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Domestic demand and global production in the Eurozone: A multi-regional input-output assessment of the global crisis

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This paper studies the effects of domestic and foreign demand impulses in euro area economies following the Great Recession of 2008-09 and the Eurozone crisis of 2011-12. Using a global Input-Output framework we apply a set of metrics to assess spillover effects of international trade in intermediates triggered by the dynamics of final demand. Our findings suggest that while cross-country trade spillovers have played a crucial role during the Great Recession, they have had a moderate impact when compared to the role of domestic sources of final demand during the Eurozone crisis. Hence, a strategy of coordinated fiscal austerity cannot be sustained by empirical evidence.

Keywords: Global Crisis; International Trade; Multi-regional Input-Output Analysis

JEL Classifications: C67, F14, R15

1. Introduction

The Eurozone is undergoing a systemic crisis whose impact, beyond its financial dimension, can be analysed from different perspectives. One approach is to study the consequences of structural interdependence among its member economies and, more specifically, the effects of global production, i.e. the ever-finer local specialisation and geographic fragmentation of manufacturing processes, on domestic income and employment.

With the current crisis, the measurement of 'spillover' effects due to global production and finance has become a research priority (e.g. IMF 2013). It has been

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argued, however, that the impact of trade spillovers in the Eurozone is positive, though small (European Commission 2012, p. 108), and in any case of reduced importance when compared to financial linkages.[1]

Thus, some research questions come to the fore. First of all, how have different members of the Eurozone been affected by trade spillovers during the Great Recession of 2008-09? In the second place, but more importantly, how these outcomes compare to the effects of austerity policies undertaken in some euro area countries during 2011-12? As a matter of fact, the sovereign debt crisis and the tight fiscal discipline imposed by EU institutions have caused a new recession and soaring unemployment rates.

Looking at future possible scenarios in the Eurozone, a relevant question is whether the recessive effects of austerity policies in deficit countries could be compensated by increasing foreign demand coming from surplus economies. If this is not the case, boosting domestic final demand may be a necessary condition for a sustained recovery.

This paper aims at answering the above questions by means of a multi-regional Input-Output scheme, assessing to which extent these views correspond to empirical evidence.

Up to now, research on these issues based on Input-Output techniques has been quite scarce, probably due to data limitations. Setting up a global multi-regional inter-industry scheme is truly demanding.[2] Such a complex dataset has not been freely available until the recent release of the World Input-Output Database (WIOD) Project (Timmer 2012; Dietzenbacher et al. 2013). With this instrument at hand, it is possible to trace the precise source of final demand which activates output (and therefore income and employment) of each industry in every Eurozone country.

We proceed, after this short introduction, with an account of some preceding efforts to quantify trade spillovers in relation to the Great Recession (Section 2). We introduce the methodological framework in Section 3; then Section 4 reports and discusses the empirical results obtained. Finally, Section 5 summarises and concludes.

[1] In fact, "the share of financing from surplus countries is larger than the share of exports to these countries" (European Commission 2012, p. 111).

[2] A global Input-Output framework requires to know precisely how much of commodity i in country r is bought by industry j in country s, being necessary to merge national Input-Output tables with merchandise and service international trade statistics.

2. Estimation of the impact of the Great Recession and consequent policies

After the financial crisis and the Great Recession, two questions were raised among macroeconomic analysts: (i) how important demand spillovers have been, in explaining both the collapse of trade and transmission of the global recession (e.g. compared to financial linkages across countries) and (ii) the size of the impact of the fiscal stimuli adopted in individual countries, on themselves and on their partners, also in view of assessing the fiscal space for coordinated policy alternatives.

As to the first question, we recall that during 2009 there were synchronized declines in output across most countries of the globe (Antonakakis 2012). World trade in real terms fell by about 10% between 2008 and 2009,[3] exceeding the fall in real world GDP by a factor of roughly four (Bems et al. 2010, 2011).[4] In addition to trade in final goods, production sharing and trade in intermediate goods played a crucial role, due to increasing vertical specialisation (di Giovanni, J. and Levchenko, A. A. 2010).

Essentially, production of intermediates is activated — at a *global* scale — by the dynamics of *domestic* final uses: private and government consumption as well as gross capital formation. In fact, changes in final demand have been acknowledged to be the main explanation of the collapse in world trade during the Great Recession (Bems et al. 2012).[5] Hence, the interpretation of this episode in terms of international contagion of effective final demand failures, with particular attention to compositional (investment) and sectoral (intermediates and durables) effects, has gained momentum in recent years (Eaton et al. 2011).

As to the second question, it must be noticed that domestic demand still plays a prominent role in most of the economies under analysis. Hence, the dichotomy between fiscal austerity and stimulus cannot be overlooked by merely focusing on trade spillovers. What is sure is that when austerity measures are taken by several countries at the same time, their impact — on production, income and employment — is much higher. For example, Auerbach and Gorodnichenko (2012),

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[3] Between 2008 and 2009, world imports fell by 9.99% at constant 2005 prices in US Dollars (Source: UNSD National Accounts Main Aggregates Database, December 2012 release).

[4] Note that this amplified co-movement between trade flows and income has seen an unprecedented increase during the last decades: the long-run elasticity of world trade to GDP between 1985 and 2000 has been estimated at 3.39 (Irwin 2002, p. 96).

[5] The decline of real expenditure with its compositional effects have been considered of much greater importance than, for example, trade credit constraints (Levchenko et al. 2010).

besides confirming that trade can be an important channel of how fiscal shocks are propagated across countries, show that "amplified fiscal spillovers would increase the argument in favor of coordinated fiscal stimulus" (p. 15).

Hence, both research questions are inextricably intertwined. For example, Liu (2009) quantifies the impact of the global financial crisis on China through a structural vector auto-regression analysis. The finding is that the impact is indeed sizeable: a 1% decline in economic growth in the USA, the EU and Japan is likely to lead to a 0.73% decline in growth in China one year later. He also finds that that the massive fiscal stimulus adopted in the country largely offsets the significant shortfalls in external demand. It is estimated that the fiscal stimulus package will be able to generate additional growth in the range of 4-5%.

In the case of the EU, some studies have analysed the impact at a regional level too. For instance, Rivera (2012) has investigated the uneven impact of the economic crisis on the territory of the EU; he remarked that the economic crisis primarily hit regions specializing in the manufacturing sector, although the largest unemployment increases occurred in regions with a high dependence on construction.

As refers to research specifically devoted to the impact of fiscal stimuli, Coenen G. and Trabandt (2012) focus on the European Economic Recovery Plan (EERP) enacted in response to the financial crisis of 2008-09. In total, the fiscal stimulus measures amount to 1.1% and 0.8% of GDP in the years 2009 and 2010, respectively[6] (this in addition to the operation of automatic fiscal stabilisers and to the extra budgetary actions, such as capital injections, loans and guarantees to the financial sector). The authors find that EERP had a sizeable, although short-lived, impact on Eurozone GDP. The large impact derives from fiscal multipliers larger than one for government consumption and investment, in presence of adequate monetary accommodation.[7]

In this respect, the recent debate on the size of fiscal multipliers — among macroeconomists and econometricians — has relevant policy implications. In fact, the supporters of tough austerity measures, in order to consolidate public finances, ar-

[6]Support for households' purchasing power (reduction in VAT, direct taxes, social security contributions, as well as direct aid, such as income support for households and support for housing or property markets) accounts for about 40% of the total stimulus. Support for investment (infrastructures and public investment) and businesses (reduction of taxes and social security contributions, subsidies, export promotion, etc.) account for roughly 30% and 20% of the total stimulus, respectively. Labour-market actions (wage subsidies and active labour-market policies) account for about 10% of the total stimulus.

[7]The estimation is made by means of an extended version of the ECB's New Area-Wide Model (an open-economy DSGE model) with a richly specified fiscal sector.

gue that fiscal multipliers are rather low and consequently restrictive fiscal policies do not cause large falls in income and production. On the other hand, even the IMF (2012) now maintains that the value of the fiscal multipliers, since the Great Recession, has significantly increased, suggesting a more gradual fiscal adjustment.[8]

However, macro-econometric analyses of this sort are usually based on complex relationships between aggregate magnitudes,[9] hindering the emergence of aggregate properties coming from inter-industry interactions between thousands of industries in different countries around the globe. It may turn out that sectoral composition of production and trade is of utmost importance to assess aggregate outcomes for income and employment.

In fact, Groot et al. (2011), in investigating the impact of the crisis on European countries and regions, consider three classes of explanations: (i) the extent to which countries are integrated in the global economy via financial and trade linkages, (ii) the differences in their institutional frameworks, and (iii) the differences in their sectoral composition. The latter turns out to be the most important factor.

By acknowledging this insight, few recent studies have dealt with the research questions at stake by resorting to multi-regional Input-Output analysis, where each region represents a national economy. For example, Bems et al. (2010) use a global Input-Output framework to quantify US and EU demand spillovers and the elasticity of world trade to GDP during the global recession of 2008-09. The estimated elasticity of world trade to GDP is 2.8, when final demand changes in all countries.[10] In particular, they find that 20-30% of the decline in the US and EU final demand was borne by foreign countries, especially NAFTA and emerging Europe, respectively.[11]

Our paper goes precisely in this direction, by introducing a set of metrics to quantify the share of own income activated by different sources of foreign final demand in a global accounting framework. We focus not only on structural relations

[8] It has even been concluded that "growth disappointments should be larger in economies that planned greater fiscal cutbacks"(Blanchard and Leigh 2013, p. 3).

[9] This is also the case of Auerbach and Gorodnichenko (2012), who adopt an innovative method to identify fiscal shocks and apply it to a large set of OECD countries.

[10] Thus, for an elasticity of 4, demand forces alone account for roughly 70% of the trade collapse. Crucially, the estimated elasticity of trade to GDP is high because the model allows for asymmetries in demand changes across sectors. Their analysis reflects in particular the role played by durable goods, which are both highly traded as a final demand component and tightly integrated into global supply chains.

[11] However, due to the database they employ (GTAP 7 for year 2004), and the estimation method adopted for off-diagonal inter-regional trade matrices, results concerning year 2008-09 might have to be treated with care.

(i.e. year-by-year coefficient ratios), but also on the computation of actual and model-implied demand-induced GDP changes.

However, differently from traditional domestic multiplier analyses discussed above (e.g. Coenen G. and Trabandt 2012), our paper deals with an 'open' global Input-Output scheme where consumption and investment are not endogenised as a function of income. Hence, the transmission mechanism at work, i.e. final demand trade spillovers, corresponds to the operation of domestic and international 'Leontief' multipliers, triggered by inter-country linkages of final demand. Therefore, in principle, it is not possible to make accurate comparisons between multipliers computed under these two different methodologies. Note, however, that both notions may be conceptually related, e.g. "[w]ith increasing fragmentation, domestic multiplier effects of fiscal stimulus programs will be lower, while foreign spillovers increase" (Timmer et al. 2012, p. 27).

On grounds of method, the case for pursuing a global Input-Output *accounting* exercise, with respect to standard techniques, may also be considered. First, rather than performing out-of-sample prediction of endogenous variables during crisis periods (as in calibrated DSGE models or VAR specifications), we perform a purely accounting exercise of the Great Recession, decomposing *actual* changes in income attributable to *actual* changes in domestic final demand in every region. Second, by adopting an Input-Output structure, we take a clear-cut theoretical position as regards the induced character of vertical specialisation. In many econometric specifications (e.g. Beetsma et al. 2006, p. 660), nothing prevents that lagged intermediate exports may be used to explain contemporaneous exports of final goods, which we find difficult to justify, from a theoretical point of view.

In the third place, as regards definitional issues, in canonical GVAR specifications (e.g. Pesaran et al. 2004, p. 132), contemporaneous domestic prices and quantities are linked with lagged and contemporaneous prices and quantities, using a *fixed* constant matrix of bilateral trade as weights. But how can it be consistent to evaluate cross-country effects in *output* while assuming a constant or predetermined average value for such a crucial component of GDP such as exports? By adopting an accounting approach domestic magnitudes are not linked through indirect statistical relationships, but through consistent actual accounting identities. Finally, there is also an important conceptual difference between our approach and standard DSGE models. Within the latter, spillovers are given a behavioural interpretation: "if it [spillover] is meant to refer to unintended consequences, there are no spillovers when policy reaction functions take into account other policymakers' instruments" (Corsetti in the Panel discussion of Beetsma et al. 2006, p. 685). On the contrary, our definition of spillover is solely based on observable and measurable magnitudes. We view this as an essential point in conveying the fact that empirical general interdependence overrides the methodological individualism implied by such a behavioural definition of spillover.

To sum up, besides providing a set of metrics based on a global Input-Output accounting scheme, our main contribution lies in performing an analysis of final demand trade spillovers for euro area economies not only during the Great Recession (2008-09), but also in relation to the Eurozone crisis (2011-12). In view of the enduring consequences of these two recessive episodes, it would be useful for the design of coordinated policy alternatives to quantify their impact on GDP. This is approached in the sections that follow.

3. Methodology

3.1 Basic accounting framework

The main accounting identity for the expenditure side of a global system with K regions with n industries in each of them and three components of final demand $u = \{c_g, c_p, gcf\}$ is given by:[12]

$$\mathbf{z} \equiv \mathbf{X}\mathbf{e}_x + \mathbf{F}\mathbf{e}_f \tag{1}$$

By defining the matrix of intermediate production and trade ($\mathbf{X}$) in intensive terms (per unit of industry gross output): $\mathbf{A} := \mathbf{X}\widehat{\mathbf{z}}^{-1}$, we obtain an $(n \times K) \times (n \times K)$ "global sourcing matrix" (Stehrer and Ward 2012, p. 166), capturing the requirements of domestic or foreign intermediates by every industry in every region of the system.

[12]The three components of final demand are: government consumption (c_g), private consumption (c_p), which includes the consumption expenditure of Non-profit institutions serving households (NPISH), and gross capital formation (gcf), which includes gross fixed capital formation, changes in inventories and valuables. Appendix A below specifies the notation regarding the meaning and dimension of each vector and matrix used. All throughout the paper, vectors are indicated by lower case boldface characters (e.g. $\mathbf{z}$), and are column vectors unless explicitly transposed (e.g. $\mathbf{z}^T$), while matrices are indicated by upper case boldface characters (e.g. $\mathbf{X}$), except for lower case characters with a hat (e.g. $\widehat{\mathbf{z}}$), indicating diagonal matrices with the vector elements on the main diagonal. Moreover, $\mathbf{e} = [1 \dots 1]^T$ is used to represent sum vectors of different dimensions according to the corresponding subindex (e.g. $\mathbf{e}_x$, $\mathbf{e}_f$, $\mathbf{e}_n$).

Global production is directly linked by matrix **A**. However, by looking at the economic process as a circular flow (Leontief 1928), this framework allows to explicitly account for indirect linkages between each source of final demand (in matrix **F**) and (consequent) gross value added and (originating) employment (which are income side magnitudes), assessing to which extent these are induced or activated by each final buyer. In this way a scalar figure for each "final demand-source industry" combination may summarise the comprehensive operation of the global network of intermediate inputs. To do this we first define the $(n \times K) \times (3 \times K)$ matrix **S**:

$$\underset{(nK)\times(3K)}{\mathbf{S}} := \widehat{\mathbf{z}}^{-1}\mathbf{BF} = \begin{bmatrix} s_{1,1}^{c_p,1} & s_{1,1}^{c_g,1} & s_{1,1}^{gcf,1} & \cdots & s_{1,1}^{c_p,K} & s_{1,1}^{c_g,K} & s_{1,1}^{gcf,K} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ s_{n,1}^{c_p,1} & s_{n,1}^{c_g,1} & s_{n,1}^{gcf,1} & \cdots & s_{n,1}^{c_p,K} & s_{n,1}^{c_g,K} & s_{n,1}^{gcf,K} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ s_{1,K}^{c_p,1} & s_{1,K}^{c_g,1} & s_{1,K}^{gcf,1} & \cdots & s_{1,K}^{c_p,K} & s_{1,K}^{c_g,K} & s_{1,K}^{gcf,K} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ s_{n,K}^{c_p,1} & s_{n,K}^{c_g,1} & s_{n,K}^{gcf,1} & \cdots & s_{n,K}^{c_p,K} & s_{n,K}^{c_g,K} & s_{n,K}^{gcf,K} \end{bmatrix} \tag{2}$$

where $\mathbf{B} := (\mathbf{I} - \mathbf{A})^{-1}$ is the global Leontief inverse. Note that each element of matrix $\mathbf{S} = [s_{i,r}^{u,s}]$ stands for the proportion of gross output of industry $i = 1 \dots n$ in region $r = 1, \dots, K$ that is activated by final demand component $u = \{c_g, c_p, gcf\}$ of region $s = 1, \dots, K$.

Given that the rows of matrix **S** sum to one, exhausting the value of gross output by industry in each region, we may decompose the proportion of value added $(\widehat{\mathbf{v}})$ or employment $(\widehat{\mathbf{l}})$ for every source industry in all regions activated by each final demand component:

$$\mathbf{v} = \widehat{\mathbf{v}}\mathbf{e}_x = (\widehat{\mathbf{v}}\mathbf{S})\mathbf{e}_f = \mathbf{M}_v\mathbf{e}_f \tag{3}$$

$$\mathbf{l} = \widehat{\mathbf{l}}\mathbf{e}_x = (\widehat{\mathbf{l}}\mathbf{S})\mathbf{e}_f = \mathbf{M}_l\mathbf{e}_f \tag{4}$$

For example, each element of $\mathbf{M}_v = [m_{i,r}^{u,s}]$ represents the income of industry $i = 1 \dots n$ in region $r = 1, \dots, K$ that is activated by final demand component $u = \{c_g, c_p, gcf\}$ of region $s = 1, \dots, K$. Thus, convenient aggregation of $\mathbf{M}_v$ or $\mathbf{M}_l$ by activated industries (column-wise) and by activating source of final demand (row-wise) allows us to quantify, at different levels, the direct, internally derived and spillover effects on value added (income) and employment, triggered by global final demand.[13]

With these basic elements in mind, our aim is to derive country-aggregate consequences of disaggregated industry-specific final demand impulses, by means of a series of metrics introduced below: the structural dependence of 'activated' on 'activating' regions, foreign trade spillovers triggered by final demand and, finally, sources of changes in employment.[14]

3.2 Metrics

3.2.1 Domestic income generated by foreign final demand

A possible measure of structural dependence of region r on region s consists in computing the proportion of value added in region r activated by final demand of region s:

$$\theta_v^{r,s} = (1/y_r) \sum_u \mathbf{e}_r^T \mathbf{M}_v \mathbf{e}_s^{(u)} \tag{5}$$

for $u = \{c_g, c_p, gcf\}$, $r = 1, \ldots, K$ and $s = 1, \ldots, K$, where aggregate income for activated region r is given by: $y_r = \mathbf{e}_r^T \mathbf{v} = \mathbf{e}_r^T \mathbf{M}_v \mathbf{e}_f = \sum_s \sum_u \mathbf{e}_r^T \mathbf{M}_v \mathbf{e}_s^{(u)}$.

For example, $\theta_v^{deu,ita}$ represents the proportion of German income activated or induced by Italian final demand. Note that this concerns Italian demand not only for German products but for any source of net output. Hence, this measure includes comprehensive spillover and feedback effects: Italian final demand for French products which require German inputs to be produced indirectly contribute to German GDP. This is all captured in $\theta_v^{deu,ita}$. Hence, the evolution of $\theta_v^{r,s}$ describes the ultimate sources of final demand which generate income in each region, thus assessing the dependence of an activated country on all others as well as on its own domestic demand.

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[13]In order to aggregate, two basic summation rules that we will use throughout are: $\mathbf{e}_x^T = \sum_r \mathbf{e}_r^T$ and $\mathbf{e}_f = \sum_s \sum_u \mathbf{e}_s^{(u)}$. For an accurate specification of vectors $\mathbf{e}_x$, $\mathbf{e}_f$, $\mathbf{e}_r$, $\mathbf{e}_s^{(u)}$ see Appendix A.

[14]We thank an anonymous referees for calling our attention on the need to justify our procedure of introducing a multi-sectoral accounting framework and then reporting aggregate country-level results. The key point to be grasped is that country-level aggregation is performed only *after* disaggregated sectoral computations have been carried out. There is a crucial difference between aggregating *first* and *then* inverting a matrix, with respect to inverting a matrix *first* and *then* aggregating the results, due to the fact that matrix inversion is a *non*-linear operation. Hence, compositional effects still play a crucial role, as each component is specified in its full sectoral dimension, and it is only when results at the most detailed level are obtained that a bottom-up aggregation is performed. This notwithstanding, exploring the industry-level differences composing a country-aggregate spillover figure is a very relevant question for further research, especially within a global Input-Output accounting framework.

3.2.2 Final Demand Trade Spillovers

A quantitative assessment of income reductions induced by final demand should distinguish between domestic and foreign determinants. As a starting point, consider matrix $\mathbf{M}_v$ defined in equation (3) above. By assuming that only final demand matrix $\mathbf{F}$ is changing amongst the components of $\mathbf{M}_v$, we may apply element-wise growth rates of final demand to matrix $\mathbf{M}_v$ and obtain the resulting trade spillovers. Mathematically, we compute:[15]

$$g_v^{r,s(u)} = (1/y_r)\mathbf{e}_r^T(\mathbf{M}_v \circ \mathbf{G}_f)\mathbf{e}_s^{(u)}, \quad g_v^{r,s} = \sum_u g_v^{r,s(u)}, \quad g_v^r = \sum_s g_v^{r,s} \tag{6}$$

where $\mathbf{G}_f = [g_{i,r}^{u,s}]$ is a matrix of dimension $(n \times K) \times (3 \times K)$ containing the growth rates of final demand. For example, $G_{food,ita}^{c_p,deu}$ is the growth rate of German private consumption demand for Italian food products. Note that $g_v^{r,s(u)}$ may be further aggregated by final demand component (obtaining $g_v^{r,s}$), as well as by regional source of activating demand (obtaining g_v^r). Hence, $g_v^{r,s}$ provides a bilateral measure of the exposure of country r to changes in final demand of country s, while g_v^r provides a synthetic indicator of income changes in country r induced by final demand, regardless of their source of origin.

Additionally, we may specify the change in each final demand component u of every activating region s, with respect to aggregate domestic final demand f_s as:

$$g_f^{s(u)} = (1/f_s)\mathbf{e}_x^T(\mathbf{F} \circ \mathbf{G}_f)\mathbf{e}_s^{(u)}, \quad g_f^s = \sum_u g_f^{s(u)} \tag{7}$$

with $f_s = \sum_r \sum_u \mathbf{e}_r^T \mathbf{F} \mathbf{e}_s^{(u)}$, and where we aggregate over final demand components $g_f^{s(u)}$ to obtain g_f^s.

Note that any proportional change in domestic final demand does not necessarily translate into an equal proportional change in own income. But given that, in a global setting, the aggregate change in world income equals the aggregate change in global final demand, part of domestic demand changes are most probably absorbed by foreign countries. Hence, the extent to which changes in domestic final uses are borne by others provides a measure of trade spillovers. With $g_v^{r,s}$ and g_f^s, a synthetic indicator of country-specific final demand trade spillovers — due to Bems et al.

[15]Operator $\circ$ indicates the element-wise scalar product between two matrices of the same dimension (the Hadamard product), i.e. $[\mathbf{A} \circ \mathbf{B}]_{ij} = [\mathbf{A}]_{ij}[\mathbf{B}]_{ij}$.

(2010) — may be obtained in our framework by computing:

$$\lambda_v^r = 1 - \frac{g_v^{r,r}}{g_f^r} \tag{8}$$

where λ_v^r "captures the share of the change in final demand that is borne by foreign countries" (Bems et al. 2010, p. 310). Intuitively, for a negative shock, λ_v^r conveys the idea of the percentage of the change in domestic demand that 'leakages' into income reductions of others.

As a complementary measure, we compute the proportional change in income of country r originating from final demand changes of countries $s \neq r$, with respect to the weighted average of proportional demand changes in these countries:

$$\varphi_v^r = \frac{\sum_{s\neq r} g_v^{r,s}}{\sum_{s\neq r} g_f^s (f_s / \sum_{s\neq r} f_s)} \tag{9}$$

Intuitively, φ_v^r conveys the idea of the extent to which an economy can take advantage of, or be particularly affected by, demand changes in the rest of the world. This metric may be plausibly interpreted as an elasticity (a ratio of proportional changes). Hence, a value greater than one indicates that the response of own income to changes in foreign demand has been more than proportional, while a value close to zero suggests that the effect of domestic demand dominates over global dynamics.

Both λ_v^r and φ_v^r play a crucial role in explaining the connection between own income changes and different sources of final demand. We may see this by departing from equation (6), adopting the perspective of country r, and making explicit the separation between domestic (r) and foreign ($s \neq r$) sources:

$$g_v^r = \sum_s g_v^{r,s} = g_v^{r,r} + \sum_{s\neq r} g_v^{r,s} \tag{10}$$

From (8) we have that:

$$g_v^{r,r} = (1 - \lambda_v^r) g_f^r \tag{11}$$

while from (9) we may obtain:

$$\sum_{s\neq r} g_v^{r,s} = \varphi_v^r \frac{\sum_{s\neq r} g_f^s f_s}{\sum_{s\neq r} f_s} \tag{12}$$

Hence, by introducing (11) and (12) into (10) we may finally decompose demand-induced income changes in country r into two determinants:

$$g_v^r = \underbrace{(1-\lambda_v^r)g_f^r}_{\text{own demand}} + \underbrace{\varphi_v^r \frac{\sum_{s\neq r} g_f^s f_s}{\sum_{s\neq r} f_s}}_{\text{others' demand}} \tag{13}$$

Notably, expression (13), for given technical conditions, allows to *explain* income changes by means of a weighted average of changes in domestic and foreign final demand, the weights being (the complement to one of) λ_v^r and φ_v^r, respectively.

Finally, in order to obtain a more detailed picture of each activating foreign source of demand, we compute the 'contribution to growth' of each component of final demand u in every activating region s to the aggregate change in income of activated region r:

$$\delta_v^{r,s(u)} = \frac{\mathbf{e}_r^T(\mathbf{M}_v \circ \mathbf{G}_f)\mathbf{e}_s^{(u)}}{\mathbf{e}_r^T(\mathbf{M}_v \circ \mathbf{G}_f)\mathbf{e}_f}, \quad \delta_v^{r,s} = \sum_u \delta_v^{r,s(u)} \tag{14}$$

For example, $\delta_v^{ita,deu}$ stands for the percentage of the aggregate change in Italian income which can be attributed to changes in German final demand.

3.2.3 Structural decomposition of changes in employment

Structural decomposition analysis is a technique that allows to decompose the change in a variable into changes in its determinants. In this case, we focus on the change in matrix $\mathbf{M}_l = \widehat{\mathbf{a}}_l\mathbf{BF}$ between 2008 ($t = 0$) and 2009 ($t = 1$).[16] Being defined as the product of three elements: unitary direct labour requirements ($\widehat{\mathbf{a}}_l$), total (direct and indirect) input requirements per unit of monetary output ($\mathbf{B}$) and final demand by region and component ($\mathbf{F}$), changes in matrix $\mathbf{M}_l$ are due to the composite change of its determinants. Each possible decomposition of its growth should leave two components fixed while allowing for the third one to change between time periods. Hence, from among the $3! = 6$ possible combinations we have chosen to compute:

$$\begin{aligned}\Delta\mathbf{M}_l :&= \mathbf{M}_{l1} - \mathbf{M}_{l0} \\ &= \widehat{\mathbf{a}}_{l1}\mathbf{B}_1\mathbf{F}_1 - \widehat{\mathbf{a}}_{l0}\mathbf{B}_0\mathbf{F}_0 \\ &= \widehat{\mathbf{a}}_{l0}\mathbf{B}_0(\mathbf{F}_1 - \mathbf{F}_0) + \widehat{\mathbf{a}}_{l0}(\mathbf{B}_1 - \mathbf{B}_0)\mathbf{F}_1 + (\widehat{\mathbf{a}}_{l1} - \widehat{\mathbf{a}}_{l0})\mathbf{B}_1\mathbf{F}_1\end{aligned} \tag{15}$$

[16] From (2) and (4), matrix $\mathbf{M}_l = \widehat{\mathbf{l}}\mathbf{S}$ can also be expressed as $\mathbf{M}_l = \widehat{\mathbf{l}}\widehat{\mathbf{z}}^{-1}\mathbf{BF}$. Defining $\widehat{\mathbf{a}}_l = \widehat{\mathbf{l}}\widehat{\mathbf{z}}^{-1}$ as the diagonal matrix of direct labour requirements per unit of monetary gross output of each industry in every region, gives $\mathbf{M}_l = \widehat{\mathbf{a}}_l\mathbf{BF}$.

As has been rightly pointed out by Dietzenbacher and Los (1998), in the presence of discrete time periods elapsing between observations, decompositions cannot be unique. Therefore, while reporting the relative standard deviation of multiple decomposition forms in Appendix B, we here provide an economic intuition as regards the choice of (15).

We aim to separate the operation of three effects: (i) final demand — $\widehat{\mathbf{a}}_{l0}\mathbf{B}_0(\mathbf{F}_1 - \mathbf{F}_0)$, (ii) total intermediate input requirements — $\widehat{\mathbf{a}}_{l0}(\mathbf{B}_1 - \mathbf{B}_0)\mathbf{F}_1$, and (iii) direct labour requirements — $(\widehat{\mathbf{a}}_{l1} - \widehat{\mathbf{a}}_{l0})\mathbf{B}_1\mathbf{F}_1$.

(i) As a first step we evaluate the change in final demand with unchanged technique. This provides a measure of the importance of trade in final commodities, without involving any change in secondary or induced effects that demand triggers.

(ii) Changing final demand naturally affects the coefficients of the Leontief inverse $\mathbf{B}$, with two possible counterbalancing outcomes. On the one hand, foreseen demand contraction reduces orders, thus reducing the transactions per unit of gross output in the system: coefficients decrease. On the other hand, a falling net output, *ceteris paribus*, causes coefficients to increase, as from the same intermediate transactions a lower net product is obtained. Hence, if the first effect prevails, so gross output falls proportionally more than final demand, coefficients are reduced. If instead the second effect prevails, so gross output reductions are 'lagged' with respect to demand shrinking, then coefficients increase. To consider the interplay between these effects, direct labour coefficients take their original value ($\mathbf{a}_{l0}$) and we evaluate changes in $\mathbf{B}$ according to new demand conditions ($\mathbf{F}_1$).

(iii) Lastly, we consider changes in direct labour requirements per unit of gross output ($\mathbf{a}_l$). Given that employment dynamics is generally lagged with respect to production, this should be the last effect to be measured. Hence, we evaluate the change in direct labour with new intermediate inputs and final demand conditions.

In this way, for each "final demand-source industry" combination it is possible to decompose the change in employment into the three above-mentioned determinants. By conveniently aggregating $\Delta\mathbf{M}_l$ as defined in (15) a quantitative assessment of the impact of the Great Recession of 2008-09 on employment is attempted in Section 4.

On the basis of the set of metrics just introduced, the following section reports the results of their application to analyse Euro Area economies during the Great Recession (2008-09) and the Eurozone Crisis (2011-12).

4. Empirical computations and discussion of results

The main data source to perform the empirical computations has been the World Input-Output Database (WIOD) Project (Timmer 2012),[17] which provides a times-series of square[18] industry × industry Input-Output tables at basic current (and past-year) prices for the period 1995-2009. The WIOD setting consists in 41 regions,[19] with 35 industries each, obtaining $41 \times 35 = 1435$ geo-industries. The Multi-regional Input-Output scheme provided by this database conforms to the requirements needed to set-up the accounting framework discussed in Section 3.

The empirical exploration performed in the present paper explicitly focuses on a selection of eleven Eurozone countries, grouped in two categories:[20] (i) the *core-EZ* group, i.e. five surplus countries in the Eurozone (Germany, the Netherlands, Austria, Belgium, Finland) and France; (ii) the *PIIGS* group, i.e. four deficit Eurozone countries (Portugal, Italy, Greece and Spain) and Ireland.[21]

Both groups include an *outlier*. In the case of *core-EZ*, the outlier is France; as opposed to the rest of the group, France experienced, over the 1995-2009 period, a strong deterioration of its trade balance, and was characterised in 2009 by a very large deficit. Italy, the outlier among *PIIGS*, has also experienced a sharp deterioration in its trade balance; however, the dimension of its economy and the characteristics of its industrial system make it quite different from the other four countries in the group.

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[17] The WIOD Project has been funded by the EC as part of the 7th. Framework Programme, and it has been developed and deployed by a Consortium of European institutions from the Netherlands, Spain, Austria, Germany, Belgium, France and Greece. See `http://www.wiod.org/` for details. The database can be accessed for free.

[18] The fixed product sales structure assumption has been used in the WIOD Project to obtain a square Input-Output system from a set of International Supply and Use Tables. See Timmer (2012) for details.

[19] The 41 regions included are: each of the EU27 countries, the U.S., Canada, Mexico, Brazil, China, India, Japan, South Korea, Australia, Taiwan, Turkey, Indonesia, Russia, and an aggregate *RoW* region covering the Rest of the World.

[20] In order to simplify exposition and comments we have concentrated on a subset of 11 amongst the 17 Euro Area countries, noting however that this subset accounts for 98% of the GDP of the Eurozone.

[21] All throughout tables and figures we identify these eleven economies by their ISO3 code: Germany (DEU), the Netherlands (NLD), Austria (AUT), Belgium (BEL), Finland (FIN), France (FRA), Italy (ITA), Spain (ESP), Greece (GRC), Portugal (PRT) and Ireland (IRL).

4.1 Trends in global sourcing (1995-2009)

A first characterisation of the trends in international production sharing for the 11 countries analysed emerges by looking at Table 1, which reports the structural dependence of each activated country on final demand coming from different activating regions, i.e. the activated country itself ($\theta_v^{r,r}$), the rest of the Eurozone ($\theta_v^{r,RoEZ}$), the rest of EU ($\theta_v^{r,RoEU}$) and the rest of the world ($\theta_v^{r,RoW}$).[22]

Table 1.: Domestic income activated by own and foreign sources of final demand

(in % of gross value added in each activated country)

Acti-	$\theta_v^{r,r}$				$\theta_v^{r,RoEZ}$				$\theta_v^{r,RoEU}$				$\theta_v^{r,RoW}$			
vated	1995	2002	2007	2009	1995	2002	2007	2009	1995	2002	2007	2009	1995	2002	2007	2009
DEU	80.8	72.6	66.8	70.7	7.0	9.2	10.4	8.8	2.9	4.6	5.6	4.2	9.3	13.7	17.1	16.3
NLD	63.4	64.2	62.8	63.5	17.7	15.3	16.1	15.8	5.4	6.3	7.3	6.2	13.5	14.2	13.9	14.5
AUT	76.3	67.4	64.2	67.8	10.6	13.8	14.6	12.2	3.4	5.0	5.5	4.4	9.7	13.8	15.7	15.6
BEL	60.8	57.9	59.1	62.2	23.1	20.4	18.6	17.8	5.2	6.8	6.6	5.6	10.9	14.8	15.7	14.4
FIN	71.0	69.0	68.4	72.8	8.8	9.3	8.8	6.6	5.7	6.5	5.7	4.4	14.6	15.2	17.1	16.3
FRA	82.1	80.1	81.5	83.4	7.2	7.6	7.0	5.7	2.0	2.8	2.6	1.9	8.7	9.5	8.9	9.0
ITA	80.3	80.2	79.0	82.0	8.1	7.1	7.2	5.9	2.0	2.8	2.9	2.1	9.7	9.9	10.9	10.1
ESP	85.0	82.0	83.1	84.5	8.0	8.8	7.7	7.0	1.5	2.8	2.3	1.9	5.5	6.4	6.9	6.5
GRC	93.8	90.1	87.6	88.7	2.5	2.5	2.5	2.0	0.7	1.2	1.5	1.1	3.0	6.2	8.4	8.2
PRT	81.2	81.2	79.1	81.4	10.5	9.6	10.1	8.6	2.5	2.8	2.5	2.0	5.8	6.4	8.3	8.0
IRL	53.6	47.6	51.4	48.2	18.0	15.7	14.1	14.9	11.7	9.4	8.8	8.4	16.7	27.3	25.7	28.5

Source: Own computations based on WIOD Database

Notes: RoEZ: Rest of Eurozone; RoEU: Rest of the EU27; RoW: Rest of the world

Indicator $\theta_v^{r,s}$ computed according to equation (5).

Between 1995 and 2007 (i.e. before the crisis), the proportion of income generated by domestic final demand has decreased in all countries (as can be seen by computing the difference between columns 2007 and 1995 under heading $\theta_v^{r,r}$ of Table 1); however, with the exception of Ireland, this trend was reversed during the Great Recession (2008-09). Among *PIIGS*, Greece and Ireland have increased their comprehensive dependence on foreign demand by more than 5 p.p. (though departing from sharply different initial levels), though it is within the *core-EZ* that we find the most dramatic structural change due to international fragmentation of production: Germany and Austria have increased by 14 and 12 p.p., respectively,

[22]The reading key for a representative row of Table 1 is as follows: for a given row, we have that $\theta_v^{r,r} + \theta_v^{r,RoEU} + \theta_v^{r,RoEZ} + \theta_v^{r,RoW} = 100$ *in each* of the years analysed (1995, 2002, 2007, 2009). Hence, for the case of Germany (DEU), in 1995, 80.8% of its income (i.e. gross value added) was generated by German final demand, 7% by the rest of the EZ, 2.9% by the rest of the EU27 (other than the EZ) and 9.3% by final demand coming from the rest of the world, noting that $80.8 + 7.0 + 2.9 + 9.3 = 100$.

their foreign dependence between 1995 and 2007. This is particularly impressive for Germany which, by 2007, had acquired a proportion of *Own* activating demand similar to that of other *small* open economies, e.g. the rest of *core-EZ* economies with a trade surplus.

A second peculiarity of Germany and Austria is their increasing trend in the dependence on final demand from Eurozone partners, while for the remaining nine countries this figure decreased (in a sizeable way in Belgium and Ireland) during the considered time span. Notably, this is not so for the dependence on final demand coming from (non-EZ) EU27 economies, which increased for all countries but Portugal and Greece, between 1995 and 2007.[23]

Notably, Austria, Belgium, the Netherlands and most of all Ireland out-stand for their dependence on foreign sources; the contrary holds for Greece, with around 90% of its income being generated from domestic demand. Moreover, the only trend common to all countries is the increasing importance of final demand coming from outside the EU in determining own GDP, a trend which is particularly strong in the case of Ireland and, again, Austria and Germany.[24]

4.2 The Great Recession (2008-09)

The way in which the trends in production sharing across Eurozone economies came to terms with the collapse of world trade during the Great Recession may be inferred from Table 2, which displays synthetic indicators of the trade spillovers induced by final demand changes on GDP.[25]

By looking at λ_v^r — column (5) — we obtain the share of domestic final demand

[23] This asymmetry might suggest that the presence of a common *market* is of greater importance than the institution of a common *currency* in explaining the productive integration among European economies.

[24] These results are in line with recent findings on Global Value Chains (GVC) using the WIOD database: "[a]veraged across products, Belgium, Ireland and the Netherlands had the most fragmented GVCs in 2008, followed by Germany, the Czech Republic, and Hungary, where fragmentation increased at a high pace since 1995. We also find that in 1995, European value chains were mainly fragmented across other EU countries. Afterwards, however, there has been a strong trend towards increased participation of non-European countries." (Los et al. 2013)

[25] The reading key for a representative row of Table 2 runs as follows. If we consider the case of Germany (DEU), we note that between 2008 and 2009, demand-induced GDP reductions originating in a drop of German final demand amounted to 0.43 (percentage) points ($g_v^{r,r}$), while the comprehensive figure for the income reduction due to decreasing final demand (irrespective of its source of origin) was 3.79 points (g_v^r). German domestic final demand fell by 2.31 points (g_f^r), while world final demand, *excluding* Germany, fell by 2.21 points ($\overline{g}_f^{s\neq r}$). Spillover figure $\lambda_v^r = 0.82$ indicates that 82% of the fall in German final demand (of 2.31 points) was borne by income reductions in foreign countries, while the elasticity value of $\varphi_v^r = 1.52 > 1$ indicates that the response of own income to changes in foreign demand has been more than proportional.

Table 2.: Actual Final Demand Trade Spillovers, Great Recession (2008-09)

(columns (1)-(4) in percentage points)

Country	Income		Demand		Spillovers	
iso3	$g_v^{r,r}$	g_v^r	g_f^r	$\overline{g}_f^{s\neq r}$	λ_v^r	φ_v^r
	(1)	(2)	(3)	(4)	(5)	(6)
DEU	-0.43	-3.79	-2.31	-2.21	0.82	1.52
NLD	-2.10	-3.66	-4.62	-2.19	0.55	0.71
AUT	-0.66	-3.96	-2.85	-2.21	0.77	1.49
BEL	-0.92	-2.57	-3.62	-2.21	0.75	0.75
FIN	-3.50	-6.42	-6.54	-2.20	0.46	1.33
FRA	-1.86	-3.48	-2.34	-2.21	0.21	0.73
ITA	-1.29	-3.45	-3.48	-2.17	0.63	1.00
ESP	-4.17	-5.35	-6.98	-2.08	0.40	0.57
GRC	-1.79	-2.06	-3.04	-2.21	0.41	0.12
PRT	-3.37	-5.48	-5.83	-2.20	0.42	0.96
IRL	-5.46	-6.49	-13.09	-2.18	0.58	0.47

Source: Own computations based on WIOD Database

Notes: $g_v^{r,r}$ is the change in own income induced by a change in domestic final demand,
g_v^r measures total demand-induced GDP changes, g_f^r is the change in domestic final demand,
while $\overline{g}_f^{s\neq r}$ is the weighted average of final demand changes in all countries but r.
Detailed explanation for spillover indicators λ_v^r and φ_v^r can be found in section (3.2.2).
Columns (1)-(2), (5) and (6) computed according to equations (6), (8), and (9), respectively.
Column (4) is specified as: $\overline{g}_f^{s\neq r} = \sum_{s\neq r} g_f^s(f_s/\sum_{s\neq r} f_s)$.
Column (2) can be obtained as: (2)=[1-(5)]×(3)+(6)×(4), see (13) for details.

changes which had to be faced by income reductions of other trade partners. Not surprisingly, for Germany, Austria and Belgium more than 75% of the drop in domestic final demand was 'exported' to others. The fact that these countries' GDP depends for more than 30% on foreign sources of final demand (as can be seen from $\theta_v^{r,r}$ for year 2009 on Table 1) helps to explain this fact.

The case of Italy is of interest, given that it structurally depends to a lesser extent on foreign sources, though during 2009 more than 60% of its drop in final demand was borne by other countries. This result for Italy acquires more significance when compared to France, which has almost the same level of structural foreign dependence (as can be read from Table 1) but almost 80% of the fall in domestic final demand corresponded to a drop in its GDP, during 2008-09.

Countries with a sharp decline of domestic demand had a relatively lower value for λ_v^r (e.g. Finland, Spain, Portugal). In fact, it is sensible to guess that λ_v^r for Ireland would have been higher, had it not been for its dramatic fall in domestic final demand (-13.09 p.p.). In this connection, from $g_v^{r,r}/g_v^r$ — the ratio of columns (1) to (2) — we infer for which economies the fall in domestic demand has been the crucial determinant of demand-induced reductions in GDP: Greece, Ireland, Spain and Portugal. On the contrary, by looking at φ_v^r — column (6) — we observe the particularly high amplifying effect of changes in demand from the rest of the world for income reductions in Germany, Austria and Finland (with φ_v^r significantly greater than unity).

Hence, during the Great Recession, *PIIGS* have generally been more sensitive to domestic demand reductions while *core-EZ* countries have been more vulnerable to (and inflicting more damage to) their trade partners. Interestingly, the dynamics of France and Italy went precisely in opposite directions to that of their respective group, i.e. Italy resembled a *core-EZ* country, while the crucial role of domestic demand in France was similar to that of other countries of the Eurozone periphery.

In any case, we have only considered so far demand-induced GDP reductions, i.e. we have implicitly assumed that the technique in use remained fixed when computing income changes. However, given that technical coefficients have changed during the crisis, actual GDP reductions did not coincide with those implied solely by final demand trade spillovers.

Therefore, if data is available, technique effects should be also considered when assessing the determinants of sharp GDP reductions, like those observed between 2008 and 2009. Notably, the fact that employment has also had an acute reaction during the Great Recession, suggests that it might be revealing to decompose actual changes in employment — rather than GDP — into final demand and technique effects, in order to clearly see to what extent forms of labour protection prevented employment from falling accordingly to the full reduction in output.

The latter consideration leads us to consider Table 3, showing the structural decomposition of employment changes in the Eurozone between 2008 and 2009.[26]

[26] As discussed in section 3.2.3, structural decompositions are not unique. We have already provided a detailed explanation of the rationale for adopting the specification contained in expression (15) above, while a sensitivity analysis for all possible 6 decompositions is performed in Appendix B, showing that with the adoption of the present formulation the conclusions obtained in the analysis below are not compromised. The reading key for a representative row of Table 3 runs as follows. If we consider Germany (DEU), between 2008 and 2009, the change in labour inputs per unit of gross industry output (direct labour coefficients) contributed to an increase of 1.77 million employment units or 4.42 points (column (i) in absolute value and percentage points, respectively), the effect of changing total (direct and indirect) intermediate input coefficients was resposnsible for a negative effect of 428 thousand employment units or 1.06 points (column (ii)), while domestic final demand reductions implied a decrease in employment of 1.35 million units or 3.37 points (column (iii)). The combination of these three effects is reported under column 'Total', which, for the case of Germany, was slightly negative (a net reduction of 5 thousand employment units), meaning that labour hoarding practices compensated to a great extent the fall in final demand and intermediate input coefficients. Percentage points are computed with respect to the 2008 employment level reported under column 'Level 2008'.

Table 3.: Structural Decomposition of Changes in Employment, Great Recession (2008-09)

	(employment in 1000 persons engaged)					*(in p.p. of 2008 level)*			
Country	Direct Labour	Total Inputs	Final Demand	Total	Level 2008	Direct Labour	Total Inputs	Final Demand	Total
	(i)	(ii)	(iii)			(i)	(ii)	(iii)	
DEU	1779.7	-428.7	-1356.1	-5.0	40276.0	4.42	-1.06	-3.37	-0.01
NLD	158.1	6.3	-264.7	-100.3	8730.8	1.81	0.07	-3.03	-1.15
AUT	142.3	-32.2	-146.2	-36.0	4253.1	3.35	-0.76	-3.44	-0.85
BEL	89.9	3.8	-109.6	-15.8	4454.0	2.02	0.09	-2.46	-0.36
FIN	90.0	-7.1	-154.2	-71.3	2525.3	3.56	-0.28	-6.11	-2.82
FRA	748.4	-85.0	-985.7	-322.4	25883.1	2.89	-0.33	-3.81	-1.25
ITA	869.2	-401.9	-888.9	-421.6	25260.2	3.44	-1.59	-3.52	-1.67
ESP	-716.4	390.1	-1038.8	-1365.0	20545.9	-3.49	1.90	-5.06	-6.64
GRC	45.5	0.0	-79.4	-33.9	4791.6	0.95	0.00	-1.66	-0.71
PRT	36.2	152.3	-323.3	-134.7	5226.9	0.69	2.91	-6.19	-2.58
IRL	-38.1	46.3	-178.9	-170.7	2098.7	-1.81	2.21	-8.53	-8.13
Total	3205.0	-356.0	-5525.8	-2676.8	144045.6	2.23	-0.25	-3.84	-1.86

Source: Own computations based on WIOD Database

Notes: Structural Decomposition computed according to equation (15)

While the overall outcome of the contraction in global final demand is negative for all countries, we can decompose it into four items, whose sign varies across regions: (i) the effect of changes in unitary direct labour requirements (*Direct Labour*); (ii) the effect of changes in input requirements per unit of monetary output (*Total Inputs*); and (iii) the effect of decreasing final demand (*Final Demand*). According to the sign combination of these effects, we identify three cases:

(1) *Germany*, *Austria*, *Finland*, *France*, *Greece* and *Italy*: Effect (i) is positive, while effects (ii) and (iii) are negative. During recessions, intermediate transactions of circulating capital items tend to decrease and being substituted with a reduction in inventories, which of course would lead to a decrease in input coefficients. At the same time, however, output goes down, so that unitary requirements, *ceteris paribus*, increase. In this case, the former effect prevailed, and the net outcome is an average decrease of input coefficients. Moreover, increasing direct labour requirements prevented the loss of about 1.7 million jobs in Germany, and more than 1.6 million jobs in both France and Italy, making the net effect much less dramatic than it could have been.

(2) *Netherlands*, *Belgium* and *Portugal*. Effects (i) and (ii) are positive and (iii) is negative. Though more modest than in the previous case, especially in Portugal, some form of cyclical productivity decrease ameliorated potential employment reduction. In this case, however, intermediate transactions did not

go down to such an extent as to counteract the effect of output fall on input coefficients.

(3) *Spain* and *Ireland*. All effects other than (ii) are negative. It deserves to be noticed that these are the only two countries in which no forms of labour hoarding were implemented in support of employment; on the contrary, the Great Recession caused a more than proportional jobs cut, which has been particularly harsh in Spain. No surprise, therefore, that the economic outlook for Spain and Ireland were among the worst of the whole Eurozone.

At this point, the question that remains to be faced is the geographical distribution of final demand impulses which originated GDP reductions during the Great Recession. To assess the extent of the response of Eurozone incomes to the realised fall of final demand in the US, we computed — for given technical coefficients, and by means of equation (14) — the contribution to the change in aggregate gross value added induced by changes in each component of domestic, as well as foreign, final demand. Results are reported in Table 4.[27]

As can be read from column (7) of Table 4, income reductions directly and indirectly caused by the fall in US final demand have been modest for the economies analysed, especially when compared to intra-EZ and intra-EU effects — columns (5) and (6), respectively. Germany, Austria, Belgium and Italy have been particularly vulnerable to worsening international conditions *relative to* the fall in domestic final demand, as can be read from column (4). Moreover, in all countries but Ireland, general government consumption — column (2) — has played an important counter-cyclical role, while the dynamics of gross capital formation — column (3) — remains the crucial source of falling GDP during the Great Recession.

[27]The reading key for a representative row of Table 4 runs as follows. The row for Germany (DEU) describes the percentage distribution of demand-induced changes in GDP by source of origin (for a Total of −100.00 in column (9), the negative sign implying that aggregate income change has been negative). Thus, we read that domestic final demand (column (4)) accounted for 11.26 points of demand-induced GDP reductions. Columns (1)-(3) disaggregate further the domestic component, having that private and government consumption (c_p in column (1) and c_g in column (2)) go in opposite direction with respect to the negative effect exerted by gross investments (gcf in column (3)), and noting that $8.05+15.46-34.76 = -11.2$ (i.e. column (4)). The remaining 88.74% of income reductions is explained by changes in foreign (final) demand (as detailed in columns (5)-(8)): 29.83 points due to the rest of the EZ, 21.92 points due to the rest of EU27 (other than the EZ), 10.46 points due to the USA, and 26.55 points due to the rest of the world.

Table 4.: Contribution to demand-induced GDP growth by originating source of final demand, Great Recession (2008-09)

(contribution to change in country-aggregate gross value added in percentage points)

	Domestic components			Domestic and foreign sources of final demand					
	$\delta_v^{r,r(c_p)}$	$\delta_v^{r,r(c_g)}$	$\delta_v^{r,r(gcf)}$	$\delta_v^{r,r}$	$\delta_v^{r,RoEZ}$	$\delta_v^{r,RoEU}$	$\delta_v^{r,USA}$	$\delta_v^{r,RoW}$	Total
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DEU	8.05	15.46	-34.76	-11.26	-29.83	-21.92	-10.46	-26.55	-100.00
NLD	-35.26	30.53	-52.60	-57.34	-12.77	-16.98	-3.78	-9.13	-100.00
AUT	16.60	4.89	-38.16	-16.67	-38.60	-19.01	-9.20	-16.52	-100.00
BEL	12.51	20.65	-68.77	-35.61	-20.81	-23.11	-2.10	-18.36	-100.00
FIN	-9.72	4.21	-49.04	-54.55	-18.57	-13.06	-4.90	-8.92	-100.00
FRA	10.70	7.35	-71.57	-53.52	-18.67	-9.79	-5.24	-12.78	-100.00
ITA	-5.07	17.63	-49.83	-37.26	-22.86	-13.56	-7.70	-18.62	-100.00
ESP	-27.94	7.69	-57.54	-77.80	-8.34	-5.55	-1.95	-6.36	-100.00
GRC	-0.94	85.12	-171.07	-86.89	-9.41	-9.71	-3.12	9.14	-100.00
PRT	-26.78	1.51	-36.19	-61.46	-20.51	-6.60	-4.46	-6.97	-100.00
IRL	-3.28	-6.45	-74.43	-84.16	-6.34	-9.03	1.96	-2.43	-100.00

Source: Own computations based on WIOD Database

Notes: (4)=(1)+(2)+(3) and (9)=(4)+(5)+(6)+(7)+(8). Contribution to growth indicators $\delta_v^{r,s(u)}$ and $\delta_v^{r,s}$ computed according to equation (14)

4.3 The Eurozone Crisis (2011-12)

The implementation, from summer 2009, of fiscal stimulus packages in some countries — together with a slight increase in fixed capital formation, particularly of machinery — led to a recovery that lasted for the whole 2010, both in core-EZ countries and, to a smaller extent, in some countries of the Eurozone periphery. However, the sovereign debt crisis was about to explode.

By the end of 2011, almost all countries amongst *PIIGS* were implementing strong fiscal restrictions and drastic reforms of pension systems, labour markets, and public welfare in general. As a direct consequence of budget consolidation policies, sharp reductions in government expenditure (between -2.9% and -4.4%) followed throughout 2012. It seems important, therefore, to provide a quantitative assessment of the effects of fiscal austerity on the *whole* set of Eurozone economies analysed.

While structural decompositions may be computed when full observations for two time periods are available, in the presence of partial information only isolated effects can be estimated. In this case, departing from direct labour ($\mathbf{a}_l$) and total input ($\mathbf{B}$) requirements for 2009 (the last year of available data in the WIOD database), we applied to the 2009 final demand matrix ($\mathbf{F}$) a set of growth rates for the period 2011-12, distinguishing between final demand components (c_p, c_g,

gcf) in each activating region s.[28] Therefore, matrix $\mathbf{G}_f$ took the form:

$$\mathbf{G}_f = \begin{bmatrix} g^{c_p,1} & g^{c_g,1} & g^{gcf,1} & g^{c_p,2} & g^{c_g,2} & g^{gcf,2} & \dots & g^{c_p,K} & g^{c_g,K} & g^{gcf,K} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ g^{c_p,1} & g^{c_g,1} & g^{gcf,1} & g^{c_p,2} & g^{c_g,2} & g^{gcf,2} & \dots & g^{c_p,K} & g^{c_g,K} & g^{gcf,K} \end{bmatrix} \tag{16}$$

The limitations of applying a uniform growth rate to each column of matrix $\mathbf{F}$ are manifold. Two of particular relevance are: (i) if only $\mathbf{F}$ is assumed to be changing, relevant movements in technical coefficients might remain unattended (precisely when employment lags begin to be felt as firms are no longer able to follow job retention practices in the expectation of demand recovery), and (ii) compositional changes in the structure of final expenditure are not considered. As an aside, by discussing results in terms of GDP aggregates by region, the sectoral composition of changes within each country remains in the background, deserving an own separate exploration.

Differently from the structural decomposition and the *actual* final demand trade spillovers, which are strictly an accounting exercise of what has actually happened between two discrete time-periods, the *model-implied* demand spillovers — computed under such simplifying assumptions for matrix $\mathbf{G}_f$ — might not reveal the 'whole picture' of what has been going on during 2012.[29] Clearly, the possible interaction between changes in the technique in use and the level and composition of final demand cannot be ruled out. Hence, keeping all elements of matrix $\mathbf{M}_v$ fixed and studying the implied consequences for a given change in matrix $\mathbf{F}$ may not capture (lagged or contemporaneous) effects of a fall in final demand on, for example, labour hoarding practices, affecting direct labour coefficients.

With these limitations in mind, model implied income changes triggered by final demand dynamics during the Eurozone crisis have been computed using the metrics introduced in section 3.2.2. Synthetic indicators are reported in Table 5.[30]

To begin with, note that while the dynamics of global final demand has been expansionary (as can be read from $\overline{g}_f^{s \neq r}$ in column (4) of the Table), the only two

[28]We thus considered growth rates to be uniform across industries and destination country for a given component u of final demand from activating country s. Appendix C reports the set of growth rates utilised for this exercise.

[29]We thank an anonymous referee for calling our attention on the interplay between final demand and technical coefficients in estimates of isolated spillover effects.

[30]The reading key for Table 5 follows the same logic as previously specified for the case of Table 2.

Table 5.: Model implied Final Demand Trade Spillovers, Eurozone Crisis (2011-12)

(columns (1)-(4) in percentage points)

Country	Income		Demand		Spillovers	
iso3	$g_v^{r,r}$	g_v^r	g_f^r	$\overline{g}_f^{s \neq r}$	λ_v^r	φ_v^r
	(1)	(2)	(3)	(4)	(5)	(6)
DEU	-0.05	0.37	-0.26	2.21	0.80	0.19
NLD	-0.84	-0.53	-1.48	2.13	0.43	0.15
AUT	0.06	0.37	0.09	2.09	0.34	0.15
BEL	-0.32	-0.11	-0.61	2.10	0.47	0.10
FIN	-0.80	-0.29	-1.35	2.09	0.41	0.25
FRA	-0.47	-0.28	-0.67	2.21	0.29	0.09
ITA	-4.19	-3.94	-5.24	2.35	0.20	0.11
ESP	-3.36	-3.31	-3.98	2.24	0.16	0.02
GRC	-7.91	-7.65	-9.32	2.15	0.15	0.12
PRT	-5.39	-5.27	-6.84	2.12	0.21	0.06
IRL	-0.83	-0.12	-1.52	2.09	0.45	0.34

Source: Own computations based on WIOD Database and EC-AMECO May 2013 Release
Notes: $g_v^{r,r}$ is the change in own income induced by a change in domestic final demand,
g_v^r measures total demand-induced GDP changes, g_f^r is the change in domestic final demand,
while $\overline{g}_f^{s \neq r}$ is the weighted average of final demand changes in all countries but r.
Detailed explanation for spillover indicators λ_v^r and φ_v^r can be found in section (3.2.2).
Columns (1)-(2), (5) and (6) computed according to equations (6), (8), and (9), respectively.
Column (4) is specified as: $\overline{g}_f^{s \neq r} = \sum_{s \neq r} g_f^s (f_s / \sum_{s \neq r} f_s)$.
Column (2) can be obtained as: (2)=[1-(5)]×(3)+(6)×(4), see (13) for details.

countries of the subset analysed with positive demand-induced GDP spillovers have been Germany and Austria (both with only +0.37 p.p.). And even in Germany the domestic contribution to demand spillovers has been negative (though approaching zero). Hence, differently from the Great Recession of 2008-09 (see Table 2), during 2012 the Eurozone has been going against the upward trend of the world economy.

Related to this first point, in all countries but Germany and Austria, the contraction explained solely by the negative impulse of domestic final demand has been greater than the total demand-induced GDP fall, i.e. the ratio $g_v^{r,r}/g_v^r$ is greater than one. Hence, in all these countries, foreign demand sources have had a partially offsetting positive effect on income, greater in *core-EZ* surplus countries like Belgium, Finland and the Netherlands; while almost negligible for the case of *PIIGS* (with the exception of Ireland). Hence, it seems clear that the contractionary consequences of austerity policies have not been offset by foreign demand within the Eurozone periphery (not even for Ireland).

This prevalence of domestic sources in explaining the degree of demand-induced GDP reductions is confirmed by comparing columns (5) and (6) of Table 5 with the respective columns of Table 2: higher values for both λ_v^r and φ_v^r can be found during the Great Recession (2008-09) as compared to the Eurozone crisis (2011-12). In fact, while for Germany and Finland the share of domestic demand changes which has to be borne by others — λ_v^r in column (5) — has remained relatively stable, the reduction for the case of Italy has been dramatic. Thus, the role of the Italian economy as an agent capable of inflicting potentially destabilising effects to its trade partners has been reduced.

Predictably, the fall in φ_v^r has been more acute than that observed for λ_v^r. Given that φ_v^r captures the extent to which a given economy has been hurt by or taken advantage of the dynamics of global final demand, the relatively low values for column (6) of Table 5 make apparent the difficult situation of each Eurozone country with respect to the world economy. The case of Spain is exemplary: during 2012 the elasticity of domestic income spillovers with respect to the growth of foreign final demand has been almost zero.

Table 6.: Contribution to demand-induced GDP growth by originating source of final demand, Eurozone Crisis (2011-12)

(contribution to change in country-aggregate gross value added in percentage points)

	Domestic components			Domestic and foreign sources of final demand								
	$\delta_v^{r,r(c_p)}$	$\delta_v^{r,r(c_g)}$	$\delta_v^{r,r(gcf)}$	$\delta_v^{r,r}$	$\delta_v^{r,RoP_{EZ}}$	$\delta_v^{r,RoC_{EZ}}$	$\delta_v^{r,RoEZ}$	$\delta_v^{r,RoEU}$	$\delta_v^{r,USA}$	$\delta_v^{r,BRIC}$	$\delta_v^{r,RoW}$	Total
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
DEU	73.44	68.16	-155.92	-14.31	-55.78	-16.38	-2.52	-0.34	27.41	74.40	87.53	100.00
NLD	-74.35	0.35	-85.18	-159.18	-46.68	-11.76	-0.70	6.92	14.23	43.99	53.18	-100.00
AUT	40.03	-9.49	-13.97	16.57	-55.24	-29.03	-7.73	-5.66	19.47	68.77	92.85	100.00
BEL	-160.32	13.38	-156.31	-303.25	-244.89	-128.74	3.67	31.03	71.65	209.41	261.14	-100.00
FIN	227.51	60.82	-566.81	-278.48	-48.07	-18.23	2.98	7.41	22.90	99.28	112.21	-100.00
FRA	-16.63	121.46	-276.97	-172.14	-49.54	-12.62	-1.05	4.00	16.81	43.43	71.11	-100.00
ITA	-50.70	-15.36	-40.44	-106.50	-2.33	-1.37	-0.28	0.16	1.30	3.61	5.41	-100.00
ESP	-29.59	-21.39	-50.33	-101.31	-4.89	-1.54	-0.10	0.36	0.77	2.05	4.66	-100.00
GRC	-69.61	-11.11	-22.59	-103.31	-0.39	-0.07	-0.19	0.17	0.23	0.53	3.04	-100.00
PRT	-50.79	-17.21	-34.22	-102.22	-3.48	-0.88	-0.04	0.29	0.62	2.72	3.00	-100.00
IRL	-197.00	-463.31	-45.11	-705.42	-243.60	-39.65	-1.55	66.18	189.15	185.35	449.55	-100.00

Source: Own computations based on WIOD Database, UNSD National Accounts, EC-AMECO May 2013 Release
Notes: RoP_{EZ} (Rest of PIIGS-Eurozone), RoC_{EZ} (Rest of Core-Eurozone), $RoEZ$ (Rest of Eurozone other than PIIGS and Core countries), $RoEU$: Rest of EU27 countries other than EZ.
Columns (4)=(1)+(2)+(3) and (12)=(4)+(5)+(6)+(7)+(8)+(9)+(10)+(11). Contribution to growth indicators $\delta_v^{r,s(u)}$ and $\delta_v^{r,s}$ computed according to equation (14)

To complete the picture given so far, Table 6 displays the geographic distribution of demand-induced GDP changes by originating source of final demand.[31] With the exception of Germany and Austria, in both *core-EZ* countries and *PIIGS*, the most

[31] The reading key for Table 6 follows the same logic as previously specified for the case of Table 4.

important determinant of demand spillovers has been the *domestic* component — $\delta_v^{r,r}$ in column (4) of the Table, confirming the results of Table 5.

While all *core-EZ* countries (with the exception of Austria) kept sustained growth rates of public expenditure — $\delta_v^{r,r(c_g)}$ in column (2), GDP reductions brought about by fiscal consolidation undertaken in Portugal, Italy, Ireland, Greece and Spain accounted for more than 10% of their fall in income.[32] Besides their direct effects, budget consolidation depressed both private consumption and gross capital formation, especially in Italy, Ireland and Spain.

By looking at $\delta_v^{r,RoP_{EZ}}$ in column (5), a key insight of the exercise emerges: for all *core-EZ* countries without exception, the drop in final demand from *PIIGS* contributed to around 50% of their *own* GDP reduction. Only for Ireland such a result can be seen amongst *PIIGS*.[33] Furthermore, effects going in the opposite direction (from *core-EZ* to *PIIGS*) have been negligible.

In the light of this configuration, a relevant question is: to what extent the income consequences for *core-EZ* countries induced by the drop in final demand from *PIIGS* have been compensated by the positive impulse coming from e.g. BRIC economies? By computing the difference between columns (5) and (10) we see that while for Germany, Austria and Finland this negative effect has been more than offset, the opposite occurs in the Netherlands, Belgium and France. Hence, for three surplus economies at the heart of the Eurozone, extra-EZ spillovers still dominate over 'imported' austerity consequences.[34]

To sum up, during the Eurozone crisis the drop in domestic final demand has been the key driver of demand-induced GDP reductions, both for *core-EZ* countries (with the exception of Germany and Austria) as well as for *PIIGS*. When comparing Table 6 with Table 4, the role of trade spillovers during the Great Recession (2008-09) was clearly of greater relevance. This notwithstanding, first-order negative effects exerted by *PIIGS* on *core-EZ* countries suggests that austerity policies undertaken within the Eurozone periphery *did* have sizeable consequences beyond

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[32] The figure for Ireland is particularly striking (-463%), noting that it has been almost entirely offset exclusively by foreign demand coming from outside the EU, USA and BRIC (+449% under column (11) of the Table).

[33] In fact, the case of Ireland emerges with its own peculiarities, being the only country which was able to take advantage of growth in the US, BRIC and the RoW to the point of (almost entirely) offsetting the negative demand impulses coming from other Eurozone economies.

[34] Moreover, note that the effects coming from the remaining six Euro Area economies (not explicitly analysed), as well as from the rest of EU countries — columns (7) and (8), respectively — are clearly of a smaller order of magnitude (with the exception of the presumable influence of the UK on Belgium and Ireland), as compared to those coming from *PIIGS*.

national borders. Therefore, if the Eurozone is to achieve a sustained recovery, pursuing a coordinated fiscal stimulus should not be excluded from the policy alternatives to be considered.

5. Summary of results and concluding remarks

After the financial crisis (2007-08) and the Great Recession (2008-09) that hurt the global economy, EU countries have been injured by the Eurozone crisis (2011-12). Its deepening has also been caused by the uncertain, delayed and inadequate economic policy responses. Then, the euro area has suffered from a new recession, hitting especially the "PIIGS" (Portugal, Ireland, Italy, Greece and Spain) countries. While unemployment and social pain are soaring, the financial situation of these countries has not substantially improved; this self-inflicting result is the consequence of coordinated austerity measures in times of recession.

In considering policy alternatives for the Eurozone it is of utmost importance to assess the role of effective demand in determining activity levels as well as the international trade transmission of final demand impulses. In order to measure these two phenomena, we have proposed a set of metrics derived from a global Input-Output framework. From a methodological point of view, we have advanced a decomposition of demand-induced GDP changes as a weighted average of domestic and foreign final demand dynamics, the weights being two 'spillover' indicators introduced in section 3.2. Moreover, we have analysed the contribution to the growth of GDP by each foreign source of final demand and, in order to consider the effects of changing technical coefficients, we have performed a structural decomposition of employment changes, when data requirements allowed.

The results of the computations performed may be summarised in four key points:

(1) The evolution of the share of domestic income generated by foreign sources of final demand between 1995 and 2009 (Table 1) showed that: (i) the most visible effect of global sourcing is the reduction in the share of GDP activated by domestic demand in Germany and Austria, and (ii) the presence of a common currency (the euro) has not led to an increase in the share of own income originated in intra-Eurozone final demand (Germany and Austria being the only exceptions).

(2) During the Great Recession, *PIIGS* have generally been more sensitive to domestic demand reductions while *core-EZ* countries have been more vulnerable

to (and inflicting more damage to) their trade partners. In fact, as can be read from Table 2, for Germany, Austria and Belgium more than 75% of the drop in domestic final demand was 'exported' to others. Moreover, from Table 4, it emerged that demand-induced GDP reductions in Eurozone countries due to the fall in US final demand have been overall modest, when compared to intra-EZ and intra-EU spilllovers.

(3) The structural decomposition of employment changes during the Great Recession (Table 3) revealed that in countries where "flexible" labour markets prevailed (e.g. Spain and Ireland), the evolution of direct labour coefficients has been pro-cyclical, accelerating employment destruction. It is interesting the comparison with respect to countries (like France or Belgium) which have instead been reinforcing dismissal protection (ILO 2012, p. 29). This suggests a crucial role for employment protection legislation (EPL) in preventing employment from falling to the same extent as output; a fact that contradicts the political stance in favour of a complete labour market flexibility, especially if not accompanied by adequate growth-oriented policies.

(4) The simulation of demand-induced GDP reductions tirggered by austerity policies in the Eurozone periphery (Tables 5 and 6) suggests that, with the exception of Germany and Austria, in both *core-EZ* countries and *PIIGS*, the most important determinant of the fall in income has been the *domestic* component of final demand. Moreover, for all *core-EZ* countries without exception, the drop in final demand from *PIIGS* contributed to around 50% of their *own* GDP reduction. This notwithstanding, for Germany, Austria and Finland, the expansion of BRIC countries has more than offset the negative spillovers coming from PIIGS.

These results hint at the consequences of an "export-led" strategy in which all Eurozone countries pursue a competitive wage deflation by means of loose employment protection and increased vulnerability to *extra*-Eurozone demand. It emerged quite clearly that this state of affairs is not likely to be sustainable.[35]

Hence, the key policy implication is that, while coordinated austerity measures are self-inflicting, Eurozone countries should reconsider the prominent role of domestic sources of final demand in determining activity levels, acknowledging that

[35]Note, in fact, that even the greatest world exporter, China, has seen a reversing trend in its income dynamics: "[d]omestic final demand for *non-tradables* has become the main source of growth" (Timmer et al. 2012, p. 2, italics added).

spillovers may significantly amplify potential gains from coordinated action.[36] Such a "coordinated domestic demand-led" policy,[37] in which fiscal expansion, together with targeted industrial and income policies, are tipping points for a sustained recovery, remains essential. This paper has illustrated comprehensive effects of global interdependence, though only concentrating on country-level results. Needless to say, a whole spectrum of multi-sectoral details awaits to be explored.

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[36] The key point no. (4) above already suggests this conclusion. Furthermore, as an extension to this line of argument, a preliminary analysis of cross-income elasticities has been carried out in order to identify those economies which could both benefit the most from a coordinated fiscal stimulus and, at the same time, induce the highest amplifying effects on others. Unfortunately, due to space constraints, the analysis could not be included in the final version of the paper. However, for the interested reader, these additional results are available upon request.

[37] Of course, it would be better that a demand-led policy should be undertaken at the EU level, together with structural policies as well as more effective crisis-management tools to counteract huge macroeconomic shocks (like the sovereign debt crisis). But the size of the EU budget rules out this solution and the latest agreement concerning the 2014-20 budget show that EU institutions are moving toward the opposite direction (even contradicting many official proposals such as the blueprint for a deep and genuine EMU prepared by the EU Commission in 2012).

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Appendix A: Matrix notation

The setting of the World Input-Output Database WIOD (Timmer 2012) consists in $K = 41$ regions: 40 individual countries and an aggregate 'Rest of the World' (*RoW*) region, with $n = 35$ industries each, obtaining $K \times n = 1435$ geo-industries. For all magnitudes below subindexes $r, s = 1, \ldots, K$ stand for the activated (r) and activating (s) region, respectively; while superindex u indicates each of the three different components of domestic final uses. The basic elements of the expenditure side of this multi-regional Input-Output scheme are:

$$\underset{(1435\times1435)}{\mathbf{X}} = \begin{bmatrix} \mathbf{X}_{11} & \cdots & \mathbf{X}_{1K} \\ \vdots & \ddots & \vdots \\ \mathbf{X}_{K1} & \cdots & \mathbf{X}_{KK} \end{bmatrix}, \text{with } \underset{(35\times35)}{\mathbf{X}_{rs}} \qquad \text{(Intermediates)}$$

$$\underset{(1435\times123)}{\mathbf{F}} = \begin{bmatrix} \mathbf{F}_{11} & \cdots & \mathbf{F}_{1K} \\ \vdots & \ddots & \vdots \\ \mathbf{F}_{K1} & \cdots & \mathbf{F}_{KK} \end{bmatrix}, \text{with } \underset{(35\times3)}{\mathbf{F}_{rs}} \qquad \text{(Final Demand)}$$

$$\text{and } \underset{(35\times3)}{\mathbf{F}_{rs}} = \begin{bmatrix} \mathbf{f}_{rs}^{c_g} \; \mathbf{f}_{rs}^{c_p} \; \mathbf{f}_{rs}^{gcf} \end{bmatrix}, \text{with } \underset{(35\times1)}{\mathbf{f}_{rs}^{u}}, u = \{c_g, c_p, gcf\}$$

$$\underset{(1435\times1)}{\mathbf{z}} = \begin{bmatrix} \mathbf{z}_1 \\ \vdots \\ \mathbf{z}_K \end{bmatrix}, \text{with } \underset{(35\times1)}{\mathbf{z}_r} \qquad \text{(Gross Output)}$$

$$\underset{(1435\times1)}{\mathbf{e}_x} = \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix} \quad \underset{(123\times1)}{\mathbf{e}_f} = \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix} \quad \underset{(35\times1)}{\mathbf{e}_n} = \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix} \qquad \text{(Sum vectors)}$$

$$\underset{(1\times1435)}{\mathbf{e}_r^T} = \begin{bmatrix} \mathbf{0}^T \cdots \mathbf{0}^T \, \mathbf{e}_n^T \, \mathbf{0}^T \cdots \mathbf{0}^T \end{bmatrix}$$

(Aggregation vector by industry for region r)

$$\underset{(123\times1)}{\mathbf{e}_s^{(u)}} = \begin{bmatrix} 0 \cdots 0 \; 1 \; 0 \cdots 0 \end{bmatrix}^T$$

(Selection vector for final demand component u of region s)

Instead, the income side components considered in the analysis are:

$$\underset{(1\times1435)}{\mathbf{v}^T} = \begin{bmatrix} \mathbf{v}_1^T \cdots \mathbf{v}_K^T \end{bmatrix}, \text{with } \underset{(1\times35)}{\mathbf{v}_r^T} \qquad \text{(Gross Value Added)}$$

$$\underset{(1\times1435)}{\mathbf{l}^T} = \begin{bmatrix} \mathbf{l}_1^T \cdots \mathbf{l}_K^T \end{bmatrix}, \text{with } \underset{(1\times35)}{\mathbf{l}_r^T} \qquad \text{(Employment)}$$

Appendix B: Sensitivity analysis of the structural decomposition of employment changes during the Great Recession (2008-2009)

Recall the structural decomposition of employment changes defined in expression (15) of Section 3.2.3:

$$\Delta \mathbf{M}_l = \mathbf{M}_{l1} - \mathbf{M}_{l0} = \widehat{\mathbf{a}}_{l1}\mathbf{B}_1\mathbf{F}_1 - \widehat{\mathbf{a}}_{l0}\mathbf{B}_0\mathbf{F}_0$$

In order to evaluate whether the conclusions derived from Table 3 depend on the specification chosen, we have computed all possible $3! = 6$ alternative decompositions of changes in matrix $\mathbf{M}_l$ and assessed the relative variability of each component.

Expressions (B1)-(B6) specify alternative additive decompositions of changes in employment:[38]

$$\begin{aligned}
\Delta \mathbf{M}_l &= (\widehat{\mathbf{a}}_{l1} - \widehat{\mathbf{a}}_{l0})\mathbf{B}_1\mathbf{F}_1 + \widehat{\mathbf{a}}_{l0}(\mathbf{B}_1 - \mathbf{B}_0)\mathbf{F}_1 + \widehat{\mathbf{a}}_{l0}\mathbf{B}_0(\mathbf{F}_1 - \mathbf{F}_0) && \text{(B1)}\\
&= (\widehat{\mathbf{a}}_{l1} - \widehat{\mathbf{a}}_{l0})\mathbf{B}_0\mathbf{F}_0 + \widehat{\mathbf{a}}_{l1}(\mathbf{B}_1 - \mathbf{B}_0)\mathbf{F}_0 + \widehat{\mathbf{a}}_{l1}\mathbf{B}_1(\mathbf{F}_1 - \mathbf{F}_0) && \text{(B2)}\\
&= (\widehat{\mathbf{a}}_{l1} - \widehat{\mathbf{a}}_{l0})\mathbf{B}_0\mathbf{F}_1 + \widehat{\mathbf{a}}_{l1}(\mathbf{B}_1 - \mathbf{B}_0)\mathbf{F}_1 + \widehat{\mathbf{a}}_{l0}\mathbf{B}_0(\mathbf{F}_1 - \mathbf{F}_0) && \text{(B3)}\\
&= (\widehat{\mathbf{a}}_{l1} - \widehat{\mathbf{a}}_{l0})\mathbf{B}_1\mathbf{F}_0 + \widehat{\mathbf{a}}_{l0}(\mathbf{B}_1 - \mathbf{B}_0)\mathbf{F}_0 + \widehat{\mathbf{a}}_{l1}\mathbf{B}_1(\mathbf{F}_1 - \mathbf{F}_0) && \text{(B4)}\\
&= (\widehat{\mathbf{a}}_{l1} - \widehat{\mathbf{a}}_{l0})\mathbf{B}_0\mathbf{F}_0 + \widehat{\mathbf{a}}_{l1}(\mathbf{B}_1 - \mathbf{B}_0)\mathbf{F}_1 + \widehat{\mathbf{a}}_{l1}\mathbf{B}_0(\mathbf{F}_1 - \mathbf{F}_0) && \text{(B5)}\\
&= (\widehat{\mathbf{a}}_{l1} - \widehat{\mathbf{a}}_{l0})\mathbf{B}_1\mathbf{F}_1 + \widehat{\mathbf{a}}_{l0}(\mathbf{B}_1 - \mathbf{B}_0)\mathbf{F}_0 + \widehat{\mathbf{a}}_{l0}\mathbf{B}_1(\mathbf{F}_1 - \mathbf{F}_0) && \text{(B6)}
\end{aligned}$$

Table B1 reports the empirical computation of expressions (B1)-(B6) during the Great Recession (2008-09).

The relative standard deviation (RSD, hereinafter) for every component (Direct Labour, Total Inputs and Final Demand) in each country, indicates to what extent the corresponding value has changed under each specification, as compared to their average. As regards 'Direct Labour' effects, only for Italy, Portugal and Greece the RSD is above 0.1 (and only for Greece it arrives at 0.2), meaning that deviations do not account for more than 10% of the average value of the effect within each country. In the case of the 'Total Inputs' effect, RSD are higher (particularly for the Netherlands, Belgium, Finland and France), but the only case where there is a sign-reversion of the effect is the case of Greece (with an RSD of 1.12).[39]

[38] Note that expression (B1) corresponds to the case analysed in the main text, as given by formula (15).
[39] This effect for Greece is approximately zero, and the cases where it deviates from zero is clearly negative.

Table B1.: Alternative Structural Decompositions of Employment Changes, Great Recession (2008-2009)

(employment in 1000 persons engaged)

	Direct Labour ($\Delta\widehat{\mathbf{a}}_l$)						
Country	(1)	(2)	(3)	(4)	(5)	(6)	RSD
DEU	1779.7	2128.5	1904.3	1995.9	2128.5	1779.7	0.08
NLD	158.1	186.1	162.8	181.0	186.1	158.1	0.08
AUT	142.3	168.4	150.7	159.6	168.4	142.3	0.08
BEL	89.9	97.6	91.2	96.2	97.6	89.9	0.04
FIN	90.0	106.2	94.6	101.5	106.2	90.0	0.08
FRA	748.4	875.6	806.2	817.8	875.6	748.4	0.07
ITA	869.2	1121.0	982.2	999.2	1121.0	869.2	0.11
ESP	-716.4	-730.0	-675.4	-775.0	-730.0	-716.4	0.04
GRC	45.5	70.1	52.2	63.0	70.1	45.5	0.20
PRT	36.2	46.8	37.5	45.5	46.8	36.2	0.13
IRL	-38.1	-32.4	-32.5	-38.2	-32.4	-38.1	0.09
	Total Inputs ($\Delta\mathbf{B}$)						
Country	(1)	(2)	(3)	(4)	(5)	(6)	RSD
DEU	-428.7	-575.9	-553.2	-443.3	-553.2	-443.3	0.14
NLD	6.3	4.3	1.5	9.3	1.5	9.3	0.66
AUT	-32.2	-38.8	-40.6	-30.0	-40.6	-30.0	0.15
BEL	3.8	3.1	2.5	4.5	2.5	4.5	0.26
FIN	-7.1	-9.7	-11.7	-4.9	-11.7	-4.9	0.38
FRA	-85.0	-112.4	-142.8	-54.6	-142.8	-54.6	0.41
ITA	-401.9	-545.8	-514.9	-424.0	-514.9	-424.0	0.13
ESP	390.1	379.6	349.1	424.5	349.1	424.5	0.09
GRC	0.0	-6.9	-6.7	0.2	-6.7	0.2	1.12
PRT	152.3	170.0	151.1	171.2	151.1	171.2	0.07
IRL	46.3	45.5	40.7	51.3	40.7	51.3	0.10
	Final Demand ($\Delta\mathbf{F}$)						
Country	(1)	(2)	(3)	(4)	(5)	(6)	RSD
DEU	-1356.1	-1557.6	-1356.1	-1557.6	-1580.3	-1341.4	0.08
NLD	-264.7	-290.6	-264.7	-290.6	-287.9	-267.7	0.05
AUT	-146.2	-165.7	-146.2	-165.7	-163.9	-148.4	0.06
BEL	-109.6	-116.5	-109.6	-116.5	-115.9	-110.2	0.03
FIN	-154.2	-167.8	-154.2	-167.8	-165.8	-156.4	0.04
FRA	-985.7	-1085.6	-985.7	-1085.6	-1055.2	-1016.2	0.04
ITA	-888.9	-996.8	-888.9	-996.8	-1027.7	-866.8	0.07
ESP	-1038.8	-1014.6	-1038.8	-1014.6	-984.1	-1073.2	0.03
GRC	-79.4	-97.1	-79.4	-97.1	-97.3	-79.6	0.11
PRT	-323.3	-351.5	-323.3	-351.5	-332.6	-342.2	0.04
IRL	-178.9	-183.8	-178.9	-183.8	-179.1	-184.0	0.01

Source: Own computations based on WIOD Database

Notes: Columns (1)-(6) correspond to each of the alternative decompositions in equations (B1)-(B6), respectively. Column 'RSD' corresponds to the relative standard deviation (RSD) of each row, computed as $RSD = |\sigma_x/\mu_x|$.

In fact, throughout the analysis in the main text, we have classified Greece into the group of countries with a negative 'Total Inputs' effect.

Understandably, the fact that this latter effect depends on changes in a full $K \times K$ matrix ($\mathbf{B}$) might give rise to higher variability in some countries. Finally, the values of RSD associated to the 'Final Demand' effect are notably low (only for Greece it reaches 0.1).

To sum up, these results suggest that there is no risk of misclassifying any of the countries analysed into a different category than the one to which it has been assigned by the use of decomposition (B1) in the empirical analysis of Section 4.

Appendix C: Estimates of growth rates of final demand by component and GDP for WIOD countries (2011-2012)

For each final demand component of each country in the WIOD database a (uniform) column-specific growth rate has been applied to estimate income spillovers during 2011-12. The countries involved are each of the EU27 partners, the U.S., Canada, Mexico, Brazil, China, India, Japan, South Korea, Australia, Taiwan, Turkey, Indonesia, Russia, and an aggregate RoW region covering the Rest of the World.

The main sources of estimates for government consumption (c_g), private consumption (c_p) and gross capital formation (gcf) levels during 2011 and 2012 have been the UNSD Main National Accounts Database (July 2012 Release), EC-AMECO Database (May 2013 Release), and World Bank's World Development Indicators Database (July 2013 Release).

Due to various methodological differences, these sources do not always provide the same estimate for a given figure. In this cases, we have privileged the UNSD Main National Accounts Database, being the most complete database for the variables involved in terms of spatial and time coverage.

Moreover, to estimate the figures for the *RoW* region, we have computed World values for the variables concerned, and deduced from this grand total the sum of the respective values for all the 40 countries individually present in the dataset. The results are reported in Table C1 below.

Table C1.: Growth rates of domestic final demand by component and GDP (2011-2012)

(in percentage points)

Country	C_g	C_p	GCF	GDP	Country	C_g	C_p	GCF	GDP
		Core Eurozone					Rest of EU27		
DEU	1.38	0.65	-5.41	0.66	BGR	-1.35	2.59	9.57	0.78
NLD	0.01	-1.43	-4.15	-0.96	CZE	-0.96	-3.54	-3.25	-1.28
AUT	-0.19	0.40	-0.41	0.79	DNK	0.17	0.56	-0.23	-0.47
BEL	0.06	-0.56	-1.59	-0.20	GBR	2.20	1.18	0.85	0.27
FIN	0.78	1.73	-13.26	-0.21	HUN	-2.26	-1.41	-11.60	-1.73
FRA	1.40	-0.10	-5.28	-0.05	LTU	0.68	4.75	-18.00	3.62
		PIIGS			LVA	-0.18	5.14	-0.39	5.58
ITA	-2.93	-4.25	-11.15	-2.37	POL	0.05	0.77	-3.09	1.78
ESP	-3.66	-2.13	-8.69	-1.42	ROU	1.66	1.06	2.11	0.69
GRC	-4.23	-9.07	-17.54	-6.38	SWE	1.24	1.54	-2.55	0.89
PRT	-4.41	-5.62	-13.66	-3.17			BRIC		
IRL	-3.38	-0.93	-0.76	0.94	BRA	-1.69	0.08	8.41	0.87
		Rest of Eurozone (RoEZ)			RUS	-6.51	4.87	4.69	3.44
CYP	-1.66	-2.99	-26.41	-2.43	IND	3.89	3.97	5.14	3.24
EST	3.97	4.43	17.19	3.22	CHN	10.27	10.25	8.15	7.72
LUX	5.00	1.70	2.87	0.31			Rest of Countries		
MLT	5.64	-0.55	-6.41	1.00	AUS	2.86	4.43	4.97	5.60
SVN	-1.64	-2.92	-17.81	-2.34	IDN	18.32	6.18	13.30	6.23
SVK	-0.59	-0.56	-10.34	2.03	KOR	4.28	1.70	-3.81	1.96
		NAFTA			JPN	2.67	2.35	4.63	2.00
USA	-1.37	1.85	7.34	2.21	TUR	5.51	-0.73	-7.68	2.17
CAN	-0.03	1.65	7.01	1.77	TWN	3.21	1.44	7.92	6.26
MEX	0.96	3.34	2.06	3.90	ROW	2.47	3.43	4.54	2.61

Source: Own computations based on EC-AMECO (May 2013 Release), UNSD National Accounts (July 2012 Release), and World Bank WDI (July 2013 Release).

Notes: GCF includes gross fixed capital formation and changes in inventories and valuables.