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

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Abstract

This article 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 gross domestic product (GDP) growth. Export and import links increase the firm-level correlation but net out for firms that both export to and import from the same market, evidence that this type of 'natural hedging' can help reduce a 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. Natural hedging is quantitatively important at the firm level and also plays a role in limiting overall comovements.

KEYWORDS

firm heterogeneity, granular effects, international trade, natural hedging, transmission of shocks

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 (see e.g., Acemoglu, Carvalho, Ozdaglar, & Tahbaz-Salehi,- 2012; di Giovanni, Levchenko, & Mejean, 2014; Gabaix, 2011). Similarly, the international trade of countries is typically dominated by relatively few firms and in recent work di Giovanni, Levchenko, and Mejean (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 firm-level linkages with foreign markets in terms of

trade and affiliations within multinational firms matter substantially for the correlation between the French value added growth and GDP growth of partner countries. On average severing such linkages is predicted to lower the correlation with a foreign country from around 0.3 to 0.2.

The current article makes use of similarly rich firm × national market export and import data for all Swedish private sector firms for 1997–2014 to examine the firm level contribution of trade on international comovement. Our main innovation is to examine the transmission of international shocks when the firm both imports and exports from the same currency area. Matching the origin of imports with the destination of exports (henceforth

referred to as simply 'matching trade') could reduce a firm's exposure to foreign shocks, or alternatively could increase a firm's exposure to foreign shocks. We investigate whether it is *net trade* or *gross trade* that matters in determining a firm's exposure to foreign shocks.

di Giovanni et al. (2018) use dummy variables to capture whether a firm exports to and imports from a given market. One might interpret this as implying that the effects are determined by gross trade. 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 & Rose, 1998; Imbs, 2004; Johnson, 2014; Ductor & Leiva-Leon, 2016). The focus in the previous literature has thus been on gross trade.

Our article is motivated by the hypothesis that, at least for some types of shocks, it is net trade that determines exposure: the effects of exports and imports on firm level correlations with foreign GDP might be partly offset.[1] For instance, consider a positive growth shock to the United Kingdom which leads to a depreciation of the Swedish krona (SEK) against the British pound. Other things equal a depreciation of SEK that increases export revenue from UK (when measured in SEK) will at the same time increase import costs from the UK and offset the effect on profits. This is an example where the net exposure will be lower than gross exposures and serves as a motivation for the examination of the effect of two-way trade on firm-level correlations with foreign GDP. We document that matched trade at the firm level is indeed common in the Swedish data using a modified Grubel–Lloyd index, which has been used previously to characterize the degree of intra-industry trade.

We find that firms that match trade reduce their exposure to foreign shocks. We also establish effects of gross trade that are similar to the effects reported by di Giovanni et al. (2018) using French data. Thus, exporting to, or importing from, a market exposes the firm to shocks originating from that market, but matching exports and imports effectively reduces the firm's exposure to these shocks. According to our model, the predicted correlation between a foreign market's GDP growth and the firm's value added growth is close to zero for instances of matched trade. This suggests that at the firm level, it is net trade that determines the exposure of the firm to foreign shocks.

This first set of results is a contribution to microeconomic and corporate finance aspects of trade. Matched trade flows at the firm level might come about by differential trade costs (as in gravity models of trade, see e.g., Head & Mayer, 2014 or Chaney, 2018) or in other ways that might be viewed as a coincidence from the perspective of the firm. It might also come about through strategic risk management decisions by firms ('natural hedging'). In teaching of risk management (see e.g., Brealey, Myers, & Allen, 2017), and in discussions of firm 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'.[2]

In the present article, we do not try to establish the motivation for matched trade at the firm level. We aim to provide evidence on the effects of natural hedging, of interest to the literature on risk management, by documenting whether more balanced trade flows at the firm level are associated with a lower correlation between firm level value added and foreign GDP.[3] Note that we apply the term 'natural hedging' somewhat loosely. Strictly speaking matching trade at the country-firm level only acts as a hedge for a well-defined exchange rate shock and matching imports and exports do not neccesarily serve as a hedge for other country-specific shocks, an argumentation that we develop further below.

The new micro-evidence in this article supports the notion that natural hedging of currency risk has a strong effect on firm variability in value added. We are not aware of any previous research that attempts to quantify the effect of this type of natural hedging on the variability of value added.[4] Let us however highlight an important related article, using similar data as we do, which 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, Itskhoki, and Konings (2014)). While the focus in that article differs from the present, it similarly establishes important connections between import and export markets.

Does the firm-level phenomenon of matched trade that we report have macro-economic implications for the role of bilateral trade in the international transmission of shocks? We establish that firm-level trade/affiliate links provide an important contribution to international business-cycle comovements. On average severing, these firm-level international links reduces the correlation between Swedish value added growth and foreign GDP growth from 0.722 to approximately 0.621. 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 would be substantially reduced. The largest firms thus play a central role in the international transmission of shocks. Moreover, we establish that matched trade at the firm level has a economically significant effect on aggregate correlations between Swedish and foreign GDP. The

aggregate effect of severing firm-level international links is reduced by around 20% when matched trade effects are included. In sum, we document substantial effects of matched trade both at the firm-level and in aggregate.

These results tie into a rich literature that examines the role of bilateral trade in the international transmission of shocks. As noted above the literature typically reports a strong positive relation between trade and business cycle comovements: countries that trade more have stronger covariance of business cycles. Understanding the reasons for the correlation is important for instance for understanding the effects of a monetary union (which motivated the seminal work of Frankel & Rose, 1998) or more broadly for understanding how shocks affect the world economy. Generating the magnitude of business cycle comovement found in the data in theoretical international real business cycle models has proven elusive and generated a large body of work focused on understanding how models can match the facts (see e.g., Johnson, 2014; Kose & Yi, 2006). One concern with the interpretation of empirical work is that common shocks, rather than trade itself, might be driving correlations and substantive work finds important effects for other linkages, for instance financial linkages (see e.g., Imbs, 2004; Kalemli-Ozcan, Papaioannou, & Peydro, 2013). With relatively aggregated data it is hard to control for the types of shocks that affect economic activity, in particular as they might concern expectations (see e.g., Forbes & Rigobon, 2002 for a related examination of international stock market comovement). By using differential trade patterns for different firms di Giovanni et al. (2018) have been able to rely on firm-level data to identify effects of trade linkages on correlations. In following their approach, we add to the evidence on the causal contribution of trade to business cycle comovements.[5]

The next section outlines a theoretical framework and presents the empirical model used to estimate the 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 then presents results, first at the firm level and then at the aggregate level. The final section concludes.

2 | MATCHED TRADE AND THE TRANSMISSION OF FOREIGN SHOCKS TO THE FIRM

2.1 | Theoretical motivation

At the firm level, trade and multinational linkages with a foreign country are associated with a significantly higher correlation between the firm and that country (di Giovanni et al., 2018). However, some firms export and import from the same country, that is, they engage in matched trade.

Matching trade may increase or decrease the firm's exposure to foreign shocks. The outcome depends in part on the nature of the foreign shocks. In the following, we outline a simple theoretical framework to anchor the discussion.[6]

Consider a firm f that sells to a set of countries (including the home country) indexed with $n \in (i, N)$ and uses intermediate inputs from various source countries $m \in (1, M)$ in year t. Export and import destinations are taken as given and we thus disregard the extensive margin of trade.[7] Assume that the marginal cost of producing is constant such that the profit function is separable across destinations: $c_{fnt} = c_{ft} \forall n$. Further assume that firms' technology is given by a Cobb–Douglas production function with labor and intermediate goods as production factors. The marginal cost of producing then becomes

$$c_{ft} = w^{\alpha} \left(\Pi_m p_{I,mt}^{SM_{fm}} \right)^{1-\alpha} \quad (1)$$

where α is the labor share and all firms face an identical labor cost w. $1 - \alpha$ is the share of intermediate goods in costs. $p_{I,m}$ denotes the price of intermediate goods sourced from country m and SM_{fm} is the firm specific share of inputs from country m. The home country is one of the m potential sources, which allows the model to capture a pure exporter.

Further assume that demand in country n for firm f's product is log-linear with elasticity $\sigma > 1$ and affected by a market-specific demand shifter D_n. Profit for a firm (disregarding fixed costs) is then given by

$$\pi_{ft} = \sum_n \left(p_{fnt} - c_{ft} \right) p_{fnt}^{-\sigma} D_{nt} \quad (2)$$

where p_{fnt} denotes the firm's price in market n. Maximization of profits with respect to price gives the standard condition that $p_{fnt} = c_{ft}(\sigma/(\sigma - 1))$. Substituting marginal costs (Equation 1) and optimal prices into the expression for profit (Equation 2) yields an expression for profit as dependent on wages, import prices, demand shocks and the set of countries with which a firm trades. We take the natural logarithm of the resulting expression and use total differentiation to approximate the growth of value added for firm f:

$$\gamma_{ft} = d\ln \sum_n \pi_{fnt}$$
$$\approx \sum_n SX_{fnt-1} d\ln \pi_{fnt}$$
$$\approx \sum_n SX_{fnt-1} d\ln D_{nt}$$
$$- (\sigma - 1)\alpha d\ln w_t - (\sigma - 1)(1 - \alpha) \sum_m SM_{fmt-1} d\ln p_{I,mt} \quad (3)$$

where SX_{fnt-1} is the share of market n in a firm's revenue and SM_{fmt-1} is the share of intermediate inputs from country m. The shares SX_{fn} and SM_{fm} are henceforth assumed to be constant to simplify the exposition.[8]

With these basic elements in place, we first examine two cases where a firm is exposed to shocks originating from a foreign country: (a) a pure exporter, (b) a firm that both exports and imports (matched trade).

If we assume that all shocks are uncorrelated across countries, then a firm that exports to a country n but does not import from that country would have a covariance with country n as given by

$$cov\left(\gamma_{ft}, \gamma_{nt}\right) = SX_{fn} \times cov(d\ln D_{nt}, \gamma_{nt}) \qquad (4)$$

where γ_{nt} denotes the growth rate of GDP in year t in country n. A firm that both exports to, and imports from, country n would have a covariance that decomposes according to

$$cov\left(\gamma_{ft}, \gamma_{nt}\right) = SX_{fn} \times cov(d\ln D_{nt}, \gamma_{nt}) \\ -(\sigma-1)(1-\alpha)SM_{fn} \times cov\left(d\ln p_{nt}^{I}, \gamma_{nt}\right) \qquad (5)$$

If revenue and cost move in the same direction in response to a foreign shock, that is, if both $cov(d\ln D_{nt}, \gamma_{nt})$ and $cov\left(d\ln p_{nt}^{I}, \gamma_{nt}\right)$ have the same sign, then matching trade decreases $cov(\gamma_{ft}, \gamma_{nt})$. This is clearly the case if prices are rigid in the currency of the country of production and the exchange rate is a main conduit for the shock. Higher export revenue due to a depreciation against country n are then offset by higher cost of imports from n.[9] Nominal exchange rate movements notwithstanding, there are clearly other events that would yield the same outcome, such as positive growth shocks in country n can increase sales revenue and import costs at the same time.

However, matching trade would *increase* the firm's exposure to foreign shocks if $cov(d\ln D_{nt}, \gamma_{nt})$ and $cov\left(d\ln p_{nt}^{I}, \gamma_{nt}\right)$ have different signs. For example, a negative GDP shock in the foreign country, due to political gridlock and/or labor strikes, could plausibly lead to a fall in demand (negative revenue shock) and higher cost of imports (positive cost shock) and we would then expect

$$cov(d\ln D_{nt}, \gamma_{nt}) > 0 \\ cov(d\ln p_{nt}^{I}, \gamma_{nt}) < 0. \qquad (6)$$

In the latter case Equation (6), together with Equation (5), imply that revenue and cost shocks amplify the volatility of profits for a firm that matches exports and

imports with a single country. Sourcing inputs from the same destination country would then increase the firm's exposure to shocks specific to that country.

The theoretical discussion has highlighted that simultaneously exporting to, and importing from, a given foreign country can both lower and raise the correlation of firm level value added with country-specific shocks relative to a pure exporter and analogously for a pure importer. The model as presented indicates that the effects of exports and imports on covariance are additive. This implies that in the empirical work that follows it would not be a concern if the effect of source country shocks on the correlation with a firm's value added were identified mainly off of pure importers. However, under the simple structure above, imports are only intermediate inputs in production and source country shocks only affect value added via import prices.

In practice, we may expect a richer set of shocks to affect costs and demand. Particularly important may be that imports of final goods from a country might increase as an effect of local demand shocks that are correlated with source country growth. As a simple example note that growth in Italy might be correlated with a taste shock for Italian food products among Swedish consumers. Consider a case where some imports are consumption goods and are imported by a wholesaler h with the same demand function as above but with a simpler cost structure and a source country specific demand shifter S_m,

$$\pi_{ht} = (p_{hmt} - p_{I,mt})p_{hmt}^{-\sigma}S_m \qquad (7)$$

Value added growth for such a pure importer would be

$$\gamma_{ht} \approx d\ln S_{mt} - (\sigma-1)d\ln p_{I,mt}$$

and a positive covariance between S_m shocks and source country GDP growth can generate a strong positive correlation between firm growth in value added and source country shocks. This highlights that pure importers of finished products may be quite different from firms that both export and import. To allow for this to impact, the estimations we allow for effects that are different for firms that match trade with a given partner country than for those that do not.

2.2 | Empirical model

We follow the methodology of di Giovanni et al. (2018). The growth rate of firm value added is defined as

$\gamma_{ft} = \pi_{ft}/\pi_{ft-1} - 1$. Let ω_{ft-1} denote the share of firm f in the aggregate value added of Swedish firms. The growth in total Swedish value added is $\gamma_{At} = \sum_f \omega_{ft-1} \gamma_{ft}$. International comovement is measured by the correlation between GDP growth rate of country n denoted by γ_{nt}, and the growth in total Swedish value added γ_{At}. This correlation can be rewritten as the weighted sum of firm level correlations with foreign growth rates:

$$
\rho\left(\gamma_{At}, \gamma_{n,t}\right) = \frac{cov\left(\sum_f \omega_{ft-1} \gamma_{ft}, \gamma_{nt}\right)}{\sigma_A \sigma_n}
$$
$$
= \sum_f \omega_{ft-1} \frac{\sigma_f}{\sigma_A} \rho\left(\gamma_{ft}, \gamma_{nt}\right) \tag{8}
$$

where σ_f, σ_A and σ_n are the standard deviations of the growth rates of firm value added, aggregate Swedish value added and country n GDP, respectively. To examine the firm-level determinants of the correlation between value added growth of firm f and country n GDP growth, we estimate the following equation:

$$
\rho\left(\gamma_{ft}, \gamma_{n,t}\right) = \alpha + \beta_1 EX_{f,n} + \beta_2 EX_{f,n} \times match_{f,n}^{EX}
$$
$$
+ \beta_3 IM_{f,n} + \beta_4 IM_{f,n} \times match_{f,n}^{IM} + \beta_5 AFF_{f,n} + \delta_f + \delta_n + \eta_{f,n}. \tag{9}
$$

$EX_{f,n}$ is a dummy variable that is equal to 1 if firm f exports to country n over at least 4 years. $IM_{f,n}$ is the corresponding dummy variable for imports.

We also include indicator variables to capture instances where a firm imports to and exports from the same country: $match_{f,n}^{EX}$ is a dummy that is equal to 1 if firm f both exports and imports with country n and exports more than it imports from country n (i.e., is a net exporter) and $match_{f,n}^{IM}$ is the corresponding dummy variables for imports. Absent these interactions effects the impact of the exporter and importer dummy variables on the correlation will be identified by pure exporters, pure importers and by firms that both import and export: matched trade effects are not separately identified. Inclusion of the interaction terms allows for a refinement of the interpretation for the impact of matched export and import flows on the correlation of a firm's growth with foreign GDP. As exemplified by the discussion of source-country specific demand shocks in the previous section, the estimates of correlations based on pure importers of consumer goods may for instance reflect different mechanisms than those for two-way traders that import intermediate inputs. That said, the model is reduced-form and does not allow us to distinguish various structural sources of comovements.

Results may therefore be sensitive to the period and idiosyncrasies of Swedish trade.

$AFF_{f,n}$ is dummy variable 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 $match_{f,n}^{EX}$ and $match_{f,n}^{IM}$, this specification is identical to the benchmark specification in di Giovanni et al. (2018).[10]

In a second set of regressions, we estimate the same specification but use continuous levels of exports and imports. We define $SX_{f,n}$ as the average share of firm f's export revenue from country n in total firm sales for firms that export at least 4 years from a country. Likewise, $SM_{f,n}$ is the average share of firm f import costs from country n in total firm costs for firms that import at least 4 years from a country.

3 | DATA AND DESCRIPTIVE STATISTICS

Our source of data is Sweden's official statistical agency, SCB (2019). We use yearly data on firm × country exports and imports for all Swedish private sector firms with at least 10 employees.[11] We consider trade with the 15 largest export destinations during this time period.[12] The trade data are from Statistics Sweden and cover 1997–2014. The dummy variable on whether a firm is a Swedish affiliate (AFF) of a country n firm is from the database Serrano.[13] Sweden has a floating exchange rate throughout the period.

Table 1 describes these bilateral trade patterns at the firm level. The average firm in the sample exports to around four destinations (out of the 15) and imports from around four origins. While there is some overlap it is clear that many firms do not match trade: the majority of firms either export to, or import from, a given market as indicated by the fact that the average number of trading partners is above eight. At the firm level, the correlation between the number of export and import markets is 0.74 suggesting that firms that exports to more destinations also import from more origins. Both exports and imports are quite concentrated as indicated by mean Herfindahl–Hirschmann indices (HHI) of export and import concentration of around 0.75.[14]

To further gauge the magnitude of matched trade at the firm level we consider a close analogue of Grubel–Lloyd index of intra-industry trade, used to measure the extent 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 adapt the method to a Grubel–Lloyd index of

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	200,316	200,316	200,316	200,316	200,316	200,316
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

Note: The table presents summary statistics at the firm level for Swedish private sector firms engaged in importing and/or exporting over the period 1997–2014. HHI exports is a Herfindahl–Hirschmann index of concentration: the sum of squared shares of value of exports over markets N over total firm exports, and analogously for HHI 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.

'natural hedging', which we denote GLINH. It is analogous to a Grubel–Lloyd index of intra-industry trade at the level of total manufacturing (see e.g., OECD (2011)). For each firm f we define

$$GLINH_{ft} = \left(1 - \frac{\sum_{n=1}^{N} |X_{nft} - M_{nft}|}{\sum_{n=1}^{N} (X_{nft} + M_{nft})} \right) \times 100 \quad (10)$$

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. The index takes a value 100 if the firm's trade flows are perfectly matched across all foreign markets N, and a value of 0 if trade flows are totally unbalanced. GLINH is therefore a measure of natural hedging at the firm level and higher values are associated with more natural hedging.[15] To the best of our knowledge, this is the first application of the Grubel–Lloyd index to firm-level trade flows. Across the sample of firms engaged in trade, GLINH averages around 12, indicating a relatively low level of natural hedging. For perspective note that a firm which sells for 80 SEK to one market and 20 SEK to another, and imports for 10 SEK from both markets, achieves a GLINH of 33.

The lower panel of Table 1 reports the same statistics for the largest 50 firms in the sample. As expected, the largest firms have more trade partners, and have a higher incidence of matched trade with a mean GLINH of around 30. These largest firms will therefore have a disproportionate effect on transmitting foreign shocks to aggregate effects in Sweden.

In Table 2, we report summary statistics for the regression sample. The average correlation between firm-level value added growth and trading partner GDP growth is 0.07.[16] 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 affiliate of a firm based in n.

4 | RESULTS

4.1 | Firm-level correlations

We first replicate the results of di Giovanni et al. (2018), using dummy variables to capture firm trade links. The

TABLE 2 Summary statistics regression sample of firms, Sweden 1997–2014

	Variable	Mean	SD	Min.	Max.
$\rho(\gamma_{f,t},\gamma_{n,t})$	Correlation	0.072	0.575	−1	1
$EX_{f,n}$	Exporter dummy	0.057	0.232	0	1
$IM_{f,n}$	Importer dummy	0.063	0.243	0	1
$EX_{f,n} \times match_{f,n}^{EX}$		0.032	0.176	0	1
$IM_{f,n} \times match_{f,n}^{IM}$		0.023	0.15	0	1
$SX_{f,n}$	Exporter share	0.002	0.024	0	0.998
$SM_{f,n}$	Importer share	0.002	0.018	0	0.959
$SX_{f,n} \times match_{f,n}^{EX}$		0.002	0.022	0	0.998
$SM_{f,n} \times match_{f,n}^{IM}$		0.001	0.013	0	0.902
$AFF_{f,n}$	Affiliate	0.008	0.089	0	1
$N = 1{,}207{,}530$					

Note: 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 matched trade dummy variables as used in Table 3 and rows 6–9 the corresponding levels of trade. *AFF* is a dummy for if firm f is an affiliate of a firm in n.

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 × net exp.				−0.0111**	−0.00822***	−0.00337
				(0.00449)	(0.00241)	(0.00246)
Importer × net imp.				−0.0161***	−0.00886***	−0.00427*
				(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

Note: This table reports the result of estimation Equation (9) with $\rho(\gamma_{ft},\gamma_{nt})$ as dependent variable and trade patterns captured by dummy variables. Standard errors clustered at the firm level: *p* < .10, **p* < .05, ***p* < .01.

results from estimating Equation (9) are reported in Table 3, Columns (1), (2) and (3). In Column (1), we see that firms which export to, or import from, a country have a higher correlation with that county's GDP growth. Under Column (2) we add firm fixed effects and find that exporting to a country raises the correlation by 0.003 and importing raises the correlation by 0.009. These numbers

are similar in magnitude as the corresponding figures in di Giovanni et al. (2018).[17] The firm fixed effects account for a large share of the variation in the data and we see that *R*-squared increases sharply. Under Column (3) we add country fixed effects and find that the coefficients are somewhat larger, and that being an affiliate of a firm based in a given country raises the correlation by around 0.008.

The addition of country fixed effects captures business cycles that tend to be correlated across countries. Our estimates of firm-level country-specific trade linkages remain relatively unchanged with the addition of country fixed effects, which is a contrast to the French evidence where the addition of country fixed effects halves the coefficient on exports and reduces the coefficient on imports by three quarters. Differences in time periods may be a partial explanation for the difference.[18] The evidence reported here provides further support for the conclusion in di Giovanni et al. (2018) that trade and ownership linkages matter for the transmission of shocks.

In Columns (4), (5) and (6) of Table 3 we include interaction effects to capture matched trade with a respective country. Point estimates for these interaction effects are negative across all three specification, which indicates that matching trade has a moderating effect on the firm's exposure to foreign GDP shocks. Indeed, in Column (5) we cannot reject that the total effect of matched trade with country n has zero effect on $\rho(\gamma_{ft}, \gamma_{n,t})$, for both net exporters and net importers.[19] We also note that, as in the French case, estimated effects are stronger for import links than for export links. In Table 3 Columns (2) and (3), the estimated effect of imports is significantly larger than exports at the 5 and 1% levels of significance, respectively.[20]

These results are based on a dummy variable representation of firm-level trade links across countries. This binary measure of trade could lend too much weight to firms that trade very little with a foreign country. We can also take into account the intensity of the trade links, which we turn to in Table 4.

We repeat the estimation of Equation (9), but this time firm-level trade links are captured using a continuous measure of trade intensity, that is, firm-level export and import links are captured with $SX_{f,n}$ and $SM_{f,n}$, respectively. Both specifications, with share or binary trade links, yield similar results: compare Columns (1), (2) and (3) of Table 4 with the corresponding columns in Table 3. Under Column (3), which includes firm and country fixed effects, we report again that exporting and importing are associated with a higher correlation with the GDP, and that the magnitude and statistical significance of the effects are stronger for imports than for exports. In Columns (4), (5) and (6) of Table 4, we include interaction effects for matched trade.

In Column (5), with firm fixed effects, the estimated effects indicate that matching imports and exports from a country reduces firm exposure to foreign GDP variation. We cannot reject that the total effect of matching trade with country n has zero effect on $\rho(\gamma_{ft}, \gamma_{n,t})$, for both net exporters and net importers.[21] Natural hedging limits the firm's exposure to foreign shocks. Our results suggest that

TABLE 4 Correlation with foreign GDP and firm level trade linkages (trade shares), Sweden 1997–2014

Variables	(1)	(2)	(3)	(4)	(5)	(6)
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 × net exp.				−0.0652	−0.0695***	−0.0527**
				(0.0475)	(0.0259)	(0.0260)
Imports × net imp.				−0.0126	−0.0632**	−0.0416
				(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

Note: This table reports the result of estimation Equation (9) 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: *$p < .10$, **$p < .05$, ***$p < .01$.

the correlation between firm level profits and foreign GDP is driven by firms that do not match trade with a country. With country fixed effects the coefficients on the interaction terms decrease somewhat and the coefficient on interaction for net importers is no longer significant. Being a foreign affiliate increases the firm's exposure to foreign GDP shocks.

In sum, our results provide evidence that firm-level trade increases the correlation between a firm's value added growth and the GDP growth of the trading partner. This corroborates the research of di Giovanni et al. (2018). However, matching imports and exports from a country at the firm level reduces the firm's exposure to foreign shocks. The export and import effects cancel for firms that both export to, and import from, a particular partner country. The firm's exposure to foreign shocks is therefore a function of the net trade with a given country, suggesting that natural hedging works from the perspective of the firm. Natural hedging may matter at the firm level, but we can also determine if the firm-level effects affect the aggregate correlations between the Swedish economy and its trade partners, an issue that we turn to in the next section.

4.2 | Aggregate implications

The country-level correlation between Swedish value added growth and GDP growth in country n can be expressed as a weighted average of firm-level correlations, as described in Equation (8). We use the relationship between firm-level and aggregate correlations to examine three counterfactual settings. In the first counterfactual, we sever firm-level trade and affiliate links and ignore the effects of natural hedging. For the computation, we use the coefficients obtained from the estimation of Equation (9) and reported in Column (6) of Table 3. The predicted firm-level effect of severing all international links is simply

$$\Delta \hat{\rho}_{f,n} = -\beta_1 EX_{f,n} - \beta_3 IM_{f,n} - \beta_5 AFF_{f,n}$$

We use $\Delta \hat{\rho}_{f,n}$, together with Equation (8), to compute the aggregate effect of severing all international links. Following the method of di Giovanni et al. (2018), we use the average of ω_f over the life of the firm in the sample.

Table 5 reports aggregate correlations with Sweden's top 15 trading partners and the results of the

TABLE 5 Changes in aggregate correlations across Sweden's top 15 trade partners

Country	ρ_A (1)	Sever trade and affiliate linkages: baseline		Sever trade and affiliate linkages: no granularity		Sever trade and affiliate linkages: natural hedge	
		$\Delta \rho_A$ (2)	$SE(\Delta \rho_A)$ (3)	$\Delta \rho_A$ (4)	$SE(\Delta \rho_A)$ (5)	$\Delta \rho_A$ (6)	$SE(\Delta \rho_A)$ (7)
Belgium	0.875	−0.087	0.013	−0.008	0.001	−0.071	0.011
China	0.128	−0.085	0.013	−0.010	0.001	−0.067	0.012
Germany	0.831	−0.122	0.017	−0.017	0.002	−0.098	0.019
Denmark	0.909	−0.118	0.017	−0.017	0.002	−0.096	0.015
Spain	0.681	−0.073	0.012	−0.006	0.001	−0.059	0.010
Finland	0.848	−0.114	0.016	−0.013	0.002	−0.091	0.016
France	0.872	−0.098	0.014	−0.010	0.001	−0.079	0.015
Great Britain	0.817	−0.114	0.016	−0.014	0.001	−0.093	0.015
Italy	0.905	−0.091	0.013	−0.010	0.001	−0.074	0.012
Japan	0.744	−0.074	0.011	−0.006	0.001	−0.057	0.012
Netherlands	0.795	−0.107	0.015	−0.013	0.001	−0.087	0.014
Norway	0.650	−0.154	0.023	−0.030	0.004	−0.121	0.022
Poland	0.470	−0.079	0.013	−0.007	0.001	−0.061	0.013
Russia	0.459	−0.060	0.010	−0.002	0.000	−0.047	0.009
USA	0.853	−0.144	0.020	−0.021	0.002	−0.115	0.020
Average	0.722	−0.101		−0.012		−0.081	

Note: 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 (8) 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 6 of Table 3.

counterfactual exercises. Column (1) reports the aggregate correlation across trade partners. The country-level correlations range from 0.13 for China to above 0.8 for large countries like Germany and USA, and close countries like Denmark and Finland. Column (2) presents the change in the aggregate correlation when international linkages at the firm level are severed, which is the weighted sum of $\Delta \hat{\rho}_{f,n}$ across all firms in the sample. Aggregate correlations are reduced by 0.10 on average. This means that the average correlation between Swedish value added growth and foreign GDP growth would fall from 0.72 to 0.62 under this counterfactual. Column (3) reports the standard error of the estimated reduction in aggregate correlation, and all estimates are statistically significant at the 1% level.

These counterfactual reductions in correlations are similar to those reported for France in di Giovanni et al. (2018), table 8), with an estimate of −0.098 for France compared to −0.101 for Sweden. The level of aggregate correlations between Sweden and its trade partners is much higher at 0.722 compared to 0.291 for France in the 1993–2007 period. A potential reason for the difference that time period covered in the present article includes the great recession when the business cycle in many countries experienced a large simultaneous fall and an, albeit less coordinated, coincident recovery. We note that the average aggregate correlations for Sweden for the period 1997–2007 falls to approximately 0.5. A second potential reason is that Sweden is a smaller and more open economy than France, and as such Sweden's economy can be expected to comove more with its trade partners.

In the second counterfactual setting, we again sever firm-level international links but weigh all firms equally in the aggregation. To remove the effect of granularity from the aggregation we compute Equation (8) and set $\omega_f = 1/k$ where k is the population of firms in the sample. In Column (4), we report the predicted counterfactual change in the correlation between Swedish value added growth and foreign GDP growth. Without granularity, the aggregate effect of severing firm-level international links is small: on average the fall would be −0.012 and average aggregate correlation would thus be reduced from 0.722 to 0.710. Granularity plays a key role in generating aggregate effects from severing firm-level international linkages [compare Column (2) and Column (4)]. With factual firm weights the effect of severing international links is economically consequential at −0.083, whereas it is economically inconsequential without granularity at −0.01.

Granularity plays an even greater role in Sweden than in France: the French case reported in di Giovanni et al. (2018), table 8) finds that 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 is in line with expectations as Sweden is a smaller country with exports that are more heavily dominated by relatively few large firms. This reasoning can help clarify the reductions in correlations across Sweden's trade partners. For instance, the no-granularity counterfactual reduction in correlation with equal weights is greatest for neighbouring 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 for the no-granularity counterfactual are low, the estimated effects are all statistically significant at the 1% level as seen by the standard errors in Column (5).

With the third counterfactual, we ask if matched trade at the firm level plays an important role in determining macro-level comovements. At the firm level, we have established that natural hedging reduces the firm-level correlation with a foreign market sufficiently to make it statistically indistinguishable from zero, and we have also established that firm-level international links matter in aggregate. However, it is not clear if firm-level matched trade has any impact on aggregate comovements. We therefore repeat the first counterfactual with factual firm weights, and estimate a $\Delta \hat{\rho}_{f,n}^{matched}$, which includes the effects of matched trade, using the results reported in Column (6) of Table 3:

$$\Delta \hat{\rho}_{f,n}^{matched} = -\beta_1 EX_{f,n} - \beta_2 EX_{f,n} \times match_{f,n}^{EX}$$
$$-\beta_3 IM_{f,n} - \beta_4 IM_{f,n} \times match_{f,n}^{IM} - \beta_5 AFF_{f,n}.$$

We aggregate these firm-level effects of severing international trade links using Equation (8) and find that including matched trade effects has a consequential effect on aggregate correlations. We report the results in Column (6) of Table 5. The average fall in correlation, when we include natural hedging is −0.081, whereas the average fall in the benchmark specification is −0.101. Natural hedging thus results in a limited, but still economically significant, reduction in aggregate correlations.

To understand the foundation for a non-trivial, but limited, effect of matched trade on aggregate correlations we note that even though matched trade matters at the firm-country level the summary statistics in Table 1 indicate that overall the extent of matched trade is limited. The index of natural hedging (GLINH) is on average 12.4 and 30.3 for the 50 largest firms. To put the latter in perspective note that these largest firms on average import from around 10 markets and export to around 10 markets. An average GLINH of 30 would then for instance be generated by a firm is a pure exporter in eight markets and a

pure importer in eight markets with a 70% matched trade for the remaining four markets (net exporter in two and net importer in two). Such a pattern would be consistent with a large effect of matched trade on covariances at the firm level in those four markets but a limited effect of matched trade on overall correlations.

5 | CONCLUSION

Understanding the extent and sources of international business cycle comovement is a central issue for research in international finance and of importance for guiding policy on monetary unions and international policy coordination. Theoretical developments and access to micro data have spurred interest in the role of firm-level linkages in business cycle comovements.

We establish that firm-level exposure to foreign markets is a function of the firm's net trade with that market. The evidence we report suggests that natural hedging works. We document the extent of natural hedging at the firm level and examine its effect on firm-level correlations. Natural hedging is important at the firm level, and also quantitatively important for macro-level business cycle correlations across countries. Our results for Sweden are qualitatively and quantitatively similar to the pioneering work on French data, and we are thus among the first to establish the robustness of these mechanisms outside the French context. 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. With these findings, the article makes a contribution to research at the intersection of corporate finance and international finance.

CONFLICT OF INTEREST
The authors declare there is no conflict of interest.

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ENDNOTES

[1] Also note that 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.

[2] There is remarkably little research on this form of natural hedging. One exception is the questionnaire evidence in Ito, Koibuchi, Sato, and Shimizu (2016) who report that 40% of responding firms use matching of currencies as a means of exchange rate risk management.

[3] Hoberg and Moon (2017) use textual analysis of U.S. 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.

[4] 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, Brown, & Minton, 2010; Hutson & Laing, 2014), even if some early studies suggested limited or no effects (Allayannis, Ihrig, & Weston, 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 (e.g., allowing stable investments in the face of credit constraints as in Froot, Scharfstein, & Stein, 1993). On the second we note that the evidence indeed indicates that use of financial derivatives lowers risk but that substantial risk remains (Bartram, Brown, & Conrad, 2011; Guay & Kothari, 2003) – which leaves open an interest in the effectiveness of natural hedging.

[5] In taking account of the development of (import) costs, we also relate to work using more aggregate data but that attempts to control for input costs as in Duval, Li, Saraf, and Seneviratne (2016) who use country-pair level data on value added in trade and find a stronger correlation between this measure of trade and business cycle correlation.

[6] We are grateful to an anonymous referee for suggesting this kind of modelling framework.

[7] See Antras, Fort, and Tintelnot (2017) for an analysis of interactions between sourcing decisions and fixed costs across origins.

[8] We are interested in the transmission of shocks through a firm's linkages with foreign markets and will use constant weights as part of our empirical strategy. Time varying weights risk confounding our measure of economic shocks.

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

[10] 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.

[11] We limit attention to firms that are active in at least 3 years and drop firms in the healthcare and financial sectors.

[12] 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.

[13] The Serrano database is available from the Stockholm School of Economic's Swedish House of Finance Research Data Center.

[14] 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.

[15] It should be acknowledged that there is some noise in this measure. As is typical, Swedish trade data are reported Free On Board (FOB) for exports and Cost, Insurance, Freight (CIF) for imports. We do not know the extent to which actual contracts deviate from these conditions and instead specify for instance Ex Works or Free Along Ship (see Ramberg, 2011 for a detailed description of different contractual specifications of how transport and insurance costs are handled). The noise so introduced should be limited however; the evidence is patchy but detailed studies indicate that the CIF-FOB margin is 3–5% for the US and lower yet for European countries, see Miao and Fortanier (2017) for a survey.

[16] 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.

[17] They report 0.005 for exports and 0.013 for imports in the comparable specification.

[18] In particular one might ask if the years of the financial crisis, 2008–2009, are important for the different findings. Table 6 reports the same specifications as in Table 3 but excluding the years of the financial crisis. As seen, the results are quite similar.

[19] The estimated total effect of trade linkages for firms that match trade is −0.001 with a p-value of .614 for net exporters, and .003 with a p-value of .088 for importers.

[20] Under column (2) and (3), $EX_{f,n} < IM_{f,n}$ is statistically significant at the 5 and 1% levels, respectively.

[21] The estimated total effect of trade linkages for firms that match trade is −0.001 with a p-value of .924 for net exporters, and .009 with a p-value of .613 for importers.

DATA AVAILABILITY STATEMENT

Research data are not shared. The study uses data at the level of firms and individuals from Sweden's national statistical agency SCB (2019) and sharing data violates legal requirements. In Sweden, data for individual respondents (microdata) are protected by the Secrecy Act. However, it is possible for researchers to apply for access to microdata - see https://www.scb.se/en/services/guidance-for-researchers-and-universities or contact mikrodata@scb.se further information.

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APPENDIX A.

T A B L E A1   Correlation with foreign GDP and firm level trade linkages (dummy variables), Sweden 1997–2014. Excluding years of the financial crisis 2008 and 2009

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Exporters	0.0235***	0.00412*	0.00530**	0.0338***	0.0112***	0.00837***
	(0.00314)	(0.00222)	(0.00235)	(0.00414)	(0.00284)	(0.00286)
Importer	0.0404***	0.00997***	0.0123***	0.0491***	0.0148***	0.0142***
	(0.00291)	(0.00194)	(0.00200)	(0.00346)	(0.00228)	(0.00232)
Exporter × net exp.				−0.0190***	−0.0135***	−0.00598*
				(0.00464)	(0.00336)	(0.00339)
Importer × net imp.				−0.0211***	−0.0122***	−0.00475
				(0.00446)	(0.00321)	(0.00320)
Affiliate	−0.00583	0.00855	0.0116**	−0.00524	0.00877*	0.0116**
	(0.00569)	(0.00520)	(0.00520)	(0.00569)	(0.00521)	(0.00521)
Constant	0.0543***	0.0570***	0.0825***	0.0543***	0.0571***	0.0825***
	(0.00131)	(0.000145)	(0.00137)	(0.00131)	(0.000145)	(0.00137)
Observations	1,154,002	1,154,002	1,154,002	1,154,002	1,154,002	1,154,002
R-squared	0.000	0.327	0.330	0.000	0.327	0.330
Firm FE	No	Yes	Yes	No	Yes	Yes
Country FE	No	No	Yes	No	No	Yes

Note: This table reports the result of estimation Equation (9) with $\rho(\gamma_{ft}, \gamma_{nt})$ as dependent variable and trade patterns captured by dummy variables. Standard errors clustered at the firm level: $^*p < .10$. $^{**}p < .05$. $^{**}p < .01$.