Industrial linkage and regional shock spillover: An empirical exploration of the EMU

Koen Breemersch*

Abstract

This paper analyzes how a particular asymmetric shock propagates in the European Monetary Union (EMU). It uses the Chinese trade penetration shock and decomposes the exposure of a regional labor market to this shock into a direct shock and two indirect shocks. The indirect shocks are determined based on industrial linkages of the industries operating in the regional labor market. The linkages to domestic and foreign industries are considered separately to identify the strength of propagation through both types of linkages. The results show that in total 1.9 million jobs in the EMU were lost during the period of 1999 to 2007 as a result of Chinese import competition. However, regional labor markets in core countries benefited from China's integration in the world economy as the industries in these markets delivered inputs to foreign industries that saw strong export growth to China. This was less the case with peripheral economies, indicating that a core-periphery model emerges when it comes to the foreign propagation of a shock. Larger and more peripheral economies in the EMU underwent a strong propagation of the import competition shock within the domestic economy. The industrial structure of the EMU is thus likely to exacerbate the asymmetric impact of shocks rather than mitigate it. The paper finds that the results propagate in the theoretically anticipated direction and that Chinese trade penetration had greater impact on the labor market than TFP shocks. (JEL: E32, F15, F16, F4)

*University of Leuven, Vlamingenstraat 83, 3000 Leuven, Belgium, (e-mail: koen.breemersch@kuleuven.be). I would like to thank Jozef Konings, Jože Damijan, Jan Van Hove, Glenn Magerman and Hylke Vandenbussche for comments on the paper. I also thank seminar participants at KU Leuven for useful comments and suggestions.

1 Introduction

Since its creation, the Eurozone has been subject to several shocks that have exposed the frailties in its economic design. With labor markets that remain largely bound by country borders, a single monetary policy and constrained fiscal policy options, policy makers lack the necessary instruments to mitigate the effects of asymmetric shocks. The ability of a single currency zone to deal with these shocks had been the subject of a debate among economists prior to the emergence of the single currency.

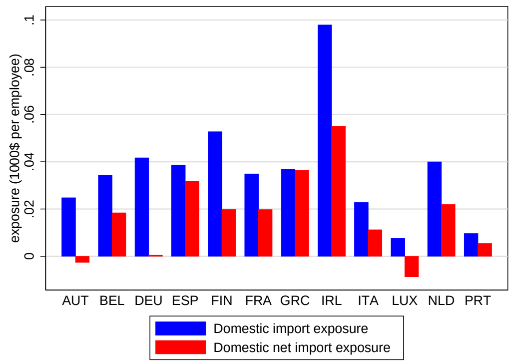
The central objective of this debate was to identify the preconditions of an optimum currency area and explore whether the future Eurozone would adhere to these conditions and thus be successful. In simplifying this debate, one can generally distinguish between two opposite views. On the one hand, Frankel and Rose (1998) argued that greater trade integration would induce increased business-cycle comovement. A single currency would represent an additional step in lowering transaction costs between Eurozone countries and therefore endogenously create closer trade relations. Nevertheless, these lower transactions costs could also be a source of increased fragility in the view of Krugman (1993). With lower costs, industrial specialization at the national level could increase making the Eurozone more fragile to asymmetric shocks.

The debate continues to be of particular relevance given the tumultuous period that the European Monetary Union (henceforth EMU) has gone through since the start of the Eurozone crisis. In this paper I want to get back to the fundamentals of this debate and use recent data to empirically analyze the EMU's sensitivity to asymmetric shocks. I combine both specialization (in terms of employment) and the trading network of industries in analyzing how one well-defined shock affects regional labor markets in the EMU. By focusing on a single shock, it is possible to trace the effects of the shock more directly and learn how the supply chain of a country's or region's industrial structure operates in spreading shocks across the EMU. While a multitude of shocks is likely to have affected the European regional labor markets, the Chinese trade penetration shock is a particularly potent shock to explore this question as it has been shown to have had considerable repercussions for regional labor markets in both the US (Autor and Dorn, 2013) and European countries (Balsvik et al., 2013; Dauth et al., 2014; Donoso et al., 2014). Additionally, the shock has been distinctly asymmetric in nature as shown in Figure 1 where the change in (net) import penetration of different European countries is pictured between 1998 and 2007 relative to the total market size in that country in 1998.

Analyses of the labor market effects of the Chinese trade penetration shock have relied on the employment specialization patterns of regional labor markets to uncover the exposure of a region to a shock. However, in my analysis I also address how supply chain links between countries help to spread this shock between regions and across country boundaries. To achieve this, this paper relies on recent insights from the network literature that has shown that the network structure of trade plays an important role in propagating shocks within supply chains and across industries, accounting for both intra-sectoral and inter-sectoral effects of shocks. By combining both the specialization and the network aspect, it is shown how the interplay of these characteristics matter in determining the sensitivity of the EMU to asymmetric shocks.

The findings of this paper contribute to the literature in multiple ways. First, I find that the labor markets of the original EMU countries have shed around 1.9 million jobs as a result of competition from Chinese goods. The effects emerge as a result of the interaction of both the network structure and the specialization pattern of a regional market, rather than only the latter. Hence, the trade network and the specialization pattern of a region must be considered concomitantly

Figure 1: Change in import and net import penetration ratio 1998-2007 in EMU countries



rather than separately. Secondly, this paper finds that there are considerable differences in the extent to which regional labor markets were affected. While this discrepancy is noticeable within individual countries, it is particularly pronounced between countries. Several of the small core countries of the EMU have even slightly benefited from the Chinese trade penetration shock. Their strong industrial ties to foreign (predominantly German) industries that gained from the booming demand from China led to increased demand for inputs from the Belgian, Dutch, Austrian and Luxembourg industries. However, many of the larger countries or countries that are situated on the periphery of the EMU only weakly imported shocks from abroad so that the shocks in their own country were mostly disseminated within their own domestic industrial network, exacerbating the original asymmetry of the shock. This means that in terms of the foreign propagation of shocks, a clear core-periphery model emerges. For instance, I find that while the positive exposure of some German industries to the trade opportunities in China meant that their small export-oriented neighbors benefited by delivering inputs to these industries, my results indicate that Germany itself was overall negatively affected by the shock. A third finding of this paper is thus that strong inter-country supply chain links do not necessarily lead to similar overall outcomes to industrially interlinked countries. Domestic supply chains that are only weakly linked to foreign industries could have averse effects on a regional economy or labor market that outweigh the opposite effects coming from the foreign supply chain. Overall, one of the key findings of this paper is that the current industrial structure of the EMU is likely to exacerbate asymmetries rather than mitigate these. Therefore a successful economic union requires the existence of other adjustment mechanisms so that economic divergence between the member countries is reduced.

This paper relies on several strands of the literature for its analysis. I apply the methodology of Acemoglu et al. (2015, 2016) and use the World Input-Output Tables constructed by Dietzenbacher et al. (2013) to analyze how countries are exposed to shocks that occurred in both the domestic and the foreign market. Since the Chinese import and export penetration shock mostly functions as a direct demand shock to an industry, I rely on the Acemoglu et al. (2016) framework that shows that demand shocks propagate upstream through an industry's supply chain. Increased demand for one industry's output leads to increased output for those industries providing inputs to the industry receiving the original shock. In the Acemoglu et al. (2016) framework a supply shock also only propagates uni-directionally downstream through the supply chain. Baqaee (2016) and Carvalho et al. (2017) show that this straightforward propagation pattern is mostly a result from model assumptions and that a shock will also, although more weakly, propagate in the opposite direction. To assess whether the Chinese trade penetration shock also propagated downstream rather than only upstream, both types of propagation shocks are included in my model. My results also show that the shock propagates strongly in one direction, in line with the models in the literature. However, there is no indication that the trade penetration shock also propagated downstream in the EMU supply chain. The fact that these shocks are shown to comply with the predictions of micro-based models despite the use of macro-economic shocks is testament to the strength of this propagation mechanism on a macro-economic level.

This paper is also closely linked to the research on the interaction between trade and business-cycle comovement. Frankel and Rose (1998) found that increased trade intensity between two nations led to increased business-cycle comovement between these nations. Ng (2010) and di Giovanni and Levchenko (2010) showed that the input-output links for countries and sectors, respectively, are an important factor in establishing this result. The difference in my framework and the existing literature is that I approach this question by looking at the propagation of one well-defined shock through the production network whereas the literature has mostly focused on aggregate patterns of comovement. In this way, I avoid the issue that comovement can be a result of an interaction between industrial specialization, vertical integration and bilateral trade intensity (Imbs, 2004). This issue is particularly pertinent in the comovement literature as comovement might foster increased trade intensity rather than the other way around (di Giovanni et al., 2016). While my paper does not look at the comovement of business cycles, it does find that interlinked network structures have profound effects on how shocks are propagated in the production network. Two countries will not experience similar outcomes from asymmetric shocks even if both share a strongly interlinked production network. If one of the two countries harbors a strong domestic network that is weakly interlinked internationally, the domestic network will operate to aggravate the existing asymmetry of an idiosyncratic shock. This finding suggests that the conversion of the EMU in an optimum currency area will require flexibility in the application of a number of policy instruments as the underlying industrial structure remains prone to asymmetric economic evolutions.

The paper proceeds as follows. In the next section I give a brief overview of the theoretical framework underlying the shock propagation mechanism. In section 3 I then offer empirical evidence on the structure of trade linkages in the EMU. Section 4 then presents the empirical framework that is applied in the paper to analyze how these trade linkages matter in the propagation of shocks. In section 5, I discuss the data and elaborate on the computation of the main shock variables. Section 6 shows the econometric results and provides insight into the economic significance of the findings. Section 7 concludes.

2 A theoretical framework of shock propagation

The Acemoglu et al. (2015) model provides the general features that form the theoretical backbone of the shock propagation mechanism explored in this paper. Acemoglu et al. also considers the propagation of a Chinese import shock in the empirical analysis. Its theoretical model highlights the propagation of a demand shock by modeling a shock in government purchases for the good of an industry. Moreover, the focus of their model is exclusively on the output of the relevant industry although their empirical exposition shows that the shock propagation extends its effects to employment as well. Employment shall also be the focal point of my empirical analysis. This allows me to link my empirical analysis to estimates obtained in the literature on the labor market effects of China. However, for expository purposes on the propagation of shocks, I will keep the theoretical framework in line with the one presented by Acemoglu et al. (2015) and thus focus on the effects on output.

In the model, firms produce in a perfectly competitive economy consisting of N industries. The firms within each industry n have the following constant returns to scale production function:

$$y_n = e^{z_n} l_n^{\alpha_n^l} \prod_{n=1}^{N} x_{nj}^{a_{nj}}, \tag{1}$$

where l_n is the labor that is employed and z_n represents a productivity shock. x_{nj} are the inputs produced by industry j and used as an input in industry n. The inclusion of these inter-industry sales in the production function create the intricate network structure which links the individual industries. Additionally, industries can also sell their output to final consumers, c_n, and the government, G_n, so that the market is fully cleared:

$$y_n = c_n + \sum_{j=1}^{N} x_{jn} + G_n. \tag{2}$$

Consumer preferences also have a Cobb-Douglas form and are represented by the following equation:

$$u(c_1, c_2, \dots, c_N, l) = \gamma(l) \prod_{n=1}^{N} c_n^{\beta_n}, \tag{3}$$

where β_n reflects the normalized weight of the preference of each industry good n in the household's preferences.

Prices of an industry good i are defined as p_i. The static equilibrium is obtained after both profit and preference maximization. In this equilibrium, intermediate good shares in total output of an industry n, a_{nj}, are equal to $\frac{p_j x_{nj}}{p_n y_n}$. These elements can be stacked in an input/output-matrix $\mathbf{A}$ of dimension $N \times N$:

$$\mathbf{A} = \begin{bmatrix} a_{11} \dots a_{1n} \\ \vdots \ddots \vdots \\ a_{n1} \dots a_{nn} \end{bmatrix}. \tag{4}$$

The Leontief inverse of matrix $\mathbf{A}$ can be represented by $\mathbf{H} \equiv (\mathbf{I} - \mathbf{A})^{\mathbf{-1}}$ with elements h_{nj}.

Since the empirical analysis will extensively focus on the propagation of a demand shock, the theoretical predictions with regards to the effect on an industry's output are most of interest. These follow from

$$d \ln y_n = \frac{d\,(p_j G_j)}{p_n y_n} + \sum_{j=1}^{N} h_{j\widehat{n - \mathbf{1}}_{j=n}} \times \frac{1}{p_j y_j} \times d\,(p_j G_j - RC_n), \tag{5}$$

where RC_n is a resource constraint effect and $\mathbf{1}_{j=n}$ is an indicator function equal to one when industry j and n are the same. It effectively separates a demand shock to an industry n in the direct own effect (the first term of the right-hand side of the equation 5) and the indirect network effect (which is captured by the second term on the right-hand side). Interestingly, As the discussion above indicates, the propagation mechanism of Acemoglu et al. (2015) is always unidirectional and opposite for supply and demand shocks. This is a specific feature of the chosen preference and production functions. Demand shocks could equally propagate to downstream industries that buy inputs of the affected industries if the demand shock were to affect prices. However, as a result of the constant returns to scale assumption, prices are independent of the demand-side in the current setting. The demanded quantity is thus altered as a result of a demand shock without a negative price shock causing decreased downstream demand for the goods of the industry.

The Carvalho et al. (2017) model generalizes the Acemoglu et al. (2012) setting and analyzes the propagation of supply shocks with a CES production function and logarithmic preferences. In this setting, a supply shock no longer exclusively propagates downstream but can also propagate upstream or horizontally. The former occurs as a result of a labor substitution effect where a downstream industry will adjust labor in response to a negative supply shock to its supplier that led to higher prices of the inputs to the downstream industry. This adjustment could attenuate or partially offset the original shock depending on the elasticity of substitution. While there is both upstream and downstream propagation in this setting, the downstream propagation effect of a supply shock dominates in terms of its size.

While the demand shock propagation described by Acemoglu et al. (2015) is thus relatively straightforward, there are important nuances that result from the knife-edge income and substitution effects of the Cobb-Douglas functional form. In the empirical analysis, the focus will mostly lie on uncovering the upstream propagation effects of demand shocks. However, it is more than conceivable that Chinese import competition has also affected prices of intermediate good-supplying industries thereby causing possible downstream propagation effects. As the models have shown that upstream propagation to supplying industries will dominate over any downstream propagation effects to input-consuming industries induced by the demand shock, this channel will mainly be considered in the empirical analysis.

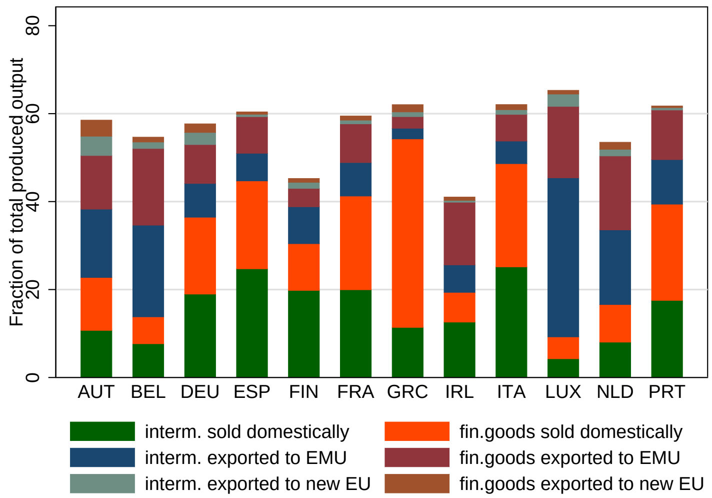
3 The EMU industry and trade linkages

While the Acemoglu et al. (2015) model was backed up with evidence, it focused on a single large country in its analysis. However, here I wish to focus on the interactions between multiple countries. To obtain a first rough indication of the trade linkages between manufacturing industries, I plot the within- and between-country trade of intermediate and finished goods. These are derived from the WIOD tables (Dietzenbacher et al., 2013) and presented in Figure 2. It contains trade between the original EMU member states themselves, but also between the member states and the member states and the EU countries that were not part of the original EMU[1].

Unsurprisingly, manufacturing industries in larger countries sell a larger fraction of their output in the domestic market compared to the manufacturing industries in smaller countries. This outcome not only complies with the predictions of a basic gravity model, it also corresponds to the home bias in trade puzzle first discussed by McCallum (1995). Smaller periphery countries such as Greece and Portugal also sell a larger fraction of their manufacturing output on the domestic market. The small core countries on the other hand actively engage in trade with other EMU

[1]These countries include the new member states that joined the EU prior to 2008 such as Estonia, Latvia, Hungary, Slovakia, Slovenia, Romania, Bulgaria, Czech Republic, Lithuania, Cyprus, Malta and Poland as well as the other EU countries: Denmark, Sweden and the United Kingdom.

Figure 2: Composition of industry trade of original EMU-countries in 2007



countries, selling large fractions of both final goods and especially intermediate goods to the other members of the EMU. This difference in trade structure likely entails a difference in integration of the cross-border supply chains, implying that the manufacturing industries from the periphery countries are more isolated from the rest of the EMU production structure. Ireland and Finland both stand out as a large fraction of their output is sold to members outside of the original EMU.

While Figure 2 provides a general impression of the trade interlinkages between the different EMU members, it gives no indication of the importance of certain sectors as potential propagators for shocks within the EMU economy. For the US economy, Acemoglu et al. (2012) have shown that a limited number of sectors serve as general input providers to the entire economy and are thus central nodes in the production structure of the US economy. Shocks in these core sectors will spread through the entire economy as inputs are supplied to downstream industries. In Figure 3 I develop similar measures to study the potential for shocks in certain domestic industries to spread across the foreign EMU economies. If certain sectors in some countries act as central providers or demanders of inputs, then shocks in these industries can be evenly spread around its foreign trading network. The first measure, the weighted outdegree, is directly derived from the network literature and reveals an industry's importance as input provider to foreign industries. Formally, it is computed as:

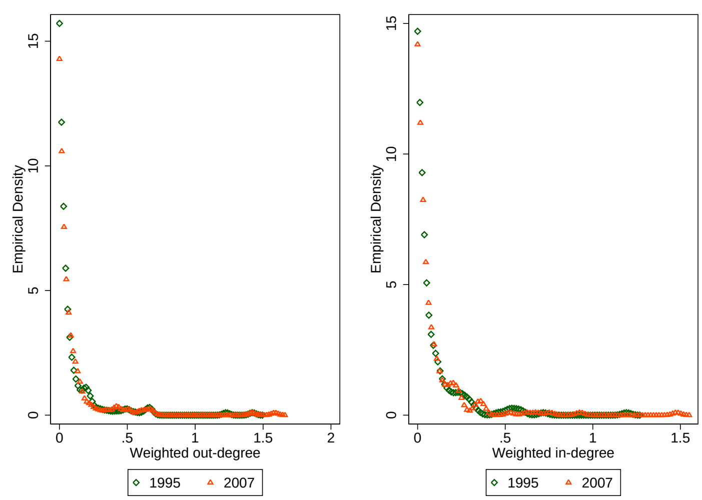
$$od_{j(c)} = \sum_{f \neq c} \sum_{n}^{N} \frac{inputs_{j(c) \rightarrow n(f)}}{output_{n(f)}} \tag{6}$$

$od_{j(c)}$ is the foreign weighted outdegree of an industry j in a country c. Each trade linkage of this industry j with a foreign industry n in country f is weighted by the fraction of inputs industry j provides relative to the total output of the industry n. If an industry j is an important input provider to several foreign industries, it will thus have a high foreign weighted outdegree. While this outdegree stems directly from the Acemoglu et al. (2012) model, there is no immediate theoretical counterpart in that same model that reflects the importance of an industry as an input demander. Nevertheless, when one extends the Acemoglu et al. setting as in Baqaee (2016), the diffusion of shocks is of a more complex nature where not only the supplier centrality is relevant, but also the consumer centrality. To capture this aspect of consumer centrality, I construct a second measure that looks at the importance of an industry j in country c as an input demander of foreign goods and call this the indegree of an industry. Again, each link with a foreign industry n in country f is weighted. However, this time the weight is computed as the fraction of goods the industry j demands relative to the total output of the foreign industry n. A large industry with a supply chain consisting of a substantial number of foreign input providers could thus end up with a high indegree, signaling that industry's role as a central node in the trading network as an input demander.

$$id_{j(c)} = \sum_{f \neq c} \sum_{n}^{N} \frac{inputs_{n(f) \rightarrow j(c)}}{output_{n(f)}} \tag{7}$$

I compute the two degree measures based on WIOD data in 1995 and 2007 for each of the 16 manufacturing industries per original EMU member. The results are plotted in a kernel density plot in Figure 3. Both graphs are strongly skewed thereby revealing that a limited number of industries act as important input providers and input demanders in the EMU economy.

Figure 3: Foreign weighted out-degree and in-degree distribution for EMU manufacturing industries



Given the size of their economies, it is no surprise that the main industries making up the tails of these distributions are mostly from Germany, France and Italy. These industries could thus be important as potential propagators of shocks to foreign economies. However, it seems that the industries that are mostly demanding/supplying goods to these tail-industries are mostly situated in the small core countries of the EMU such as Belgium, Austria, Luxembourg and the Netherlands, and to a lesser extent in France. Shocks would therefore mostly propagate to these economies rather than the industries in other economies.

This preliminary analysis would suggest that supply chain linkages can prove important in analyzing the propagation of shocks. However, in the run-up to the creation of the EMU considerable attention was paid to the differential patterns of specialization across different economies as sources of asymmetric economic movement. Indeed, Krugman (1993) argued that the lowering of transaction costs as a result of increased economic integration leads to more clustering and increased regional specialization in terms of the employment in certain industries. These patterns of specialization were analyzed by Amiti (1999) for European economies by computing a country Gini index based on the industrial activity. I repeat this exercise to compare industrial specialization in 2007 in EMU countries to 1995 by using data from EU KLEMS (O'Mahoney and Timmer, 2009) based on the value added generated by each industry[2].

Table 1: Evolution of country Gini indices in the EMU over time

	Gini index Value added	
	Gini index 1995	Gini index 2011
Austria	0.16	0.14
Belgium	0.18	0.26
Finland	0.32	0.27
France	0.09	0.09
Germany	0.14	0.19
Greece	0.42	0.49
Ireland	0.44	0.59
Italy	0.18	0.20
Luxembourg	0.45	0.44
Netherlands	0.25	0.29
Portugal	0.38	0.34
Spain	0.15	0.20

[a]

Source: Amiti (1999) method applied to EU Klems data

While patterns of specialization have diverged across economies, it stands out that several economies have undergone slight increases in specialization of their production structures. The theory of Krugman (1993) suggests that this has left the EMU economy more vulnerable to idiosyncratic shocks in certain economies. However, the linkages between industries imply that these shocks can be partially spread to linked industries abroad. While this paper is not intended as a definitive settlement of this discrepancy in views, the importance of the domestic and the foreign industrial network in shock propagation will be weighed off. In the next section I develop an empirical model that incorporates both the industrial specialization of a region in the EMU and the industrial interlinkages. Through the choice of a well-defined shock, i.e. the Chinese trade shock, I can then gain more insight into the relevance of industrial links for regional economies.

4 Empirical framework

In this section, I describe the main underlying methodology that forms the cornerstone of the empirical approach. First, a trade penetration shock is decomposed into its direct, domestic network and foreign network components. The decomposition shows to what extent increased imports

[2]Results were similar when using industry-level employment.

directly affect an industry and how the industry itself is indirectly affected as a supplier of inputs to domestic and foreign industries that compete with Chinese imports. Next, I translate the national level shocks into regional shocks using the pattern of industrial specialization at the regional level as in Autor and Dorn (2013). In this way, regions that house industries specialized in the production of those goods competing with China face stronger local exposure to the emergence of China. I shall refer to this type of exposure as direct exposure. Moreover, I also account for the regional exposure to downstream import penetration shocks, which shall be referred to as indirect exposure. So the use of this framework allows me to empirically uncover to what extent the direct exposure effect of a region compares to the indirect exposure to other industries through its industrial production network. The direct exposure effect has been widely used in the literature to assess the sensitivity of a region to import penetration shocks. However, the possibility that regions are indirectly exposed to shocks through a combination of both specialization and network linkage was not accounted for. By contrasting the direct exposure and the indirect exposure, on the one hand, and the domestic and foreign indirect exposure, on the other hand, the role of industrial linkages to regions is highlighted.

4.1 National shocks

The theoretical exposition highlighted that the Chinese import shock resembles a downstream demand shock that propagates upstream to those industries that provide inputs to the industry hit by the shock. More specifically, the direct exposure of an industry j to a shock in a downstream industry n consists of the fraction of output that is provided by the industry j to the downstream industry n[3].

$$\widehat{a_{jn}} = \frac{Sales_{j \to n}}{Sales_j}$$

These elements, however, do not reflect the full link between upstream and downstream vertically integrated sectors. An upstream sector j can equally provide indirect input to a downstream industry n. For example, the metal industry can provide the necessary components directly to a car industry for it to produce cars. However, the car industry would also require electronic equipment that is installed in the car. The metal industry will indirectly provide inputs to the car industry by first selling the inputs to the electronic equipment industry that sells its final product as an input to the car industry. Decreased demand for products of the car industry would then lead to decreased demand for metals as direct inputs, but also as indirect inputs through the electronic equipment. The full linkage between an industry j and an industry n is represented by the Leontief inverse element $\hat{h_{jn}}$[4]. it represents the total amount of inputs that are demanded by industry n from industry j, both directly and indirectly, for the production of one unit of industry n output. To account for the fact that the industries might be situated in different countries, the country subscripts are included in the notation of the link. Therefore, $\widehat{h_{j(c),n(f)}}$ encompasses the entire link of an upstream industry j in country c to the downstream industry n in country f. Note that when industry j and industry n are effectively the same industries in the same country, the Leontief coefficient will be greater than one. This results from the fact that the industry partially supplies its own inputs. For the production of cars, the car industry will produce certain car parts itself that serve as inputs into its own production process.

[3] For the sake of parsimony, I will limit the exposition here to the import demand shock.

[4] This element is computed by stacking all the $\hat{a_{jn}}$ elements in a matrix $\hat{\mathbf{A}}$ and computing the Leontief inverse $(\mathbf{I} - \hat{\mathbf{A}})^{-\mathbf{1}}$ of this matrix. The individual elements of this matrix are then the Leontief inverse elements $\hat{h_{jn}}$.

I define a Chinese import penetration shock to industry n in country f as the change in total dollar amount of Chinese imports of industry n goods per industry employee[5]. Throughout the paper I lag employment by three periods to avoid potential simultaneity issues. Firms might anticipate an import penetration shock in the near future and therefore offshore part of their manufacturing activity to reduce costs of production, thereby increasing the observed national shock. By lagging the employment variable, I eliminate this simultaneity issue. Formally, this is represented as:

$$\Delta Imp.pen^{CHN}_{n(f)t} = \frac{\Delta Imports^{f \leftarrow China}_{n(f)t}}{E_{n(f)t-3}}. \tag{8}$$

Using this definition, I can now construct the national shock variable for a given focal industry j as a weighted sum of the shocks in all downstream industries.

$$\begin{aligned} Shock_{j(c)t} &= \sum_{n(f)} \widehat{h_{j(c),n(f)}} \Delta Imp.pen^{CHN}_{n(f)t} \\ &= \Delta Imp.pen^{CHN}_{j(c)t} + \sum_{n(f)} \left(\widehat{h_{j(c),n(f)}} - 1_{j(c)=n(f)} \right) \Delta Imp.pen^{CHN}_{n(f)t} \end{aligned} \tag{9}$$

To obtain the complete shock undergone by the upstream industry, I sum over all industries in both the domestic and foreign network and weigh these according to the input provision by the industry. In the second line of equation 9 I decompose this shock into the direct shock that the industry j in country c experiences due to import penetration in its own industry and sum over all shocks in the downstream industries n in countries f. The link variable, $h_{j(c),n(f)}$, at the end of time period $t-1$ is used to express these links. I lag these links by one period so that I use the industrial links one year prior to when the import penetration shock occurred. The industrial links thus pre-date the shock while being sufficiently recent to reflect realistic links between the industries. $1_{j(c)=n(f)}$ is an indicator function that is equal to one when the industry provides inputs to itself. This indicator function splits the network shock into a direct exposure effect and an indirect exposure effect. By separating the direct and the indirect effect, I isolate the network effect in the second term and the direct shock in the first term.

Finally, I decompose the network effect in the second term of equation 9 in a domestic and a foreign network effect. This follows from a straightforward decomposition of equation 9.

$$\begin{aligned} \sum_{n(f)} \left(\widehat{h_{j(c),n(f)}} - 1_{j(c)=n(f)} \right) \Delta Imp.pen^{CHN}_{n(f)t} &= \sum_{n(c)} \left(\widehat{h_{j(c),n(c)}} - 1_{j(c)=n(c)} \right) \Delta Imp.pen^{CHN}_{n(c)t} \\ &+ \sum_{\substack{n(f) \\ c \neq f}} \left(\widehat{h_{j(c),n(f)}} \right) \Delta Imp.pen^{CHN}_{n(f)t} \end{aligned} \tag{10}$$

The first term of equation 10 is the exposure of the industry j in country c to the Chinese import penetration shock in all downstream industries in country c. The second term focuses on all value chains that cross country borders and represents the exposure of a domestic industry to all foreign

[5] These imports are expressed in thousands of dollars.

industries. An industry that provides a large amount of its output as inputs to foreign sectors is therefore strongly exposed to the shocks in those industries.

Using the methodology of Acemoglu et al. (2015) I have just decomposed the total exposure of an industry to a Chinese import penetration shock into a direct shock to the industry and a domestic and foreign network shock that is propagated to an input-supplying industry. Intranational trade will thus propagate shocks withing the country boundaries, while international trade will spread these across countries. Now I introduce regional employment specialization to translate these national shocks to regions.

4.2 Regional shocks

To perform an analysis at the regional level using the decomposition in equations 9 and 10 would require regional import penetration measures and a regional input-output table. However, both these variables are only available at a more aggregated national level. Hence, I follow Autor and Dorn (2013) and use the regional employment structure in manufacturing to translate the change in exposure at the national level to the regional level. Regions that are specialized in import-competing industries, will proportionately suffer a larger direct shock by Chinese import competition compared to those that specialize in relatively unaffected industries. Here, I will first construct the direct exposure shock of a region p and thereafter use the same methodology to construct similar domestic and foreign network exposure shocks at the regional level.

The direct import exposure of a region p in country c at time t to imports from China can be expressed as:

$$\Delta Imp_{p(c)t}^{CHINA} = \sum_j \frac{E_{jp(c)t-3}}{E_{pct-3}} \Delta Imp.pen_{j(c)t}^{CHN}. \tag{11}$$

$\frac{E_{jp(c)t-3}}{E_{p(c)t-3}}$ captures the employment in industry j relative to total industrial employment in the region p. I again lag the employment variables by three years to control for potential endogeneity issues. The variable $\Delta Imp_{p(c)t}^{CHINA}$ thus translates each import exposure measure $\Delta Imp.pen_{j(c)t}^{CHN}$ at the national level into a regional equivalent that explicitly accounts for the industrial specialization of that region and then sums over all the manufacturing industries j. By accounting for the differing industrial structure across regions, the shock that captures the approximate exposure of a region to a national shock and creates variation across regions. However, industrial specialization can equally entail that employment in some regions is concentrated in industries that have experienced a growth in export opportunities as a result of the increased purchasing power of Chinese customers. To accommodate this possibility, the regional import penetration measure can be easily transformed into an export penetration measure using the same set-up as in equation 11.

$$\Delta Exp_{p(c)t}^{CN} = \sum_j \frac{E_{jp(c)t-3}}{E_{p(c)t-3}} \Delta Exp.pen_{j(c)t}^{CHN} \tag{12}$$

The only difference with the variable in equation 11 is that I replace national imports of goods in industry j with national exports to China of goods in industry j.

To translate the national industrial network shocks to regional equivalents, I proceed similarly. Hence, the domestic and foreign exposure of each industry j in a country c, reflecting the first and second term of equation 10 respectively, are weighted with the share of employment in that industry in region p relative to total manufacturing employment in the region p. The following equations are a way to translate equation 10 to regional labor markets:

$$\Delta Imp\, Dom.Link^{CN}_{p(c)t} = \sum_j \frac{E_{jp(c)t-3}}{E_{p(c)t-3}} \sum_{n(c)} \left(\widehat{h_{j(c),n(c)}} - 1_{j(c)=n(c)}\right) \Delta Imp.pen^{CHN}_{j(c)t};$$
$$\Delta Imp\, For.Link^{CN}_{p(c)t} = \sum_j \frac{E_{jp(c)t-3}}{E_{p(c)t-3}} \sum_{\substack{n(f)\\ c\neq f}} \left(\widehat{h_{j(c),n(f)}}\right) \Delta Imp.pen^{CHN}_{n(f)t}.$$

$\Delta Imp\, Dom.Link^{CN}_{p(c)t}$ is the approximated exposure of a region p of country c to the import penetration shock in the domestic network of the industries that the region harbors. If regional manufacturing is primarily concentrated in activities that provide inputs to industries in the same country that face strong competition from Chinese imports, the region is indirectly affected through these industrial links. Similarly, $\Delta Imp\, For.Link^{CN}_{p(c)t}$ embodies the approximated exposure of the region to the foreign network shocks experienced by each industry j that is active in region p of country c. A caveat of this approach is that the link variable at the national level represents an average. This average will differ from the industrial link of the regional industries. For instance, industries in regions that are situated at the border with another country will be interlinked more to the industry in the neighboring country than industries situated at the very center of a country. Nevertheless, if the region at the border and the region at the center of the country have the same pattern of industrial specialization, I implicitly assume that their industrial links to the neighboring country are of the same magnitude[6].

The change in the export exposure measure is constructed by changing the imports by exports. $\Delta Exp\, Dom.Link^{CHINA}_{p(c)t}$ is then the positive shock that a region p experiences as a result of the fact that each industry in its region provides inputs to domestic industries that have increased exports to the Chinese market. Those regions whose industries are closely linked with foreign industries could benefit through the changed exposure of these foreign industries. $\Delta Exp\, For.Link^{CHINA}_{p(c)t}$ approximates this exposure.

4.3 Econometric Specification

I want to gain an insight into the relative importance of the industrial interlinkages in propagating shocks between regions using the above constructed direct and indirect trade penetration shocks. I mainly use the following two specifications to assess this question empirically[7]:

$$\begin{aligned}\Delta L_{pt} \quad &= \beta_1 \Delta Imp^{CN}_{pt} + \beta_2 \Delta Imp\, Dom.Link^{CN}_{pt} + \beta_3 \Delta Imp\, For.Link^{CN}_{pt} + \\ &\quad \beta_4 \Delta Exp^{CN}_{pt} + \beta_5 \Delta Exp\, Dom.Link^{CN}_{pt} + \beta_6 \Delta Exp\, For.Link^{CN}_{pt} + \\ &\quad \mathbf{X'_{pt-1}} \beta_7 + \gamma_t + \gamma_c + \epsilon_{pt}\end{aligned}$$

[6] In the econometric analysis, I shall interact the foreign exposure of regions bordering a neighboring country with a border dummy. While this is still not a perfect substitute for a region-specific input-output table, I find only weakly significant indications that there are indeed differences in propagation depending on whether the region is at a border or not.

[7] To not overly clutter the main text, I drop the country c subscript in the formulas.

ΔL_{pt} is the change in the share of manufacturing employment to total working age population for region p in country c between year t and the start of the period. The regression is run on data for EMU regions and using two stacked periods from 1999 to 2003 and from 2004 to 2007. China joined the WTO in 2001 and therefore both periods are expected to show strong effects of the emergence of China on the world stage. However, the second stacked period from 2004 to 2007 is characterized by the entry of several Central and Eastern European countries in the European Union. Although trade integration will have proceeded gradually even before 2004, I choose to use two separate stacked periods to control for the EU-entry event. Additionally, this offers more variation in the sample which is particularly interesting for small countries with few regions.I account for the trade penetration shocks caused by the further integration of the Central- and Eastern European economies in a robustness check in the empirical section. The vector $\mathbf{X'_{pt-1}}$ consists of a number of control variables that are included in the specification to control for a number of labor market characteristics at the beginning of the stacked period. Through including these variables, I isolate the trade shock effect and avoid the possibility of picking up unrelated trends on the shock variables. In the main specification I only include the share of manufacturing employment in total regional employment at the end of the prior year. This variable controls for the differences in manufacturing employment between the regions and the possibility that the decline in employment is mostly a direct consequence of the more general decline that occurred in manufacturing during the period. I add further controls such as the share of higher skilled employment in the region and the share of female employment in the regional labor force as a robustness check[8].

Standard errors are clustered at the country level to account for spatial auto-correlation between the regions of the same country. I include both country fixed effects γ_c and time fixed effect γ_t.

A problem that inhibits correct identification of the coefficients is the possibility that a third shock simultaneously affected the dependent and the independent variables, not allowing me to ascribe a causal interpretation to my coefficients. The literature has so far mostly attempted to assess the labor market effects of an import penetration shock in a single country. While the endogeneity is an issue at this level, the problem becomes even more prevalent when considering a group of regions spread over several countries as I do here. The demand booms in some European countries have caused a strong surge in imports while the evolution of employment was positive. Autor and Dorn (2013) resolve the issue by using a 2SLS procedure. They use industry-level growth of Chinese exports to several other high-income countries and construct the instrument as in equation 11. By focusing on exports to several other destination markets, the instrument exclusively captures the growth in exports that is a result of Chinese productivity growth and decreased transport costs. Acemoglu et al. (2015, 2016) extend this instrument to look at network effects of an import penetration shock. The application of a similar 2SLS strategy is not possible here because the variables exhibit a higher degree of variation as a direct consequence of using multiple countries in the sample[9]. By using a single instrument, I am not able to sufficiently explain discrepancies between markets. In the next section, I address this issue by constructing a variable that captures the change in Chinese imports and exports due to supply factors. In section 6 I present results where I use both this measure and the endogenous measure that consists of the

[8] Several other controls often used in the literature were not available due to inconsistent reporting of these variables across all regions in the sample.

[9] Since the change in the import exposure measure is obtained through translating the national import exposure to the regional level using the regional industrial structure, the variation in this variable arises from the differences in regional specialization. By contrast, using multiple countries implies that variation not only comes from the differences in regional specialization, but also from differences in the changes of import exposure at the national level.

change in the imports and exports to gauge the scale of the endogeneity issue.

Some general remarks on my main specification are still in order. First, while my current specification looks at the direct effects of Chinese import competition on regional employment, it does not account for the full China effect which is more convoluted by concurrent evolutions brought about by China's rise. Outward FDI to China and offshoring via the globalization of value chains will have directly affected domestic jobs. Implicitly, some of these effects might be captured by my specification. Nevertheless, the intricate workings of these channels are not perfectly captured by including my import competition measure. Moreover, given the complexity of this issue, I shall keep the discussion in this paper limited to Chinese import competition and not attempt to consider the full effect of China's rise. Secondly, China has known a steep rise to its current status as global powerhouse. Semantically, one might argue that the associated rise in Chinese imports that was experienced by many countries does not constitute a shock as such. However, I follow the semantics of Autor and Dorn (2013) and refer to it as a shock since it reflects the rapid pace with which global trade has altered over a fairly short period.

5 Data

In this section, I will elaborate on the construction of an exogenous change in imports measure and discuss the data sources that are used in the construction of the data. Thereafter, I present some descriptive statistics.

5.1 Sources and shock construction

The main challenge of the analysis is to construct a change in import penetration variable that provides a sufficient amount of variation across the countries in the sample, but remains exogenous to idiosyncratic shocks that simultaneously shift the import exposure of a country and the evolution of the employment. However, the analysis will mostly be performed by using a variable that estimates the change in import exposure on the basis of gravity residuals (Autor and Dorn, 2013; Dauth et al., 2014). The change in the gravity residual over time differences out domestic shocks. This leaves only the relative changes in bilateral transport costs and productivity as explanations for the change in Chinese imports at the country-level. Hence, by using these gravity residuals I obtain an estimate of the part of the import penetration shock that is caused by Chinese supply-side factors, while eliminating the endogenous part of the shock that inhibits correct identification in the specification.

Although I defer the more technical discussion of the methodology to appendix A, I will summarize here the exact construction of the variable to clarify its workings. I use export data from the UN COMTRADE database available from 1998 to 2007 at the SITC rev.3 product level and subsequently collapse these into 12 manufacturing industries at the NACE rev.1.1 level using the relevant correspondence tables. I use exports of a particular Chinese industry to a high-income destination market and compare these to the exports by a member of the EMU in the same industry and to the same country. These relative exports average out the importance of import demand factors in the destination market. They therefore exclusively represent how Chinese industrial exports fare compared to the exports of members of the EMU to that same market. By using a number of high-income destination markets to compare the evolution of these relative exports, I obtain a general picture of how the exporting EMU country has lost or improved its relative comparative advantage in a certain industry compared to China. The change in the comparative advantage is a result of a combination of two factors: (*i*) the relatively stronger increase in productivity of Chinese exporters; (*ii*) the relatively stronger drop of bilateral transport costs of Chinese exporters as China gained improved access to foreign markets by joining the WTO. In a final step, I multiply this change in comparative advantage with the initial industry imports from China. The resulting measure is the structural import competition shock that is not related to local demand factors. A simple measure based on the observed change in exports to China can again lead to endogeneity issues as a local supply shock can simultaneously affect exports and employment. However, I would like to find out how the improvement in export opportunities to China has relatively surpassed those to other more established destination markets. I therefore again rely on the gravity approach of Dauth et al. (2014) to construct a residual that captures the log change in these export opportunities. A supply shock in the industry of an EMU member would affect exports to both China and other developed countries and is therefore differenced out. This only leaves the stronger relative decrease in bilateral transport costs with China and increased relative expenditure in China as an explanation for the improved export exposure to China. I again refer to appendix A for the technical details of the construction of this variable.

I use the WIOD dataset (Dietzenbacher et al., 2013) to construct the industrial linkages and compute the regular trade exposure measures. The WIOD provides data over the yearly period from 1995 to 2011. It consists of 40 countries and reports the dollar amount that a given industry in a specific country provides as input to another industry. The flows are reported at the industry level using NACE rev. 1.1 two-digit industries and includes a total of 35 industries for each country included in the database, of which 12 are manufacturing industries that will be the main focus of this paper. The employment data comes from several sources. The EU Klems database provides data on employment on the national level. The regional employment data is from the Labor Force Survey (LFS) and the Structural Business Survey (SBS) provided by Eurostat for the period of 1996 to 2007. A more detailed discussion on issues related to these regional employment level data and the construction of the shares of employment in each region is provided in appendix C.

5.2 Descriptive statistics

In table 2 I present the descriptive statistics of the variables that will be applied in the econometric analysis. There, it is revealed that the change in manufacturing employment is situated in a wide range of values, but overall the manufacturing employment to population ratio has on average decreased across the different regions in the sample. Employment in manufacturing in a region at the end of the year $t-1$ was normalized by subtracting the mean, thereby leading to an average of 0. Again, inter-regional discrepancies are highlighted by the wide interval of values of this variable. Next, I focus on the import and export penetration measure from and to China, respectively, in panels B and C. The variable shows the change in imports and exports in 1,000 USD per employee. In panel B I focus on the effectively observed change in imports and exports to construct the penetration measures. As I have argued, these measures are partially driven by demand shocks. In panel C,the approximated trade penetration measure that deals with this endogeneity problem is reported. Several points are noteworthy. First, the direct exposure of a region is on average about two times as large as the indirect industrial linkage exposure[10]. Secondly, the average region has not only suffered from the emergence of the China on the world stage, but also benefited

[10]The total indirect exposure to shocks in both the domestic economy and foreign economies is the sum of the changes in exposure through the domestic and the foreign link.

from the opportunities offered by a growing Chinese market. This is demonstrated by the positive change in the export exposure to China. However, this positive effect is of a lower order than the import penetration measure, implying that on average, regions experienced a positive change in net import exposure to China. Thirdly, the structural trade penetration measures based on revealed comparative advantage have larger maximum values than the observed trade penetration shocks. This is mostly the case in industries where Chinese exports have grown strongly compared to domestic exports in that same industry. Finally, the table hides a substantial amount of discrepancy between the different countries. In appendix D I report descriptive statistics by country. There, it stands out that the regions of the smaller, central countries experience foreign linkage shocks that are on average larger than the exposure of these regions through their domesitc production network to trade penetration changes. This finding contrasts with larger countries or countries in the periphery of the EMU, where the domestic industrial linkage shock is more important[11].

Table 2: Descriptive statistics

	Average	st.dev	min	max
Panel A: General statistics				
Δ manuf.employment to population	-0.28	1.12	-4.18	2.75
Employment in manufacturing at $t-1$	0	7.36	-14.94	15.65
Panel B: Observed import penetration				
Δ Chinese Imports	2.60	1.72	0.03	13.69
Δ Chinese Imports through domestic link	0.69	0.42	0.01	2.30
Δ Chinese Imports through foreign link	0.43	0.25	0.06	1.27
Δ Chinese Exports	1.66	1.31	-0.01	6.73
Δ Chinese Exports through domestic link	0.51	0.39	0.00	1.74
Δ Chinese Exports through foreign link	0.32	0.19	0.05	1.04
Panel C: gravity residual shock				
Δ Chinese Imports	2.46	1.76	0.20	17.72
Δ Chinese Imports through domestic link	0.62	0.36	0.02	2.99
Δ Chinese Imports through foreign link	0.38	0.19	0.07	1.06
Δ Chinese Exports	1.38	1.74	0.01	20.37
Δ Chinese Exports through domestic link	0.48	0.56	-0.05	3.13
Δ Chinese Exports through foreign link	0.31	0.15	0.05	0.75

6 Econometric Results

6.1 Main results

I will first present the results of my baseline specification and give some intuition as to the economic meaning of the estimates. In the next subsection I then elaborate more extensively on the relevance of the estimates for European regions and countries to gather insights on how asymmetric shocks affect the EMU.

[11]The exception is Portugal that still had higher foreign linkage shocks as a result of the country's strong industrial links to the Spanish economy.

In table 3 the results of my baseline specification are reported. In columns (1) and (2) I use the observed imports of Chinese goods to construct the import penetration shock measure. Here, I only account for the domestic shock exposure of industries. To understand what this actually entails, consider the following example for the Belgian textile industry. In column (1) and (2) the shock measure only captures the trade penetration exposure that the textile industry endures in the Belgian market. From column (3) onward I reconstruct the shock variable as a weighted exposure measure that weights the exposure to a trade penetration shock in each Eurozone market according to the fraction of the exports to the total size of that market. This is described more formally in appendix B. So for a Belgian textile industry this would mean that I not only consider its exposure to a trade penetration shock of Chinese textile products in Belgium, but the exposure in all EMU markets to which the Belgian textile industry exports. These redefined shocks will be applied in the econometric specification.

The results in column (1) and (2) show that the direct demand shock to an industry has the expected negative effect as also found in the literature (Autor and Dorn, 2013; Balsvik et al., 2013; Dauth et al., 2014; Donoso et al., 2014). However, the coefficient is never significantly different from zero, possibly as a result of underlying endogeneity issues in the estimation. Since the amount of imported goods is also driven by local demand shocks, which would evidently also affect regional employment, the estimated coefficient is severely biased towards zero. Despite this bias working against my overall result, I still find a highly negatively significant impact of the domestic linkage shock of a region in column (2). A rise in import penetration of 1,000 USD per employee in all downstream industries decreases the manufacturing employment to population ratio in a region by 1.27 percentage points. Import penetration shocks in industries that demand the output of region p as an input to their production processes thus affect overall region p employment. However, no similar result is found for foreign industries that demand the output of region p industries as inputs.

In the remainder of the table I use the gravity residual approach to obtain the structural nature of the Chinese import demand shock. The absolute value of the coefficient in column (3) is rather low in comparability to evidence found in the literature for e.g. the U.S. regional labor markets, yet it holds both the expected sign and is significant. In column (4) I construct the variable $\Delta Imp.tot_{pt}^{CN}$ which consists of the sum of the direct import penetration shock to a region and all industrial link shocks. The coefficient is of the same order of magnitude to the one in column (3). However, it is important to remember that this shock includes all direct and network propagation effects and is thus larger in size, so that the estimated effect on regional employment has now increased overall.

In columns (5) and (6) I extend the estimates by decomposing the network structure shocks to analyze the role of the regional network linkages in which I am interested. In these columns I add the domestic linkage and foreign industrial linkage shock undergone by the region to find an answer to the question whether industrial linkages matter in the propagation of shocks between regions. Hence, these specifications analyze the added value of considering not only the specialization in terms of employment but also the industrial network of industries in the diffusion of a shock. If the effects of foreign shock propagation far outweigh those of direct and domestically propagated shocks, asymmetric shocks would be spread around the Eurozone so that close trade relations between EMU members also imply a similar business-cycle. Therefore, I obtain an indication of the importance of domestic specialization (and domestic trade) relative to international trade in evaluating how the EMU's industrial structure responds to shocks.

The results in column (5) show that the failure to account for the export exposure inhibits clear identification of the trade shock effects. While some regions may have exclusively bore the negative

Table 3: Imports from China and change in manufacturing employment: baseline results

	Dependent variable:Stacked change in manuf. employment/working age pop.						
	Observed Δ Trade			Δ trade from gravity residual			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	
$\Delta\text{Imp}_{pt}^{CN}$	-0.15	-0.06	-0.20**		-0.02	-0.08	0.12
	(0.13)	(0.13)	(0.09)		(0.09)	(0.16)	(0.20)
$\Delta\text{Imp.tot}_{pt}^{CN}$				-0.19*			
				(0.09)			
$\Delta\text{Imp.Dom.Link}_{pt}^{CN}$		-1.27***			-1.21	-3.04***	-3.61***
		(0.33)			(0.83)	(0.59)	(0.69)
$\Delta\text{Imp.For.Link}_{pt}^{CN}$		0.90			-0.53	-1.83	-1.04
		(0.99)			(1.03)	(1.59)	(1.37)
$\Delta\text{Exp}_{pt}^{CN}$						-0.02	-0.05
						(0.08)	(0.06)
$\Delta\text{Exp.Dom.Link}_{pt}^{CN}$						1.05***	1.26***
						(0.27)	(0.28)
$\Delta\text{Exp.For.Link}_{pt}^{CN}$						2.33*	3.22**
						(1.21)	(1.17)
Manuf.share	-0.04***	-0.04***	-0.04***	-0.04***	-0.04***	-0.04***	-0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Share high skill							-0.06**
							(0.02)
Share women							0.02
							(0.02)
Constant	0.10	0.65	-0.26	-0.06	0.02	0.56	-0.25
	(1.24)	(1.24)	(0.61)	(0.76)	(0.84)	(1.01)	(0.85)
Observations	256	256	256	256	256	256	256
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.239	0.275	0.236	0.238	0.244	0.320	0.372

Regression consists of 128 regions of the European Monetary Union (EMU) over two stacked periods from 1999 to 2003 and 2004 to 2007. The change in Chinese trade exposure is computed using the gravity residual. The import shock is a weighted exposure measure based on the exposure in the domestic market and all other destination markets of the EMU. Regression models are weighted by the beginning of period total population at working age. Robust standard errors clustered at the country level in parentheses.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

consequences of the growth of China's exports, others will simultaneously also have been able to export large fractions. By not accounting for this, the estimates are suffering from omitted variable bias. In column (6), the full range of export exposure measures are thus included. Based on the estimates that are obtained there, I find that the direct penetration shocks lose all significance and that the domestic network shocks affect the employment in a region strongly. An increase of 1,000 USD per employee in the imports of all downstream domestic industries decreases employment by 3.04 percentage points in the region. The increased export exposure of the downstream industries benefits the input providing industry: an increase of 1,000 USD per employee in export exposure of all downstream industries increases regional employment by 1.05 percentage points. There is also a small positively significant effect for foreign industrial links. Although only weakly significant, an increase of 1,000 USD per employee in export penetration for all foreign downstream industries raises demand for the inputs provided by the domestic industries and raises regional employment by 2.33 percentage points. These results are robust to the inclusion of additional control variables, as seen in column (7). More specifically, I add the share of women in employment and the share of high skill employment at the start of the period to control for the initial composition of the labor force[12]. The positive shock a region experiences through its exposure to foreign industries exporting to China is now also significant. The manufacturing share of employment at the beginning of the period is a clear predictor of a possible decline in the regional employment ratio. A region that has a one percentage point higher manufacturing employment share will thus suffer a decline in the overall employment share by 0.04 to 0.06 percentage point in the following period. At least part of the noted decline in regional manufacturing employment is therefore a result of the secular decline in manufacturing employment in the regions.

My estimates offer further backing to the finding of Acemoglu et al. (2015) that the network shocks are of greater importance than the direct shocks to the industries. The latter are consistently insignificant when the industrial network variables are included. However, the major takeaway from these estimates is that there is added predictive power when considering not only a region's specialization but also its network interconnectedness. Although regions might at first glimpse appear isolated from the occurrence of a shock, they need only provide inputs to other industries that are heavily exposed to the demand shock in order to be affected. This has clear ramifications for shock propagation within the EMU. As both the domestic trade network and the foreign trade network are important, it is difficult to derive from the estimates which propagation mechanism is the most relevant. Nevertheless, it is crucial to know this. A dominating domestic network propagation effect could lead to increased asymmetry of shocks while an outward propagation to the foreign industrial network as a result of international trade would mean closer business-cycle comovement between the EMU members.

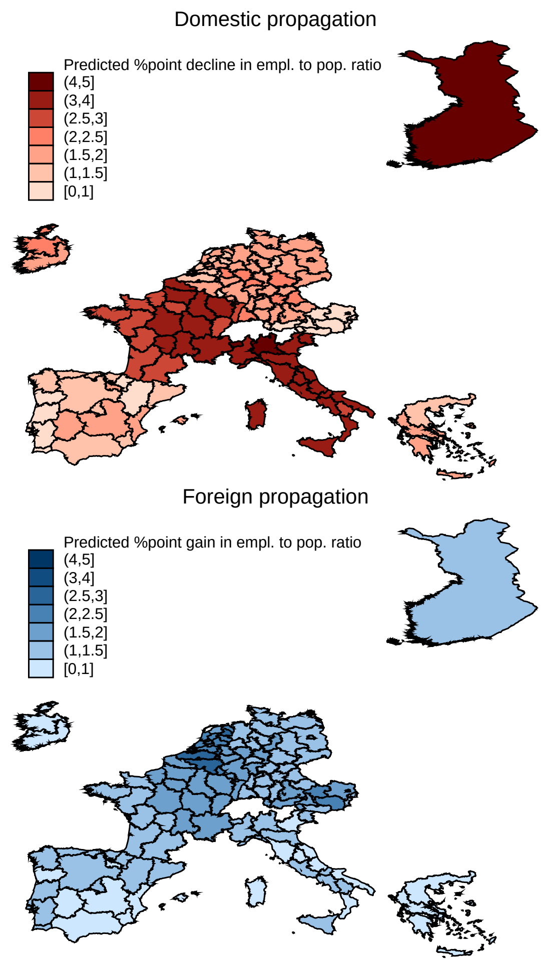
6.2 Quantifying the effects on national manufacturing employment

While consideration of the production network was thus far shown to be important in evaluating shocks, the obtained coefficients do not portray the difference in the relevance of domestically originated shocks versus foreign originated shocks for regional and national employment numbers. To evaluate this question that lies at the center of this paper, I proceed by using my estimates of

[12] A task is seen as skilled if the first number of the ISCO88 code ranges between one and three, in compliance with the literature.

column (5) of table 3 and interact these with the regional shocks summarized in table 2-D2 and aggregated over the period from 1999 to 2007[13]. I then map these results by region in figure 4.

Figure 4: Predicted regional manufacturing employment effects of Chinese trade exposure through domestic and foreign network diffusion



There are several interesting findings that can be drawn from the mapped results. For instance, it is clear from the map that the domestic propagation of the Chinese import penetration shock has varying degrees of intensity across regions and countries. Additionally, regions situated more on the fringe of the original European Monetary Union generally experience weak positive manufacturing employment effects of foreign shocks. This reflects the weak interlinkage of their industrial complex

[13]Although the effects of the exposure to import penetration shocks through foreign industrial linkages was not significant, I do take it up in my analysis to evaluate the relevance of foreign shocks compared to domestic shocks. However, the results I draw from this analysis are very similar to the ones I would draw when this import penetration shock through the foreign link is not considered.

with the rest of the EMU. Meanwhile, the closer a region is situated to the core of the EMU, the greater the positive employment effects are that a region experiences from positive export shocks originating from outside the national borders of a country. This is particularly noticeable in Belgian, Dutch, Luxembourg and Austrian regions. Industries in these regions hold strong foreign industrial ties and supplied inputs to industries benefiting from the rise of China on the world stage. The pattern in the map reveals that while networks are important in spreading shocks from specialized regions to other regions in the EMU, the network connections are not sufficiently strong with all EMU members and a rising tide in one country thus does not lift all boats in all the other EMU countries.

The regional discrepancy within some nations inhibits a proper overlook of the effects at the national level. However, while some policy instruments (e.g. fiscal policy) are sometimes partially available on a regional level, differences in policy are likely to be particularly large between countries. Moreover, with the use of a single currency, monetary policy is no longer in the position to mitigate shocks between countries and there can thus be a growing need for the flexibility of other policy instruments[14]. In table 4 I have aggregated the effects to the national level to analyze the national differences in predicted employment effects.

Table 4: Predicted employment effects from 1999 to 2007 of Chinese trade exposure

	Employment changes (in 1000s of persons) predicted by each type of propagated shock				
	Domestic propagation		Foreign propagation		
Country	Import shock	Export shock	Import shock	Export shock	**Total**
Austria	-68	19	-45	145	**51**
Belgium	-135	40	-85	276	**95**
Germany	-1,668	633	-297	1,076	**-255**
Spain	-1,110	743	-112	385	**-95**
Finland	-202	36	-23	73	**-116**
France	-1,758	590	-217	813	**-572**
Greece	-127	16	-11	30	**-91**
Ireland	-169	119	-17	43	**-24**
Italy	-1,748	344	-140	540	**-1,005**
Luxembourg	-2,163	446	-3	11	**5**
Netherlands	-209	53	-111	365	**98**
Portugal	-93	35	-39	132	**36**
EMU	**-7,289**	**2,628**	**-1,100**	**3,889**	**-1,873**

Overall, the numbers in table 4 suggest that the countries that make up the original EMU shed about 1.9 million jobs as a result of the dominating effects of Chinese import competition on the European labor market. As reported on the basis of the regional map, smaller countries that are situated in the core of the original EMU, such as Austria, Belgium, Luxembourg and the Netherlands, generally experience relatively larger effects through their foreign linkages and often smaller effects through their domestic linkages. However, in larger countries such as France and Italy the labor market has been more severely affected by the shock reverberating through the domestic network. This implies that idiosyncratic (demand) shocks to these industries can get strongly propagated within the country itself, further aggravating the asymmetric nature of such

[14] This is particularly the case in absence of migrations between national and regional labor markets as is the case in the EU.

a shock. Interestingly, while overall the German and French labor markets are negatively affected by the import penetration shock, the network links of their industrial complex to Belgian, Dutch, Austrian and Luxembourg industries have nevertheless led these latter countries to experience a positive employment shock. One can conclude from this that network links between countries do not automatically imply that the interlinked countries will have a similar impact from shocks.

One key benefit of my approach is that I am able to clearly trace a shock and its propagation effects within the economies of different countries. While I do not directly observe how this shock has affected the comovement of the business cycle between two individual economies, I am able to make a statement on the role played by input-output links between the industries of economies. Both Ng (2010) and di Giovanni and Levchenko (2010) find that closer industrial networks between two economies and between industries of two economies foster increased comovement of the economic cycle between these economies and the industries of these economies, respectively. However, comovement in these (and other) studies is often approximated by a simple correlation and thus depends on the degree of exposure to and the number of certain shocks within the time frame that is studied. While this approach allows one to directly analyze the factors that are linked to the overall correlation, it remains difficult to extrapolate these findings to policy questions in the occurrence of very specific shocks. The results reported here confirm the importance of this issue. For instance, the domestic propagation through input-output links of the Chinese trade penetration shock has had an opposite, negative effect on the domestic economy compared to the propagation of a foreign shock. This might be a characteristic specific to the Chinese trade penetration shock, which is characterized by an increase in imports of labor-intensive goods (Amiti and Freund, 2010). Therefore, industries providing inputs to other industries producing these labor-intensive goods are thus differently affected from those providing inputs to capital goods-industries. Nevertheless, it does highlight that aside from strong industrial links, it is also relevant to consider the types of shocks affecting a country's (or region's) industries to evaluate the role of the industrial network in causing comovement between countries. Hence, caution is warranted in interpreting the results of Ng (2010) and di Giovanni and Levchenko (2010) as signs that closer industrial networks unequivocally increase comovement of the business cycles.

The positive role of exports in offsetting the Chinese import competition effect on employment is not a finding unique to this paper and has recently also been found by Feenstra and Sasahara (2017). They apply the WIOD database in their analysis and report that the positive employment effects of total merchandise export growth partially offset the negative employment effects of merchandise imports. However, when considering the total export flow (also including service exports), the negative employment effects of merchandise and service imports are more than completely offset. While I do not consider these service jobs here, the results of Feenstra and Sasahara do provide corroborative evidence of the key role of exports in explaining employment evolution. Note that Feenstra and Sasahara considers a wider scope of exports and do not exclusively focus on exports to China as I do here. Nevertheless, their results come to show that there is a clear nuance that one must add to the effects labor markets have suffered at the hands of import competition. A result that also emerges from my analysis.

6.3 Robustness checks

In this section I will first the direction of shock propagation and assess whether changes in TFP can offer an alternative explanation for the results that were obtained. This allows me to observe whether the propagation mechanism was suffering from omitted variable bias as a result of the exclusion of this supply shock. Then I address the possibility that alternative trade shocks from Central and Eastern Europe might have affected regional labor markets. Finally, I turn my attention to the sensitivity of my results with respect to the unaddressed heterogeneity in my regressions, the definition of my regressors and the stacked period specification.

6.3.1 The direction of shock propagation

Theoretically, Acemoglu et al. (2015) showed that industries are generally affected by demand shocks through the downstream linkages with industries that use their output. This was also witnessed for U.S. industries as the shocks that propagated through their upstream linkages with input-supplying industries were not significantly affecting employment. I have implicitly assumed that this characteristic also holds for the original EMU's industry and that only the exposure to downstream industry shocks is important for analyzing the propagation of demand shocks to European regional labor markets. However, the theoretical discussion in section 2 showed that the unidirectional upstream propagation of demand shocks is a feature brought forth by modeling assumptions. Additionally, Chinese import competition could also have acted as a supply shock. To the extent that Chinese imports not only represent final goods but also some intermediates, China's access to the WTO and increase in productivity could have caused the original EMU's industry's to have access to cheaper and better inputs, possibly leading to a positive employment effect. Therefore, I now relax the assumption of exclusive upstream propagation of shocks which affect industries with strong downstream links to the affected industries. I allow for the possibility that a region's labor market could also be influenced as a result of the downstream propagation of a shock which reverberates to industries that consume the intermediate goods of the affected industries. In table 5 I have included a trade exposure shock of a region's industries through their upstream link with the input supplier alongside the downstream link with their output consumers. To avoid excessive confusion between the different variables, I have aggregated the foreign and the domestic industrial shock into a downstream and an upstream shock, $\Delta Imp.downstr.Link_{pt}^{CN}$ and $\Delta Imp.upstr.Link_{pt}^{CN}$, respectively. In column (2) I have done the same for the export penetration shocks.

The specification in column (1) only includes the import penetration shocks. While the coefficient for the downstream link shows a much larger effect on regional employment than the one for the upstream effect, both coefficients are not significantly different from zero. In column (2) I add all the export penetration shocks, both the direct shock faced by a region and the indirect shock through the upstream and the downstream linkages. While the upstream link of the export exposure shock significantly affects regional employment, the coefficient is very small. Overall, my result thus offers additional proof that demand shocks mainly propagate upstream from demanding industries to their suppliers by affecting the demand for the inputs of an industry. The downstream propagation effect is not sufficiently strong to overturn any of the effects of the upstream propagation. In this sense, my result is in line with the theoretical findings of Carvalho et al. (2017) and Acemoglu et al. (2015).

6.3.2 The effect of TFP shocks

In table 6 I explore the propagation of shocks further but now using a TFP shock collected from EU KLEMS O'Mahoney and Timmer (2009). By using this shock I am able to explore the propagation

Table 5: The effects of downstream and upstream demand shocks

	Dependent variable:Stacked change in manuf. employment/working age pop.	
	(1)	(2)
$\Delta\text{Imp}_{pt}^{CN}$	0.12	-0.05
	(0.16)	(0.18)
$\Delta\text{Imp downstr.Link}_{pt}^{CN}$	-1.25	-1.87***
	(1.32)	(0.47)
$\Delta\text{Imp upstr.Link}_{pt}^{CN}$	-0.01	0.03
	(0.24)	(0.15)
$\Delta\text{Exp}_{pt}^{CN}$		-0.00
		(0.04)
$\Delta\text{Exp.downstr.Link}_{pt}^{CN}$		0.72**
		(0.31)
$\Delta\text{Exp.upstr.Link}_{pt}^{CN}$		-0.00**
		(0.00)
Constant	-0.28	-0.09
	(0.94)	(0.64)
Observations	256	256
Time Fixed Effects	Yes	Yes
Country Fixed Effects	Yes	Yes
R^2	0.275	0.374

Regression using two stacked periods from 1999-2003 and 2004-2007 for 128 EMU regions. Manufacturing share in employment, share of skilled labor and share of women in labor force are included as controls but not reported. Industrial linkage shocks consist of the sum of domestic and foreign industrial linkage shocks. Regression models are weighted by the beginning of period total population at working age. Robust standard errors clustered at the country level in parentheses.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

effects of a supply shock rather than the demand shock I have used up until this point. Carvalho et al. (2017) show both theoretically and empirically through evidence of the supply chain disruption induced by the Japan earthquake in 2011 that supply shocks can propagate both upstream, downstream and horizontally to other input providers. The size of downstream propagation effects is also shown to dominate that of the upstream propagation. Moreover, including the TFP supply shock might deal with potential omitted variable bias issues in my baseline regression. If TFP shocks significantly affected labor markets then their exclusion from my baseline specification would mean the estimates on the trade shocks are biased. While including both upstream and downstream links for the TFP shocks alongside the same shocks for Chinese import competition would imply all possible links are included, this could also swamp the empirical model and make estimations more difficult. I therefore concentrate only on the main downstream and upstream propagation shocks for TFP and Chinese import competition, respectively, in line with the empirical specification of Acemoglu et al. (2015).

For the downstream propagation of the TFP shock, it is necessary to use the same input-output coefficients that I just applied to compute the upstream linkage shock in table 5. I refer the reader to appendix F for the definition of the shock. Regrettably, there are several downsides to using this approach. The first is the prevalence of endogeneity. The decrease in employment in certain industries will affect the TFP of that industry, leading to a biased estimate. The second downside is that the TFP data uses a more aggregated definition of the industries, so that two industries in our input-output table are now aggregated into one. Thirdly, several countries do not report TFP data on their industries in the EU KLEMS data[15]. Finally, the trade penetration shock showed greater variation across industries, creating a greater level of variation in my shock variables. This is less the case with the TFP variable.

The specifications in columns (1) to (3) build the model up, while column (4) represents a baseline estimation similar to the one in column (5) of table 3. The estimates in column (4) indicate that there is a positive employment effect of a TFP shock to a region's industries. However, in contrast to the findings of Acemoglu et al. (2015), the TFP shock has a negative impact from domestic upstream linkages. So a one percent increase in the TFP of all upstream industries decreases overall employment in the region by 0.25 percentage points (column (4)). In column (5) I combine direct and upstream regional TFP shocks with direct and downstream regional trade penetration shocks and estimate a full-fledged model. The counter-intuitive linkage effects on TFP I obtained in column (4) now disappear and only the trade penetration linkage shocks are significant. By controlling for the TFP shocks, I also find that regions are exposed to downstream foreign import penetration shocks. Note that caution is warranted in interpreting these results as definitive proof that TFP shocks were irrelevant given the existing endogeneity issues that are present in all specifications of table 6. Nevertheless, the results further underline the importance of simultaneously considering the network in which the industry functions in conjunction with the pattern of industrial specialization in evaluating the sensitivity of a region to industrial shocks.

6.3.3 The rise in trade with Central and Eastern Europe

In Europe, the Chinese trade penetration shock occurred simultaneously with the increased economic integration of Central and Eastern European (CEE) economies with the Western-European

[15]Specifically, this is the case for Greece, Portugal and Luxembourg. For Belgium there is no data in 2007 so I drop data from this country too. Therefore, I must compute foreign shocks excluding these countries from the calculation. The foreign exposure of industries in some countries will be affected by this exclusion.

Table 6: The impact of Chinese trade penetration shocks on manufacturing employment

	Dependent variable:Stacked change in manuf. employment/working age pop.				
	(1)	(2)	(3)	(4)	(5)
ΔTFP_{pt}	-0.01		0.05*	0.06*	0.01
	(0.02)		(0.02)	(0.03)	(0.03)
$\Delta\text{TFP tot}_{pt}$		-0.01			
		(0.01)			
$\Delta\text{TFP Dom.Link}_{pt}$			-0.26***	-0.25**	-0.06
			(0.07)	(0.08)	(0.11)
$\Delta\text{TFP For.Link}_{pt}$			-0.05*	0.01	-0.03
			(0.02)	(0.02)	(0.03)
$\Delta\text{Imp}_{pt}^{CN}$					0.12
					(0.29)
$\Delta\text{Exp}_{pt}^{CN}$					-0.06
					(0.06)
$\Delta\text{Imp.Dom.Link}_{pt}^{CN}$					-3.65**
					(1.49)
$\Delta\text{Exp.Dom.Link}_{pt}^{CN}$					1.42***
					(0.30)
$\Delta\text{Imp.For.Link}_{pt}^{CN}$					-2.38*
					(1.15)
$\Delta\text{Exp.For.Link}_{pt}^{CN}$					4.32**
					(1.58)
Manuf.share	-0.04***	-0.04***	-0.04***	-0.06***	-0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Share women				-0.00	0.02
				(0.03)	(0.02)
Share high skill				-0.05*	-0.07**
				(0.03)	(0.02)
Constant	-1.31***	-1.15***	0.81***	0.53**	-0.05
	(0.37)	(0.32)	(0.12)	(0.17)	(0.56)
Observations	230	230	230	230	230
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
R^2	0.161	0.164	0.212	0.259	0.332

Regression using two stacked periods from 1999-2003 and 2004-2007 for 115 EMU regions. Regression models are weighted by the beginning of period total population at working age. Robust standard errors clustered at the country level in parentheses.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

economies. The culmination of the event was the entry of several CEE countries in the European Union in May 2004. Dauth et al. (2014) showed that in the case of Germany the direct trade shocks that were brought about by the emergence of the CEE economies played a greater role in affecting regional employment than the Chinese trade penetration shocks. Moreover, the goods imported by Germany from China and CEE economies did not come from the same sectors. Rather, trade between Germany and CEE economies was more of the intra-industry kind compared to trade between Germany and China. Therefore, this raises the fear that my specification has so far failed to account for the existence of a second trade shock from the CEE economies. The estimated coefficients could thus suffer from an omitted variable bias as a result which could affect my conclusions on the role of domestic and foreign industrial links in propagating shocks.

To proceed, I create import and export penetration shocks from the CEE economies and rerun my specifications[16]. In column (1) of table 7 I show the results of my basic specification for the Chinese trade penetration shock, in column (2) I run the same specification but now only look at the trade penetration shock from CEE. Finally, I combine both the Chinese and the CEE trade penetration shock in one specification in column (3).

The results in column (2) suggest that for all the regions in the twelve countries of the EMU the trade penetration shock from the CEE was of second order importance only. Domestically, there is some upstream propagation of the import shock that influences regional employment. However, upon taking both the Chinese and the Central and Eastern European trade penetration shocks together, the evidence in column (3) shows that this perceived domestic propagation of the trade penetration shock from CEE disappears. The measured effects of the Chinese trade penetration shocks remain largely consistent with my earlier findings, with only the domestic export propagation shock diminishing in significance. This partial loss of significance is most likely due to the fact that exports to CEE and to China largely originated from the same industries. Hence, the coefficient of the indirect regional exposure to the Chinese export penetration through domestic links was inflated as it captured both the Chinese export trade penetration shocks and the CEE export penetration shocks that benefited upstream suppliers in the regions. The indirect network effects of the Chinese trade penetration shock have thus been more relevant in influencing European regional labor markets than the CEE trade penetration shock. Moreover, the propagation of Chinese trade penetration shocks remains robust to controlling for shocks from Central and Eastern Europe.

6.3.4 Border effects and shock definition

The baseline regression results show that a positive export shock in foreign downstream industries positively affects regional employment. However, the industrial links in my empirical specification are created by using national input-output links to proxy for the network links of a region. Regionalizing trade shocks and input/output-links is the most pragmatic approach to deal with the absence of a completely harmonized regional I/O-table with corresponding regional trade statistics. Nevertheless, it is problematic when specialization patterns derived from regional industrial employment do not accurately reflect reality. In absence of regional input-output data and regional trade data, the discrepancy between the constructed approximation and the true underlying values is a possible source of both unexplored heterogeneity and bias. Since I am particularly interested

[16] I define the CEE economies as Slovenia, Slovakia, Czech Republic, Poland, Hungary, Bulgaria, Romania, Estonia, Latvia and Lithuania.

Table 7: Trade exposure to China and Central-European and Eastern-European countries and employment

	Dependent variable:Stacked change in manuf. employment/working age pop.		
	(1)	(2)	(3)
$\Delta\text{Imp}_{pt}^{CN}$	0.12		0.08
	(0.20)		(0.22)
$\Delta\text{Imp.Dom.Link}_{pt}^{CN}$	-3.61***		-4.23***
	(0.69)		(1.10)
$\Delta\text{Imp.For.Link}_{pt}^{CN}$	-1.04		0.67
	(1.37)		(3.38)
$\Delta\text{Exp}_{pt}^{CN}$	-0.05		0.00
	(0.06)		(0.04)
$\Delta\text{Exp.Dom.Link}_{pt}^{CN}$	1.26***		1.01*
	(0.28)		(0.52)
$\Delta\text{Exp.For.Link}_{pt}^{CN}$	3.22**		2.99**
	(1.17)		(1.35)
$\Delta\text{Imp}_{pt}^{CEE}$		0.09	0.04
		(0.05)	(0.03)
$\Delta\text{Exp}_{pt}^{CEE}$		-0.14	-0.07
		(0.16)	(0.11)
$\Delta\text{Imp.Dom.Link}_{pt}^{CEE}$		-0.74*	0.07
		(0.38)	(0.41)
$\Delta\text{Exp.Dom.Link}_{pt}^{CEE}$		0.87	0.65
		(0.71)	(0.65)
$\Delta\text{Imp.For.Link}_{pt}^{CEE}$		-1.01	-1.05
		(1.82)	(1.65)
$\Delta\text{Exp.For.Link}_{pt}^{CEE}$		2.14	0.65
		(2.64)	(1.59)
Constant	-0.25	-0.55	-0.26
	(0.85)	(0.73)	(0.61)
Observations	256	256	256
Time Fixed Effects	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes
R^2	0.372	0.292	0.379

Regression using two stacked periods from 1999-2003 and 2004-2007 for 128 EMU regions. Manufacturing share in employment, share of skilled labor and share of women in labor force are included as controls but not reported. The superscript CEE refers to all shocks computed using Central and Eastern European trade integration. Regression models are weighted by the beginning of period total population at working age. Robust standard errors clustered at the country level in parentheses.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

in the cross-border shock propagation, it is of specific interest to analyze this issue further for foreign shock propagation. To test whether there is variation in how foreign shocks propagate to a region and explore whether regionalizing leads to considerable differences in the outcome of my specification, I interact my foreign indirect shocks with a border dummy that equals one when the region shares a border with any other region of a foreign EMU country. The results are presented in column (1) of table 8.

Table 8: Trade exposure to China and employment: Border effects and alternative shock definition

	Dep.var: Stacked change in manuf. employment/working age pop.	
	(1)	(2)
ΔImp_{pt}^{CN}	0.10	
	(0.18)	
$\Delta Imp.Dom.Link_{pt}^{CN}$	-3.66***	
	(0.67)	
$\Delta Imp.For.Link_{pt}^{CN}$	-0.36	2.73
	(1.39)	(1.60)
$\Delta Imp.For.Link_{pt}^{CN}$	-1.18	
× border region	(0.67)	
ΔImp_{pt}^{CN}	-0.04	
	(0.05)	
$\Delta Imp.Dom.Link_{pt}^{CN}$	1.26***	
	(0.28)	
$\Delta Imp.For.Link_{pt}^{CN}$	2.73**	0.04
	(1.18)	(0.73)
$\Delta Imp.For.Link_{pt}^{CN}$	0.75	
× Border region	(0.52)	
$\Delta Imp.Dom.Tot_{pt}^{CN}$		-0.44*
		(0.22)
$\Delta Imp.Dom.Tot_{pt}^{CN}$		0.17
		(0.10)
constant	-0.22	-1.54
	(0.72)	(0.93)
Observations	256	256
Time Fixed Effects	Yes	Yes
Country Fixed Effects	Yes	Yes
R^2	0.376	0.298

Regression using two stacked periods from 1999-2003 and 2004-2007 for 128 EMU regions in columns (1) and (3) and one long stacked period (1999-2007) in column (2). Manufacturing share in employment, share of skilled labor and share of women in labor force are included as controls but not reported. A region is considered as border region if it has a land-based connection to any region situated in a different country of the EMU. Regression models are weighted by the beginning of period total population at working age. Robust standard errors clustered at the country level in parentheses.

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

The signs on the interactions in column (1) suggest that border regions have stronger industrial shock propagation from foreign industries. However, the estimate for $\Delta Imp.For.Link_{pt}^{CN} \times$

border region is only significant at the 11 percent level and that of $\Delta Exp.For.Link_{pt}^{CN} \times border\ region$ at the 17 percent level. Thus, it is impossible to draw out strong conclusions based on these estimates. However, this heterogeneity between regions in the exposure to downstream foreign industry shocks does offer an insight into how small open economies at the core of the EMU are importing foreign shocks at a larger scale than their periphery counterparts, where few if any regions are bordering other EMU members. In appendix table 2-E1 I explore the heterogeneity in trade penetration shocks across the largest countries of the EMU for which I have sufficient data to run independent regressions. I aggregated the domestic and foreign industrial linkage shock to one large linkage shock to avoid overburdening the model with additional variables. However, as becomes clear from the results, the low number of highly aggregated regions in my data make identification of the linkage shocks very difficult at the individual country level.

I have always decomposed the total domestic shock faced by a region into a direct shock to the region and a domestic interlinkage shock. To directly evaluate the relevance of a domestic shock compared to a foreign shock and evaluate the sensitivity of my results relative to the degree of decomposition of the shock, I now combine the direct shock and the domestic interlinkage shock into a total domestic shock, $\Delta Imp.Dom.Tot._{pt}^{CN}$ and $\Delta Exp.Dom.Tot._{pt}^{CN}$. Results are reported in column (2). Only the domestic import shock exposure of a region is relevant in this set-up, confirming that the domestic shock is generally still the most important one in my model. The existing industrial structure of a region/country therefore seems to be the most important factor in determining the sensitivity to shocks, while foreign trade links only mitigate part of the overall shock effect and are currently too weak to ensure effects are spread around equally across the EMU. This would also indicate that the home bias in trade puzzle has thus far not been overcome by the introduction of the common currency.

6.3.5 Adjusting the time periods

I now evaluate the sensitivity of my results to the stacked period definition. I do this by running the regressions for each time period separately in column 1 and 2 and in one long period. Since I also include country fixed effects, the identification will become particularly difficult for many of the smaller countries as these typically consist of less regions. While the current specifications are thus highly demanding, the emergence of any significant results would be testament to the strength of these propagation effects. I report the results in table 9.

In column (1) and (2) I run the regressions separately for the periods 1999 to 2003 and 2004 to 2007, respectively. In general the results do not show that for these individual periods, any of the shocks are significantly propagated. This is a likely consequence of the loss of variation in terms of the time periods combined with the short time period over which the regressions are run so that shocks are not as large as they are in one long period. In column (3) I use long stacked periods from 1999 to 2007 to mitigate the latter concern. One of the most remarkable features is the counter-intuitive sign for the domestic industrial linkage shock, for which ex-ante one would expect to obtain a negative sign. All other signs, except for the one on the direct export shock $\Delta Exp._{pt}^{CN}$ are as anticipated. Clearly, it is reassuring that my result also emerges in the long period specification given its challenging econometric requirements. Nevertheless, the problematic identification in all specifications underline the need for disaggregated data in these types of regressions.

Moreover, it must also be noted that I only use the beginning of period input-output links. As these change in my baseline specification between the two periods, there is more variation in baseline specification which is absent in the specifications in table 9.

Table 9: Trade exposure to China and employment: Border effects and alternative shock definition

	Dep.var: Stacked change in manuf. employment/working age pop.	
	(1)	(2)
ΔImp_{pt}^{CN}	0.10	
	(0.18)	
$\Delta Imp.Dom.Link_{pt}^{CN}$	-3.66***	
	(0.67)	
$\Delta Imp.For.Link_{pt}^{CN}$	-0.36	2.73
	(1.39)	(1.60)
$\Delta Imp.For.Link_{pt}^{CN}$ × border region	-1.18	
	(0.67)	
ΔImp_{pt}^{CN}	-0.04	
	(0.05)	
$\Delta Imp.Dom.Link_{pt}^{CN}$	1.26***	
	(0.28)	
$\Delta Imp.For.Link_{pt}^{CN}$	2.73**	0.04
	(1.18)	(0.73)
$\Delta Imp.For.Link_{pt}^{CN}$ × Border region	0.75	
	(0.52)	
$\Delta Imp.Dom.Tot_{pt}^{CN}$		-0.44*
		(0.22)
$\Delta Imp.Dom.Tot_{pt}^{CN}$		0.17
		(0.10)
constant	-0.22	-1.54
	(0.72)	(0.93)
Observations	256	256
Time Fixed Effects	Yes	Yes
Country Fixed Effects	Yes	Yes
R^2	0.376	0.298

Regression for 128 EMU regions run for each stacked period separately (column 1: 1999-2003; column 2: 2004-2007) and one long period (column 3: 1999-2007). Manufacturing share in employment, share of skilled labor and share of women in labor force are included as controls but not reported. Regression models are weighted by the beginning of period total population at working age. Robust standard errors clustered at the country level in parentheses.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

7 Conclusion

This paper has analyzed the role of regional industrial networks in propagating shocks to the regional economies of the original European Monetary Union. To analyze this research question, I have used the Chinese trade penetration shock which caused increased competition for industries and affected the suppliers of inputs to these industries. My results show that it is not only relevant to look at the pattern of industrial specialization in considering the sensitivity of a region to specific shocks, but also the interaction of that pattern of specialization with the industrial network of the underlying industries. Moreover, I find that the domestic and the foreign industrial networks do not always propagate in a similar way. When considering both the import penetration and the export opportunity shock offered by China's emergence at the world stage, the domestic industrial network especially propagated the negative import competition effect while the foreign industrial network predominantly propagated the positive export opportunity effect. It is thus impossible to state that industrial links unequivocally increase business-cycle comovement as domestic and foreign propagation may function in opposite directions from one another.

Specifically for the original countries that make up the EMU, I show that small, core countries are more exposed to foreign shocks because they are more tightly industrially integrated with their large neighbors. In this light, I also present suggestive evidence that regions that border other EMU countries import the shocks from these economies more strongly. However, periphery countries are less likely to import these same shocks and are more prone to the asymmetric effects of idiosyncratic shocks. Moreover, large countries such as Italy have experienced strong detrimental domestic propagation of the Chinese import penetration shock. If this pattern holds in the case of idiosyncratic shocks, the dominance of domestic propagation of shocks is likely to increase asymmetry between economies. Hence, in general the domestic industrial structure of regions and countries predominantly causes shocks to be propagated within the domestic network, rather than be spread to other countries via the foreign links.

This paper has also presented corroborating evidence for several findings in the network literature. The trade penetration shock has mostly occurred in final goods and acted as direct competition to domestic industries who have faced less demand for their output as a result. The evidence in this paper shows that regions with high employment numbers in industries that are specialized in providing inputs to industries undergoing competition from China have been strongly affected. Regions that employ relatively larger numbers in industries buying inputs from other industries undergoing Chinese import competition, were left unaffected. This outcome is in line with several theoretical models predicting that the upstream propagation of a demand shock dominates the downstream propagation effects of that same shock. Moreover, I find that the network effect dominates the direct effect faced by an industry. Upon comparing the trade penetration shock and a TFP shock, my findings suggest that the former was most important in shaping the regional employment patterns in pre-crisis EMU.

There are several further avenues for future research. First, my sample contains aggregated regions and aggregated industries. Typical country level studies have used a much finer definition of industries and have defined the regions at the community zone level rather than the much more aggregated NUTS2 level used here. The use of this aggregated sample allowed me to combine the WIOD data with an international panel of regions. At the national level, it will be necessary to find a sufficiently detailed definition of the input-output table between sectors both with domestic industries and with foreign industries. A possible benefit of this approach is that one is able to still find significant direct effects of a trade penetration shock in contrast to my findings. Another way forward is to analyze the same question but with different shocks. In this context, Acemoglu et al. (2015) studies different types of shocks and compares there direct effect to their indirect, network effect. Finally, one of the key findings of this paper is that the current industrial structure of the EMU is likely to exacerbate asymmetries rather than mitigate these. However, Elliott et al. (2014) has looked at the effects of diversification and integration on the degree of financial contagion in a system and found that the effects are generally non-monotonic. Research could attempt to focus on these non-monotonic effects and how they matter for both industrial network effects and industrial integration theories of the EMU.

References

Acemoglu, D., Akcigit, U., and Kerr, W. (2015). Networks and the macroeconomy: An empirical exploration. Technical Report 21344, National Bureau of Economic Research.

Acemoglu, D., Autor, D., Dorn, D., Hanson, G., and Price, B. (2016). Import competition and the great us employment sag of the 2000s. *Journal of Labor Economics*, 34(1):S141–S198.

Acemoglu, D., Carvalho, V. M., Ozdaglar, A., and Tahbaz-Salehi, A. (2012). The network origins of aggregate fluctuations. *Econometrica*, 80(5):1977–2016.

Amiti, M. (1999). Specialization patterns in europe. *Review of World Economics*, 135(4):573–593.

Amiti, M. and Freund, C. (2010). The anatomy of china's export growth. In Feenstra, R. and Wei, S.-J., editors, *China's Growing Role in World Trade*, pages 35–62. University of Chicago Press.

Autor, D. and Dorn, D. (2013). The growth of low skill service jobs and the polarization of the u.s. labor market. *American Economic Review*, 103(5):1553–1597.

Balsvik, R., Jensen, S., and Salvanes, K. G. (2013). Made in china, sold in norway: Local labor market effects of an import shock. *Journal of Public Economics*, 127:137–144.

Baqaee, D. R. (2016). Cascading failures in production networks.

Carvalho, V. M., Nirei, M., Saito, Y. U., and Tahbaz-Salehi, A. (2017). Supply-chain disruptions: Evidence from the great east japan earthquake. Technical Report 2017-01, University of Chicago.

Dauth, W., Findeisen, S., and Suedekum, J. (2014). The rise of the east and the far east: German labor markets and trade integration. *Journal of the European Economic Association*, 12(6):1643–1675.

di Giovanni, J. and Levchenko, A. a. (2010). Putting the parts together: Trade, vertical linkages, and business cycle comovement. *American Economic Journal: Macroeconomics*, 2(2):95–124.

di Giovanni, J., Levchenko, A. a., and Mejean, I. (2016). The Micro Origins of International Business Cycle Comovement.

Dietzenbacher, E., Los, B., Stehrer, R., Timmer, M., and de Vries, G. (2013). The construction of world input output tables in the wiod project. *Economic Systems Research*, 25(1):71–98.

Donoso, V., Martín, V., and Minondo, A. (2014). Do differences in the exposure to chinese imports lead to differences in local labour market outcomes? an analysis for spanish provinces. *Regional Studies*, 3404(September 2014):1–19.

Elliott, M., Golub, B., and Jackson, M. O. (2014). Financial networks and contagion. *American Economic Review*, 104(10):3115–3153.

Feenstra, R. C. and Sasahara, A. (2017). The china shock, exports and u.s. employment: A global input-output analysis. Technical Report 24022, National Bureau of Economic Research.

Frankel, J. a. and Rose, A. K. (1998). The endogeneity of the optimum currency area. *The Economic Journal*, 108:1009–1025.

Imbs, J. (2004). Trade, finance, specialization, and synchronization. *Review of Economics and Statistics*, 86(August):723–734.

Krugman, P. (1993). *Adjustment and Growth in the European Monetary Union*, chapter Lessons of Massachusetts for EMU, pages 241–261. Cambridge University Press.

McCallum, J. (1995). National border matter:canada-u.s. regional trade patterns. *The American Economic Review*, 85(3):615–623.

Ng, E. C. Y. (2010). Production fragmentation and business-cycle comovement. *Journal of International Economics*, 82(1):1–14.

O'Mahoney, M. and Timmer, M. (2009). Output, input and productivity measures at the industry level: the eu klems database. *Economic Journal*, 119(538):374–403.

A Estimating import exposure using the gravity residual

The gravity residual approach to computing import exposure follows Autor and Dorn (2013) and Dauth et al. (2014). Given the detailed discussion provided by these papers, our aim here is to simply summarize the technicalities in a very concise way. The purpose of the exercise is to obtain the evolution of comparative advantage based on the exports of China and a member of the EMU to several high-income destination markets. To do so, we start from a basic gravity equation and compare the exports of goods in an industry j to a third market f for China and an EMU member c.

$$\ln Exports_j^{China\to f} - \ln Exports_j^{c\to f} = \ln\left(\frac{z_j^{China}}{z_j^c}\right) - \qquad (\sigma_j - 1)\left[\ln\left(\frac{\tau_j^{China\to f}}{\tau_j^{c\to f}}\right)\right] \tag{13}$$

z_c^j is the export capability of a country c in an industry j. σ_j reflects the general elasticity of substitution for goods of industry j and $\tau_j^{c\to f}$ are the iceberg transport costs for shipping goods of industry j from country c to country f. Note that we only look at exports, so that any demand effects that raise import demand in country c are now effectively excluded.

To estimate this gravity equation empirically, a regression is run using time-invariant country$\times$industry fixed effects, α_j^c, and time-invariant country$\times$destination market fixed effects, $\alpha^{c\to f}$. A sample of nine high-income, OECD destination markets that are not a member of the EMU are selected[17]. As the left-hand side of the regression and that of the theoretical gravity equation coincide, the right-hand side of the regression equation and the right-hand side of equation 13 can be equated. Afterwards, I rewrite the resulting expression in function of the residual $\epsilon_{j,t}^{c\to f}$ of the regression equation. I then obtain:

$$\epsilon_{j,t}^{c\to f} = \left(\ln\left(\frac{z_{j,t}^{China}}{z_{j,t}^{c}}\right) - \alpha_j^c\right) + \left[-(\sigma_j - 1)\ln\left(\frac{\tau_{j,t}^{China\to f}}{\tau_{j,t}^{c\to f}}\right) - \alpha^{c\to f}\right].$$

The change in the residual, $\Delta\epsilon_{j,t}^{c\to f}$ between moment t and moment $t-1$ represents the change in the relative comparative advantage and the trade costs of China compared to country c. By differencing, the fixed effects can be eliminated from the equation.

$$\begin{aligned}\Delta\epsilon_{j,t}^{c\to f} = &\left[\ln\left(\frac{z_{j,t}^{China}}{z_{j,t}^{c}}\right) - \ln\left(\frac{z_{j,t-1}^{China}}{z_{j,t-1}^{c}}\right)\right] + \\ &\left[-(\sigma_j - 1)\left[\ln\left(\frac{\tau_{j,t}^{China\to f}}{\tau_{j,t}^{c\to f}}\right) - \ln\left(\frac{\tau_{j,t-1}^{China\to f}}{\tau_{j,t-1}^{c\to f}}\right)\right]\right].\end{aligned}$$

It is now clear that the change in the residual reflects the logarithmic change in the comparative advantage of country c compared to China in exports of goods from industry j to country f. I compute the differences for each of the stacked periods by calculatng the difference in the residuals of 2003 compared to 1998 and the difference from 2007 compared to 2003. $\Delta\epsilon_{j,t}^{c\to f}$ is then averaged over all destination markets f for each stacked period and country $c\times$industry combination to obtain $\overline{\Delta\epsilon_{j,t}^{c}}$.

Finally, to compute the import penetration resulting from the loss of relative comparative advantage, we exponentiate $\overline{\Delta\epsilon_{j,t}^{c}}$ and multiply it with the imports in 1998 or 2003, depending on the stacked period. The change in imports caused by the change in supply factors is then[18]:

$$\Delta Imports_{j,t}^{c\leftarrow China} = \left(e^{\overline{\Delta\epsilon_{j,t}^{c}}} - 1\right) Imports_{j,t-1}^{c\leftarrow CHINA}.$$

The construction of the export exposure measure proceeds in a similar fashion. The difference is situated in the definition of the theoretical gravity equation, which now, following Dauth et al. (2014), takes the following form:

$$\ln Exports_j^{c\to China} - \ln Exports_j^{c\to f} = \ln\left(\frac{z_j^{China}}{z_j^{f}}\right) - \quad (\sigma_j - 1)\left[\ln\left(\frac{\tau_j^{c\to China}}{\tau_j^{c\to f}}\right)\right]. \tag{14}$$

[17]These are Canada, the United Kingdom, Iceland, Sweden, Japan, Australia, New Zealand, Norway and the United States.

[18]We subtract 1 from the exponentation term so that we obtain the total increase in imports rather than the absolute imports.

In this expression, the exports of an EMU member country c to China are compared to the exports of the same member to a country f. The implicit reasoning is that an increase in Chinese expenditure or the decrease in bilateral trade costs will have increased Chinese demand for goods of industry j of member country c relative to another destination market. The final export exposure measure then boils down to:

$$\Delta Exports_{j,t}^{c \to China} = \left(e^{\overline{\Delta \epsilon_{j,t}^{c}}} - 1 \right) Exports_{j,t-1}^{c \to CHINA}.$$

B Weighting the import shock exposure measure

The direct exposure of a country to a shock can strongly differ from the total exposure if a large fraction of an industry j in country c is exported abroad where it is again faced with a shock. Especially for traditionally very open industries in small countries this problem can be particularly pertinent. A shock measure that only accounts for the exposure in the domestic market of an industry could then portray a misguided picture of reality, inhibiting the potential for correct identification of the effects of the trade penetration change.

Therefore, a weighted measure is constructed that weights the exposure that an industry j of country c is faced with in each EMU destination market. The weights are computed in the following way:

$$w_j^{c \to f} = \frac{Sales_j^{c \to f}}{MarketSize_j^f}, \tag{15}$$

where $MarketSize_j^f$ is equal to the sum of domestic absorption and net imports. The exposure of an industry to a shock in a particular country is thus assumed to depend on how important an industry is compared to the total market size. Using these weights, the redefined shock is a weighted average of all shocks in the home market and all destination markets.

$$\Delta Weight.Imports_{j,t}^{c \leftarrow China} = \sum_f w_j^{c \to f} \Delta Imports_{j,t}^{c \leftarrow China}. \tag{16}$$

If an industry were to sell all its output domestically and there are no additional imports from abroad, then the measure in equation 16 can be represented as the simple domestic trade penetration shock. However, the calculation of the shock could matter strongly for very open economies, such as many of the smaller central countries in the EMU. Some of the industries in these open economies often export a large fraction of their output abroad are therefore more likely to be affected by import penetration shocks abroad[19].

C Discussion and construction of regional employment data

The variation of employment at the regional level reveals the relative exposure of a region to the trade penetration changes. However, the data for employment in the different manufacturing sectors is not always readily usable and requires detailed inspection. In table 2-C1 presents an overview of the sources of the data and the regional NUTS level at which the data is available. The data sources report the employment level for each of the 12 NACE rev.1.1 2-digit manufacturing industries that are tracked throughout this paper. The regional employment level data stem from two sources. The Structural Business Survey (SBS) is performed by the national institutions of the EU members data and surveys regional employers. Eurostat centralizes the national data and performs checks before publishing it. Information on employment is acquired by interviewing enterprises. The enquiry

[19] The WIOD dataset does not contain all countries of the world so we cannot compute the weighted average over all destination markets. Instead we compute it over all members of the EMU, the UK, Sweden, Denmark, the United States, Canada, Japan and Australia.

contains both large enterprises and a representative sample of small enterprises that is used to form aggregate employment trends. Data are available on the NACE rev.1.1 level for the period of 1995 to 2007. The Labour Force Survey (LFS) data contain the results of a household sample survey on the labour force status of members of the households. As with the data obtained through the SBS, the survey is also conducted by the national institutions in the different member states of the European Union and processed by Eurostat. The employment data is available at the regional level and offers information on employment and unemployment, as well as more detailed information concerning the NACE rev. 1.1 sector of employment, the education of the individuals, etc.

Table 2-C1: Data sources for regional employment at the NACE rev. 1.1 level

Country	Source	type regional definition
Austria	SBS (Eurostat)	NUTS2
Belgium	LFS (Eurostat)	NUTS1
Finland	EU Klems	National data
France	SBS (Eurostat)	NUTS2
Germany	SBS (Eurostat)	NUTS2
Greece	LFS (Eurostat)	NUTS2
Ireland	SBS (Eurostat)	NUTS2
Italy	SBS (Eurostat)	NUTS2
Luxembourg	EU Klems	National data
Netherlands	SBS (Eurostat)	NUTS2
Portugal	SBS (Eurostat)	NUTS2
Spain	SBS (Eurostat)	NUTS2

The NUTS2 data of the SBS dataset are generally used. The preference for this dataset over the LFS dataset rests on its more complete reporting of employment numbers. The LFS dataset does not report numbers if a certain statistical threshold is not passed due to a lack of responding units. Smaller regions therefore contain many missing values or highly fluctuating values for very small industries on their territory. NUTS2 regions are more aggregated than the commuting zones definition used by Autor and Dorn (2013) but form the most detailed level at which data is available in a cross-country analysis for Europe that ther author knows of. The definition of the NUTS2 regions underwent a change for most countries during the time frame from 1995 to 2007. As a result, it has become necessary to aggregate some NUTS2 levels to obtain a region that remains consistently the same over the studied period. The severity of the problem is especially pernicious in Finland and Portugal. The Finnish definition of NUTS2 regions has been subject to a major overhaul in 1999 and several regions were split up and recombined with other regions. The revision has made it impossible to track employment in the NACE rev. 1.1 manufacturing sectors consistently over time and therefore it was necessary to use the national employment data. The national data of EU Klems for Luxembourg is also used. Given the size of the country, it is no surprise that disaggregation of the national data at the level of regions is not available.

Belgian and Greek data were collected from the LFS dataset at the NUTS1 level rather than the more disaggregated NUTS2 level. The reason for this aberration with respect to the other countries in the sample is due to a structural break that occurs in the SBS data at the NUTS2 level. For Belgium, the survey methodology started sampling firms with less than 20 employees from reference year 1999 onwards. The change in the statistical approach is clearly visible and therefore data from the LFS were used as an alternative. Data at the more aggregated NUTS1 regional level is used to overcome the issue of the missing values in the sample. A similar problem also occurred for the Greek data in the SBS dataset. There, a change in the survey methodology in 2002 led to a clear structural break in the data rendering that dataset unusable.

Although the SBS data is available from 1995 onwards for the other countries in the sample, the French data seems to have undergone a structural break in 1996 compared to 1995. Moreover, no data are available for Italy in 1995. Therefore, the regional employment shares can only be computed from 1996 onwards.

The empty values that are present in the sample are filled through the following procedure. In a first step, it is necessary to ensure that any missing values in the total national employment of the SBS survey follow the same trend as the EU Klems data. Therefore, the national data of SBS is interpolated using the EU Klems dataset. Secondly, any missing total regional employment values are linearly interpolated so that the variable $E_{p(c)t}$ is obtained. During this procedure, it is ensured that the sum of employment of all regions adds up to the total employment at the national level that was obtained in the first step. This is achieved by rescaling the interpolated values[20]. Having obtained the total regional employment numbers, missing values are filled at the regional industrial level and the share of employment of each NACE rev.1.1 sector in the total employment of the relevant region $E_{jp(c)t}/E_{p(c)t}$ is computed. Missing values are obtained by linearly interpolating these shares. By performing this procedure in this manner, it is implicitly assumed that the employment share of the region evolves linearly over time. Of course, such an assumption leads to some differences between the employment share in the sample and the share that is observed in reality. However, given that the employment shares do not change dramatically over the years, it is expected that the differences with reality are small. Next, the interpolated shares are rescaled so that the total employment shares in all NACE rev.1.1 sectors add up to a 100% at the regional level[21]. A problem in this procedure is that some values for industries at the regional level do not have data on the start and/or end period and all values can therefore not be fully interpolated. In this case, the last historically observed employment share of the industry at the regional level is used and adjusted so that total employment adds up to a 100%.

[20] The rescaling occurs according to the share of employment in total employment. If a region for which data needed to be interpolated only represents a small part of total national employment, the regional employment will be adjusted much more lightly than a region that represents a large share of total employment.

[21] Again a rescaling occurs according to the size of the industry relative to all industries for which data needed to be interpolated.

D Descriptive statistics by country

Table 2-D1: Descriptive Statistics by country

	Average	min	max	Average	min	max
	Austria			Greece		
Δ Manuf.Employment to population	-0.50	-2.56	0.642	-0.23	-1.10	0.63
Δ Imports	1.52	0.82	2.86	1.91	1.28	2.79
Δ Imports through domestic link	0.16	0.12	0.22	0.47	0.36	0.56
Δ Imports through foreign link	0.55	0.37	0.85	0.10	0.07	0.13
Δ Exports	1.19	0.14	6.29	0.46	0.07	1.68
Δ Exports through domestic link	0.14	0.10	0.18	0.09	0.02	0.18
Δ Exports through foreign link	0.39	0.27	0.61	0.06	0.05	0.09
	Belgium			Ireland		
Δ Manuf.Employment to population	-0.56	-1.56	-0.20	-1.34	-1.66	-0.87
Δ Imports	3.46	2.67	4.63	10.41	3.492	17.72
Δ Imports through domestic link	0.36	0.32	0.43	1.60	0.33	2.99
Δ Imports through foreign link	0.85	0.70	1.01	0.44	0.38	0.50
Δ Exports	2.02	0.49	3.52	11.35	5.84	20.37
Δ Exports through domestic link	0.24	-0.02	0.59	1.71	0.55	2.93
Δ Exports through foreign link	0.64	0.59	0.69	0.24	0.19	0.30
	Germany			Italy		
Δ Manuf.Employment to population	-0.05	-1.97	2.02	0.11	-1.60	2.49
Δ Imports	2.53	1.48	5.15	1.42	0.82	2.29
Δ Imports through domestic link	0.59	0.42	0.86	0.64	0.35	1.10
Δ Imports through foreign link	0.36	0.17	0.58	0.26	0.18	0.41
Δ Exports	1.37	0.46	2.58	0.69	0.30	1.25
Δ Exports through domestic link	0.45	0.15	0.97	0.35	0.26	0.47
Δ Exports through foreign link	0.30	0.20	0.39	0.22	0.15	0.30
	Spain			Luxembourg		
Δ Manuf.Employment to population	0.24	-2.06	2.75	-1.22	-1.32	-1.11
Δ Imports	1.49	1.03	2.77	1.27	0.35	2.18
Δ Imports through domestic link	0.67	0.51	1.05	0.11	0.02	0.20
Δ Imports through foreign link	0.26	0.13	0.45	0.73	0.64	0.82
Δ Exports	1.27	0.11	6.90	1.92	0.72	3.12
Δ Exports through domestic link	1.02	0.09	3.13	0.06	0.04	0.08
Δ Exports through foreign link	0.20	0.10	0.36	0.55	0.45	0.65
	Finland			Netherlands		
Δ Manuf.Employment to population	-0.24	-0.43	-0.06	-0.66	-4.18	1.83
Δ Imports	3.76	2.29	5.22	3.58	2.39	5.52
Δ Imports through domestic link	1.06	0.77	1.35	0.40	0.34	0.47
Δ Imports through foreign link	0.46	0.34	0.59	0.71	0.43	1.06
Δ Exports	1.31	0.36	2.25	1.77	0.84	2.55
Δ Exports through domestic link	0.41	0.14	0.69	0.19	0.11	0.28
Δ Exports through foreign link	0.32	0.28	0.37	0.53	0.37	0.75
	France			Portugal		
Δ Manuf.Employment to population	-0.65	-3.69	2.71	-1.39	-3.84	0.08

Δ Imports	3.53	2.21	6.32	0.37	0.20	0.75
Δ Imports through domestic link	1.00	0.61	1.63	0.13	0.10	0.19
Δ Imports through foreign link	0.37	0.23	0.51	0.31	0.11	0.58
Δ Exports	1.28	0.01	3.59	0.38	0.09	1.83
Δ Exports through domestic link	0.63	-0.05	1.54	0.17	0.04	0.39
Δ Exports through foreign link	0.33	0.14	0.63	0.23	0.13	0.38

Table 2-D2: Descriptive Statistics by country

	1998-2003	2004-2007	1998-2003	2004-2007
	Austria		Greece	
Δ Manuf.Employment to population	-0.55	-0.51	-0.44	-0.20
Δ Imports	0.99	1.68	0.92	1.15
Δ Imports through domestic link	0.13	0.21	0.25	0.22
Δ Imports through foreign link	0.32	0.47	0.06	0.08
Δ Exports	1.45	0.72	0.08	0.99
Δ Exports through domestic link	0.16	0.11	0.03	0.15
Δ Exports through foreign link	0.52	0.30	0.07	0.04
	Belgium		Ireland	
Δ Manuf.Employment to population	-0.61	-0.25	-1.02	-1.58
Δ Imports	2.27	2.53	2.53	8.59
Δ Imports through domestic link	0.32	0.23	0.24	1.47
Δ Imports through foreign link	0.54	0.66	0.27	0.32
Δ Exports	3.28	0.70	6.05	18.47
Δ Exports through domestic link	0.47	-0.01	0.55	2.89
Δ Exports through foreign link	0.63	0.63	0.30	0.20
	Germany		Italy	
Δ Manuf.Employment to population	-0.44	0.32	0.17	-0.29
Δ Imports	1.42	1.96	1.11	1.81
Δ Imports through domestic link	0.40	0.44	0.48	0.78
Δ Imports through foreign link	0.20	0.32	0.16	0.19
Δ Exports	1.98	0.83	0.68	0.80
Δ Exports through domestic link	0.71	0.20	0.35	0.36
Δ Exports through foreign link	0.27	0.34	0.25	0.19
	Spain		Luxembourg	
Δ Manuf.Employment to population	0.60	-0.61	-1.32	-1.11
Δ Imports	1.16	1.43	1.09	1.85
Δ Imports through domestic link	0.49	0.57	0.06	0.14
Δ Imports through foreign link	0.15	0.22	0.48	0.56
Δ Exports	2.53	0.46	0.72	3.12
Δ Exports through domestic link	1.91	0.14	0.04	0.08
Δ Exports through foreign link	0.15	0.26	0.65	0.45
	Finland		Netherlands	
Δ Manuf.Employment to population	-0.06	-0.43	-0.97	-0.44
Δ Imports	1.70	3.63	2.06	2.37

Δ Imports through domestic link	0.61	1.01	0.30	0.24
Δ Imports through foreign link	0.25	0.38	0.42	0.58
Δ Exports	0.36	2.25	1.44	2.01
Δ Exports through domestic link	0.14	0.69	0.15	0.24
Δ Exports through foreign link	0.37	0.28	0.61	0.45
	France		Portugal	
Δ Manuf.Employment to population	-0.77	-0.57	-2.24	-1.28
Δ Imports	1.88	2.88	0.47	0.69
Δ Imports through domestic link	0.49	0.79	0.15	0.20
Δ Imports through foreign link	0.25	0.30	0.19	0.32
Δ Exports	0.55	2.12	1.23	0.15
Δ Exports through domestic link	0.04	1.19	0.33	0.05
Δ Exports through foreign link	0.49	0.17	0.33	0.23

E Shock propagation in the largest EMU countries

Table 2-E1: Shock propagation in the largest EMU countries

	Dependent variable:Stacked change in manuf. employment/working age pop.					
	Spain			Germany		
$\Delta \text{Imp}_{pt}^{CN}$	-1.46**	-1.70**	-0.83	-0.35	-0.36	-0.41
	(0.56)	(0.67)	(0.57)	(0.32)	(0.32)	(0.48)
$\Delta \text{Exp}_{pt}^{CN}$		0.18	0.08		0.09	0.28
		(0.14)	(0.11)		(0.59)	(0.67)
$\Delta \text{Imp.Tot.Link}_{pt}^{CN}$			0.37			0.77
			(0.93)			(2.68)
$\Delta \text{Exp.Tot.Link}_{pt}^{CN}$			2.16***			-1.53
			(0.34)			(1.68)
Constant	1.28	1.53	-1.68	0.77	0.72	0.99
	(0.95)	(1.06)	(1.42)	(0.54)	(0.59)	(0.98)
Observations	34	34	34	68	68	68
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.529	0.553	0.734	0.437	0.437	0.444
	Italy			France		
$\Delta \text{Imp}_{pt}^{CN}$	-1.75**	-2.26***	-2.23***	0.90	0.82	0.60
	(0.73)	(0.73)	(0.71)	(0.68)	(0.62)	(0.82)
$\Delta \text{Exp}_{pt}^{CN}$		0.95	1.13		0.82	1.03
		(0.58)	(1.26)		(0.56)	(0.67)
$\Delta \text{Imp.Tot.Link}_{pt}$			-0.10			2.99
			(3.06)			(6.73)
$\Delta \text{Exp.Tot.Link}_{pt}$			-1.24			-2.96
			(6.47)			(5.49)
Constant	2.43***	2.50***	3.19	-1.30	-1.50	-1.97
	(0.88)	(0.82)	(2.67)	(1.39)	(1.42)	(2.48)
[1em] Observations	38	38	38	42	42	42
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.562	0.594	0.596	0.244	0.295	0.301

$\Delta Imp.Tot.Link_{pt}^{CN}$ and $\Delta Exp.Tot.Link_{pt}^{CN}$ are the total industrial linkage exposure (domestic+foreign) of a region.
*** Significant at the 1 percent level;** Significant at the 5 percent level; * Significant at the 10 percent level.

F Propagation of a supply shock

In contrast to a trade penetration shock, a TFP shock is a supply shock. Industries that use the output of other industries in their production process will be positively affected if the upstream industry can provide better or cheaper inputs. Therefore the standard upstream input-output link between two industries can be used to determine how the shock will propagate through the production network. This is expressed in equation F that shows how relevant an upstream provider is to the production of one unit of input of a downstream input-user.

$$\hat{a_{nj}} = \frac{Sales_{n \to j}}{Sales_j}$$

The Leontief inverse of this element is expressed in bold, $\widehat{\mathbf{a_{nj}}}$

Then, the TFP shock to an industry n in country f is computed as follows:

$$\Delta TFP_{n(f)t} = \frac{\Delta TFP_{n(f),t}}{TFP_{n(f),t-1}} \tag{17}$$

Then this shock is translated into a direct regional shock. Moreover, the domestic linkage and the foreign linkage shock are defined as follows:

$$\Delta TFP\, Dom.Link_{p(c)t} = \sum_j \frac{E_{jp(c)t-3}}{E_{p(c)t-3}} \sum_{n(c)} \left(\widehat{\mathbf{a_{n(c),j(c)}}} - 1_{j(c)=n(c)}\right) \Delta TFP_{j(c)t} \tag{18}$$

$$\Delta TFP\, For.Link_{p(c)t} = \sum_j \frac{E_{jp(c)t-3}}{E_{p(c)t-3}} \sum_{\substack{n(f) \\ c \neq f}} \left(\widehat{\mathbf{a_{n(f),j(c)}}}\right) \Delta TFP_{n(f)t} \tag{19}$$