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ITALIAN FIRMS RESPONSE TO FOREIGN SHOCKS DURING THE CRISIS

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From Micro to Macro (and Back): Italian Firms Response to Foreign Shocks during the Crisis

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Abstract

Following the "granularity approach" recently developed in the economic literature, the goal of this paper is to measure the response of Italian firms to foreign shocks in 2005-2016 decade, when Italian business cycle negatively deviated from those of other main advanced economies. To do that, using a dataset of around 400 thousands Italian firms always present in the decade, we adopt a two-step methodology. In the first step, following a "from micro to macro" perspective, we study the direct and indirect contributions of each firm to the co-movements between the Italian business cycle and those of the 10 main trading partners.

In the second step, we go back from macro to micro and move from correlation to shocks transmissions, so as to detect whether firms that are (directly and/or indirectly) connected to foreign business cycle are also able to transmit shock impulses on the domestic economy. This ability is related to the relevance of firms within the network of domestic transactions. To take into consideration this aspect, we introduce a firm-level "Indicator of systemic relevance" (IRIS) which summarizes the role of firm's economic size and domestic connectivity. Comparing IRIS and firm-level response values, we find that firms characterized by the highest levels of IRIS (top 1%) explain about 50% of Italian business system reactivity. This evidence also suggests that Italy presents a given degree of granularity in the indirect response to foreign shocks, especially in manufacturing.

Keywords: Granularity, Business cycle, Shocks transmission, Trade

JEL code: F14, E32, O12, F41

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1. Introduction

Theoretical and empirical literature has deeply analyzed the transmission of business cycle shocks among countries and sectors. The view adopted has been mainly a macroeconomic one: among others, shocks can be originated from, and transmitted through, real (productivity, trade) or financial (capital controls, liquidity, banking system) movements, changes in fiscal and/or monetary policy.

However, contrary to what has long been considered, micro-level shocks can determine macroeconomic outcomes. In this vein, business cyclical fluctuations can also arise from idiosyncratic shocks to individual firms. In particular, this would occur in two cases: a) when firms are large enough to significantly affect the dynamics of a country's GDP, value added or exports (Gabaix 2011); b) when the linkages among sectors are such as to allow possible shocks occurring in a single industry − for example a significant change in the international trade relations of this sector − to spread to the rest of the production system (Acemoglu *et al*., 2012).

Considering the first issue, Gabaix (2011) shows that idiosyncratic shocks affecting firms may not average out, leading to movements in the aggregates, when firm size distribution is extremely fat-tailed. This is the case of US economy, where in 1975-2010 the sales of top 50 firms accounted for 24% of total GDP on average. Gabaix defined this view as "granular" hypothesis: many economic fluctuations are due to the large firms, defined as "incompressible grains of economic activity".

Gabaix's work has given rise to a vein of literature that has applied this intuition not only to the business cycle fluctuations but also to the volatility of other macroeconomic aggregates, including international trade flows (see, for example, di Giovanni *et al*., 2014 and 2018; Carvalho and Grassi, 2019). In fact, granularity is also related to the overall trade performance of countries and sectors and it is especially relevant where concentration of exports or foreign direct investment among the largest players is larger than the concentration of output or employment (Mayer and Ottaviano, 2007; Barba Navaretti *et al.*, 2011).

Since the Frankel and Rose (1998) work, empirical literature has showed that countries exhibiting greater bilateral trade and multinational production linkages have more correlated business cycles. This positive association has been interpreted as evidence of transmission of shocks across countries. This approach, in its most common formulations and applications, adopts a supply-side vision reflected in the study of shocks in productivity growth.[1] In comparison with the traditional approach focused on the evaluation of the GDP correlations, the micro-founded analysis of international co-movements has two main advantages (di Giovanni *et al.,* 2018). Firstly, it allows for an explicit consideration of multinational ties between firms and countries, and permits to distinguish the effect of common shocks from firm-specific ones. Secondly, it allows to evaluate how the heterogeneity of firms − in terms of size and international linkages − is reflected in macroeconomic aggregates.

Considering Italian business system, the presence of granularity is uncertain due to two potentially conflicting elements (Gnocato and Rondinelli, 2018). On the one hand, the significant prevalence of very small firms would weaken the hypothesis of granularity. On the other hand, the diffusion of different forms of agglomeration between firms (e.g. groups, districts, networks), as well as the presence of intense

[1] Recently, however, Dosi *et al*. (2018) presented theoretical elaborations and empirical evidence to support a demand-side granularity, based on the dynamics of investments.

sectorial relations, would strengthen the possibility that any shocks at firm or sector level may spread to the rest of the economy and contribute to aggregate cyclical fluctuations.

Following the approach of di Giovanni *et al*. (2018), the aim of this paper is to measure the Italian firms' response to the 10 main trading partners. We choose to focus on the firms' response – beside correlation – because of the peculiarities of the period here considered (2005-2016). The decade has been indeed characterized by two different episodes of crisis, which made Italian business cycle deviate from the ones of other main advanced economies. In fact, after the GDP fall caused by the collapse of international trade (2008-2009), Italy has experienced a brief recovery followed by a second period of recession (2012-2013), due to a crisis of confidence in its public debt sustainability. This trends led to a clear gap between the Italian and main non-European economies (United States and China) business cycle, as well as with respect to the main European countries. Germany and France, for example, showed a rather marked slowdown following the rebound of 2010, but they continued to record positive GDP growth rates; afterwards they experienced a new acceleration (Germany) or maintained a stable growth dynamics (France). An even greater asynchrony characterized Italian and US cyclical trajectories: after the recovery of 2010, in fact, US GDP growth was more dynamic and above all more stable than the Italian one (as well as those of the main European countries). Finally, in China, during the same period there was a slowdown in the pace of the economy growth, with a progressive and constant deceleration of about three percentage points, after a decade characterized by average annual growth rates above 10 percent.

Therefore our contribution to the literature is twofold. Firstly, we derive a firm-level measure of shock sensitivity, thus obtaining a micro-founded measure of aggregate shock transmission. Secondly, we investigate the role of indirect transmission of shocks using a firm-level "Indicator of systemic relevance" (which summarizes firms' economic size and domestic connectivity) to account for the relative importance of firms within the network of domestic transactions.

The rest of the paper is organized as follows. Section 2 describes data. Section 3 derives a theoretically-founded twofold decomposition of the determinants of the co-movement between Italy and its main trading partners: the first one refers to the role of internationalized *vs*. domestic firms; the second decomposition relates to the role of direct *vs*. indirect linkages between Italian firms and foreign countries. Section 4 presents the results. Section 5 concludes.

2. Data

We build a firm-level database referred to 2005-2016 integrating several information sources:

a) the statistical register Frame-Sbs, which annually reports information on firms' structure (number of workers, business sector, location, age) and Profit and Losses account variables (value of production, turnover, value added, labour cost) for all the about 4.2 million of Italian firms operating in industry and services sectors (excluding finance and public administration);

b) the statistical register "Asia Groups" which, on a census basis, contains data on the presence of foreign affiliates in Italy and Italians affiliates abroad;

c) the Coe-Tec statistical register, which provides the annual value of bilateral foreign trade of all Italian exporting or importing firms, with specification about export destination and import origin countries.

Restrictions have been imposed to the dataset in order to select relevant firms. In particular, bearing in mind the structure of the Italian business system, characterized by an overwhelming presence of SMEs (firms with less than 10 workers account for over 95% of total firms, 47% of total employment and 12% of total value added), we choose to considered only firms with more than 1 person employed and positive value added. Moreover, we restricted our analysis to the co-movements with the top ten Italian export destination countries (i.e. Germany, France, Switzerland, the Netherlands, Spain, Belgium, Poland, the United States, China, United Kingdom), which in 2016 accounted for about 60% of Italian total exports.

Referring to 2005-2016, the resulting dataset is a balanced panel of 383.440 firms, covering in 2016 approximately 10% of total enterprises, 40% of total value added and almost 50% of overall export.

Dummy variables indicating whether a firm exports, imports, has affiliates in a destination country or is an affiliate of a foreign multinational firm, are defined by collapsing the time dimension. Namely, these dummies are set to 1 whenever the firm satisfies the corresponding condition in at least one year in the whole period of observation.

3. Methods

Following di Giovanni *et al*. (2018), a three steps estimation procedure allows to identify the contribution of the firm-specific component to aggregate fluctuations. In particular, along the first step micro effects are estimated in order to stress if and to what extent international (direct and indirect) linkages are relevant in explaining business cycle co-movements. In the second step, macro aggregates are back-casted starting from micro movements. In the third step, the relative relevance of direct and indirect linkages and the role of size are evaluated.

3.1 Micro effects of aggregate fluctuations

Correlation between firms' value added growth rates and the GDP growth rate of each of the top 10 Italian destination countries is calculated:

$$\rho(\gamma_{ft}, \gamma_{Ct}) = \frac{\mathrm{cov}(\gamma_{ft}, \gamma_{Ct})}{\sigma_f \sigma_C} \qquad [1]$$

where ρ is the correlation, γ_{ft} is the growth rate of the value added of firm f, γ_{Ct} is the GDP growth rate of destination country C; σ_f and σ_C are the respective standard deviations.

Correlations are then used as a dependent variable in a fixed-effect panel model with the aim of studying the microeconomic determinants of correlation:

$$\rho(\gamma_{ft}, \gamma_{Ct}) = \alpha + \beta_1 EXP_{f,C} + \beta_2 IMP_{f,C} + \beta_3 AFF_{f,C} + \beta_4 HQ_{f,C} + \beta_5 DS_{f,j,C} + \beta_6 US_{f,j,C} + \delta_f + \delta_c + \eta_{f,C} \qquad [2]$$

where $EXP_{f,C}$ and $IMP_{f,C}$ are dummy variables that assume value 1 when firm *f* exports/imports into/from country *C* in at least one of the years considered; $AFF_{f,C}$ are dummy variables that assume value 1 when firm *f* is an affiliate of a foreign multinational headquartered in country *C*, $HQ_{f,C}$ is a dummy variable that assumes value 1 when a firm *f* is an Italian multinational with affiliates in *C*; finally, δ_f and δ_c are firm and country fixed effects respectively.

The first four terms of equation [2] grasp the direct components (through trading activity and/or their belonging to multinational groups) of the cyclical co-movement between Italian firms and the 10 countries considered. The fifth ($DS_{f,j,C}$) and the sixth term ($US_{f,j,C}$) of Equation [2] measure the indirect components. In this latter case, however, the effect is determined by trade relationships between domestic firms (i.e. enterprises not directly connected with any foreign country) and internationalized ones (i.e. those directly connected *via* trading or multinational corporate relations).

In particular, $DS_{f,j,C}$ and $US_{f,j,C}$ are expressed as:

$$DS_{f,j,C} = INPUTINT_f \sum_i IO_{ij} \left(\frac{NIM_{j,C}}{N_i}\right) \qquad [3]$$

$$US_{f,j,C} = DOMINT_f \sum_i IO_{ij} \left(\frac{NEX_{j,C}}{N_i}\right) \qquad [4]$$

where *i* and *j* indicate sectors, and firm *f* belongs to sector *j*. $INPUTINT_f$ is the firm's total input usage intensity, defined as the total material input spending divided by material input spending plus wage bill, averaged across years; $DOMINT_f$ is the domestic sales intensity, defined as the share of firm *f* sales that goes to the domestic market, averaged across years; NIM_i is the number of Italian firms in sector *i* that import from country *C*; NEX_i is the number of Italian firms in sector *i* that export to country *C*. Finally, IO_{ij} captures the relations among sectors, proxied by the domestic direct requirement coefficient of the 2014 Italian input-output tables and defined as the share of spending on domestically produced sector *i* inputs in production in sector *j*.

Therefore, Equation [3] (downstream relations) defines the indirect relationships determined by a domestic (Italian) firm buying intermediate inputs from (Italian) firms that import from a country *C*. Symmetrically, Equation [4] (upstream relations) grasps the indirect relationships determined by a domestic (Italian) firm selling its output to (Italian) firms that export to a country *C*.

3.2 From Micro to Macro

The second step of our analysis investigates the macroeconomic implications of micro relationships. In fact, the aggregate correlation is additive in the individual firm-level correlations with foreign GDP:

$$\rho(\gamma_{At}, \gamma_{Ct}) = \sum_f w_{ft-1} \frac{\sigma_f}{\sigma_A} \rho(\gamma_{ft}, \gamma_{Ct}) \qquad [5]$$

where γ_{At} is the aggregate Italian value added and w_{ft-1} is a system of weights defined by the share of the each firm *f* value added on the Italian total value added. Therefore, the impact of individual firms on aggregate correlations (Equation [5]) can be distinguished, as in the micro analysis, in the two components respectively referring to firms directly and indirectly connected to a given country:

$$\rho(\gamma_{At},\gamma_{Ct}) = \frac{\sigma_{I_C}}{\sigma_A}\rho\left(\sum_{f\epsilon I_C} w_{ft-1}\gamma_{ft},\gamma_{Ct}\right) + \frac{\sigma_{I_C^c}}{\sigma_A}\rho\left(\sum_{f\epsilon I_C^c} w_{ft-1}\gamma_{ft},\gamma_{Ct}\right) \qquad [6]$$

where I_C is the group of internationalized firms, which are directly connected with foreign countries (i.e. firms exporting to *C*, importing from *C*, being affiliates of multinationals based in *C* or being Italian multinationals with affiliates in *C*); I_C^c is the group of domestic firms, which have only indirect connections with *C*.

3.3 Looking for granularity: the role of size

In order to verify the presence of granularity for Italy, we run the same exercise developed in di Giovanni *et al*. (2018), which provides a first evidence of whether the directly connected firms are able to play an appreciable role in aggregate co-movements. To do that, we need to further decompose this direct effect. In principle, the contribution of directly connected firms to business cycle correlation can be noticeable because these firms are large or because they are more correlated. To detect the role of size, we single out the change in the aggregate co-movement that would occur if all firms were of equal size. Starting from the decomposition of aggregate correlation in direct and indirect effects as in Equation [6], for each directly connected firm we use estimates in Equation [2] to compute the predicted change in its correlation with country *C* if it were no longer connected with *C*:

$$\hat{\Delta}\rho(\gamma_{ft},\gamma_{Ct}) = -\hat{\beta}_1 EXP_{f,C} - \hat{\beta}_2 IMP_{f,C} - \hat{\beta}_3 AFF_{f,C} - \hat{\beta}_4 HQ_{f,C} \qquad [7]$$

It is possible to turns off all the different types of direct links or their combinations. Indeed, starting from the individual effect, it is possible to predict the aggregate business cycle correlation between Italy and country *C* if all cross-border links were severed:

$$\hat{\Delta}\rho(\gamma_{At},\gamma_{Ct}) = \sum_f w_{ft-1}\frac{\sigma_f}{\sigma_A}\hat{\Delta}\rho(\gamma_{ft},\gamma_{Ct}) \qquad [8]$$

3.4 Response in times of troubles: a counterfactual exercise

The main goal of this paper is to measure the Italian firms' response to the main trading partner growth dynamic. With this aim, we run an exercise that quantifies the variation of the Italian firms (and aggregate)

value added in reaction to a hypothetical +1% in the observed annual average growth rates of Italy's 10 main trading partners during the 2005-2016 decade.

We actually run this exercise referring to a time period characterized by a turbulent dynamics of the Italian economy. The exercise is based on the calculation of the parameters (β) indicating the OLS marginal effects. The parameters are obtained as follows.

Given the aggregate Italian value added growth rate:

$$\gamma_{At} = \sum_f w_{t-1}\,\gamma_{ft} \qquad [9]$$

the correlation between Italian value added growth rate and GDP growth rate of foreign country is:

$$\rho(\gamma_{At}, \gamma_{Ct}) = \frac{cov(\gamma_{At}, \gamma_{Ct})}{\sigma_A \sigma_C} \qquad [10]$$

Substituting Equation [9] in Equation [10], we obtain:

$$\rho(\gamma_{At}, \gamma_{Ct}) = \frac{cov(\sum_f w_{t-1}\gamma_{ft}, \gamma_{Ct})}{\sigma_A \sigma_C} = \frac{\sum_f w_{t-1} cov(\gamma_{ft}, \gamma_{Ct})}{\sigma_A \sigma_C} = \sum_f w_{t-1} \frac{\sigma_f}{\sigma_A} \rho(\gamma_{ft}, \gamma_{Ct}) \qquad [11]$$

The last term of Equation [11] is valid because:

$$cov(\gamma_{ft}, \gamma_{Ct}) = \rho(\gamma_{ft}, \gamma_{Ct}) \sigma_f \sigma_C \qquad [12]$$

In our case, parameters (β) of the marginal effects is:

$$\beta(\gamma_{At} | \gamma_{Ct}) = \frac{cov(\gamma_{At}, \gamma_{Ct})}{\sigma_C^2} \qquad [13]$$

where:

$$\beta(\gamma_{At} | \gamma_{Ct}) = \frac{cov(\sum_f w_{t-1}\gamma_{ft}, \gamma_{Ct})}{\sigma_C^2} = \frac{\sum_f w_{t-1} cov(\gamma_{ft}, \gamma_{Ct})}{\sigma_C^2} \qquad [14]$$

However, since:

$$cov(\gamma_{ft}, \gamma_{Ct}) = \beta(\gamma_{ft}|\gamma_{Ct})\sigma_C^2 \qquad [15]$$

substituting Equation [15] in Equation [14] we obtain:

$$\beta(\gamma_{At}|\gamma_{Ct}) = \frac{cov(\sum_f w_{t-1}\gamma_{ft}, \gamma_{Ct})}{\sigma_C^2} = \frac{\sum_f w_{t-1} cov(\gamma_{ft}, \gamma_{Ct})}{\sigma_C^2} = \sum_f w_{t-1}\beta(\gamma_{ft}|\gamma_{Ct}) \qquad [16]$$

Moreover, in this case, we can also replicate the decomposition into direct and indirect effects like in previous Equation [6]:

$$\beta(\gamma_{At}|\gamma_{Ct}) = \sum_{f\in I_c} w_{t-1}\beta(\gamma_{ft}|\gamma_{Ct}) + \sum_{f\in I_c^c} w_{t-1}\beta(\gamma_{ft}|\gamma_{Ct}) \qquad [17]$$

4. Results

4.1 Micro evidences

Table 1 reports the estimated coefficients of Equation [2] for the Italian economy as a whole. In column 1 the basic specification is reported. The coefficients are estimated from the variation within the same firm across the ten partner countries.

Table 1. Main estimation results: whole economy

	Model		
	(1)	(2)	(3)
Importer	0.010	0.008	0.005
	(0.000)	*(0.000)*	*(0.000)*
Exporter	0.012	0.010	0.004
	(0.000)	*(0.000)*	*(0.000)*
Italian multinational	0.009	0.017	0.005
	(-0.005)	*(-0.005)*	*(-0.005)*
Affiliate of a foreign MNE	0.004	0.004	0.005
	(-0.004)	*(-0.004)*	*(-0.004)*
Indirect importer (DS)	-0.362	0.047	0.269
	(-0.007)	*(-0.014)*	*(-0.023)*
Indirect exporter (US)	0.129	1.047	0.241
	(-0.007)	*(-0.014)*	*(-0.022)*
Observation	3834430	3834430	3834430
Adjusted R2	0.000	0.016	0.030
Firm Fixed effects	Yes	Yes	Yes
Country Fixed effect	No	Yes	No
Country-sector fixed effects	No	No	Yes

Notes: Standard errors clustered at the firm level (in parentheses). This table reports the results of estimating Equation (2) for the whole economy. The independent variables are binary indicators for whether the firm imports from a country, exports to it, is an affiliate of a multinational firm from that country, or is a Italian multinational with affiliates in that country. "Indirect importers" is the downstream indirect linkage indicator $DS_{f,j,c}$ defined in (3). "Indirect Exporters" is the upstream indirect linkage indicator $US_{f,j,c}$ defined in (4).

In column 2 we add country fixed effects, while in column 3 the interaction term between country and sector fixed effects is used. The contrast between the specifications with and without country and sector fixed effects shows why it is important to control for common shocks (grasped by this type of variables), especially in the case of direct linkages: the magnitude of estimated coefficients in column 3 falls by a relevant factor. In other words, common shocks account considerably in transmitting shocks through trade.

Importing and exporting activities are associated with increases in the correlation of 0.05 and 0.04, respectively; they are both positive and strongly significant. Foreign affiliates in Italy have a 0.05 higher correlation with the parent country, while the effect on the cyclic correlation of being an Italian multinational with affiliates in a particular country is not statistically significant. This latter result could be due to the relatively low weight of multinational groups in the Italian business system.

In order to have a clue of the heterogeneity underlying the aggregate results of Table 1, we look at macro-sectors, disentangling the influence exerted by the direct and indirect relations with foreign countries on business cycle co-movement (Table 2).

Table 2. Main estimates results: macro sectors

	Manufacturing	Construction	Wholesale and retail trade	Market services	Other services
Importer	0,007	0,009	0,004	0,001	0
	(0.000)	(0.003)	(0.001)	(0.002)	(0.004)
Exporter	0,001	0,01	0,006	0,01	0,022
	(0.000)	(0.004)	(0.001)	(0.003)	(0.008)
Italian multinational	-0,001	0,024	0,015	-0,003	-0,018
	(0.007)	(0.038)	(0.007)	(0.012)	(0.035)
Affiliate of a foreign MNE	0,002	0,013	0,007	-0,005	0,038
	(0.005)	(0.014)	(0.007)	(0.009)	(0.020)
Indirect importer (DS)	0,146	1,101	0,126	0,359	0,576
	(0.036)	(0.088)	(0.043)	(0.051)	(0.106)
Indirect exporter (US)	-0,051	1,183	0,325	0,314	0,261
	(0.033)	(0.075)	(0.045)	(0.053)	(0.118)
Observation	802320	446490	1109870	988.930	469.740
Adjusted R2	0,049	0,008	0,0181	0,013	0,0142
Firm Fixed effects	Yes	Yes	Yes	Yes	Yes
Country-sector fixed effects	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors clustered at the firm level (in parentheses). This table reports the results of estimating Equation (2) for the whole economy. The independent variables are binary indicators for whether the firm imports from a country, exports to it, is an affiliate of a multinational firm from that country, or is a Italian multinational with affiliates in that country. "Indirect importers" is the downstream indirect linkage indicator $DS_{f,j,C}$ defined in (3). "Indirect Exporters" is the upstream indirect linkage indicator $US_{f,j,C}$ defined in (4).

Being an exporter has a positive impact on correlation, higher than the average effect estimated for economy as a whole for all the sectors except manufacturing. However, in the case of manufacturing (but also for construction), being an importer increases business cycle correlation more than the average. In other words, for manufacturing firms, domestic demand is even more effective than foreign demand in favoring the cyclical alignment between Italy and the main trading partners. The statistically significant effect of being a Foreign affiliates in Italy on correlation is exclusively due to the wholesale and retail trade sector.

As for the indirect links, downstream relationships (indirect importing) show a slightly greater effect on the synchronization of the business cycle with respect to the upstream relations (indirect exporting) except wholesale and retail trade. Both types of effect also show a significant influence on construction. Upstream relationships are statistically not significant for manufacturing, while the downstream ones show a positive contribution to the alignment of the cycle between firms and countries.

In summary, our results show that export activity represents, in almost all sectors (with the relevant exception of manufacturing), the most significant direct vehicle of synchrony between the performance of Italian firms and the business cycle of the main trading partners. In contrast, proprietary control appears to have no significant effect on the cyclical correlation, most likely due to the relatively low weight of multinational groups in the Italian production system. The indirect transmission channels instead show a clear sectoral heterogeneity. In fact, upstream-type effects have a greater influence in construction and trade, while downstream connections are more relevant for synchronization with foreign countries in the case of manufacturing and service industries.

4.2 Macro evidences

After having estimated the firm level correlation with foreign countries GDP, using decomposition in Equation [6], Table 3 reports the aggregate correlation $\rho(\gamma_{At}, \gamma_{Ct})$ between Italy and each of the considered trading partners. Total correlation is also decomposed to take into account the role of directly connected firms, and the role of the rest of production system.

Table 3. Aggregate correlation: contributions of direct and indirect terms

Country	Directly connected	Not directly connected	Olbserved correlation
Germany	0.32	0.09	0.41
Switzerland	0.28	0.13	0.41
Belgium	0.26	0.15	0.41
France	0.28	0.11	0.39
Netherlands	0.23	0.13	0.36
Spain	0.23	0.09	0.32
China	0.18	0.13	0.32
Poland	0.16	0.12	0.28
USA	0.18	0.09	0.27
UK	0.16	0.09	0.25
Average	**0.23**	**0.11**	**0.34**

Notes: This table reports the results of decomposition in Equation [6]. The last column reports the actual correlation in the data.

Results shows that, on average, 66% of the aggregate correlation is taken up by the directly connected firms.

Italian co-movement is higher with Germany (together with Switzerland and Belgium, with a correlation equal to 0.41), while a lower correlation is recorded with the United Kingdom (0.25), United States (0.27)

and China (0.32). Direct links are the main responsible for the observed aggregate co-movement with all the countries considered, while the effect of not directly connected firms is generally limited.

4.3 Granularity: the role of size

In general, however, the higher correlations reported for the directly connected firms are not necessarily evidence of transmission of shocks. Following Di Giovanni et al (2018), we make use of the micro-econometric estimation results to isolate the role of the transmission of shocks, predicting the aggregate business cycle correlation from Italy and country *C* if all cross-border links were severed like in (8).

Firstly, we check the relevance of direct linkages for the aggregate co-movements. Results are reported in Table 4. On average, the aggregate correlation would decrease by about 0.013 if firms stopped being connected. It is possible to disentangle the contribution of trade linkages ($\widehat{\Delta}\rho$ Trade, column 3) and of multinational linkages ($\widehat{\Delta}\rho$ MNE, column 4): the first one account for more than 95% of the total (-0.0127 out of -0.0134).

Table 4. Changes in aggregate correlation: direct linkages

Country	$\hat{\Delta}\rho(Y_{At}, Y_{Ct})$	$\hat{\Delta}\rho$ Trade	$\hat{\Delta}\rho\ MNE$	$\hat{\Delta}\rho\ Eq.W$
Germany	-0.0119	-0.0113	-0.0006	-0.0014
Switzerland	-0.0122	-0.0120	-0.0002	-0.0018
Belgium	-0.0153	-0.0143	-0.0010	-0.0021
France	-0.0140	-0.0137	-0.0003	-0.0016
Netherlands	-0.0156	-0.0147	-0.0009	-0.0024
Spain	-0.0136	-0.0125	-0.0011	-0.0015
China	-0.0094	-0.0092	-0.0001	-0.0011
Poland	-0.0135	-0.0129	-0.0006	-0.0018
USA	-0.0139	-0.0132	-0.0007	-0.0024
UK	-0.0147	-0.0135	-0.0012	-0.0019
Average	**-0.0134**	**-0.0127**	**-0.0007**	**-0.0018**

Notes: This table reports the results of the aggregation exercise in Equation (8). Column 3 and 4 presents the change in the correlation due to severing of trade linkages and multinational linkages separately. Column 5 presents the change in the correlation due to severing of direct linkages assuming that all firms have equal size.

In the last column, the change in the aggregate co-movement that would obtain if all firms were equal in size is reported. The variation in aggregate correlation (-0.0018) is much smaller than the one reported in column 2. This evidence gives us a measure of the role of larger firms in explaining the co-movement with foreign countries: larger firms (that are generally more directly correlated with foreign countries) roughly increase the impact on correlation by seven times.

In Table 5 the total change in aggregate correlation, obtained taking also indirect linkages into account is shown. The predicted change in aggregate correlation is now larger (-0.107 against -0.013). On average, indirect linkages explain around 87% of total change, against 13% of direct one.

Table 5. Changes in aggregate correlation: direct plus indirect linkages

Country	$\hat{\Delta}\rho(Y_{At}, Y_{Ct})$	$\hat{\Delta}\rho$ Trade	$\hat{\Delta}\rho$ MNE	$\hat{\Delta}\rho$ Indirect
Germany	-0.085	-0.012	-0.001	-0.073
Switzerland	-0.100	-0.012	0.000	-0.088
Belgium	-0.123	-0.015	-0.001	-0.108
France	-0.103	-0.014	0.000	-0.088
Netherlands	-0.138	-0.015	-0.001	-0.121
Spain	-0.094	-0.013	-0.001	-0.080
China	-0.069	-0.010	0.000	-0.060
Poland	-0.105	-0.013	-0.001	-0.091
USA	-0.133	-0.014	-0.001	-0.119
UK	-0.121	-0.014	-0.001	-0.105
Average	**-0.107**	**-0.013**	**-0.001**	**-0.093**

These evidences related to the importance of indirect effects seem to be in contradiction with those emerging from table 3, where indirect linkages are less relevant than direct one on in explaining aggregate correlation. However, we have to bear in mind that when we calculate the aggregate effects using Equation [6], each firm is classified in a mutually exclusive way: it is included in I_C (the group of firms directly connected with foreign countries) or in I_C^c (domestic firms not directly connected to foreign countries). This is not the case when we run exercises like in Equations [7] and [8]: indirect effects of Table 5 also include domestic relations (like purchases and sales of goods and services) between Italian firms directly connected with foreign countries.

Making a comparison with Di Giovanni *et al.* (2018) results, in Italy the contribution of indirect effects to the change in correlation is higher than in French economy (it explains 87 vs 59% of total change). These differences could depend both on the time period considered and differences in the structure of production systems. French results are related to the pre-crisis period (1995-2007); in our work, during the period under investigation the increasing gap between domestic (decreasing or stagnating) and foreign (more dynamic) demand has increased the relevance of exporters also for domestic connectivity. Furthermore, the number of Italian exporters is higher in absolute terms, but they account for a much smaller share of total firms, and they are smaller in size. These differences could in part explain the higher relevance of indirect linkages in Italy.

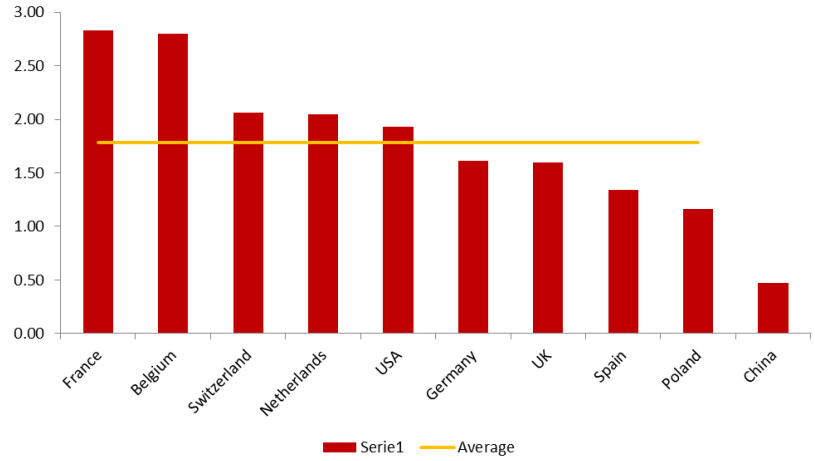
4.4. Italian business cycle response to foreign shocks

We are interested in studying the impact of foreign country shock on Italian business system rather than the intensity of cyclical co-movements in a period (2005-2016) when Italy's business cycle was negatively deviating from those of other main advanced economies.

To do that, as showed in paragraph 3.4, we are able to derive the Italian elasticities to foreign partner country shocks using the same conceptual framework of di Giovanni *et al.* (2018) on co-movements. By this way, we can obtain a measure of aggregated elasticity from firm-level response coefficients.

After having calculated firm-level response to foreign shocks, we can obtain aggregate's impact response on foreign GDP changes by summing up the firm-level coefficients as follows from Equation [16]. Results are reported in Figure 1.

Figure 1. Foreign country shocks impact on Italian economy



In the period considered, an increase/decrease of main foreign partner GDP by 1% would increase/decrease Italian value added by 1.8% on average. Larger part of this impact is due to manufacturing response (around 50%), while market services and wholesale and retail trade explain around 20% of the average elasticity (Table 6).

Table 6. Sector contribution to Italian average foreign country shock

Industry	Weighted average	Contribution to Italian Average
Manufacturing	0.86	0.48
Energy and water	0.09	0.05
Construction	0.10	0.06
Wholesale and retail trade	0.31	0.17
Market services	0.37	0.21
Other services	0.06	0.03
Italian Average	**1.78**	-

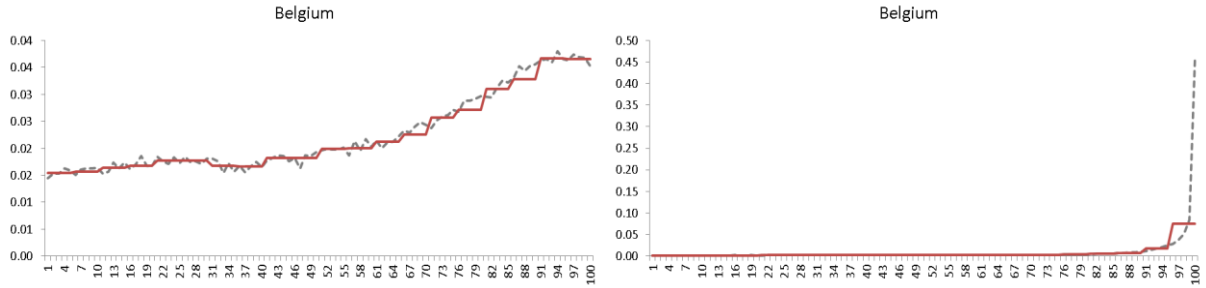
Microfoundation of shock transmission is interesting because it allows to detect whether firms that are (directly or indirectly) connected to foreign business cycle are also able to transmit shock impulses on the domestic economy. This ability seems to be important when looking at results showed in Table 5: indirect effects (transmission by domestic transactions) account for almost the overall correlation between Italian value added growth and that of trading partners.

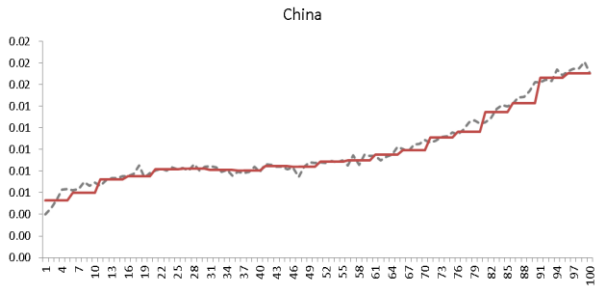
The capacity of indirect transmission of shocks is related to the relevance of firms within the network of domestic transactions. In turn, a firm relevance largely depends on two characteristics: its size (to be intended in a broad sense) and its connectivity with the rest of the business system.

In order to take account for such aspects, for each Italian firm we calculate an "indicator of systemic relevance" (IRIS – *Indicatore di rilevanza sistemica*, in Italian), combining its size and connectivity. The size is measured by factor analysis applied on three firm size-related variables: employment, turnover and age. The connectivity, in turn, is aimed at grasping the role of individual firms in Italian domestic transactions. In other words, the indicator should measure the firm contribution to its industry's activation degree – both as supplier of other industries and as buyer from other industries. This contribution is measured in both its components: the direct (i.e. the firm contribution to the overall activation capacity of its industry) and indirect one (i.e. the size and density of the firm's industry transaction network with other industries). For this latter component, we used the Network analysis indicator to measure the indegree and outdegree centrality of the firm's industry egonetwork. Both the direct and indirect indicators have been calculated on the basis of the Italian input-output tables, and referred to each firm according to its weight within the industry, in terms of turnover (for the upstream connections) and intermediate costs (for the downstream connections).

In Figure 2, we compare IRIS and firm-level response values, by partner countries. On the right side we report the distribution of weighted (by value added) firms contribution to the aggregate response in comparison with their level of IRIS. On the left side, we report the same comparison using unweighted firm contributions. For each partner countries, left side figures show a positive relationship between firm response and domestic systemic relevance: firm response to foreign shocks increases with higher level of IRIS. The same positive relationship applies for the right side figures, but with a very different slope: firms with the highest IRIS value (100 percentile) accounts for 40 to 50% of the total reaction to each foreign country business cycle. These patterns can be considered as a clue of granularity. As a matter of fact, firms in the top percentile of IRIS are far more productive (about 3 times), larger (about 50 times) and internationalized (about 10 times) than the sample average.

Figure 2. Contribution to total weighted and unweighted response by percentile and quintile of IRIS, countries. (Grey dotted: percentile. Red line: quintile. Weighted response on right side. Unweighted response on left side)

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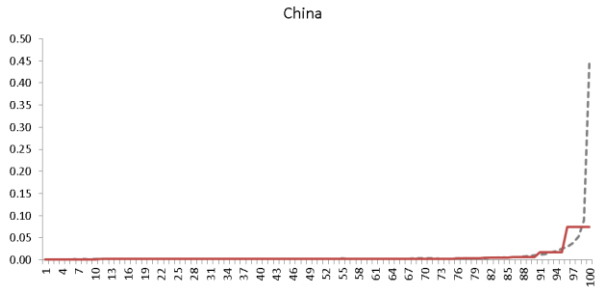
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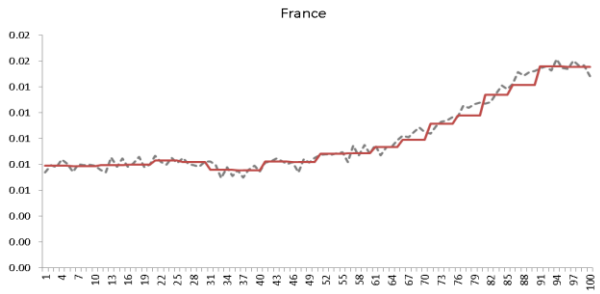
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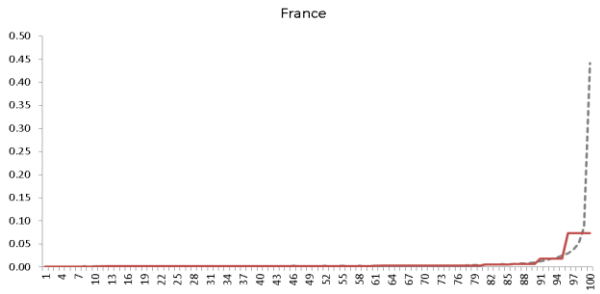
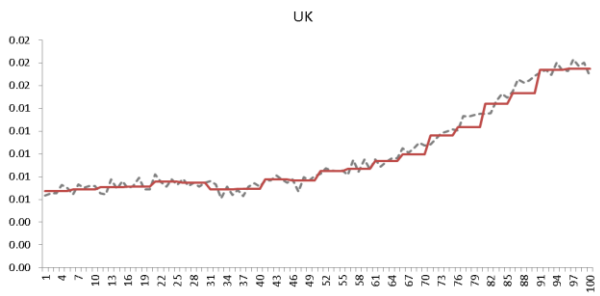

France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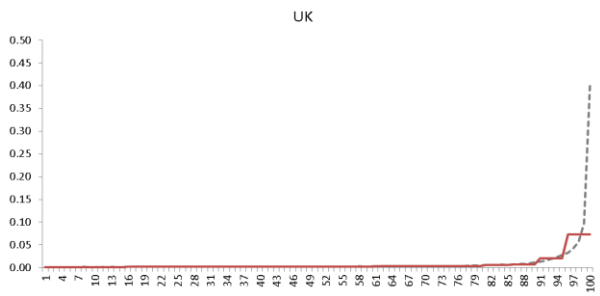
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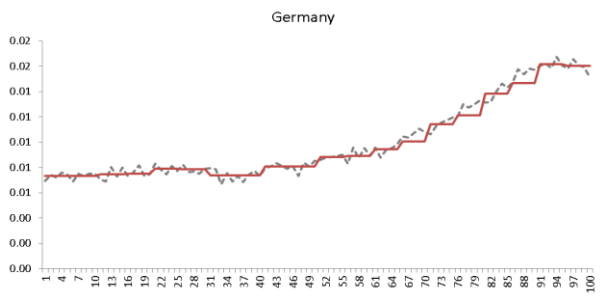
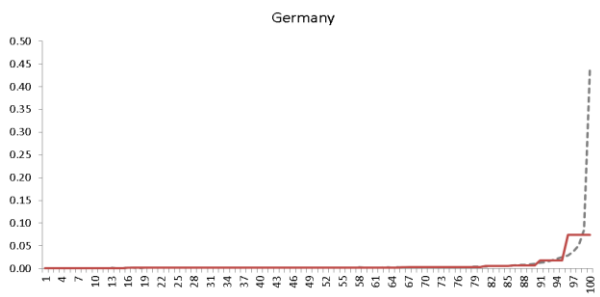
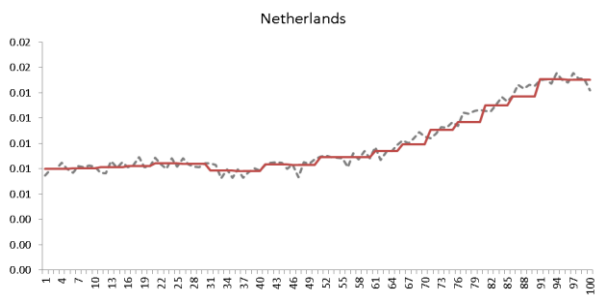

Germany


Germany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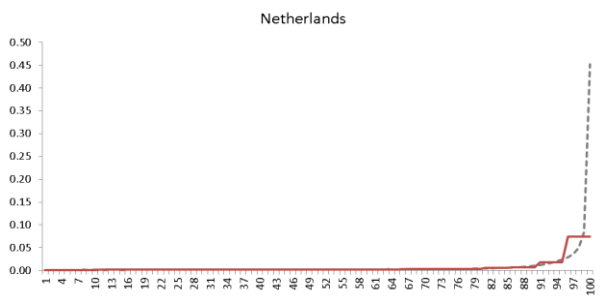
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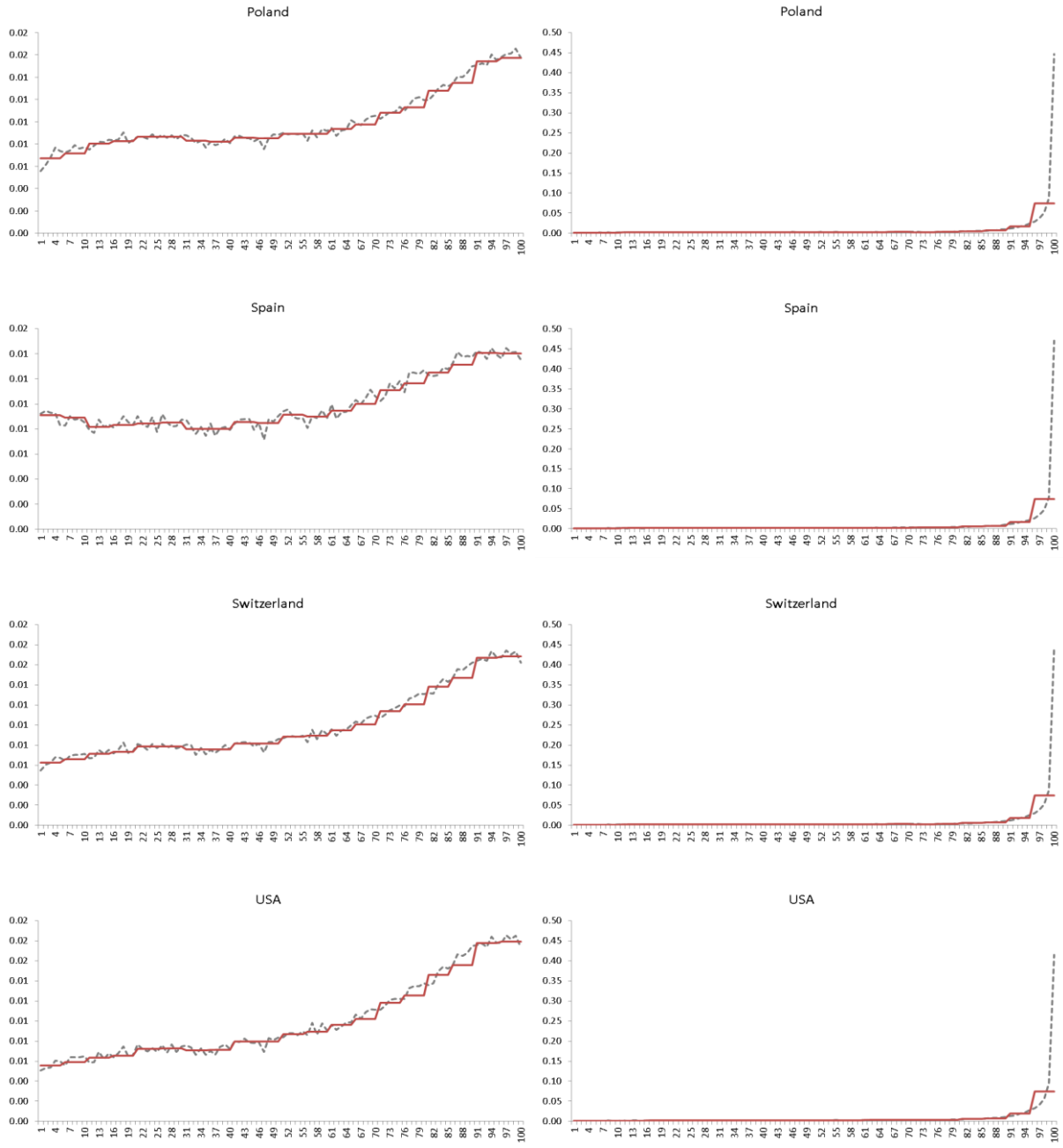
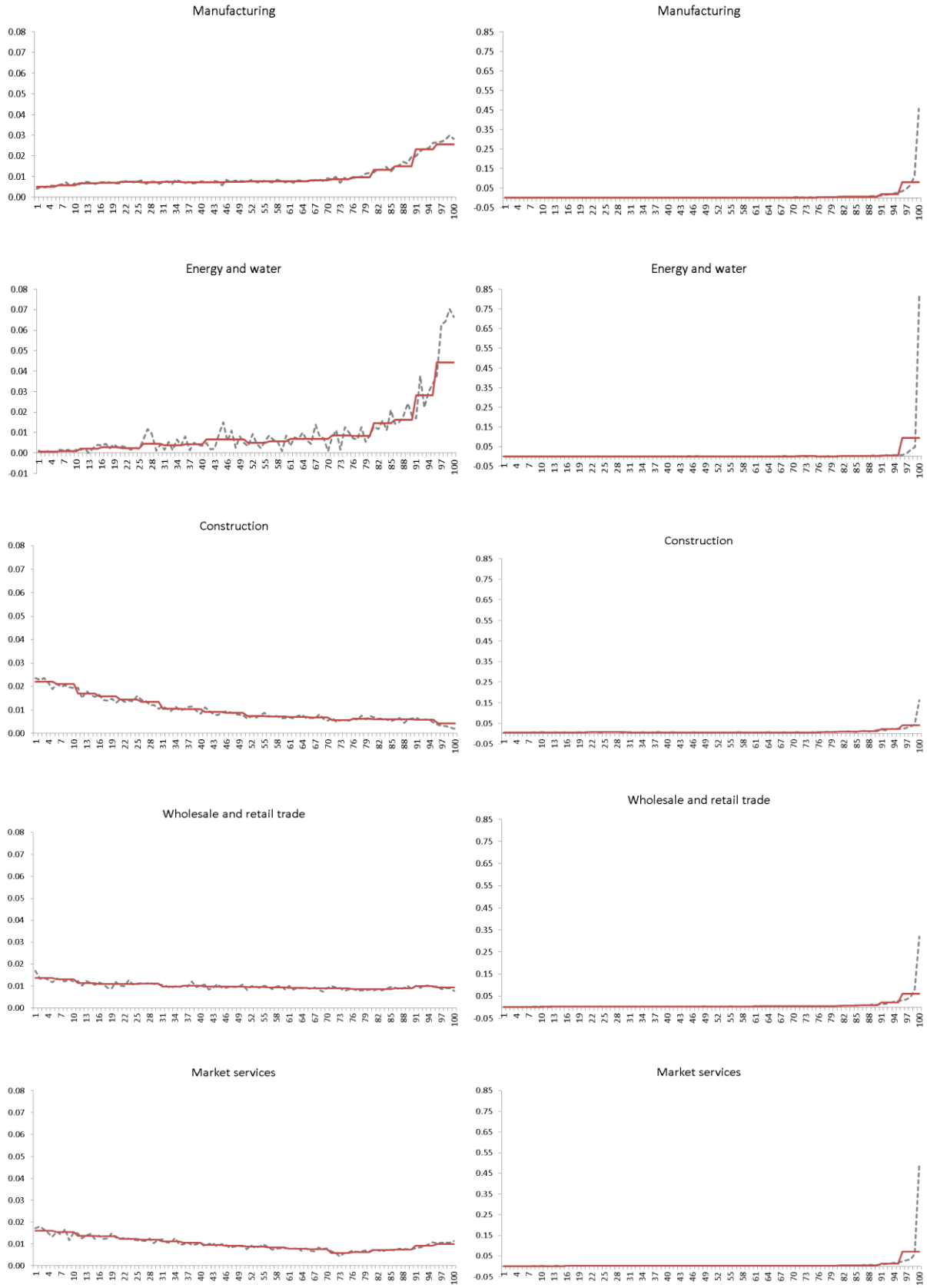
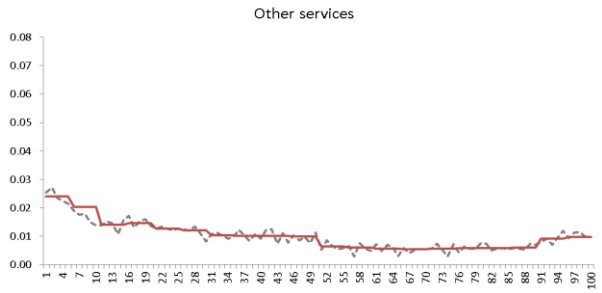


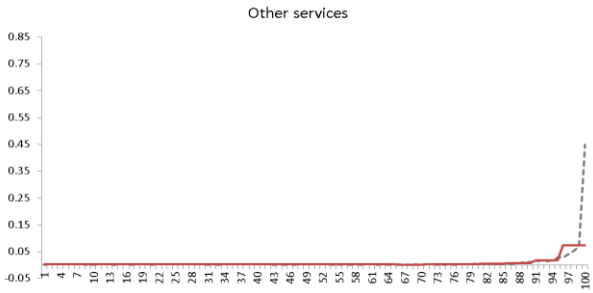
The same pictures are reported in Figure 3, revealing heterogeneity in sectoral patterns. On the one hand, in manufacturing and energy sectors a positive relationship between firm response and IRIS emerges. On the other hand, construction and services show a generally negative correlation between transmission propensity and systemic relevance. In this case, however, differently from Figure 1, the percentiles of IRIS values are composed of a different set of firms. In fact, in Figure 1, we include all firms (directly or indirectly) connected to each foreign country, while in Figure 2, IRIS percentiles include different amounts of firms for each sector, because they are defined not by sector but for the economy as a whole.

In particular, a comparison between Figures 1 and 2 reveals that the higher response of most systemic firms (100 percentile) is mainly explained by manufacturing and energy sectors, which include about 60% of firms belonging to the top 1 percentile of IRIS.

Figure 3. Contribution to total weighted and unweighted response by percentile and quintile of IRIS, sectors. (Grey dotted: percentile; Red line: quintile; Weighted response on right side, Unweighted response on left







5. Conclusions

The application to the Italian economy of the methodology of di Giovanni *et al.* (2018) allows us to highlight the predominant role of indirect effects in the correlation between the Italian business cycle and that of Italy's main trading partners. In particular, a variant of this approach makes it possible to study, at firm level, the transmission of foreign shocks in a decade (2005-2016) in which the Italian business cycle was misaligned from that of the main trading partners. In doing so, we analyze both direct and indirect transmission channels. As for the first ones, firms' trade linkages prevail on MNE membership to explain the correlation between Italian firms value added and trading partners GDP growth; furthermore, firm size is a relevant factor in amplifying the magnitude of business cycle correlation. In the Italian case, however, indirect effects proved to be prevalent, highlighting the importance of firms' connectivity. This latter, i.e. the ability of firms to transmit shocks *via* domestic transactions, is assessed in the light of the relationship between two components: the response of firms with respect to international business cycle, and the relevance of firms within the business system. To this end, a firm-level indicator of systemic relevance (IRIS) was introduced, which summarizes the role of economic size and domestic connectivity. In this context, firms characterized by the highest level of IRIS (top 1%) turn out to explain about 50% of the shock response of the Italian business system. This evidence suggests that Italy presents a given degree of granularity in the indirect response to foreign shocks, especially in manufacturing sectors.

This result paves the way to further analyses and policy implications. The capacity of a country to benefit from positive foreign shocks does not necessarily origin from the presence of large exporters, as in Gabaix-like granular hypothesis, but also from the ability of firms to be connected in the domestic network of transactions. As a consequence, an effective policy measure to boost transmission mechanisms can be represented by a stimulus to augment the intensity of inter-firm relationships rather than only by supporting an increase in firm size. This is all the more important to countries like Italy, where the firm size distribution is particularly fragmented and the economic literature pointed out the presence of relevant constraints to firms growth.

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