Matched trade at the firm level and the micro origins of international business-cycle comovement*

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Abstract

This paper uses firm × national market export and import data for all Swedish private sector firms for 1997-2014 to examine the firm-level contribution of trade and foreign ownership to the correlation between Swedish value added growth and partner country GDP growth. Export and import links raise the firm-level correlation but these effects net out for firms that both export and import from the same market, evidence that this type of "natural hedging" can help reduce firm's exposure to foreign economic shocks. We proceed to aggregate the firm-level results to the whole economy and find that severing firm-level ties with a foreign market is predicted to lower the correlation between Swedish value added growth and foreign GDP growth from 0.72 to 0.64 on average. Gabaix's "granularity" of trade is central to this result: if all firms are given equal weight overall correlations are essentially unaffected by severing firm level ties. While natural hedging is quantitatively important at the firm level, it has no important effect on overall comovements.

Keywords: International transmission of shocks, Granular effects, Firm heterogeneity, Natural hedging.

JEL: F14, F23, F44, G32

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1 Introduction

The distribution of firm size is highly skewed and shocks to large firms can have important aggregate effects as shown by a recent empirical literature that studies firm level data (see e.g. Gabaix (2011), Acemoglu et al. (2012), Di Giovanni et al. (2014)). Similarly, international trade is typically dominated by few firms and in recent work di Giovanni et al. (2018) examine the role of international firm-level linkages in explaining the correlation of international business cycles. Using French data for 1993-2007 they establish that trade linkages with foreign markets, and affiliations within multinational firms, matter for the correlation between the growth of French firm's value added and GDP growth of partner countries. On average severing such linkages is predicted to lower the aggregate correlation of GDP between France and a foreign country from around 0.3 to 0.2.

In the current article we extend the methodology of di Giovanni et al. (2018) by relaxing the assumption that export and import effects are additive. Their treatment variables capture firm-level trade/affiliation links to a given market, but does not differentiate between firms that import and export from the same market. Implicitly, they assume that the export and import effects are additive. This follows the thrust of the previous literature on the links between bilateral trade and the correlation of national growth which has examined the link between GDP growth and bilateral trade, as measured by the sum of exports and imports (see e.g. Frankel and Rose (1998) Imbs (2004), Johnson (2014), Ductor and Leiva-Leon (2016)). In other words, the focus in the previous literature has been on *gross trade*.

The innovation in our paper is to distinguish the transmission of international shocks for firms that export and import from the same market (or simply *matched trade* henceforth). Our paper is motivated by the hypothesis that, at least for some types of shocks, the effects of exports and imports on firm-level correlations with foreign GDP might partly offset. For instance a positive growth shock to the UK leading to a depreciation of the Swedish Crown against the British Pound would increase export revenue from the UK (in SEK), yet at the same time increase import costs from the UK. Net trade may therefore have an offsetting effect on profits.

Using firm-level trade data for the universe of Swedish firms, we document that matched trade flows at the firm-level cause a lower correlation between shocks to firm-level value added and shocks to foreign GDP. The estimated contribution of trade linkages to this correlation is essentially zero for firms that match trade flows. Moreover, we identify similar effects of gross trade in the Swedish data as di Giovanni et al. (2018), thereby

replicating their results. The role of the nominal exchange rate in propagating shocks is of long-standing interest and the application of the di Giovanni et al. (2018) methodology to a country with a floating exchange rate against all its trading partners (Sweden rather than France as in di Giovanni et al. (2018)) is therefore of interest beyond replication.

Our paper thus contributes to micro-economic research on the effects of firm-level trade linkages on business-cycle comovements and confirms that matched and gross trade linkages, and multinational affiliations, matter. The new micro evidence in this paper supports the logic of "natural hedging," and demonstrates that this risk management strategy has a strong effect on firm variability in value added.[1] We also document that matched trade at the firm-level is indeed common in the Swedish data, and derive a new index to describe the degree of matched trade.[2] We are not aware of any previous research that attempts to quantify the effect of this type of natural hedging on firms.[3] An important related article, using data similar to ours, establishes that the pass-through of exchange rate changes into export prices is lowered if the net effect on marginal cost is moderated by a large share of imported inputs (Amiti et al. (2014)).[4] The focus in that article differs from ours, although both study the role of trade connections in the transmission of shocks.

We do not investigate the motivation for firms to engage in net trade: we take firm-level trade linkages as given. From the perspective of the firm, exporting to and importing from a market could be about differential trade costs (as in gravity models of trade,

[1]Hoberg and Moon (2017) use textual analysis of US annual reports in connection with changes in the set of foreign currency derivatives available to establish that the kind of natural hedging that we are interested in indeed appears to affect trade patterns.

[2]The index is an application of the Grubel-Lloyd index that has previously been used to characterize the degree of intra-industry trade.

[3]We examine natural hedging in terms of trade flows. There are two other phenomena that are sometimes also referred to as natural hedging. One is that a firm may establish production capacity in large foreign markets. This mechanism has been subject of some research and on balance the results indicate that production capacity abroad serves to limit exposure (Bartram et al. (2010), Hutson and Laing (2014)), even if some early studies suggested limited or no effects (Allayannis et al. (2001)). A second form of natural hedging is to denominate loans in the currency of important export markets, which is a common practice among the firms surveyed in Graham and Harvey (2001). One may of course wonder why firms would distort real operations in order to manage risk - why not let investors rather than firms manage risk and why not use financial instruments? On the first question we note that a number of reasons for risk management by firms have been put forward (for instance allowing stable investments in the face of credit constraints as in Froot et al. (1993)). On the second we note that the evidence indeed indicates that use of financial derivatives lowers risk but that substantial risk remains (Guay and Kothari (2003), Bartram et al. (2011)) - which leaves open an interest in the effectiveness of natural hedging. Topics of natural hedging fall pertain to a broader area of how internationally trading firms manage uncertainty, see e.g. the editorial in Chinn et al. (2018) for a discussion.

[4]Fauceglia et al. (2014) do a similar exercise using sector level data from Switzerland.

see e.g Head and Mayer (2014) or Chaney (2018)). It might also be a strategic risk management decision by firms, e.g. "natural hedging". In teaching of risk management (see e.g Brealey et al. (2017)) and in discussions of risk management strategies a policy of "natural hedging" or "matching of currency footprints" is often discussed. For instance in its annual report Daimler (2017, p. 303) states *"The Group's currency exposure is reduced by natural hedging...To provide an additional natural hedge against any remaining transaction risk exposure, Daimler generally strives to increase cash outflows in the same currencies in which the Group has a net excess inflow".*

Our paper also contributes to the macro-economic issue of aggregate implications of firm-level trade effects, and the role of bilateral trade in the international transmission of shocks. We establish that firm-level trade/affiliate links have an important contribution to international business-cycle comovements. On average the severing these firm-level international links reduces the correlation between Swedish value added growth and foreign GDP growth from 0.72 to approximately 0.64. We also establish that while the effect of matched trade is important at the firm level, the aggregate effect is small. The aggregate effect of severing firm-level international links is essentially unchanged when matched trade effects are included. However, firm granularity plays an important role in these counterfactual exercises. If all firms were equal in size (in terms of sales), then the contribution of firm-level linkages is substantially reduced. The largest firms, play a central role in the international transmission of shocks.

From a macro-economic aspect, these issues are important for understanding the effects of a monetary union (which motivated the seminal work of Frankel and Rose (1998)) or more broadly for understanding how shocks affect the world economy. Generating the business cycle comovement observed in the data with theoretical international real business cycle models has proven elusive and there is a large body of research focused on how to improve model fit in this regard (see e.g. Kose and Yi (2006), Johnson (2014)). Duval et al. (2016) use country-pair level data on value added in trade rather and find a stronger correlation between this measure of trade and business cycle correlation. One concern with the interpretation of empirical work with aggregate data is that common shocks, rather than trade itself, might be driving correlations. Substantive work finds important effects for other linkages, for instance financial linkages (see e.g. Imbs (2004), Kalemli-Ozcan et al. (2013)). With aggregate data it is harder to control for the types of shocks that affect economic activity, such as expectations (see e.g. Forbes and Rigobon (2002) for a related examination of international stock market comovement).

The next section presents the empirical model and includes a theory based discussion

of the predicted effects of matched export and import flows on correlations with foreign GDP. Section 3 presents the data and describes bilateral trade patterns at the firm level in detail. Section 4 presents results, first at the firm level and then at the aggregate level. The final section concludes.

2 Empirical model

We follow the methodology and notation of di Giovanni et al. (2018) closely. Let x_{ft} denote the value added of firm f in year t and thus the growth rate of firm value added is given by $\gamma_{ft} = x_{ft}/x_{ft-1} - 1$. Using w_{ft-1} denote the share of firm f in overall value added by Swedish firms we can then express the growth in total Swedish value added as $\gamma_{At} = \sum_f w_{ft-1}\gamma_{ft}$. International comomevent is then measured by the correlation between GDP growth rate of country N and γ_{Nt} which can be rewritten as the weighted sum of firm level correlations with foreign growth rates (letting σ denote the respective standard deviation):

$$\rho(\gamma_{At}, \gamma_{N,t}) = \frac{cov(\sum_f w_{ft-1}\gamma_{ft}, \gamma_{Nt})}{\sigma_A \sigma_N} \tag{1}$$

$$\rho(\gamma_{At}, \gamma_{N,t}) = \sum_f w_{ft-1} \frac{\sigma_f}{\sigma_A} \rho(\gamma_{ft}, \gamma_{Nt}) \tag{2}$$

To examine the firm-level determinants of the correlation between value added growth of firm f and country N GDP growth we estimate variants of the following equation:

$$\rho(\gamma_{ft}, \gamma_{N,t}) = \alpha + \beta_1 EX_{f,N} + \beta_2 EX_{f,N} \times NETEXP_{f,N} \tag{3}$$

$$+\beta_3 IM_{f,N} + \beta_4 IM_{f,N} \times NETIMP_{f,N} + \beta_5 AFF_{f,N} + \delta_f + \delta_N + \eta_{f,N}. \tag{4}$$

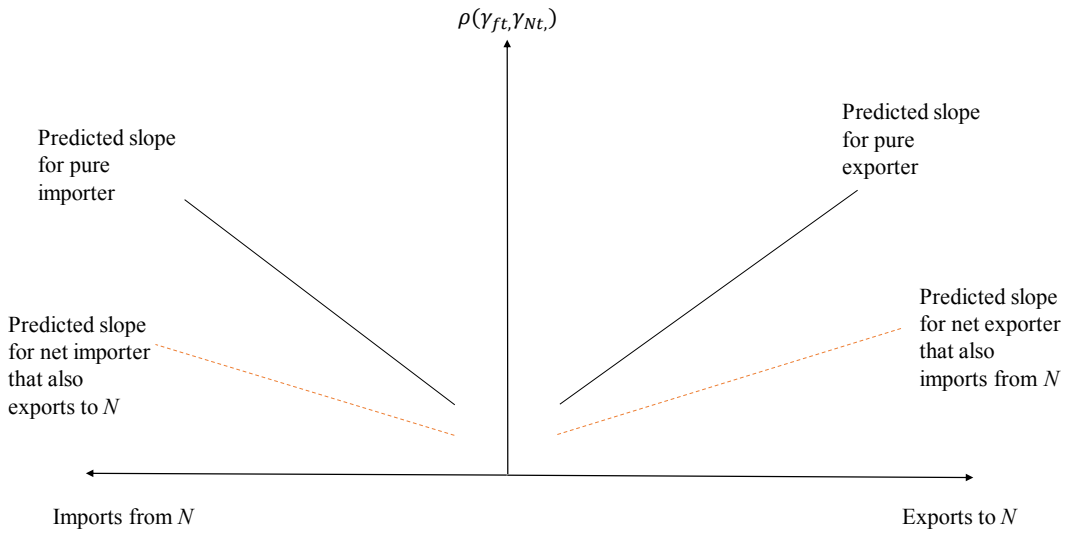
In a first set of regressions $EX_{f,N}$ is a dummy which takes the value 1 if firm f exports to N and $NETEXP_{f,N}$ is a dummy that takes the value 1 if firm f both exports and imports to/from N and in addition is a net exporter. $IM_{f,N}$ and $NETIMP_{f,N}$ are the corresponding dummy variables for imports, $AFF_{f,N}$ is dummy that takes the value 1 if firm f is an affiliate of a firm in N. Firm and country fixed effects are denoted by δ and finally $\eta_{f,N}$ is an econometric error term. Apart from the interaction terms with net exports and net imports this specification is identical to the benchmark specification in

di Giovanni et al. (2018).[5] In a second set of regressions we estimate the same specification but instead use continuous levels of exports and imports.

2.1 Predictions regarding the effect of net trade on the correlation with foreign GDP

As a starting point we hypothesize that the more a firm exports to a country N, the greater the correlation with country N shocks and likewise for imports. Figure 1 illustrates the predicted patterns, other things equal, for the case where we use continuous measures of exports and imports.

Figure 1: Predicted patterns regarding correlation with GDP growth in foreign country and trade with that country.



The figure provides a schematic illustration of hypothesized relation between the correlation of a firm's value added growth and foreign GDP set in relation with that firm's trade with the country in question.

We further hypothesize that if a firm both exports and imports to country N this should be associated with a lower sensitivity. Consider the following simple example. Let quantity exported to N be denoted by q, let the local currency price in N be given by

[5] One caveat is that they also include a dummy for whether firm f is a multinational that has an affiliate in country N, this variable is not included in our data set.

p, let imported inputs from N have a constant marginal cost (in N's currency) of c^* and let domestic inputs have a constant marginal cost denoted c. A share h of marginal costs are imported. For simplicity assume that a foreign GDP shock has no direct effect on the revenue or costs of the firm but that it affects the exchange rate e. The profit and the effect of the exchange rate change on profits, other things equal,[6] will then be given by:

$$\pi = e(p - hc^*)q - (1 - h)cq \tag{5}$$

$$\frac{d\pi}{de} = (p - hc^*)q \tag{6}$$

The higher the share of imported inputs (h), the lower the effect on profits of an exchange rate change which provides a simple way of illustrating the effect of countervailing exposure from imports and of the impact of natural hedging on profits.

While intuitive the situation is less clear under more general conditions where foreign GDP shocks may affect revenue and cost via many channels. Consider instead the following simple set-up where profits depend on revenue R which is subject to a revenue shock (ϵ_r) and costs (C) that are subject to a cost shock (ϵ_c). We could then express profits for a firm trading with country N as:

$$\pi = R + \epsilon_r - (C + \epsilon_c) \tag{7}$$

At a deeper level assume that both revenue and cost shocks are related to a foreign GDP shock denoted by ϵ_N which will manifest itself in terms of revenue and cost shocks for the firm. Let us highlight two intuitive cases on the relation between ϵ_N on the one hand, and cost and revenue shocks on the other hand. First consider the case where there is a floating exchange rate between the firm's country and the foreign partner. A positive GDP shock in an export market is then likely to act like a positive demand shock and in addition the currency of the export market is likely to appreciate with a further positive effect on revenue. On the other hand the appreciation of the foreign currency would also make imports from that country more costly, leading to an offsetting effect.[7] If foreign

[6]For simple expositional purposes we here assume that the local currency price is unchanged, which would be the case if there are sufficient price adjustment costs. A rich literature examines theory and empirics of exchange rate pass-through, see e.g. Burstein and Gopinath (2014).

[7]Indeed, an important impetus to the interest in links between trade and business cycle comovement was given by interest in how a monetary union would affect risk and the case just discussed corresponds

GDP shocks largely affect firms via an exchange rate channel one would therefore expect a positive correlation between revenue and cost shocks for a firm that both exports and imports.

However, revenue and cost shocks might also move in the opposite direction, implying a negative covariance. In this case the effect of revenue and cost shocks would combine to amplify the volatility of profits for a firm that both exports and imports. As an example think of a negative GDP shock in the foreign country that is due to political gridlock and labor strikes. Such a shock would lead to a fall in demand (negative revenue shock) and higher costs of imports (positive cost shock) and thereby a negative correlation. Rather than attempt to catalog different types of shocks we hence note that two-way trade may both attenuate and exacerbate firm level correlations with foreign GDP and it is an empirical question what the overall effect is.

Somewhat formalizing the discussion so far we might thus express the change in profit as a underlying change in revenue ΔR and the effect of a revenue shock ϵ_r which captures e.g. macro or exchange rate shocks in country N and a corresponding drift in cost and a realization of firm cost shock ϵ_c due to macro or exchange rate shocks in N. Growth in firm profits are

$$\Delta\pi = \Delta R + \epsilon_r - (\Delta C + \epsilon_c). \tag{8}$$

If two-way trade limits or increases the covariance between firm profit and foreign GDP will depend on the covariance between foreign GDP shocks and firm level cost and revenue shocks.

$$cov(\epsilon_N, \Delta\pi) = cov(\epsilon_N, \Delta R + \epsilon_r - (\Delta C + \epsilon_c)) \tag{9}$$

$$= cov(\epsilon_N, \epsilon_r) - cov(\epsilon_N, \epsilon_c). \tag{10}$$

Under an exchange rate shock (e.g. a depreciation of SEK) for a natural hedger:

$$cov(\epsilon_N, \epsilon_r) > 0 \tag{11}$$

$$cov(\epsilon_N, \epsilon_c) > 0 \tag{12}$$

to a situation where the exchange rate plays a key role in the transmission of international shocks (see e.g. Frankel and Rose (1998), Friberg and Vredin (1997), Artis and Ehrmann (2006)).

and for exporters

$$cov(\epsilon_N, \epsilon_r) > 0 \tag{13}$$

$$cov(\epsilon_N, \epsilon_c) \approx 0 \tag{14}$$

and for importers

$$cov(\epsilon_N, \epsilon_r) \approx 0 \tag{15}$$

$$cov(\epsilon_N, \epsilon_c) > 0. \tag{16}$$

If the exchange rate is an important transmission mechanism we would thus expect natural hedging to limit comovements with the foreign country, as established by inserting the preceding sets of correlations in Equation 10.

In contrast, in the case of the type of shocks exemplified by political unrest as discussed above were dominant we would expect a two-way trade to increase rather than limit exposure as seen by inserting the following covariances in Equation 10:

$$cov(\epsilon_N, \epsilon_r) > 0 \tag{17}$$

$$cov(\epsilon_N, \epsilon_c) < 0. \tag{18}$$

Sourcing inputs from the same destination country would then increase exposure and "natural hedging" would be a misnomer. Whether bilateral trade at the firm level tends to amplify or moderate volatility (and thereby correlation with foreign shocks) is thus an empirical question and let us now turn to the data.

3 Data and descriptive statistics

We use yearly data on firm × country exports and imports for all Swedish private sector firms with at least 10 employees.[8] We consider trade with the 15 largest export destinations during this time period.[9] The trade data are from Statistics Sweden and cover 1997-2014. The dummy variable on whether a firm is a Swedish affiliate (AFF)

[8]We limit attention to firms that are active in at least three years and drop firms in the healthcare and financial sectors.

[9]These are, in order of importance: Germany, Norway, United Kingdom, Denmark, USA, Netherlands, Finland, France, Belgium, Italy, China, Russia, Poland, Spain and Japan. di Giovanni et al. (2018) examine France's top nine trading partners and Brazil.

of a country N firm is from the database Serrano. Sweden has a floating exchange rate throughout the period.

The main novelty of the paper is to examine the effect of two-way trade on the firm level on correlations with foreign markets and to set the stage it is of some interest to describe these bilateral trade patterns in some detail as is done in Table 1. The average firm in the sample exports to around 4 markets (out of the 15) and imports from around 4 origins. While there is some overlap it is also clear that in many cases firms only export to or import from a given market as indicated by that the average number of trading partners is above 8. At the firm level, the correlation between the number of export and import market is 0.74 such that firms which exports to more markets also import from more markets. Both exports and imports are quite concentrated as indicated by mean Herfindahl-Hirschmann indices (HHI) of export and import concentration of around 0.75.[10]

To further gauge the magnitude of two-way trade at the firm level we consider an index that is a close analogue of Grubel-Lloyd index of intra-industry trade which is a well established index of the extent to which a country exports and imports the same goods (Grubel and Lloyd (1975)). We are interested in the overall balance of flows with different trading partners and therefore create what we term the Grubel-Lloyd index of "natural hedging", GLINH. It is analogous to a Grubel-Lloyd index of intra-industry trade at the level of total manufacturing(see e.g. OECD (2011)). Thus, for each firm f we define

$$GLINH_{ft} = \left(1 - \frac{\sum_{n=1}^{N} |X_{nft} - M_{nft}|}{\sum_{n=1}^{N} (X_{nft} + M_{nft})} \right) \times 100 \tag{19}$$

where X_{nft} is the value (in SEK) of exports to country n in year t and M_{nft} is the analogous value for imports. If trade flows are perfectly matched the index takes the value 100 and if trade flows are totally unbalanced the index takes the value of 0. In this sense we can use GLINH as a measure of natural hedging and higher values are associated with a stronger natural hedge. To the best of our knowledge this form of index has not been applied to firm level trade flows before. Despite firms importing from and exporting

[10]HHI exports is calculated as the sum of squared export shares. A firm that exports to two markets with respective shares of 0.85 and 0.15 would have an HHI of 0.75.

Table 1: Firm-level trade linkages, Sweden 1997-2014.

Statistic	Nr. export destinations	Nr. import origins	Nr. trading partners	HHI exports	HHI imports	GLINH
Full sample of firms						
mean	4.16	4.34	8.50	0.75	0.79	12.42
sd	4.94	4.40	8.42	0.32	0.29	17.21
p1	0.00	0.00	0.00	0.00	0.00	0.00
p50	2.00	3.00	6.00	0.89	0.92	4.45
p99	15.00	14.00	29.00	1.00	1.00	74.32
N	200316	200316	200316	200316	200316	200316
50 largest firms						
mean	9.46	11.03	20.49	0.69	0.77	30.31
sd	5.87	5.26	10.39	0.25	0.20	22.28
p1	0.00	0.00	0.00	0.00	0.09	0.00
p50	12.00	13.00	25.00	0.75	0.83	31.13
p99	15.00	15.00	30.00	1.00	1.00	82.41
N	653.00	653.00	653.00	653.00	653.00	653.00

The table presents summary statistics at the firm level for Swedish private sector firms engaged in importing and/or exporting, Sweden 1997-2014. HHI is a Herfindahl-Hirschmann index of concentration: the sum of squared shares of value of exports for market N in total exports and analogously for imports. GLINH is an extension of Grubel-Lloyd index to measure the degree of two-way trade at the firm level as described in the text.

to partly the same countries the index, with an average value of around 12, indicates a relatively low level of natural hedging. To put the average GLINH in perspective note that a firm which sells 80 to one market and 20 to another, and imports 10 from each of these markets, achieves a GLINH of 0.33.

In Table 2 below we present summary statistics for the regression sample. The average correlation between firm level value added growth and trading partner GDP growth is 0.07.[11] The dummy variables that capture trade patterns imply that on average 5.7% of observations correspond to cases where a firm exports to a given market and 6.3% to imports from a given market. Similarly, 3.2% of observations are observations where a firm is a net exporter but also has positive imports from the country N and 2.3% of observations are for firms that have bilateral trade with country N but are net importers from that country. The following rows give the corresponding summary statistics for these trade flows expressed in values rather than as dummy variables indicating a positive trade flow. Around 0.8% of observations correspond to the case where a firm is a Swedish affiliates of a firm based in N.

Table 2: Summary statistics regression sample of firms, Sweden 1997-2014

Variable	Mean	Std. Dev.	Min.	Max.	N
$\rho(\gamma_{f,t}, \gamma_{N,t})$	0.072	0.575	-1	1	1207530
Exporter	0.057	0.232	0	1	1207530
Importer	0.063	0.243	0	1	1207530
Exporter ×net exp.	0.032	0.176	0	1	1207530
Importer ×net imp.	0.023	0.15	0	1	1207530
Exports	0.002	0.024	0	0.998	1207530
Imports	0.002	0.018	0	0.959	1207530
Exports ×net exp.	0.002	0.022	0	0.998	1207530
Imports ×net imp.	0.001	0.013	0	0.902	1207530
Net trade	0.002	0.021	0	1.102	1207530
Affiliate	0.008	0.089	0	1	1207530

The table presents summary statistics on the sample used in regressions reported in Tables (3) and (4). The first row is the dependent variable in regressions $\rho(\gamma_{ft}, \gamma_{Nt})$: the firm-level correlation in value added growth with country N GDP growth. Rows 2-5 give the export, import and net trade dummy variables as used in Table (3) and rows 6-9 the corresponding levels of trade. Net trade reported for completeness only, not directly used in regressions as we are interested in examining separate effects for net exporters and net importers. Finally, AFF is a dummy for if firm f is an affiliate of a firm in N.

[11] This is substantially higher than the corresponding correlation in di Giovanni et al. (2018), we discuss the comparison in detail when presenting the macro-level implications in Section 4.2.

4 Results

4.1 Firm level correlations

Let us now turn to the results of estimation of Equation (7). We first follow the specification in di Giovanni et al. (2018) closely, using dummy variables to capture export and import markets and report results in Table 3. In column 1 we see that both exporting to and importing from a country for a firm are associated with a higher correlation with that county's GDP growth. Column 2 adds firm fixed effects and exporting to a country raises the correlation with around 0.003 and importing raises the correlation with around 0.009. These numbers are similar in magnitude as the corresponding figures in di Giovanni et al. (2018) (0.005 for exports and 0.013 for imports). The firm fixed effects account for a large share of the variation in the data and we see that R-squared increases sharply. Column 3 also adds country fixed effects and we see that coefficients are somewhat larger in this specification. Being an affiliate of a firm based in a given country also raises the correlation with the GDP shocks of that country, in this specification by around 0.008.

The country fixed effects capture that business cycles across countries tend to swing in tandem. That country specific trade linkages remain relatively unchanged is in some contrast to French evidence, where the coefficient on exports halves and the coefficient on imports is reduced by three quarters. A possible explanation is that Sweden has a floating exchange rate vis-à-vis all trading partners which offers a very direct link between country-level shocks and firm level value added. This is consistent with a pattern where exchange rate changes, operating via export and imports, are an important mechanism. To take an intuitive example consider Germany which is Sweden's largest export market. Expectations about business cycle and various common shocks within the EU (both Sweden and Germany are members of the EU) may lead to a correlation between German GDP and firm level value added across the whole population of Swedish firms. The fixed effects at the country level address this concern and the export and import dummy variables capture the effect of trading with Germany. Thus, the evidence supports the conclusion in di Giovanni et al. (2018) that there is robust evidence for the transmission of shocks via trade and ownership.

In columns (3) and (6) of Table 3 we include interaction effects to capture matched trade with the respective country. Point estimates are negative, which indicates that revenue and cost shocks tend to have a moderating effect on each other. Indeed, in column (5) we cannot reject that the effect of being a net exporter to country N if one

also imports from country N is zero. [12]. A simply dummy is a rather crude measure to capture the impact of these trade links, and we can also take into account the intensity of the trade links, which we turn to Table 4.

We also note that, as in the French case, coefficients are throughout stronger for imports than for exports. In Table 3 column 2 and 3, the estimated effect of imports is significantly larger than exports at the 5% and 1% levels of significance, respectively.

Table 3: Correlation with foreign GDP and firm level trade linkages (dummy variables), Sweden 1997-2014.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Exporter	0.0490***	0.00292*	0.00378**	0.0551***	0.00723***	0.00551***
	(0.00330)	(0.00162)	(0.00175)	(0.00417)	(0.00206)	(0.00209)
Importer	0.0464***	0.00894***	0.0108***	0.0528***	0.0124***	0.0124***
	(0.00295)	(0.00140)	(0.00147)	(0.00342)	(0.00163)	(0.00168)
Exporter ×				-0.0111**	-0.00822***	-0.00337
net exp.				(0.00449)	(0.00241)	(0.00246)
Importer ×				-0.0161***	-0.00886***	-0.00427*
net imp.				(0.00430)	(0.00232)	(0.00233)
Affiliate	-0.0115**	0.00590	0.00758*	-0.0109**	0.00613	0.00771*
	(0.00525)	(0.00412)	(0.00412)	(0.00526)	(0.00413)	(0.00413)
Constant	0.0660***	0.0708***	0.0877***	0.0660***	0.0708***	0.0877***
	(0.00144)	(0.000112)	(0.00115)	(0.00144)	(0.000112)	(0.00115)
Observations	1,207,530	1,207,530	1,207,530	1,207,530	1,207,530	1,207,530
R-squared	0.001	0.452	0.453	0.001	0.452	0.453
Firm FE	NO	YES	YES	NO	YES	YES
Country FE	NO	NO	YES	NO	NO	YES

This table reports the result of estimation Equation 3 with $\rho(\gamma_{ft}, \gamma_{Nt})$ as dependent variabel and trade patterns captured by dummy variables. Standard errors clustered at the firm level: * p<0.10, ** p<0.05, *** p<0.01.

Columns (1)-(3) of Table 4 replicate the corresponding columns from Table 3 and find similar patterns using trade levels rather than dummy variables for trade status. To discuss results let us turn directly to column (3) which includes firm and country fixed effects. Again we see that exporting and importing are associated with a higher correlation with the GDP of that country also after controlling for country fixed effects. Both in terms of magnitude and statistical significance the effects are stronger for imports

[12]The estimated contingent effect of trade linkages for firms that match trade is -0.001 with a p value of 0.614 for net exporters, and 0.003 with a p-value of 0.088 for importers.

than for exports. The effect of being a foreign affiliate is stable compared to Table 3. In columns (4)-(6) of Table 4 we include interaction effects. In column (5) we use firm level fixed effects and the coefficients indicate that matching import and export flows reduces firm exposure to foreign GDP variation.

This indicates that "natural hedging" serves to limit the exposure and that the correlation between firm level profits and foreign GDP is mainly driven by firms that have very unbalanced trade patterns. With country fixed effects the coefficients on the interaction terms decrease somewhat and the interaction on interaction is no longer significant.

Table 4: Correlation with foreign GDP and firm level trade linkages (trade shares), Sweden 1997-2014.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES						
Exports	0.190***	0.0144	0.0198*	0.242***	0.0684***	0.0609***
	(0.0212)	(0.0105)	(0.0107)	(0.0453)	(0.0233)	(0.0234)
Imports	0.315***	0.0425***	0.0430***	0.320***	0.0726***	0.0627***
	(0.0228)	(0.0136)	(0.0136)	(0.0325)	(0.0188)	(0.0189)
Exports ×				-0.0652	-0.0695***	-0.0527**
net exp.				(0.0475)	(0.0259)	(0.0260)
Imports ×				-0.0126	-0.0632**	-0.0416
net imp.				(0.0427)	(0.0259)	(0.0259)
Affiliate	0.00180	0.00659	0.00838**	0.00190	0.00682	0.00852**
	(0.00536)	(0.00420)	(0.00421)	(0.00536)	(0.00421)	(0.00421)
Constant	0.0705***	0.0715***	0.0882***	0.0705***	0.0715***	0.0882***
	(0.00138)	(4.27e-05)	(0.00115)	(0.00138)	(4.27e-05)	(0.00115)
Observations	1,207,530	1,207,530	1,207,530	1,207,530	1,207,530	1,207,530
R-squared	0.000	0.452	0.453	0.000	0.452	0.453
Firm FE	NO	YES	YES	NO	YES	YES
Country FE	NO	NO	YES	NO	NO	YES

This table reports the result of estimation Equation 3 with $\rho(\gamma_{ft}, \gamma_{Nt})$ as dependent variable and trade patterns captured by actual values (in SEK) of (net) exports and (net) imports. Standard errors clustered at the firm level: * p<0.10, ** p<0.05, *** p<0.01.

In summary, the micro-level evidence clearly point to that firm level trade with a market raises the correlation between a firm's value added and the GDP of the trading partner. This is in line with the evidence from France presented in di Giovanni et al. (2018). When net trade at the firm level is accounted for this serves to make the correlation statistically indistinguishable from zero however, suggesting that the logic of natural

hedging plays an import moderating role. For a firm that both exports to, and imports from, a particular partner country the two effects tend to cancel. A second question is whether such natural hedging at the firm level firm level also is important quantitatively important enough to affect the overall correlation between Swedish and foreign shocks, an issue that we turn to in the next section.

4.2 Aggregate implications

As described in Equation 2 the country level correlation between Swedish value added growth and GDP growh in country N can be expressed as a weighted average of firm-level correlations. As the aggregate correlation is built from the ground up this relation can also be used to examine counterfactual scenarios, in particular how would the aggregate correlation change if trade flows at the firm level were severed and how would they change if granularity were not an issue and all firms trading with a particular country carried the same weight? To examine the predicted firm level change in correlation as a result of severing trade flows we use the coefficients that come out of estimation of Equation 3 and reported in columns (3) and (6) of Table (3) respectively.

Table 5 presents aggregate correlations with Sweden's top 15 trading partners and the results of a set of counterfactual exercises. Column 1 presents the aggregete correlation. The country-level correlations range from 0.13 for China to above 0.8 for in particular large)(Germany, USA) and close (Denmark, Finland, Norway). Column (2) presents the change in correlation that would result if the international linkages at the firm level were severed, that is for a firm that is connected with country A it correlation decreases by the amount of the point estimates from 3 as reported in columns (3) of Table (3). The dummy variables for EXP, IMP and AFF are set counterfactually set to 0 for the respective country and the resulting change in overall correlation is outlined in column (2) of Table 5. On average correlations fall by 0.08, thus the average correlation between Swedish value added growth and foreign GDP growth would fall from 0.72 to 0.64 under this counterfactual. Column (3) gives that standard error of the estimated fall in correlation and all the changes are statistically significant at the 1% level.

These results can be compared to the results for France reported in di Giovanni et al. (2018, Table 8). The fall in correlations in the scenario without direct linkages is is quite simular, they find an estimate of -0.098 compared to -0.083 in the Swedish data. The level of correlations is much higher for the Swedish data however: 0.72 compared to 0.29 for France in the 1993-2007 period. Two potential reasons for the difference stand out:

first the time period in the present paper includes the great recession when the business cycle in many countries experienced large simultaneous falls and, albeit less coordinated, coincident recovery. Indeed the average correlation if we estimate with 2007 as an end-year falls to approximately 0.5. Second, Sweden is a more open and smaller economy than France that can be expected to swing more in tandem with the rest of the world.

In column (4) we report the predicted fall in the correlation between Swedish value added growth and foreign GDP growth if all direct (trade and affiliate) links with the respective country were severed but counterfactually all firms that all firms are the same size and hence given the same weight. The overall correlation would in this scenario fall only marginally: on average the fall would be -0.01 and hence the overall correlation would fall from 0.72 to 0.71. A comparison between column (2), the experiment with the actual size distribution of firms, and the equal weights specification in (4) shows a marked difference. With weights reflecting the actual share of value added for Swedish firms the effect is sizeable (-0.083) whereas it is economically inconsequential (-0.01) in the equal weights case. This implies that the unequal size distribution of firms, granularity, is of great importance for how trade and affiliate links transmit shocks in Sweden. For the French case as reported in di Giovanni et al. (2018, Table 8) the effect with actual weights is four times as large as the effect without granularity whereas in the Swedish case the corresponding number is eight times as large. This indicates that granularity plays an even greater role in Sweden, a result that is in line with expectations as Sweden is a smaller country with exports highly dominated by relatively few large firms. An examination of the country-by-country fall in correlations also yield patterns that lend themselves to interpretation. For instance the fall in correlation with equal weights is the greatest for neighboring Norway, a market that is served also by many smaller Swedish firms and low for a hard to enter distant market like Japan. Even though country-by-country estimates are low the estimated effects are all statistically significant at the 1% level as seen by the standard errors in column (5).

In column (6) finally we repeat the experiment in column (2) but instead use the specification that also takes account of net trade, as reported in column (6) of Table (3). We previously established that natural hedging, exporting and importing from the same market lowered the firm-level correlation with a foreign market sufficiently to make it statistically indistinguishable from zero. In other words, natural hedging had a powerful firm-level effect on comovements. We here ask the question if natural hedging also plays an important role at the macro level where we examine the correlation of Swedish value added growth with foreign GDP growth. The short answer is no. Comparing the average

fall in correlation in the natural hedge specification (-0.081) with the average fall in the benchmark specification (-0.083) we note that the direction of the difference is as expected but that the quantitative importance is trivial. This is true also as we make a country-by-country comparison.

Table 5: Changes in Aggregate Correlations across Sweden's top 15 trade partners

		Sever trade and affiliate linkages: baseline		Sever trade and affiliate linkages: no granularity		Sever trade and affiliate linkages: natural hedge	
Country	ρ_A	$\Delta\rho_A$	$SE(\Delta\rho_A)$	$\Delta\rho_A$	$SE(\Delta\rho_A)$	$\Delta\rho_A$	$SE(\Delta\rho_A)$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Belgium	0.875	-0.071	0.010	-0.006	0.001	-0.071	0.011
China	0.128	-0.070	0.010	-0.008	0.001	-0.067	0.012
Germany	0.831	-0.101	0.013	-0.014	0.002	-0.098	0.019
Denmark	0.909	-0.098	0.013	-0.014	0.002	-0.096	0.015
Spain	0.681	-0.059	0.009	-0.005	0.001	-0.059	0.010
Finland	0.848	-0.094	0.013	-0.011	0.002	-0.091	0.016
France	0.872	-0.081	0.011	-0.008	0.001	-0.079	0.015
Great Britain	0.817	-0.095	0.012	-0.012	0.001	-0.093	0.015
Italy	0.905	-0.075	0.010	-0.008	0.001	-0.074	0.012
Japan	0.744	-0.061	0.009	-0.005	0.001	-0.057	0.012
Netherlands	0.795	-0.089	0.011	-0.011	0.001	-0.087	0.014
Norway	0.650	-0.126	0.018	-0.024	0.004	-0.121	0.022
Poland	0.470	-0.064	0.010	-0.005	0.001	-0.061	0.013
Russia	0.459	-0.049	0.008	-0.002	0.000	-0.047	0.009
USA	0.853	-0.120	0.015	-0.017	0.002	-0.115	0.020
Average	0.722	-0.083		-0.010		-0.081	

Column (1) of this table reports the correlation between the Swedish growth in value added and the respective partner country GDP growth. The remaining columns present the estimated effect of various counterfactual experiments using the aggregation in Equation 2 on the correlation (columns 2, 4 and 6) as well as the respective standard errors of the estimated effects (columns 3, 5 and 7). Counterfactual exercises based on estimates reported in column 3 (columns 2 and 4 in this Table) and column 6 (column 6 in this Table) of Table (3).

5 Conclusion

The extent and sources of international business cycle comovement is a central one to research in international finance and of importance for policy regarding for instance mon-

etary unions and international policy coordination. Theoretical developments and access to detailed data have spurred interest in the role of firm level linkages for understanding business cycle comovements. Our results show that the results for Sweden are qualitatively and quantitatively similar for Sweden as for pioneering work that examines French data, thus taking steps towards understanding what patterns that appear robust across countries.

We also establish that firm-level exposure to foreign markets that stem from exporting to and importing from a given foreign market tend to net out. In other words, natural hedging appears to work. By documenting the extent of such natural hedging at the firm level and examining its effect on firm-level correlations we believe that we make a substantial contribution to this area of research in the intersection between corporate finance and international finance. While natural hedging appears important at the firm level it does not appear to have quantitatively important effect for the macro-level business cycle correlation across countries. Sweden is a relatively small country with a floating exchange rate and it will be interesting to see in future work whether these results hold also for other countries.

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