defines intra-country or own multipliers. $\mathbf{x}^s$ is the output vector of country s, and $\mathbf{m}^s$ is the output/income/employment vector of country s ($\mathbf{x}^s$, $\mathbf{v}^s$, or $\mathbf{e}^s$). $\bar{\mathbf{L}}^{s\cdot}$ is a matrix with n rows and $n \cdot m$ columns, a submatrix of the Leontief inverse, containing only the rows that correspond to country s: $\bar{\mathbf{L}}^{s\cdot} = \begin{bmatrix} \bar{\mathbf{L}}^{s1} & \bar{\mathbf{L}}^{s2} & \cdots & \bar{\mathbf{L}}^{sm} \end{bmatrix}$.

Our estimate of a spillover effect of country r's final demand on the GDP of country s is the sum over the growth-equalized inter-country income multipliers. Using $\mathbf{f}^r = \hat{\mathbf{f}}^r \ \mathbf{i}$, we have

$$\triangle v^s = (\mathbf{v}^s)' \ (\hat{\mathbf{x}}^s)^{-1} \ \bar{\mathbf{L}}^{s\cdot} \ \mathbf{f}^r \cdot 0.01 \tag{9}$$

Our estimate of a spillover effect of country r's final demand on employment in country s is the sum over the growth-equalized inter-country employment multipliers:

$$\triangle e^s = (\mathbf{e}^s)' \ (\hat{\mathbf{x}}^s)^{-1} \ \bar{\mathbf{L}}^{s\cdot} \ \mathbf{f}^r \cdot 0.01 \tag{10}$$

A.2. Size and Composition of Final Demand

$\mathbf{f}^r$, the final demand vector of country r, can be decomposed into the size and the composition of final demand. The division of each element of $\mathbf{f}^r$ by the country's total final demand, $f^r = \mathbf{i}' \ \mathbf{f}^r$, gives a vector whose elements represent the share (in country r's total final demand) of final demand by end-users in country r for output of industry i in country s. We will refer to this vector as the final demand composition of country r: $\mathbf{sf}^r = \mathbf{f}^r \div f^r$. The column sum of $\mathbf{sf}^r$ is one, and $\mathbf{f}^r = \mathbf{sf}^r \cdot f^r$.

Final demand of country r, $\mathbf{f}^r$, is the sum of private consumption $\mathbf{c}^r$, public consumption $\mathbf{g}^r$, and investment $\mathbf{k}^r$: $\mathbf{f}^r = \mathbf{c}^r + \mathbf{g}^r + \mathbf{k}^r$. The demand composition obviously varies across demand categories. $\mathbf{sc}^r = \mathbf{c}^r \div c^r$ is the composition of private consumption of country r, $\mathbf{sg}^r = \mathbf{g}^r \div g^r$ the composition of public consumption, and $\mathbf{sk}^r = \mathbf{k}^r \div k^r$ the composition of investment, where $c^r = \mathbf{i}' \ \mathbf{c}^r$ is total private consumption of country r, $g^r = \mathbf{i}' \ \mathbf{g}^r$ is total government consumption, and $k^r = \mathbf{i}' \ \mathbf{k}^r$ is total investment.

To isolate the effect of changes in the composition of final demand, we scale every shock to one percent of final demand $(0.01 \cdot f^r)$. The spillover effect of a private consumption shock in country r on income in country s is

$$\triangle v^s = (\mathbf{v}^s)' \ (\hat{\mathbf{x}}^s)^{-1} \ \bar{\mathbf{L}}^{s\cdot} \ \mathbf{sc}^r \cdot f^r \cdot 0.01 \tag{11}$$

The spillover effect of a private consumption shock on employment is

$$\triangle e^s = (\mathbf{e}^s)' \ (\hat{\mathbf{x}}^s)^{-1} \ \bar{\mathbf{L}}^{s\cdot} \ \mathbf{sc}^r \cdot f^r \cdot 0.01 \tag{12}$$

The spillover effects of shocks to public consumption and investment are computed in analogous fashion. The composition of public consumption $\mathbf{sg}^r$ (or the composition of investment $\mathbf{sk}^r$) replaces the composition of private consumption $\mathbf{sc}^r$ in the two previous equations.

A.3. The Closed Model

Basic consumption theory predicts that higher household income causes higher consumption spending. A final demand shock will initiate additional production; additional production will require more labor input; the higher demand for labor services will increase labor income; and this will increase the amounts spent by households on consumption. In input-output economics, the endogenization of household consumption is known as closing the model with respect to households.

The model is closed by expanding the inter-industry flow matrix of the open model. In the three-country example, the expanded matrix is

$$\tilde{\mathbf{Z}} = \begin{bmatrix} \mathbf{Z}^{11} & \mathbf{c}^{11} & \mathbf{Z}^{12} & \mathbf{c}^{12} & \mathbf{Z}^{13} & \mathbf{c}^{13} \\ (\mathbf{w}^1)' & 0 & 0 & 0 & 0 & 0 \\ \mathbf{Z}^{21} & \mathbf{c}^{21} & \mathbf{Z}^{22} & \mathbf{c}^{22} & \mathbf{Z}^{23} & \mathbf{c}^{23} \\ 0 & 0 & (\mathbf{w}^2)' & 0 & 0 & 0 \\ \mathbf{Z}^{31} & \mathbf{c}^{31} & \mathbf{Z}^{31} & \mathbf{c}^{32} & \mathbf{Z}^{33} & \mathbf{c}^{33} \\ 0 & 0 & 0 & 0 & (\mathbf{w}^3)' & 0 \end{bmatrix} \tag{13}$$

The elements of $\mathbf{w}^s$, a column vector of length n, represent wages and salaries paid by industries in country s to households in country s as remuneration for the provision of labor services. The entries in the labor input row of country s are positive only in the columns that represent inputs to the domestic industries, and are zero elsewhere.[16] The closed input-output model effectively treats wages and salaries as the "outputs" of the household sector. Adding each country's household output from $x_h^s = \mathbf{i}' \ \mathbf{w}^s$ as an additional element to the bottom of the domestic part of the gross output vector, i.e. after each n elements, gives the expanded gross output vector $\tilde{\mathbf{x}}$, which has length $(n+1) \cdot m$.

Household consumption vectors are added to the right of each 3×1 block of $\mathbf{Z}^{ij}$ matrices. The elements of the vector $\mathbf{c}^{11}$ represent consumption spending by households in country $r = 1$ on output of industry i in country $s = 1$, the elements of $\mathbf{c}^{21}$ represent consumption spending by households in country $r = 1$ on output of industry i in country $s = 2$, the

[16] In general households perform labor services in their country of residence: households who live in country s perform labor services in country s. The case of cross-country commuting, an exception to this rule, is ignored.

elements of $\mathbf{c}^{12}$ represent consumption spending by households in country $r = 2$ on output of industry i in country $s = 1$, and so on.

In a model with m regions, the expanded inter-industry flow matrix $\tilde{\mathbf{Z}}$ has m additional columns and m additional rows. It is a square matrix with size $(n+1) \cdot m$.[17] The input coefficient matrix of the closed model is $\tilde{\mathbf{A}} = \tilde{\mathbf{Z}}\,(\hat{\tilde{\mathbf{x}}})^{-1}$, and the Leontief inverse is $\tilde{\mathbf{L}} = (\mathbf{I} - \tilde{\mathbf{A}})^{-1}$. The *truncated* Leontief inverse $\bar{\mathbf{L}}$ is a submatrix of $\tilde{\mathbf{L}}$. The household consumption columns and the labor income rows are removed from $\tilde{\mathbf{L}}$; the truncated Leontief inverse contains only the elements that are associated with the original industries.

A.4. Trade Balance

We compute the trade balance of country 1 as the difference between a country's value added and final demand divided by value added: $\left(v^1 - f^1\right)/v^1 \cdot 100$. The trade balance computed from the WIOTs however does not coincide with the trade balance reported in common databases (e.g. AMECO). The difference is non-negligible, and it exists for two reasons. First, the WIOTs report all flows in basic prices, whereas the typical national accounts database reports flows in purchaser's prices. Second, the WIOTs report flows on the basis of the "territory principle": final consumption by industry captures consumption expenditures within the domestic market. The trade balance that is of interest to us and that is reported in balance of payments statistics follows the "residency principle": it is supposed to measure transactions between residents and non-residents. Tourism implies that residents purchase goods and services abroad and non-residents purchase goods and services on domestic territory.

The WIOTs report "Taxes less subsidies on products" and "International transport margins" on the industry-level (giving the wedge between basic and purchaser's prices) and "Direct purchases abroad by residents" and "Purchases on the domestic territory by non-residents" by country (giving the wedge between territory and residency principle). Using this information, it is straightforward to compute the *actual* trade balance in any given year in purchaser's prices according to the residency principle. To compute the *hypothetical* trade balance after the exogenous final demand shock, it is necessary to predict the changes in taxes less subsidies, transport margins, and tourism expenditures. In all cases we impose proportional changes. For instance, direct purchases abroad by Germany's residents increase in proportion to Germany's final demand, and purchases on the domestic territory by non-residents increase in proportion to world final demand excluding Germany's final demand.[18]

[17] The matrix consists of 3×3 blocks of submatrices. Each element at the bottom right in such a block, a scalar found at the intersection of the labor input row and the household consumption column, represent household purchases of labor services; we set these to zero. The WIOD assigns these transactions to the industry "Private households with employed persons", and reports the values as part of inter-industry flow matrix $\mathbf{Z}$.

[18] Details can be found in the MATLAB code, which is available upon request.

B. Temporal Stability

This section studies the temporal stability of the predictions. If historically observed changes in the data underlying the input-output model generated wild fluctuations in the predicted spillover effects, there would be little justification for applying results that are based on historical data to today's situation. If the predicted spillover effects were robust with respect to historically observed changes in the data, the predictions would carry weight under present circumstances. We perform a structural decomposition to explore the issue.

The spillover effect of an increase in final demand in country $r = 2$ (e.g. Germany) on value added in country $s = 1$ (e.g. Spain) is calculated as

$$\triangle v_t^{12}/v_t^1 \cdot 100 = \underbrace{\left[(\mathbf{v}_t^1)' \quad \mathbf{0}' \quad \mathbf{0}'\right] \; \hat{\mathbf{x}}_t^{-1} \; \bar{\mathbf{L}}_t}_{\text{Economic structure}} \; \overbrace{\mathbf{sf}_t^2}^{\text{Final demand composition}} \cdot \underbrace{f_t^2/v_t^1}_{\text{Relative size}} \tag{14}$$

The equation gives the percentage change in value added in country $s = 1$ generated by an exogenous one-percent increase in final demand in country $r = 2$. $\triangle v^{12}$ is the predicted change in value added in country 1, v^1 the level of value added in country 1, $\mathbf{v}^1$ the value added vector of country 1, $\mathbf{x}$ the world gross output vector, $\bar{\mathbf{L}}$ the truncated Leontief inverse of the closed model, $\mathbf{sf}^2$ the final demand composition of country 2, f^2 is the level of final demand in country 2, and $\mathbf{0}$ are null vectors that have appropriate length. The results reported in the body of the article are based on the latest available data from 2009; here the elements the make up the prediction carry a time index $t = 1995, \ldots, 2009$. The first three elements on the right-hand side of the equation, $\left[(\mathbf{v}^1)' \quad \mathbf{0} \quad \mathbf{0}\right] \; \hat{\mathbf{x}}^{-1} \; \bar{\mathbf{L}}$, jointly represent what we term *economic structure*. The last two elements on the right-hand side, f^2/v^1, represent what we term *relative size* (the ratio of final demand in country 2 to value added in country 1).

Table 1 reports summary statistics of the predicted spillover effects that arise when economic structure, final demand composition, and relative size jointly change over time, that is, all elements in equation 14 take on time-varying values. It can be observed that Austria records the smallest standard deviation; Austria's mean, minimum, and maximum are fairly close to the 2009 value. In this sense the spillover effect on Austria is the most robust. Belgium records the largest standard deviation, and the maximum is almost twice as large as the minimum. The spillover effect on Belgium is the least robust. Although the volatility in the predictions is non-negligible, it is reassuring that the spillover effects do not change by an order of magnitude even over a 15-year time horizon.

We can isolate the effect of the temporal variation in the economic structure by letting the economic structure vary over time $t = 1995, \ldots, 2009$, while holding the other elements constant at $t = 2009$. Analogously, we can isolate the effect of the temporal variation in the final demand composition by letting the final demand composition vary over time, while holding the other elements constant. Finally, we can isolate the effect of the temporal variation in the relative size of the economies by letting the relative size vary over time,

Table 1: Spillover effects 1995-2009

	AUT	BEL	ESP	FIN	FRA	GRC	IRL	ITA	NLD	PRT
2009	0.162	0.117	0.054	0.056	0.056	0.031	0.106	0.063	0.141	0.058
Mean	0.166	0.148	0.071	0.079	0.073	0.046	0.133	0.083	0.161	0.082
Std Dev	0.007	0.029	0.015	0.010	0.011	0.010	0.028	0.016	0.018	0.026
Min	0.154	0.108	0.049	0.056	0.056	0.031	0.098	0.063	0.135	0.054
Max	0.178	0.199	0.086	0.095	0.090	0.065	0.194	0.115	0.200	0.131

Notes: The first row shows the spillover effects predicted with 2009 data (same as reported in figure 2). The predictions vary as the underlying source data vary over $t = 1995, \ldots, 2009$. The last four rows show the mean, standard deviation, minimum, and maximum of the 15 predictions per country.

while holding the other elements constant. Figure 6 shows the outcome of this exercise. The black-solid line visualizes the predictions summarized in table 1: economic structure, final demand composition, and relative size jointly take on time-varying values. The gray-solid line represents the spillover effects that result from time-varying relative size while holding constant the world economy's economic structure and Germany's final demand composition. The dashed lines are defined analogously and should be self-explanatory.

It can be observed that spillover effects do change over time, but change is fairly gradual, and sharp jumps from one year to the next are the exception. Spillover effects decline everywhere except in Austria, where the black-solid line shows no downward trend. Germany's ability to play a locomotive role for the euro area was greater in 1995 than it was in 2009 and probably is today. The main point that we wish to emphasize is this one: change in the world economy's structure and Germany's final demand composition does not account for the decline of spillover effects in most countries – relative size does. In most cases the dashed lines (reflecting change in structure and composition) are relatively flat in comparison with the gray-solid line (reflecting change in relative size). The proximity of the solid lines to each other indicates that spillover effects declined over time largely because the size of Germany's economy declined relative to the size of other euro area economies. Germany is less able to play the locomotive role today simply because the German economy has shrunk in relative terms.

The global crisis and the associated collapse of demand in the European South partly reversed the change in relative size that occurred during Germany's "sick-man period" (1995-2005). From 2009 to 2014, Germany's final demand increased from 2366 to 2741 billion euros while for instance Spain's GDP decreased from 1079 to 1041 billion euros. The ratio of Germany's final demand to Spain's GDP increased by 20 percent. This fact suggests that the 2014 spillover effect of Germany's final demand on Spain's GDP can be expected to be about 20 percent higher than reported in our tables and figures, which are based on 2009 values.

To repeat, the spillover effects are stable in spite of the observed changes in the world economy's structure and Germany's final demand composition from 1995 to 2009 (a 15-

Notes: The black-solid line represents the spillover effects computed with economic structure, final demand composition, and relative size from $t = 1995, \ldots, 2009$. The gray-solid line represents the spillover effects computed with time-varying relative size while all other elements take on 2009 values. The black-dashed line represents the spillover effects computed with time-varying economic structure while all other elements take on 2009 values. The gray-dashed line represents the spillover effects computed with time-varying final demand composition while all other elements take on 2009 values. The y-axis scales are country-specific. Details in appendix B.

Figure 6: Structural decomposition of spillover effects

year period). We can state with reasonable confidence that the unobserved behavioral and structural change that certainly did occur since 2009 does not invalidate our results.

C. Auxiliary Data Sources

Bundesbank Germany's trade in goods and services in euros from the section "Current account by country and group of countries".[19]

AMECO Civilian labor force (variable code NLCN), GDP at current market prices (UVGD), and final domestic demand excluding inventories at current prices (UUNF).[20]

Bundesagentur für Arbeit Unemployment rate and under-employment rate from the section "Arbeitsmarkt im Überblick - Die aktuellen Entwicklungen in Kürze".[21]

[19] http://www.bundesbank.de/Navigation/EN/Statistics/statistics.html (accessed on August 15, 2015).

[20] http://ec.europa.eu/economy_finance/db_indicators/ameco/index_en.htm (accessed on August 15, 2015).

[21] http://statistik.arbeitsagentur.de/Navigation/Statistik/Statistik-nach-Themen/Arbeitsmarkt-im-Ueberblick/Arbeitsmarkt-im-Ueberblick-Nav.html (accessed on February 24, 2016).