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Bilateral corporate coherence and trade diversification at the firm level

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Bilateral corporate coherence and trade diversification at the firm level*

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Abstract

The paper introduces a novel indicator of technological relatedness across firms. It considers both imported inputs and exported products to assess the similarity of firms in terms of their technological capabilities in Austria. The indicator captures technological similarity more closely than measures relying solely on exported products or overlapping industry classes. Descriptive results indicate that companies that are more closely related in the import-export product space also export and import more complex products. More complex products in turn are related to higher labor productivity levels. The impact of the proposed measure for bilateral corporate coherence on the production costs of firms is assessed by firm-level quadratic cost functions. The results indicate that bilateral coherence and related spillovers have a significant negative impact on the total cost of production of firms on average. The associated cost reduction effect follows a mildly U-shaped pattern. The paper also assesses the impact of bilateral coherence on the margins of trade at the firm level. The results indicate that firms with a higher bilateral coherence, and associated spillovers, have a positive impact on the diversification of both the export portfolio and imported inputs. The impacts on intensive margins and both import and export concentration are more ambiguous.

Keywords: corporate coherence, spillovers, economies of scope, extensive and intensive margins in trade

JEL: I25, O11, O14

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1. Introduction

Drawing on earlier work by Rumelt (1982) the paper by Teece et al (1994) has been among the most influential contributions to recognize the role of corporate coherence as a main determinant of diversification in economic activities. In the view of these authors, firms are coherent to the extent that their constituent businesses are related to one another, such that while firms grow more diverse, they do this in related corporate activities.

The underlying notion of relatedness is key here. Over the years different relatedness measures have been developed using (exported) products, technologies (technology classes in patents), or industries (industry classifications).[1] Typically these indicators capture observed co-occurrences across units of observation (e.g., firms, patents, export product lines) and thus the similarity between essential traits in economic, productive, or technological activities. The relatedness measures are then interpreted as proxies for specific capabilities and knowledge bases upon which economic agents build when they develop or adjust their competitive strategies.

Hence, relatedness measures are considered to be predictors for the probability of a firm in entering a new economic or technological activity. As Bryce and Winter (2009) point out, this is distinct from diversification measures that capture just a state of a corporate portfolio at a specific point in time. Relatedness measures in turn characterize the flow or transition from state to state.

The theoretical rationale for relatedness indicators is that corporate diversification and expansion are shaped by consideration of economic efficiency. Opportunities for profitable

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[1] For recent discussions and elaborations see Botazzi – Pirino (2010) or Pugliese et al (2019a).

diversification arise because resources and capabilities supporting the existing portfolio of activities overlap with capabilities and resources needed for a profitable new activity. Bryce and Winter (2009) underscore that these overlaps generate economies of scope. While in the short run these are driven by indivisibilities in tangible assets that are underutilized for the specific product mix of a firm, in the long run they are more likely related to intangible assets such as specialized types of knowledge. These allow firm entering new product lines that can be produced at lower cost and better quality relative to competitors that cannot draw on such a specialized cumulated knowledge base.

The notion of corporate coherence and relatedness extends beyond firm boundaries. Firms that are related in terms of their technologies and knowledge bases are also more likely to benefit from knowledge spillovers and other untraded interdependencies such as specific work practices or tacit organizational knowledge (e.g., Klepper 2010; Friesenbichler and Glocker, 2019; Friesenbichler and Kügler, 2022). Hausmann and Klinger (2007) link product relatedness also to a higher degree of better labor mobility across economic activities as companies implicitly jointly invest in education, training, and research. This ensures a more efficient allocation of labor across firms. This stock of specialized knowledge and intangible assets across firms therefore acts like industry level economies of scope.

This gives rise to positive feedbacks which in turn are also a source of path dependence in economic development (Hidalgo et al 2007). Firms, industries, and countries tend to develop along trajectories that are to a considerable extent predetermined by their prior knowledge base. Changes to these trajectories require major investments and risk taking (c.f. Hidalgo 2022).

More recent research has also tried to explore the linkages between different types of relatedness measures. Studying path dependence in the export specialization of EU countries, Reinstaller and Reschenhofer (2019), for instance, show that unrelated diversification in the technology space can support overcoming path dependencies in the product space while at the same time deepening competitive advantages in existing specializations. Jara-Figueroa et al (2018) study the probability of survival and growth of pioneering firms, i.e., firms operating in an industry that was previously not present in a specific region. Their paper shows that the growth and survival probability of these firms increases significantly if their first employees have experience in related industries and work experience in the same location but not with experience in a related occupation. Jun et al (2019) examine whether relatedness among products or geographic neighbors is a better predictor for bilateral trade flows. They use three measures of relatedness capturing product relatedness as well as relatedness of export and import destinations. Using bilateral trade data these authors show that product relatedness is the strongest predictor for bilateral export flows, while importer and exporter relatedness (i.e., proximity in geographical export destinations and import source countries across product lines) have a strong and positive impact. This suggests that market proximity and cultural overlaps play also a significant role in trade diversification which diminishes however for technologically more advanced products (and countries).

This paper advances a new indicator for corporate coherence and knowledge spillovers across firms. Bernard et al (2018) have observed that firms decide simultaneously on the set of production locations, export markets, input sources, products to export, and inputs to import. These authors argue that there are strong interdependencies and complementarities between these margins of firm international participation, and these complementarities clearly arise most importantly from the specific technology a firm uses. The proposed indicator constructs a relatedness indicator at the firm level using information on both the products they export and the inputs they import. As both the input and the outputs side are considered simultaneously this new firm level measure captures the firm level production technology better than other measures that rely on exported products, technology classes in patents, or industry classifications.

We first validate the indicator showing that it induces similar effects to economies of scope and examines its relationship with trade diversification and firm level performance using linked statistical micro-data for Austrian firms. Bilateral coherence and related spillovers have a significant negative impact on the total cost of production of firms on average. This allows firms to diversify export portfolio as well as imported inputs more than less related firms. The companion measure for bilateral coherence in geographical markets has opposite effect, indicating that similarity in the geographical markets rather favors trade specialization.

The paper is organized as follows: Section 2 discusses the data used in our analysis. Section 3 introduces the novel indicator and assesses its characteristics. Section 4 presents estimates on the impact of the bilateral coherence indicator on total costs at the firm level. Section 5 examines the impact of bilateral coherence on the margins of trade at the firm level, and Section 6 summarizes the main results.

2. Data

The principal data source of this analysis is the "Structural Business Statistics" ("Leistungs- und Strukturerhebung", or "LSE") of Statistics Austria. These micro-level, registry data are the basis for official statistics national accounts and business statistics in Austria. The sampling includes enterprises conducting market-based activities and report a sales revenue of at least 10,000 Euros and a minimum of ten employees. It covers all firms, except micro-enterprises. In 2017, the dataset covered approximately 72.8% of the total of "persons employed" in Austria. This does not consider self-employment or the non-market activities such as the public sector. A multitude of types of firms are considered. Included are public limited companies, foreign legal types of firms, charitable foundations, or fund (legally defined, also under province law), sole traders (registered or unregistered), European economic interest groups, companies under civil law, cooperatives (Austrian and European), limited liability companies, limited partnerships, general partnerships, European companies (SE), other legal forms, savings banks, mutual insurance associations, and associations. The data set used for the present analysis covers on average 35000 enterprises per year for the period 2010-2018 and contains 147 variables.

These firm level data were matched to two other official databases of Statistics Austria. The first data base is the "Trade by Enterprise Characteristics" (TEC) statistics which is a compulsory survey for all EU Member States. It links foreign trade data at the micro level. These data are available as aggregate import and export figures in current Euros at the firm level, and at the level of two-digit product lines classified by means of the Combined Nomenclature (CN) providing annual information on import and export values in current Euros. In addition, the data base contains information on import and export shares by broad geographic regions for total exports and imports. This information was available for 25000 companies on average per year. For all other companies export or import values were set to zero if there was no related entry in the TEC database. As the analysis relies on this information as non-zero values for either imports or exports are needed to calculate the coherence measure, the present analysis relies on this smaller sample of trade active firms.

The second data base is the foreign affiliates statistics (FATS) and here especially the outward FATS data that are provide information on outward direct investments by Austrian firms by geographical destination, NACE classification of the affiliates as well as the number of foreign affiliates by region or NACE class, the number of employees in foreign affiliates as well as the turnover of the aggregate of these affiliates. As today an increasing number of multinationals globalize their activities through FDI rather than direct trade, this information was used to control for such strategies in the trade analysis in this paper. Outward FATS data were available for on average 686 firm per year. For companies where no OFATS information was provided we assumed that they were not engaging in foreign direct investment. The TEC and FATS data were linked to the Structural Business Statistics through the business register. Linking these data therefore allowed to combine firm level performance, tangible and intangible investment and labor force data with two-digit import and export data as well as information on direct investments.

To obtain real values, all nominal figures were deflated with producer price indices at the Nace Rev. 2 2-digit level using 2010 as the reference year. The deflators were obtained from the national accounts' statistics by Eurostat.

Finally, to obtain a qualitative measure of firm level exports and imports we used the Base pour l'Analyse du Commerce International (BACI) (see Gaulier and Zignago 2010) to calculate complexity scores in line with the approach proposed by Klimek et al (2012) at the 6-digit level of the Harmonized System (HS) at the 6-digit level in its 2008 version. These scores were calculated on an annual basis and then aggregated up to the HS 2-digit level using Austrian import and export shares of the HS 6-digit product lines inside each HS 2-digit product class. This data set was then matched to the firm level 2-digit import and export lines using a CN-HS correspondence. Given the relatively high level of aggregation of firm level imports and exports we will refer to them as export and import business lines.

3. Bilateral corporate coherence and knowledge spillovers

The indicator for bilateral corporate coherence proposed in this paper exploits information on the export and import product lines in which exporting companies are active. The TEC data contain information on forty CN 2-digit export and import product lines each. So, a single firm can potentially be active in 80 product lines either in products it exports or inputs it imports.

Given the high level of aggregation henceforth we refer to these product lines as lines of business. Following Jaffe (1986) we define the relatedness of a firm *i* to all other firms *j*, as

$$Coherence_{ij} = \frac{(s_i s_j')}{(s_i s_i')^{1/2}(s_j s_j')^{1/2}}, \qquad (1)$$

to obtain

$$Spill_{i,t} = \sum_{j \neq i} Coherence_{ij} KS_{jt} \qquad (2)$$

as a measure of the knowledge spillover on which a firm *i* can (potentially) draw given its relatedness to firm *j*. If $S_i = (S_{i1}, S_{i2}, \cdots, S_{i80})$ is the vector of export and import shares S_{ik} of firm *i* in product line *k*, then $Coherence_{ij}$ is the resulting measure of relatedness across exported products and imported inputs between all firm pairings *i* and *j*. The pool of product or input knowledge is then determined by the cumulated production knowledge stock KS_{jt}, which is proxied by an export knowledge stock of firm *j* up to time *t*. This stock has been calculated using the perpetual inventory method.

The advantages of these indicators are that $Coherence_{ij}$ will not automatically increase when product lines are aggregated, and by including KS_{jt} in the calculation of $Spill_{i,t}$ larger and more export intensive firms are implicitly also assumed to have larger spillovers to other firms. The $Spill_{i,t}$ indicator therefore measures the pool of common technological knowledge in the economy any firm can draw on given its relatedness in the production technology to all other firms. The production technology is captured through the specific observed input and output relations at the firm level. Overall, this measure can be viewed as a measure for economies of scope across firms originating from the joint use of similar technologies. While the $Spill_{i,t}$ indicator captures the potential spillover between firms given their level of relatedness and scale of economic activity, for simplicity we will refer to it henceforth as bilateral coherence.

Analogously an identical indicator, $SpillGeo_{i,t}$, is calculated for the proximity in geographical import and export markets. The TEC data of Statistics Austria allow to distinguish between eleven broadly defined regions of trade such as the EU, non-EU Europe, North, Central and South America and so forth. Hence, geographical market information is considerably aggregate. While the analytical focus of this paper will be on the bilateral coherence in product exports and imported inputs, the geographical indicator, is however included in the econometric analysis as spatial relatedness in import and export markets -even if very broadly defined - may have an effect both on the spillover of export competences across firms but also on rivalry across firm. Indeed, Bernard et al (2018) stress the simultaneity of product and geographic market choices. Similarly, Mayer et al (2015) stress the interdependence between product and international diversification. Geographical considerations should therefore be part of the analysis.

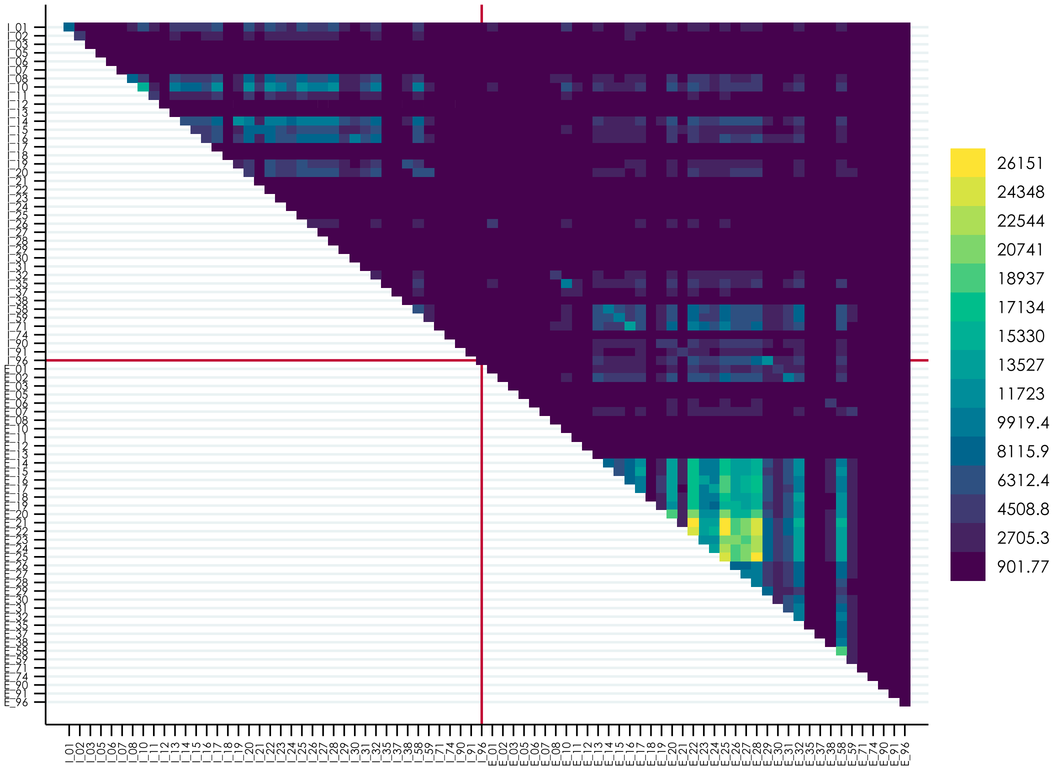
Table 1: Descriptive statistics for the bilateral coherence

Sample	Max	Min	SD	Mean	T_bar	n	N
Bilateral coherence business lines ($Spill_{i,t}$)	2.75	-1.69	1.00	0.00	4.61	21977.0	101335.0
Bilateral coherence geogr. Markets ($SpillGeo_{i,t}$)	0.52	-4.33	1.00	0.00	4.47	46111.0	206113.0
Complexity score imports	2.45	-2.25	0.55	0.33	4.56	20374.0	92977.0
Complexity score exports	1.38	-1.87	0.53	0.36	4.56	15143.0	69004.0

Source: Statistics Austria, Structural Business Statistics and Trade Statistics; BACI – Comtrade (for product complexity scores). Own calculations.

Table 1 presents descriptive statistics of the indicators. They have been standardized across firms with zero mean and standard deviation of one. The table indicates that the data set contains more geographical information on imports and exports at the firm level than product line information. The data set contains more than 100,000 data points for traded products and more than 200,000 data points for geographical destinations. Not for all of the 25,000 trade active firms observed on average per year product data is available.

Figure 1: Co-appearance of import and export business lines across Austrian companies.



Source: Statistics Austria, Structural Business Statistics and Trade Statistics; BACI – Comtrade (for product complexity scores). Own calculations.

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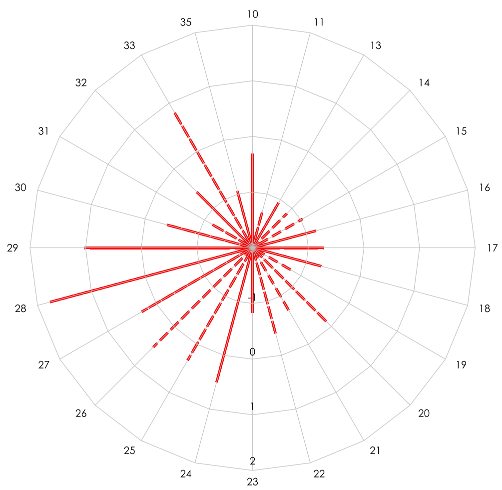
Figure 1 shows the co-appearance matrix based on counts of joint appearances of exported products and imported inputs across firms. The lower triangular matrices in the top and bottom show the absolute counts of coappearances of imports and exports in the data set at the CN 2-digit level respectively. The top right quadrant instead shows the coappearances in imported and exported product lines. Coappearances are considerably more frequent in export lines than in import lines where a central cluster is visible for the CN/NACE sectors 24 through 30, which correspond to the industrial specialization of Austria. For these sectors there are also visible some clusters between export and import lines in the upper right quadrant.

Figure 2: Bilateral coherence by NACE 2-digit manufacturing sectors



Source: Statistics Austria, Structural Business Statistics and Trade Statistics. Own calculations. Numbers at the end of the ray correspond to NACE 2-digit classes.

The resulting potential spillover indicator (Figure 2) thus captures the industrial specialization of Austria. Potential spillovers resulting from the similarity in exported products and imported inputs is particularly high in the machinery and equipment industry (28), automotive (29) and related repair and installation activities (33), the ICT (26) and electrical equipment industries (27) and the manufacture of basic iron and steel (24) and fabricated metal products (24) industries. These are the industries that studies on the competitiveness of the Austrian economy regularly identify as having a comparative advantage in international trade (Reinstaller – Friesenbichler 2020). The indicator shows also little variation over time across industries (see Figure 5 Appendix) pointing at a very stable relationship which in the present case is certainly also driven by the high level of aggregation of the underlying product level data at the firm level.

As has been argued earlier relatedness measures predict the probability of a firm entering a specific activity. Product complexity indicators are then often used to assess its potential value (cf. Hidalgo 2022). However, there is also reason to think that corporate coherence, the technological capabilities of a country and product complexity are intrinsically linked. The following tables and figures explore the relationship between product and input sophistication and bilateral coherence. The underlying assumption on the relationship between the indicators is that companies that are more related in technology are on the one hand better able to draw on available capabilities in the economy than less related ones. The breadth of competences needed to produce a product is indicative of their complexity. Hence, one should expect that in a diversified and advanced economy like Austria bilateral coherence and complexity scores are positively related as suggested by the simple pairwise correlations presented in Table 2.

Table 2: Correlation matrix for the spillover and product complexity measures

	Bilateral coherence business lines	Bilateral coherence geogr. markets	Complexity score imports	Complexity score exports
Bilateral coherence and spillovers business lines ($Spill_{i,t}$)	1			
Bilateral coherence and spillovers geogr. markets ($SpillGeo_{i,t}$)	-0.0597***	1		
Complexity score imports	0.623***	-0.0611***	1	
Complexity score exports	0.659***	-0.0698***	0.843***	1

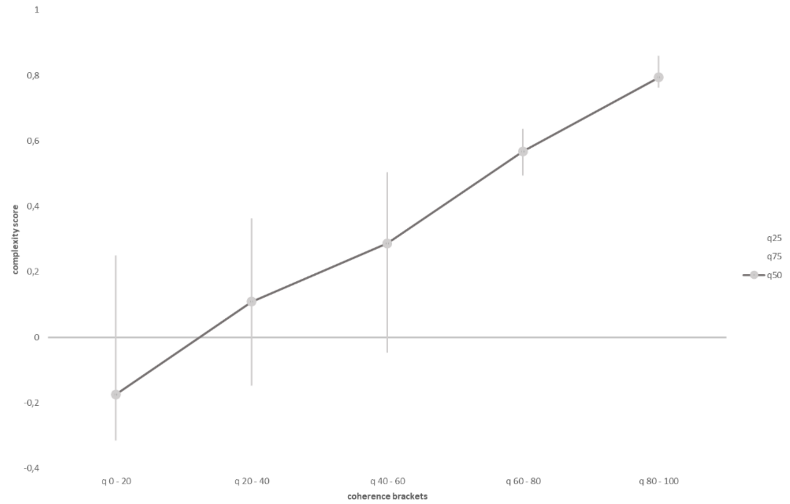
$^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

Source: Statistics Austria, Structural Business Statistics and Trade Statistics; BACI – Comtrade (for product complexity scores). Own calculations.

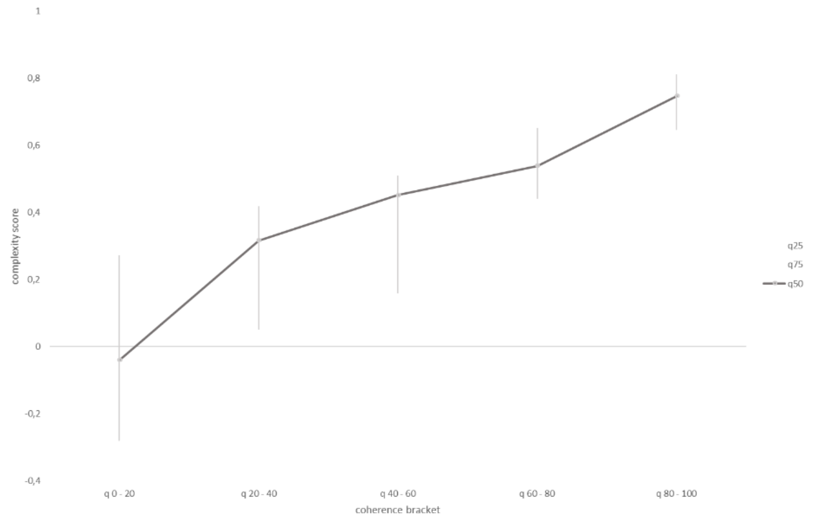
Figure 3 underscores the positive relationship between the bilateral coherence and product complexity both on the input and the output side of firms. Their average complexity increases monotonically with the level of bilateral coherence, even though the variation is much higher in the lower quintiles of the bilateral coherence distribution than on the upper end of the distribution. As higher average complexity scores for both exported products and imported inputs are also associated with higher levels of labor productivity (see Appendix Figure 6) we may assume that bilateral coherence and the potential spillovers across firms have a positive impact on the cost structure of firms. To validate this proposition, we in a first step examine its impact on the cost of production of Austrian manufacturing companies.

Figure 3: Product complexity and bilateral coherence

Exports



Imports



Source: Statistics Austria, Structural Business Statistics and Trade Statistics; BACI – Comtrade (for product complexity scores). Own calculations. Note: Vertical lines indicate the range of complexity scores between the lower 25 and the upper 75% quantile in the related quintile of the bilateral coherence distribution. The line connects the median values observed in each quintile of the bilateral coherence distribution.

4. The relationship between bilateral corporate coherence and the cost of production at the firm level

4.1 Cost function

If bilateral coherence and related potential spillovers were to impact the cost of production of firms like economies of scope, we should expect a consistent negative effect of our measure on the cost of production at the firm level. We validate the indicator by investigating the existence of economies of scope like effects induced by bilateral coherence using a quadratic cost function as they are typically used in exercises estimating economies of scale and scope for specific industries (cf. Triebs et al 2016; Molinos-Senate – Maziotis 2021).

We prefer a normalized cost over other functional forms such as the translog, as we would lose about 1/3 of observations in our sample due to zero values. We define the following normalized quadratic cost function:

$$NC_{i,t} = \alpha_0 + \beta_1 y_{i,t} + \beta_2 Spill_{i,t} + \sum_{k=1}^{m} \gamma_k\, w_{k,i,t} + \frac{1}{2}\left[\beta_3 y_{i,t} * Spill_{i,t} \ + \ \beta_4 {y_{i,t}}^2 \ + \ \beta_5 {Spill_{i,t}}^2\right] + \frac{1}{2}\sum_{k=1}^{m-1}\sum_{l=1}^{n-1} \gamma_{k,l}\, w_{k,i,t} * w_{l,i,t} + \sum_{k=1}^{m} \delta_k\, w_{k,i,t} * y_{i,t} \ + \sum_{l=1}^{n} \delta_l\, w_{l,i,t} * Spill_{i,t} + \varphi_1 T \ + \vartheta_1 T * y_{i,t} + \vartheta_2 T * Spill_{i,t} + \sum_{k=1}^{m} \pi_k\, w_{k,i,t} * T \ + \ \frac{1}{2}\varphi_2 T^2 + \sum_{q=1}^{N} \rho_q D_{q,i}, \qquad (3)$$

where $NC_{i,t}$ are the normalised total costs of production of firm *i* at time *t*. To meet the required symmetry and linear homogeneity restrictions total costs need to be normalized by one input factor (see Triebs et al 2016). In our case we have used energy costs. Variable $y_{i,t}$ is the revenue and $Spill_{i,t}$ our indicator for bilateral corporate coherence of firm i at time t, $w_{i,t}$ is its vector of normalised input prices, in our case capital and labour cost, T is a time trend and D_i is the vector of dummies included in the regression. The "$*$" operator stands for interaction terms in the equation.

This cost function is needs to be estimated simultaneously with the input demand, or the cost minimizing input shares, that follow from Shepard's Lemma. For proper identification the factor used to normalize costs and other inputs is omitted. The input demand functions take the form

$$s_{k,i} = \gamma_k + \pi_k T + \sum_{j=1}^{n-1} \gamma_{j,k}\, w_{j,k,i,t} + \mu_{1,k} y_{i,k,t} + \beta_2 Spill_{i,t}. \tag{4}$$

We have estimated the system of the normalized quadratic cost function (3) and the input shares (4) using the seemingly unrelated regression technique. Table 3 presents the descriptive statistics for the additional variables used for the estimations.

Table 3: Descriptive statistics cost estimation variables

	Max	Min	SD	Mean	T	n	N
Total cost	13375593.00	11.28	112212.20	16601.40	5.57	53854	299992
Capital cost	1568.30	-4.86	3.94	0.13	5.57	53854	299992
Unit labor cost	1473.80	0.00	19.04	40.22	5.57	53854	299992
Unit energy cost	108.00	-1.30	0.24	0.03	5.57	53854	299992
Revenue	13472908.00	0.00	110503.98	16694.57	5.57	53854	299992
Capital share	1.00	0.00	0.28	0.13	5.57	53786	299494
Labor share	1.00	0.00	0.58	0.74	5.57	53839	299838

Source: Statistics Austria, Structural Business Statistics and Trade Statistics.

Capital cost have been calculated as user costs of capital considering both interest rate payments and depreciations relative to a firm's capital stock. Unit labor costs correspond to the total wage cost per full time equivalent, and energy unit costs correspond to total energy cost per unit of production value. These data are available in the Structural Business Statistics at the firm level. All variables have been deflated using NACE 2-digit producer prices.

Table 4: Cost function estimates (SUR estimator)

	Normalised quadratic cost model
Dependent variable	Total cost
Revenue	0.24***
	(0.14)
Revenue^2	-0.00***
	(-0.14)
Capital cost	34.99***
	(0.01)
Capital cost^2	-0.04***
	(-0.27)
Labour cost	0.71***
	(0.08)
Labour cost^2	-0.00***
	(-0.47)
Capital cost x labour cost	0.00***
	(0.56)
Revenue x capital cost	-0.00***
	(-0.02)
Revenue x labour cost	0.00***
	(0.51)
Time trend	-24076.25***
	(-0.04)
Time trend x revenue	0.00***
	(0.02)
Time trend x capital cost	-64.31***
	(-0.077)
Time trend x labour cost	0.06***
	(0.05)
Time trend^2	2079.18***
	(0.04)
Bilateral coherence	-2079.01***
	(-0.006)
Bilateral coherence^2	18.32
	(0.00)
Capital cost x bilateral coherence	-32.54***
	(-0.03)
Labour cost x bilateral coherence	-0.24***
	(-0.06)
Revenue x bilateral coherence	0.03***
	(0.03)
Time trend x bilateral coherence	-540.06***
	(-0.01)
Sector dummies	Y
Constant	-10181.58***
	(-0.01)
Observations	52892
Degrees of freedom	50
RMSE	20089.25
R^2	0.999
Chi^2	96719835.2
Breusch Pagan Test p	0
Breusch Pagan Chi^2	2488.1

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Source: Statistics Austria, Structural Business Statistics and Trade Statistics. Own calculations.

In Table 4 we report the results for the cost estimations. We omit the results for the input share regressions. Due to the normalization of total costs with energy prices the estimated coefficients refer to energy price normalized total costs, which is difficult to interpret. For instance, the coefficient for revenue implies that the marginal energy price normalized cost of production for 1 Euro of revenue equals approx. 24 Euro cents. We therefore refrain from their discussion and focus on the sign and statistical significance of the $Spill_{i,t}$ indicator and its interaction and quadratic terms. The estimated coefficients are negative and significant for the direct effect of $Spill_{i,t}$ as well as most interaction terms. Interestingly the quadratic term has a positive sign. This suggests that firms that are too similar are most likely also close competitors which increases their cost of production.

Table 5: Linear combination of estimated coefficients for bilateral coherence

	Coef.	Std. Err.	z	P>z	95% Conf. Interval	
Bilateral coherence	-2651.82	315.97	-8.39	0.000	-3271.1	-2032.54

Source: Statistics Austria, Structural Business Statistics and Trade Statistics. Own calculations.

In Table 5 we show the coefficient for the linear combination of all bilateral coherence terms except for the quadratic term. The coefficient is statistically significant and negative in line with our expectations. In the next section we examine whether these results imply also effective economies of scope and how they behave over the value range of the bilateral coherence indicator. A one standard deviation difference between firms implies -2651€ lower energy cost normalized total costs.

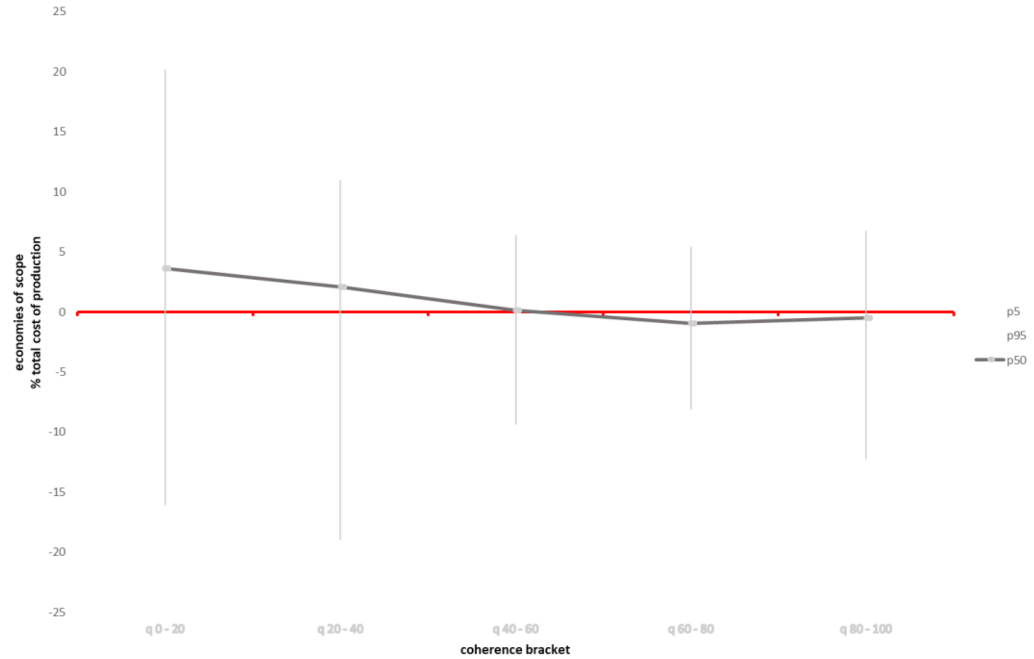
4.2 Economies of scope

Using the equation for the normalized quadratic cost function economies of scope can now be calculated as follows:

$$ESCOPE_{i,t} = \frac{C(\widehat{y_{i,t}^{Spill}}) - C(\widehat{y_{i,t}^{noSpill}})}{C(\widehat{y_{i,t}^{noSpill}})}, \qquad (5)$$

where $C(\widehat{y_{i,t}^{Spill}})$ is the predicted cost for model (3) with output $y_{i,t}^{Spill}$ and the $Spill_{i,t}$ indicator, whereas $C(\widehat{y_{i,t}^{noSpill}})$ is the predicted cost from model (3) with output $y_{i,t}^{noSpill}$ and the spill-over term not included for the prediction. Equation (5) will take on positive values when there are diseconomies of scope at the firm level, negative values for economies of scope and zero when the bilateral coherence has no effect on total cost of production.

Figure 4: Estimated economies of scope and bilateral coherence



Source: Statistics Austria, Structural Business Statistics and Trade Statistics. Own calculations. Note: Vertical lines indicate the range of bilateral coherence scores between the lower 5% and the upper 95% quantile in the related quintile of the distribution of estimated economies of scope.

Figure 4 summarizes the predicted economies of scope at the firm level over the distribution of the bilateral coherence indicator centered around the average coherence value (equaling zero in the normalized distribution). Hence, the average coherence value is the reference, and the results refer to this value. The figure shows that at low levels of corporate coherence diseconomies of scope are prevalent relative to firms with average coherence, even though we observe a wide dispersion of the predicted values. At intermediate coherence values the dispersion of the estimated (dis-)economies of scope decreases. In the top quantiles of the bilateral coherence distribution economies of scope are higher relative to firms with average coherence. .The effects are relatively small and get smaller in the top interval where also the dispersion of the estimated values increases again.

The analysis in this section therefore lends some support to the claim made in earlier papers that bilateral coherence has an impact on the performance and possibly the competitiveness of firms by reducing their costs of production.

5. Trade diversification and firm performance

5.1 Trade diversification

After analyzing the relationship between the bilateral corporate coherence indicator and firm level costs, we now turn out attention to its effect on the trade diversification of firms. In this analysis trade diversification refers to both the diversification in imported inputs as well as diversification in exported products.

Prior literature underscores the importance of both the frequent adjustment of trade margins and the role of knowledge spillovers and firm specific competences. Bernard et al (2010), for instance, argue that product switching, i.e., firm level adjustments in trade margins are frequent and widespread across firms and have a significant impact on both firm level and aggregate outcomes. They also note that some pairs of products are more likely to be coproduced within firms than other. Atkin et al (2017) highlight the importance of knowledge spillovers to produce new varieties as they reduce the cost of production and lead to improved quality of imported and higher efficiency. However, as the brief literature overview in Section 1 shows, related firm specific competences are important for the absorption of knowledge spillovers across firms.

Some influential papers have argued that multi-product exporters are characterized by core competence in the production of some varieties of products and less efficient in the production of varieties outside their core competence. (Eckel and Neary 2010). Bernard et al (2011) follow from this that firm specific competences and their interaction with firm level productivity result in changes in the composition of the export portfolio of firms. If trade costs increase firms will drop the product varieties with the lowest firm-product specific competences. If trade costs decrease, they will increase both the number of varieties as well as the level of their exports. This is in line with earlier work on the impact of corporate coherence on product diversification. We therefore hypothesize that bilateral coherence and the absorption of spillovers from related producers is positively related with increases in the extensive margins of trade at the firm level.

5.1.1 Econometric approach

We will test the main hypothesis of this section econometrically using the data set combining the Structural Business Statistics with the Trade by Enterprise characteristics (TEC) statistics provided by Statistics Austria through remote access.

When testing the hypothesis, we should keep in mind that the firm level data on imported and exported products are available only at a highly aggregated level such that changes in the margins of trade have to be interpreted in terms of more fundamental changes in business lines. These are less frequent than changes at lower level of aggregation such as six-digit product lines or four-digit industries. Hence, the explanatory variables will be relatively constant over time, which presents an econometric challenge and require a flexible estimation method.

To capture essential aspects for the margins of trade at the firm level we use three indicators. The first two are the intensive and extensive margins of trade (i.e., both for imports and exports) at the firm level. We follow Hummels and Klenow (2005) and specify the intensive margin as

$$IM_{i,t} = \frac{\sum_{k^i} X_{i,k,t}}{\sum_{k^i} X_{k,t}^{AT}}, \tag{6}$$

and the extensive margin as

$$EM_{i,t} = \frac{\sum_{k^i} X_{i,k,t}}{\sum_{k^{AT}} X_{k,t}^{AT}}, \tag{7}$$

where k^i in (6) and (7) is the set of all product or business lines present in the export or import portfolio of firm i and k^{AT} is the set of all product lines exported or imported by the country. Variable $X_{i,k,t}$ is the export value in deflated €-values of product *k* by firm *i* at time *t*, and $X_{k,t}^{AT}$ is the export value I product *k* by the country (AT) at time *t*.

The difference to the approach of Hummels and Klenow (2005) is that instead of using world exports and imports in the calculation, we must use total import and export values at the 2-digit product level in Austria as our data set is limited to this country. The impact of the bilateral coherence and spillover indicator on the margins of trade at the firm level therefore refers to the relative position of a firm with respect to other Austrian exporters and not with respect to global competitors. This is a limitation of the present analysis.

Next to the intensive and extensive margins of trade we also use a standard Herfindahl-Hirschmann-Index of export and import shares for each product line at the firm level to capture also changes in export or import concentration. As for the extensive and intensive margins also in this indicator refers to total exports at the level of 2-digit product lines in Austria.

Table 6: Descriptive statistics trade diversification variables

	Max	Min	SD	Mean	T_bar	n	N
Intensive margin exported product lines	1.00	0.00	0.01	0.00	4.27	23722	101200
Extensive margin exported product lines	1.00	0.00	0.19	0.09	4.47	46111	206113
Intensive margin imported inputs	0.40	0.00	0.00	0.00	4.43	45611	202189
Extensive margin imported inputs	0.98	0.00	0.23	0.15	4.47	46111	206113
HHI for shares of exported products	1.00	0.05	0.22	0.86	4.27	23722	101200
HHI for shares imported inputs	1.00	0.06	0.24	0.85	4.43	45611	202189
Herfindahl revenue share NACE 4-digit	0.98	0.00	0.08	0.05	5.48	63975	350870
Dummy control of foreign firms	1.00	0.00	0.14	0.02	5.49	64006	351247

Source: Statistics Austria, Structural Business Statistics and Trade Statistics.

Table 6 present the descriptive statistics for these indicators plus two additional indicators that will be used in the empirical model that have not yet been presented in Table 3. All the dependent variables that will be used in the following analysis are either share variables or variables bound between 0 and 1. Together with the fact that we use panel data and that both the dependent but also some independent variables show little variation over time, the appropriate econometric model for this type of data is a fractional response model for panel data (Papke and Wooldridge 2008).

Keeping in mind, that the analysis is limited to exporting firm the conditional mean of the dependent $y_{i,t}$ is the dependent share variable is:

$$E(y_{i,t}|\mathbf{x}_{i,t}, \boldsymbol{c}_i) = G(\mathbf{x}_{i,t}\beta + \boldsymbol{c}_i), t = 1,..,T;\ i = 1,..,N\ , \qquad (9)$$

where $\mathbf{x}_{i,t}$ and β are the vectors of exogenous explanatory variables and coefficients, and *i* and *t* are the panel dimensions. Function $G(\cdot)$ is a non-linear link function satisfying that the predicted variables will lie in the interval $[0,1]$. Variable $\boldsymbol{c}_i$ stands for the unobserved individual heterogeneity. If these unit effects are random then it depends on the explanatory variables as follows:

$$c_i|(\mathbf{x}_{i,t}, \mathbf{x}_{i,2}, \dots, \mathbf{x}_{i,T}) = \varphi_0 + \mathbf{x}_\mathrm{i}\gamma + \mathrm{a}_i, \qquad (10)$$

where $\mathbf{x}_\mathbf{i} = \boldsymbol{T}^{-1} \sum_{\boldsymbol{t}} x_{i,t}$ denotes the time averages of the explanatory variables $x_{i,t}$. For the error term in (10) we assume $\mathrm{a}_i \sim N(0, \sigma_a^2)$ with a_i being orthogonal on $\bar{\mathbf{x}}_{\boldsymbol{i}}$. In this case $c_i|(\bar{\mathbf{x}}_{\boldsymbol{i}})$ follows a $N(\varphi_0 + \bar{\mathbf{x}}_{\boldsymbol{i}}, \sigma_a^2)$ which allows the violation of the random effects assumption. The conditional mean is then

$$\left(y_{i,t}\middle|\mathbf{x}_{\boldsymbol{i},\boldsymbol{t}}, \boldsymbol{c}_{\boldsymbol{i}}\right) = G\left(\mathbf{x}_{\boldsymbol{i},\boldsymbol{t}}\beta + \varphi_0 + \mathbf{x}_\mathbf{i}\gamma + \mathrm{a}_i\right), \tag{11}$$

and by integrating out a_i from (11) we obtain the pooled non-linear random effects model based on the Mundlak correction of the form

$$E\left(y_{i,t}\middle|\mathbf{x}_{\boldsymbol{i},\boldsymbol{t}}\right) = G\left(\varphi_a + \mathbf{x}_{\boldsymbol{i},\boldsymbol{t}}\beta_a + \bar{\mathbf{x}}_{\boldsymbol{i}}\gamma_a\right). \tag{12}$$

The subscripts *a* indicate that explanatory variables and coefficients have been transformed when integrating out the error term a_i. The term $\bar{\mathbf{x}}_{\boldsymbol{i}}\gamma_a$ captures now the between variation.

This basic model can now be extended in two distinct directions. Under the assumption that the dependent variable follows an autoregressive process the model can be extended into a dynamic panel model in line with the approach suggested by Wooldridge (2005). In the present context such a model seem unwarranted as the history dependence of the process of trade diversification should already be captured by bilateral coherence. Any short run shock, that affect trade diversification will eventually be corrected to a diversification pattern associated with a specific set of technological capabilities captured by the bilateral coherence of the firm. Despite these reservations we will examine these models and present results concerning their validity.

The second possibility of extension is the two-way Mundlak approach suggested by Wooldridge (2021) where next to the within-unit time averages of the independent variables also time-period specific cross-unit averages are included to allow accounting for both time and unit unobserved heterogeneity. This is equivalent to including time dummies. In the empirical model we will include such time-period specific cross-sectional to control for unobserved time effects. We do not report the coefficients for the sake of better readability of the tables.

5.1.2 Empirical model specification

The hypothesis examined with the empirical model is that bilateral coherence and the absorption of spillovers from related producers is positively related with increases in the margins of trade at the firm level. Decisions to adjust the margins of trade are rooted in the competence base of the firm level and efficiency considerations on how to adjust the export portfolio and imported inputs to maximize returns under a regime of localized knowledge spillovers.

As has been mentioned in Section 1 the decision on product locations, export markets, input sources, products to export, and inputs to import are linked. To identify the impact of bilateral coherence and spillovers on trade diversification it is therefore also necessary to account for both the firm experience in geographical markets and the as well as the level of sophistication and complexity of the firm's production technology.

We control for the geographical aspects by including the indicator for *bilateral coherence in geographic export and import markets*. This indicator therefore captures in the trade experience of the firm as well as its closedness to the geographical trade patterns of other Austrian firms. Considering the classical factors affecting bilateral trade flows such as distance, common language, bilateral trade agreements and so forth will be a dominant factor in the geographical trade patterns of firms, the *bilateral coherence in geographic export and import markets* will therefore capture these key features. More unrelated firms are more likely also to be better capable of overcoming "gravity" and therefore be more productive (cf. Martin and Mayneris 2015).

To capture the sophistication and complexity and thus the technology induced extensive margin especially on the import side, we include the *product complexity scores for the imported inputs*, discussed in Section 3. Figure 6 in the appendix shows that product complexity scores on both the import and the export side increase with the level of labor productivity of firms. It also shows that the complexity scores of imported inputs and exported products are positively correlated (see also Table 2). Including both complexity scores for both imports and exports would introduce collinearity. Including the complexity score for imported inputs only on the other hand allows controlling for productivity levels as well as technology induced margins of trade. The expectation is that the complexity of imported inputs is positively related to especially the extensive margins especially on the input side.

To control for the cost-competitiveness of the firm we include the log of *total labor costs per full time equivalent (FTE)* in the regression. The expected sign of this indicator is a priori not clear as higher unit labor costs are possible related either to inefficiencies or higher productivity.

Next to these key factors we have to control also for a number of additional aspects that affect changes in the margins of trade at the firm level:

- While firm level productivity is a key driver for the self-selection of firms into trade (Melitz 2003), firm size affects the margins of trade more directly. Dosi et al (2017) document that the number of products firms produce and sell on the market increases log-linearly with firm size. We therefore include the *log revenue* to capture firm size.

- Stochastic shocks to productivity and consumer behavior affect how firms drop or add products to their portfolio. Such changes can be induced by both aggregate fluctuations and idiosyncratic firm level shocks (Bernard et al 2010). To control for the aggregate fluctuations, we include *aggregate technology and demand shocks* that capture economy wide variations in hours worked and hourly productivity induced either by real shocks or changes in capacity utilization.

- Firms can either invest in markets or export. This depends also on the geographical structure of their trade relations. Helpman et al (2004) show that the most productive firms invest in markets while less productive ones export. In addition, foreign markets are also served more often through FDI relative to exports when trade frictions are lower (Helpman et al 2004). The regression therefore also includes a dummy for firms that control foreign firms and are therefore active in *outward FDI*.

- Finally, competition plays a role in the adjustment of trade margins. Eckel and Neary (2010) show in a theoretical model that gains from trade arise through within firm adjustments through the contraction of the product range in response to additional competition. While firm concentration is not necessarily the best measure for the level of competition at the industry level as it does not capture the contestability, we still include a Herfindahl-Hirschmann Index of revenue shares at the Nace 4-digit industry level as important dimensions of contestability are captured by both the bilateral corporate coherence and the product complexity scores.

5.1.3 Results

Table 7 and Table 8 present the regression results for the three dependent variables discussed in Section 5.1.1. Table 7 shows the results for extensive and intensive margins as well as export concentration for exported product lines. The regression tables are split into two sections. The Section "Structural equation" captures the within unit effects, whereas the section "Unit specific heterogeneity" captures the between effects.

Looking at the export side first, the dependent variable in model (1) has been computed in line with equation (6), whereas the dependent variable in model (2) follows equation (7). The dependent variable in model (3) is a Herfindahl-Hirschman Index for the concentration of export share across exported product lines in total Austrian exports in the respective product lines.

The first important finding is that conditional on observed and unobserved heterogeneity bilateral coherence and related spillovers have – as expected -- a positive and significant effect on the extensive margin of exported products at the firm level. This holds true for both the within and between-effects. This is not true for intensive margins (2) and export concentration (3). There is a significant negative of bilateral coherence on the intensive margins of exports at the firm level. This indicates that bilateral coherence has an impact on the diversification of the export portfolio, but this goes along with a reduction in export shares across product lines. This would imply a reduction of the export concentration, such that we should observe a negative impact of bilateral coherence on export concentration. The effects are indeed negative, but they are not statistically significant. Figure 8 in the appendix also suggests that higher levels of bilateral corporate coherence are also associated with higher productivity levels. However, the dispersion is very high.

A second finding is that coherence in geographical markets has a negative effect on extensive margins. Being more closely related to other firms in export and import markets has a negative impact on the extensive margins of exports. This holds for both within and between effects. Firm that are more like their peers in terms of their geographical export and import markets have a less diversified. We also observe a negative impact on the intensive margin and the export concentration. This indicates that geographically coherent firms tend to be less diversified and less competitive if competitiveness is interpreted as the capability of firms to capture high market shares in the export markets where they are active.

Product complexity of imported input has no significant impact on both intensive and extensive margins. As there is a strong correlation between the bilateral coherence measure at the product level, it is possible that the variation of this indicator is captured by the latter. Another possibility is also that the impact of product complexity may have an ambiguous association with firm level performance. As Figure 7 in the appendix shows over the period considered in this analysis the complexity scores of products have been declining for the least productive firms and increasing at first and then stagnating for the most productive ones. This may lead to heterogenous effects especially when considering the within variation.

The various control variables indicate that larger firms have larger extensive margins, and productivity and demand shocks are positively correlated with extensive margins as well. That is, aggregate fluctuations that have a positive impact on firm level productivity or demand support are positively correlated with extensive margins. Interestingly, firms with higher unit labor costs as well as firms engaged into outward FDI are also more diversified in exports. More productive firms employ also more productive workers and pay higher wages. In addition, these firms are more likely to select themselves into multiple export activities and gain larger market shares also relative to their domestic competitors as the small but positive effect on export market concentration suggests. Firms engaged in outward FDI in turn are more likely to be more active in multiple lines of business. But outward FDI should also reduce the total value of exports as direct investment is carried out in place of traditional exports. Hence, we should see a negative effect on the intensive margin and export concentration. This is what we observe in Table 7.

Table 7: Export diversification estimations

Dependent variable:	(1) **Extensive margin**	(2) **Intensive margin**	(3) **Export concentration**
Structural equation			
Bilateral coherence/spillovers (t-1)	0.0295***	0.012	-0.00158
	-3.74	-0.280	(-0.15)
Bilateral geographical coherence/spillovers (t-1)	-0.0227***	0.001	-0.0115*
	(-6.65)	-0.080	(-2.28)
Complexity import lines (t-1)	0.00654	-0.027	-0.0096
	-1.33	(-0.97)	(-1.90)
Log labour costs per FTE (t-1)	0.123***	0.131*	0.0661***
	-10.3	-2.360	-5.32
Log revenue (t-1)	-0.00372	0.274	0.199
	(-0.03)	-1.030	-1.74
Herfindahl revenue Nace 4-digit	0.0029	0.036	0.0252
	-0.19	-0.470	-1.22
Domestic company controls foreign firms (0,1)	0.128***	-0.116***	-0.314***
	-3.52	(-3.30)	(-7.39)
Manufacturing sector dummy	0.490***	0.331***	0.729***
	-35.18	-6.51	-49.45
Aggregate supply shock	0.00512*	0.00569	0.00807*
	-2.45	-0.64	-2.3
Aggregate demand shock	0.0127*	-0.0967	-0.00156
	-2.06	(-1.69)	(-0.16)
Unit specific heterogeneity			
Bilateral coherence/spillovers (t-1)	0.316***	-0.244***	-0.0264
	-20.37	(-5.06)	(-1.33)
Bilateral geographical coherence/spillovers (t-1)	-0.338***	-0.0436*	-0.247***
	(-33.29)	(-2.04)	(-22.31)
Complexity import lines (t-1)	0.0324	0.0131	0.242***
	-1.1	-0.09	-7.59
Log labour costs per hour worked (t-1)	0.00159	0.0195	-0.0573***
	-0.17	-1.05	(-6.79)
Log revenue (t-1)	0.207***	0.0729	0.205***
	-15.44	-1.24	-14.96
Herfindahl revenue Nace 4-digit	0.172	-0.121	1.075***
	-1.32	(-0.44)	-7.22
Constant	-4.047***	-6.669***	-2.582***
	(-28.54)	(-7.51)	(-14.25)
Observations	166146	166146	166146
Log likelihood	-29960.9	-231.5	-88867.1
chi2	13271.8	2425.3	8258.9
p	0	0	0
Deviance	28024.9	137.4	154222.6
pseudo R^2	0.41	0.02	0.2
LR_{γ} (Prob > chi2)	0.00	0.23	0.00
LR_{ρ} (Prob > chi2)	1	1	1
σ^2	0.02	0.00	0.16
ρ	0.02	0.00	0.14

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Source: Statistics Austria, Structural Business Statistics and Trade Statistics. Own calculations. Time-period specific cross-sectional average of independent variables were included to control for unobserved time variation.

Table 8: Import diversification estimations

Dependent variable:	(4) **Extensive margin**	(5) **Intensive margin**	(6) **Import concentration**
Structural equation			
Bilateral coherence/spillovers (t-1)	0.015*	-0.038	0.007
	-2.08	(-0.60)	-0.77
Bilateral geographical/spillovers coherence (t-	-0.004	-0.004	-0.0122**
	(-1.54)	(-0.66)	(-2.60)
Complexity import lines (t-1)	0.039**	0.098	-0.02
	-2.94	-0.66	(-1.07)
Log labour costs per FTE (t-1)	-0.00135	-0.0275***	-0.004
	(-0.36)	(-3.30)	(-0.72)
Log revenue (t-1)	0.0882***	0.135***	0.000
	-7.71	-4.83	(-0.01)
Herfindahl revenue Nace 4-digit	0.097	0.265	-0.188*
	-1.18	-1.94	(-2.02)
Domestic company controls foreign firms (0,1)	-0.0655*	-0.103**	-0.175***
	(-2.13)	(-3.08)	(-5.93)
Manufacturing sector dummy	0.493***	0.074	0.0550***
	-41.75	-1.78	-4.58
Aggregate supply shock	-0.001	0.006	-0.002
	(-0.55)	-0.82	(-0.54)
Aggregate demand shock	0.0355***	0.017	-0.0229*
	-7.41	-0.95	(-2.28)
Unit specific heterogeneity			
Bilateral coherence/spillovers (t-1)	0.133***	-0.196***	0.015
	-9.54	(-4.98)	-1
Bilateral geographical/spillovers coherence (t-	-0.154***	0.113***	0.268***
	(-17.46)	-4.72	-28.12
Complexity import lines (t-1)	-0.0172	-0.09	0.0645**
	(-0.74)	(-0.93)	-2.65
Log labour costs per hour worked (t-1)	0.001	0.0620***	-0.0591***
	-0.17	-4.85	(-7.60)
Log revenue (t-1)	0.286***	0.0615*	-0.012
	-23.42	-2.08	(-0.97)
Herfindahl revenue Nace 4-digit	0.689***	-0.101	0.146
	-6.61	(-0.48)	-1.3
Constant	-2.691***	-5.580***	-0.0887
	(-22.82)	(-18.67)	(-0.51)
Observations	166146	166146	166146
Log likelihood	-44028.8	-179.7	-95169.3
chi2	16429.8	1580	1727.4
p	0	2.47e-323	0
Deviance	36803.9	67.81	151198.5
pseudo R^2	0.41	0.06	0.02
LR_γ (Prob > chi2)	0.000	0.259	0.000
LR_ρ (Prob > chi2)	1	1	1
σ^2	0.030	0.000	0.167
ρ	0.029	0.000	0.143

* p<0.05, ** p<0.01, *** p<0.001

Source: Statistics Austria, Structural Business Statistics and Trade Statistics. Own calculations. Time-period specific cross-sectional average of independent variables were included to control for unobserved time variation.

We have tested the validity of the random effects panel model presented in the table against two alternative specifications by means of a likelihood ratio test. The first alternative is a model without individual heterogeneity, and the second is a dynamic panel model to account for possible state dependence of the outcome variable.

We first test the null hypothesis of insignificance of individual heterogeneity. The reported likelihood ratio test L_γ tests rejects the null at the 1 percent level for regressions (1) and (3) but not regression (2). For regressions (1) and (3) therefore the random effects model seems warranted. Next, we test the null hypothesis of persistency in the dependent variable and thus state dependence against the alternative hypothesis of absence of persistency. To carry out this test the models were run with including a lagged dependent variable and its initial condition following Wooldridge (2005). The likelihood ratio test statistic L_ρ shows that the null is rejected. Hence, the use of a static panel specification is warranted, and state dependence of the dependent variable can be rejected.

Concerning model quality, the coefficient of determination $\rho = \sigma_a^2/(1+\sigma_a^2)$ indicates that unobserved heterogeneity has a limited impact on the results of regressions (1) and (2) but is significant for model (3). The pseudo -R^2 statistic for regression (1) explains a considerable amount if the observed variation in the data, whereas models (2) and (3) perform considerably worse. From this we can conclude that the results of regression (1) for the extensive margin in exported products are more robust than the other two regressions. We observe a similar performance also for the regressions on import diversification shown in Table 8.

Turning now to Table 8 the results widely eco those discussed for exported products. The within-effects however are either weaker or insignificant if compared to the results in Table 7. An important difference is in the between effect of the geographical bilateral coherence for the intensive margin in imported inputs. Here the sign of the effect is inverted relative to the effect on the intensive margin in exported products. This indicates that firms that are more related in geographical markets source their inputs from fewer geographical markets than less related ones. These firms are thus more dependent on fewer geographical markets for their inputs.

6. Conclusion

Prior research has argued that relatedness in economic activities or product lines across firms and industries reflects information on joint business field participation choices of diversified firms. Relatedness therefore provides a measure for firms search for market-entry opportunities and corporate diversification that economize on existing resources. Opportunities for profitable diversification arise because there is some overlap between the resources and capabilities that support the existing portfolio of activities and those that are required in some new line of activity. These overlaps produce economies of scope.

The paper introduces a novel indicator of technological relatedness across firms. It considers both imported inputs and exported products to assess the similarity of firms in terms of their technological capabilities in Austria. By considering both inputs and outputs the indicator captures more closely technological similarity than measures relying solely on exported products or overlapping industry classes. Descriptive results indicate that companies that are more closely related in the import-export product space export and import more complex products. More complex products in turn are related to higher labor productivity levels.

The impact of this measure on the production costs of firms was assessed estimating quadratic cost functions at the firm level. The results confirm that bilateral coherence in exported products and imported inputs and related (potential) spillovers have a significant negative impact on the total cost of production of firms on average.

The paper then assessed the impact of bilateral coherence in the input-output space on the margins of trade at the firm level. The results indicate that firms that a higher bilateral coherence and associated spillovers have a positive impact on the diversification of the export portfolio as well as imported inputs at the firm level. The impacts on intensive margins and both import and export concentration are more ambiguous.

Contrasting bilateral coherence in product markets and bilateral coherence in geographical markets leads to an interesting insight. While higher bilateral coherence in product markets favors diversification in both exported products and imported inputs. Firm level productivity tends also to increase with bilateral coherence at the product level.. The companion measure for bilateral coherence in geographical markets has opposite effect, indicating that similarity in the geographical markets rather favors trade specialization and given the geographic dispersion of Austrian trade also a stronger focus on geographically close, regional markets.

These findings complement the sector level analysis by Kügler et al (2020) who have shown that the most productive and technologically sophisticated sectors tend to diversify geographically out of regional markets into more dispersed and distant export destinations, while the least productive ones tend to focus their trade activities regional markets.

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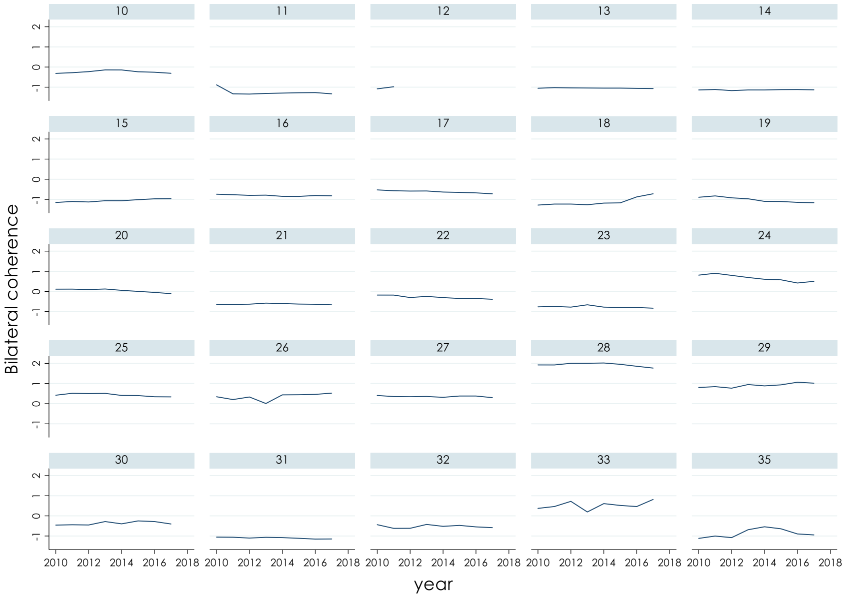
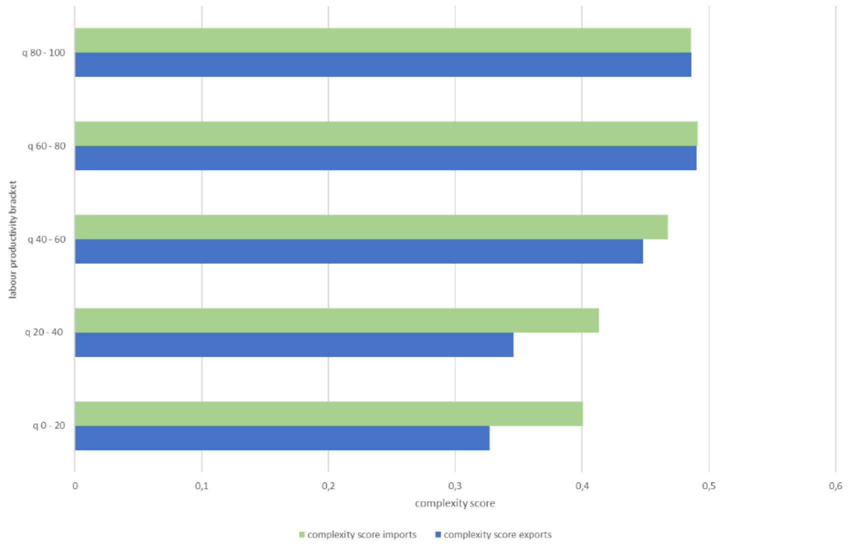
Appendix

Figure 5: Bilateral coherence over time by Nace 2-digit manufacturing sectors



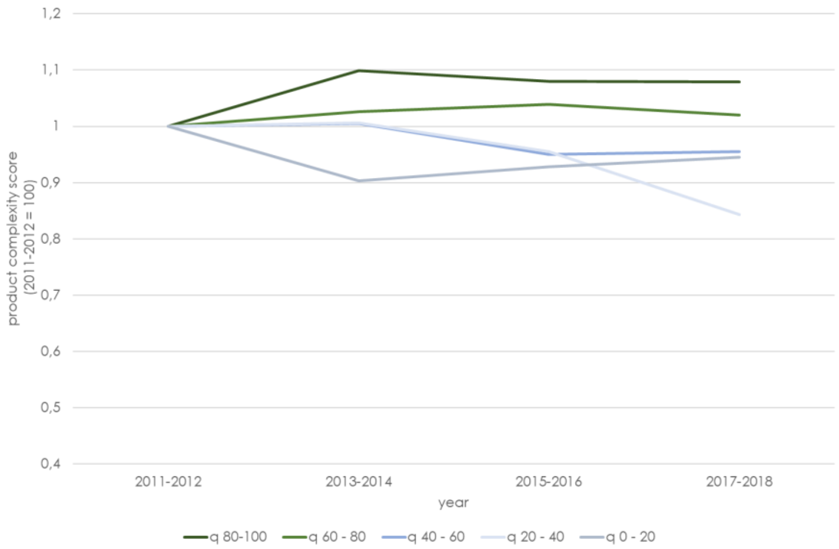
Source: Statistics Austria, Structural Business Statistics and Trade Statistics. Own calculations. Numbers on top of each plot corresponds to NACE 2-digit classes.

Figure 6: Product complexity of import and export business lines and labor productivity



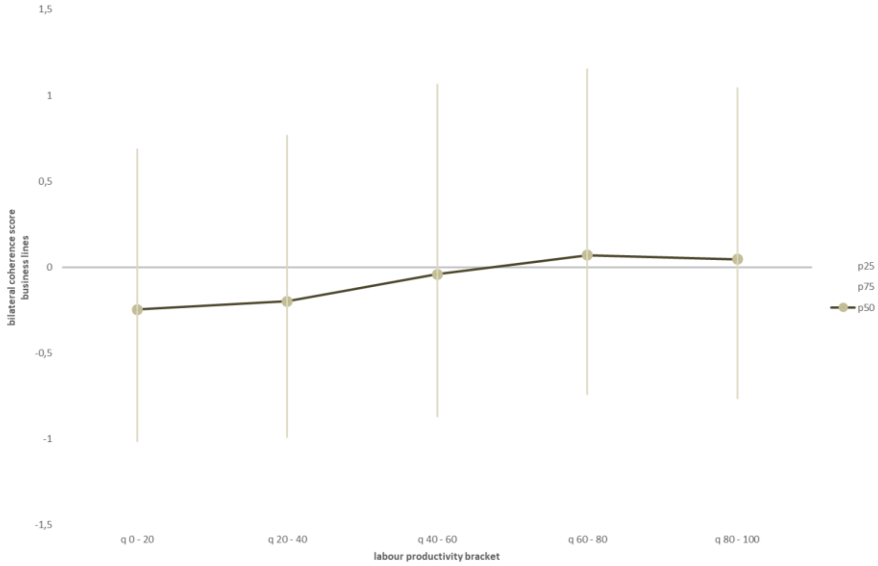
Source: Statistics Austria, Structural Business Statistics and Trade Statistics. Own calculations.

Figure 7: Product complexity exports over time in different labor productivity brackets



Source: Statistics Austria, Structural Business Statistics and Trade Statistics. Own calculations

Figure 8: Labour productivity levels and bilateral coherence



Source: Statistics Austria, Structural Business Statistics and Trade Statistics. Own calculations. Note: Vertical lines indicate the range of bilateral coherence scores between the lower 25% and the upper 75% quantile in the related quintile of the labour productivity distribution. The line connects the median values observed in each quintile of the labour productivity distribution across firms.