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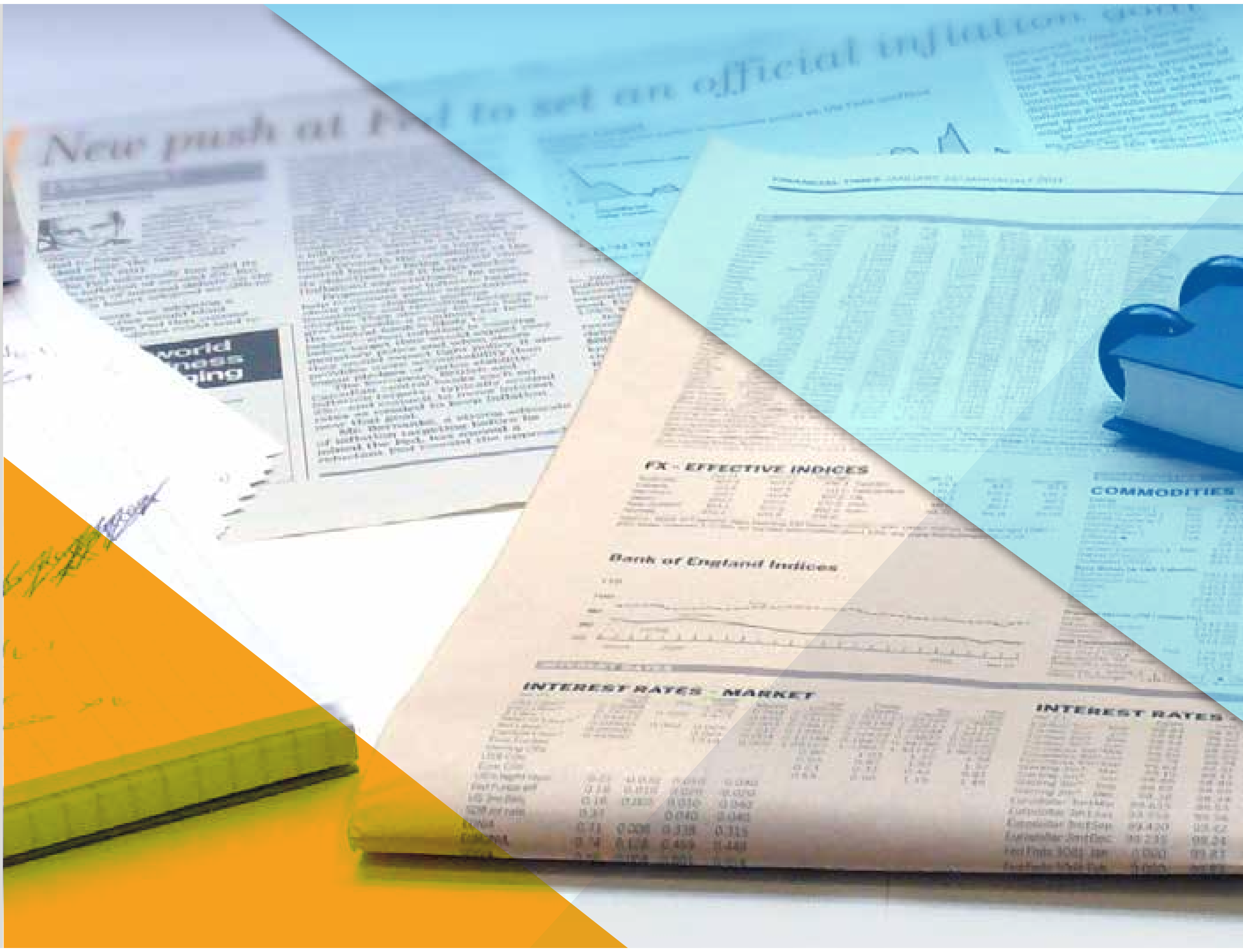
Multi-product exporters: Costs, prices and markups on foreign vs domestic markets

by Catherine Fuss



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Abstract

After establishing that exporters obtain higher margins than non-exporters, the paper takes a new look at export premia by comparing multi-product exporters' costs, prices and markups on the domestic and foreign markets. This firm-product-market analysis is made possible thanks to a unique dataset for Belgian manufacturing firms over 1996-2016. Firm-product estimates of marginal costs are obtained following De Loecker *et al*. (2016) methodology, based on firm-product production data. Combined with firm-product international transaction data, firm-product unit values can be computed separately for the domestic market and foreign markets. Markups can then be recovered at the firm-product-market level from observed unit values and estimated marginal costs. The empirical results suggest that firms select their best products, the ones with lower marginal cost, for foreign markets. They partly translate this cost advantage into lower prices, but essentially extract higher margins from these.

JEL classification: D22, D24, F14

Key words: markups, multi-product firms, pricing decisions, international trade

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Introduction

Firms' performance on foreign markets is usually considered as an indication of their competitiveness. A large strand of the literature has investigated what intrinsic features of firms differentiate an exporter from a company operating solely on the domestic market. Based on the theoretical predictions of the heterogeneous firm model developed by Melitz (2003), substantial empirical research has provided evidence that more productive firms self-select into exports. In Melitz's model, productive efficiency is directly related to the inverse of cost efficiency, so the finding that exporters are more productive than non-exporters can be interpreted in the sense that only the most efficient firms can afford the export costs.

Another strand of the literature has shown that exporters' markups are larger than those of domestic firms. The empirical analysis set out in this paper confirms this finding and goes beyond the comparison between exporters and non-exporters, where firm-level information is aggregated across products and markets. More precisely, it examines whether the markup premium takes its source from exported products that are more cost-efficient than non-exported products, or from prices that are higher on foreign than domestic markets.

This paper analyses the relationship between firm internationalisation and a set of firm conditions and outcomes. More specifically, it examines the role of marginal costs, pricing and markups. These questions have received substantial theoretical and empirical attention over the last two decades.

The seminal paper of Melitz (2003) introduces firm heterogeneity with respect to productive efficiency, in a model of monopolistic competition and trade. One important theoretical implication of the model is that only the most efficient firms do export. This theoretical prediction has received substantial empirical support, starting with earlier papers such as Bernard and Jensen (1995), and led to extensive literature (see, among others, the cross-country evidence provided in the International Study Group on Exports and Productivity, 2008; or Dhyne *et al*., 2015). In Melitz's (2003) model, wages are assumed to be identical across all firms so that firm productivity is proportional to the inverse of cost efficiency. An increase in productivity is synonymous with lower marginal costs and lower prices. However, because of a CES utility function, markups are exogenously determined by the elasticity of substitution between product varieties. They are not endogenous to firm characteristics and vary across markets only to the extent that this elasticity of substitution varies.

Melitz and Ottaviano (2008) extend Melitz's model to endogenous markups. Their model features two important ingredients. Using a quadratic utility function, they introduce horizontal demand competition that leads to endogenous markups. Both prices and markups vary across firms according to marginal costs. A higher marginal cost is associated with higher prices and lower markups. Exporting entails a trade cost so that, all else equal, exporters have to be more cost-efficient than non-exporters to be able to charge prices on foreign markets that meet foreign demand and compensate them for the export costs. The other important ingredient of their analysis is to account for differences in the "toughness of competition" across markets. The toughness of competition increases in the number of consumed varieties and diminishes with average prices, among others. Therefore, for a given firm-product variety, the price charged on foreign markets, and markups, may be higher if competition is less fierce, for example because the number of consumed varieties is lower or the market average price is higher.

Mayer *et al*. (2014) further extend Melitz and Ottaviano (2008) model to multi-product firms. This makes it possible to investigate the firm product choices along with the export decision. As in Melitz and Ottaviano (2008), firm-product prices are positively related to firm-product marginal cost and negatively to the toughness of competition, while markups diminish with marginal cost and the toughness of competition. On the production side, firm-product varieties are distributed along a competence ladder where marginal cost is lowest for the core-competence firm product and increases with distance from it. In this set-up, firms respond to tougher competition by reducing the product scope and concentrating on their core-competence product. It follows that, for a given firm, exported products have to be more cost-efficient than non-exported products to cover the export cost. In other words, firms concentrate their export product-mix on their best products.

Further developments of the Melitz and Ottaviano (2008) model include, for example, Bellone *et al*. (2016) who consider horizontal and vertical differentiation, thereby accounting for product quality, an issue that is not examined in this paper.

Several empirical analyses have confirmed that exporters are more productive than non-exporters and that exporters charge higher margins than non-exporters. With respect to this literature this paper focuses on cost competitiveness rather than on productive efficiency.[1] It considers the other side of the competitiveness coin, by characterising exported firm products in terms of their marginal costs, prices and markups rather than productive efficiency.

Second, it analyses firm export performance from the point of view of its product varieties, while most of the literature on export premia considers productivity and markups at the aggregated firm level. This paper aims to understand firm export strategies in terms of product choice.

Third, it compares the pricing and markups outcomes of exporters on the domestic versus foreign markets. Although there is substantial evidence of pricing-to-market strategy by exporters, such analysis is restricted to pricing on foreign markets. Due to a lack of relevant data, little is known between the difference in firm-product prices and markups between the domestic market and the foreign markets. Thanks to a unique dataset, this paper allows to examine these questions. One advantage of such analysis over a comparison of firm-level markups for exporters and non-exporters, is to get rid of both product composition effects and market composition effects. For example, it is possible to gauge whether markups are higher for exported products than for non-exported products, and whether margins are higher on the foreign vs domestic market.

In the present paper, the empirical strategy goes in three steps. First, in line with the literature on exporters' markups, firm-level markups are estimated along the lines of De Loecker and Warzynski (2012), based on revenue data for manufacturing firms. The estimates confirm that exporters charge higher markups than non-exporters. However, such analysis is silent about the product strategy of exporters and on their ability to use pricing-to-market to obtain higher margins.

Therefore, in a second step, firm-product marginal costs are estimated using the De Loecker *et al.* (2016) methodology. This is made possible thanks to production data that provide information on values and quantities of firm sales by (industrial) goods, the Survey of Industrial Production. One important advantage of this procedure over estimation following De Loecker and Warzynski (2012) is to obtain marginal costs that are firm-product-specific. These can be used to compare exported

1 De Cramer *et al*. (2016) also analyse the role of unit labour costs, thereby considering firm heterogeneity beyond the single indicator of productivity, and rather extending the analysis to both wages and productivity.

products with non-exported products.[2] Distinguishing between the two is important because the latter type of products may be ill-suited to evaluate a firm's export competitiveness.

While such analysis is free from product composition effects, it cannot answer the question whether export profitability originates from expanding the size of the market on which firms sell their products or from obtaining higher prices on external markets. With respect to this question, the firm-product-level analysis suffers from market composition bias. Therefore, the analysis in this paper goes one step further and differentiates between the domestic and foreign markets. The production dataset is supplemented with the Transaction Trade data that gives information on values and volumes exported by firm, product and destination country, and identical information on imports. This makes it possible to compute the values, quantities and unit values of firm products sold on the domestic market and the values, quantities and unit values of firm products sold on foreign markets. Markups on the domestic (foreign) market can then be recovered from firm unit value on the domestic (foreign) market and marginal costs estimated at the firm-product level.

The analysis is performed for Belgian manufacturing firms over the period 1996-2016. A preliminary sketch of the results is that (i) exporters have, on average, higher markups than non-exporters, (ii) firms export their best products, i.e. the ones with relatively lower marginal costs (iii) this cost advantage is only partly passed on through lower prices and mainly delivers higher margins.

This is one of the rare papers that examines pricing and markups of exporters at the product level while considering both the domestic and foreign markets. Other recent analysis are scarce, but include Blum *et al*. (2018) and Georgiev (2016, 2018). The first uses data from Chilean manufacturing firms that have the exceptional feature of having information on firms' input prices but where product information is available at the 3-digit level only, an issue discussed in the empirical section below. The authors estimate firm-product-market markups and construct marginal costs. They compare exporters and non-exporters, domestic and foreign markets. Their results indicate that firms selling the same core product at home and abroad charge a 9% lower markup abroad and 20% lower on their main foreign market; and that on the domestic market, exporters have a 11% higher markup than non-exporters. Further, they also derive demand elasticities and their results suggest that demand heterogeneity is the main factor behind the export status; productivity having a second-order role.

Georgiev (2016) relies on Danish manufacturing data that is essentially of the same nature as the one used in this paper. Combining production data at the 8-digit firm-product level with trade data at the firm-product-destination level, he derives information on the foreign markets as well as on the domestic market. His results show that import competition has different effects along the firm's product ladder and exerts stronger pro-competitive effects (translating into lower markups). This is especially the case for firms' core products, which are also the ones for which they charge higher markups.

In another paper, Georgiev (2018) relies on Bulgarian manufacturing firms over 2008-2015. He estimates markups and marginal costs at the firm, product and market level. Although this introduces extra flexibility in marginal costs and enables trade costs or quality differences to be captured, it also implies potentially high differences in the allocation of firm-level inputs across products. This is an important difference with respect to this paper, which assumes that marginal costs are specific to

[2] Another well-known advantage of production data is that the is not subject to output (and input) price bias, so that estimated TFP is not contaminated by firm-specific demand shocks.

each firm-product but do not vary according to the destination market. But the analysis is performed at the 6-digit product level, which is in my view a caveat. His results show that prices charged on export markets are on average 8% higher than those charged on the domestic market, for a given firm-product pair. But markups are 25-27% lower for exported products than for products sold on the domestic market by the same company. This is due to much higher marginal costs for product-firm varieties sold abroad than the same varieties sold on the domestic market.

The rest of the paper is organised as follows. Section 1 describes the datasets. Section 2 provides firm-level markup estimates and assess the relationship between firm internationalisation and markups. Section 3 first exposes the estimation of firm-product marginal costs and evaluates firm-product performance for exported products and non-exported products. Then it turns to the construction of firm-product market markups and prices, and compares the profitability, i.e. markups and prices, derived from export activity to that obtained on the domestic market. Section 4 concludes.

1. Data description

The empirical analysis relies on firm-product-market level data for active manufacturing firms in Belgium over 1996-2016. Various data sources are combined, at the firm, firm-product or firm-product-market levels.

A first dataset is set up at the firm level and rests on revenue-based output. Firm-level variables are obtained from firm annual accounts and VAT declarations. Firm intermediate input consumption, M_{it}, and firm nominal sales, Y_{it}, are taken from VAT declarations; while employment L_{it}, and the capital stock, K_{it}, are reported in firms' annual accounts. In a small number of cases, balance sheet data have been corrected for dates and years or an apparently erroneous number of months in the annual accounts;[3] they were then annualised;[4] and missing values were extrapolated. The sector of economic activity is given by the NACE-Rev2 classification or converted into that classification for early years. 2-digit NACE-Rev2 deflators on value added, investment and intermediate consumption are published in the National Accounts Statistics. Employment is defined as the average number of employees in full-time equivalents over the year. The firm's average wage is given by its wage bill over the average number of employees in full-time equivalents over the year. The analysis considers firms active in the manufacturing sector, i.e. classified under headings 10 to 33 in the NACE Rev2 classification, and for which employment and total assets are strictly positive and nominal fixed tangible assets larger than 100 euro. The capital stock is measured as the stock of fixed tangible assets at the beginning of the year. The capital stock, intermediate input consumption and firm sales are deflated by the corresponding sector-level deflators. This dataset is used to estimate firm-level markups.

Second, in order to obtain estimates at the firm-product level, product-level data is obtained from the Survey of Industrial Production (Prodcom), that reports information on the values and volumes

[3] For example, when the year-end date was 2 January 2005, it has been changed to 31 December 2004. By doing this, we attributed the values reported in the annual accounts to the year 2004 instead of 2005.

[4] Flows are adjusted by taking a weighted average of t and t+1 flows. Stocks are adjusted by adding to the current year stock the weighted change in stocks between the current year and next year. The procedure attributes a missing value when there is not enough information to reconstruct the entire year, for example when information about the first few months or the last months of a given year is missing. This does not apply to the last year in which the firm is observed, or to flows in the first year that the firm is covered.

of sales of industrial goods, where products are defined at a very detailed level (8 digit). This informs about real production, y_{ipt}, and allows to recover unit values uv_{ipt}. In addition to enable a product-level analysis, a decisive advantage of production data is to give an idea of physical output, and this makes it possible to estimate production function estimates that are exempt from output price bias.

Third, a distinction is made according to the market on which products are sold, thanks to the Transaction Trade database. This database reports values and volumes of international transactions, export and import, at the firm, country and product level. Export values are f.o.b.; import values are c.i.f. Products are classified using the 8-digit CN classification. Because this differs from the product classification used in Prodcom, the paper focus on products for which a one-to-one correspondence between CN and Prodcom classification and units exist; these represent the vast majority of products. A more complete description of the conversion is given in Appendix A. Only observations with positive figures reported for both quantities and values are considered. In Belgium, a substantial fraction of imported goods is re-exported. Because of its central location in Europe and thanks to the size of its main port, among others, Belgium serves as a hub for a large part of the goods shipped, meaning that data are collected for export and import transactions that may have little to do with firm costs, pricing strategy or markup decisions. Using detailed information at the firm-product level, the volume of exported products for which an identical volume has been imported within the same year is identified as re-export and cleaned from data on firm sales, imports and exports. Last, observations where exports exceed sales are excluded. From these variables, it is then possible to construct firm-product values, volumes and unit values by market and year. Two types of markets are considered: the domestic and foreign market.[5] Domestic values are obtained by subtracting export values from total sales, and domestic volumes are obtained by subtracting export volumes from production volumes.

$$uv^{dom}_{ipt} = Py^{dom}_{ipt} / y^{dom}_{ipt} \tag{1}$$

$$Py^{dom}_{ipt} = Py^{t}_{ipt} - \mathrm{P}^{\mathrm{X}}\mathrm{x}_{ipt}. \tag{2}$$

$$y^{dom}_{ipt} = y^{t}_{ipt} - \mathrm{x}_{ipt} \tag{3}$$

Last, international dummies are constructed. A dummy for multinational status is obtained from the Survey of Foreign Direct Investment, $DFDI_{it}$. The dummy is equal to one for firms that have international ownership ties (inwards or outwards) of at least 10%. In the sample, 12% of firm-year observations refers to multinationals. A dummy for export status is obtained by aggregation of export values of the entire Transaction Trade dataset at the firm and year level, $DXfirm_{it}$. In the sample, 69% of firm-year observations refer to exporters. Last, a dummy for export is defined at the firm-product level; it reveals that exporters do not sell all their production abroad; indeed 40% of the firm-product-year observations of exporters corresponds to a product that is exported.

2. Exporters' markup premia: firm-level evidence

In line with previous evidence in the empirical literature, this section provides an analysis of the relation between firm-level markups and internationalisation. Using the firm-level dataset described above, where output has been constructed as deflated firm revenues, firm-level markups, μ_{it}, are

[5] The question here is to examine differences between exported and non-exported varieties rather than characteristics, as in the pricing-to-market literature.

estimated following De Loecker and Warzynski (2012). The sample considered is all firms active in manufacturing for which sales, intermediate input consumption, total labour costs and beginning-of-the-year capital stock are positive. The first two variables are given in VAT declarations, the latter in (annualised) annual accounts.

Firm-level markups are obtained as the output elasticity with respect to intermediate inputs over the share of intermediate inputs in firm sales:

$$\mu_{it} = \varepsilon_{YM}.PY_{it}/P^{M}M_{it} \tag{4}$$

The share of intermediate inputs in firm sales is observable from the data. The output elasticity is obtained from an estimate of the production function. This paper relies on a translog production function, and assumes, consistent with evidence on labour cost adjustment in Belgium, that labour is a predetermined production input. For estimation purposes, data have been trimmed for outliers by excluding apparent labour productivity, intermediate input share and capital labour ratios that lie above the median plus 5 times the interquartile range, or below the median minus 5 times the interquartile range, where moments of these variables are computed by 2-digit sector and year. The estimation is performed on broad sectors of economic activity to guarantee enough observations by category. Because dispersion statistics on estimated markups indicate the presence of outlier values, estimated markups are therefore trimmed for outliers excluding values below the median minus 5 times the interquartile range and values above the median plus 5 times the interquartile range, where moments are defined by sector and year.

Table 1 below reports the results of regressions of firm-level markups in logarithmic term on a dummy for exporters, controlling for year effects. Firm effects are not included because the export trade is extremely stable over time. The figures reported in the first column show that μ_{it} is 13% larger for exporters than for non-exporters, controlling for year and 2-digit Nace Rev 2.0 sector.

In the second column, a dummy for multinational membership is included as a control variable. On the one hand, multinationals are typically larger and have higher market shares; so that one can expect them to charge higher markups. On the other hand, multinationals may use transfer pricing when exporting to an affiliate; this would tend to blur the relationship between export and markup-setting. Therefore, we control for multinational status in columns (2) and in the rest of the paper. The estimates reveal that the difference between exporters and non-exporters is of the same order of magnitude and remains significant. Further, multinationals charge higher markups. The first two columns show that, within a sector, markups are higher for exporters and multinationals than for purely domestic firms, that operate solely on the domestic market.

The analysis above suffers from three types of issues: a firm-level price bias, a product composition effect and a market composition effect. Indeed, firm-specific input and output prices may affect the measurement of firm-level intermediate input share, and thereby the markup estimate. Further, markups may differ between exported and non-exported products. Last, prices are likely to vary across markets, and so will firm markups. These issues are tackled in the next section that provides estimates at the firm-product and even market level.

Table 1 – Firm-level markups and firm internationalisation

	(1)	(2)
DX_{it}	0.132***	0.128***
	(0.005)	(0.005)
$DFDI_{it}$		0.028***
		(0.007)
Constant	0.943***	0.943***
	(0.009)	(0.009)
Observations	81,635	81,635
R-squared	0.151	0.152

Notes: Firms active in the manufacturing sectors over 1996-2016.

$DFDI_{it}$=1 is firm i is or belongs to a multinational;

DX_{it}=1 if firm i is an exporter

All regressions include year dummies.

Markups estimated using De Loecker and Warzynski (2012), trimmed for outliers.

Standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1

3. Export premia revisited: evidence on firm-product-market marginal cost, markup and prices

This section first explains the estimates of firm-product marginal costs and the construction of unit values and markups at the firm, product and market level in section 3.a. Section 3.b then evaluates the statistical differences between exported and non-exported products, and between foreign and domestic markets.

3.a. Estimates of marginal costs and markups at the firm-product-market level

Endowed with the firm-product market variables described in section 1, the firm-product marginal cost can be estimated using De Loecker *et al*. (2016) methodology and, using observed unit values, the firm-product market markups can be recovered. The methodology is briefly set out here but explained in more details in Appendix B. Firm-product markups are obtained as the output elasticity with respect to intermediate inputs over the share of intermediate inputs in firm sales:

$$\mu_{ipt} = \varepsilon_{YM}.PY_{ipt}/P^{M}M_{ipt}. \tag{5}$$

Compared to the De Loecker and Warzynski (2012) methodology, the issue is to obtain the output elasticity and intermediate inputs share at the product level. The output elasticity, ε_{YM}, is obtained from a production function estimates for single-product firms. Again, a translog production function is specified:

$$q_{ipt} = \beta_L l_{ipt} + \beta_K k_{ipt} + \beta_M m_{ipt} + \beta_{LL} l_{ipt}^2 + \beta_{KK} k_{ipt}^2 + \beta_{MM} m_{ipt}^2$$

$$+ \beta_{LK} l_{ipt} k_{ipt} + \beta_{LM} l_{ipt} m_{ipt} + \beta_{KM} k_{ipt} m_{ipt} + \beta_{LKM} l_{ipt} k_{ipt} m_{ipt} + \omega_{it} + \varepsilon_{ipt} \tag{6}$$

where q_{ipt}, l_{ipt}, k_{ipt} and m_{ipt} denote, respectively the logarithmic transformation of output, labour, deflated capital stock and deflated intermediate inputs. Note that, as before, labour is assumed to be predetermined. Because the estimation relies on production data, it does not suffer from firm-specific output price bias. Furthermore, the production function estimation also includes a correction for unobserved input prices. This is assumed to depend on output price, market share and interaction between the two, in addition to product and year dummies.

The production function is estimated for single-product firms. For these firms, the intermediate input share is observed. For multi-product firms, the input allocation scheme by product, ρ_{ipt}, is recovered from the input price correction function. This is a crucial step because it determines the estimated firm-product intermediate inputs $P^M M_{ipt} = \rho_{ipt}.PM_{it}$ from which intermediate input shares, $PY_{ipt}/P^M M_{ipt}$, by firm-product for all firms are computed. This is an essential component of firm-product markups as shown in the equation above, and further impacts estimated firm-product marginal costs.

Using information on firm-product unit values from Prodcom, marginal costs at the firm-product level can now be obtained as

$$mc_{ipt} = uv_{ipt} / \mu_{ipt}. \tag{7}$$

Assuming that a firm-product marginal cost is product-specific and does not depend on the market on which the good is sold, one can also estimate markups on the domestic and foreign markets respectively as

$$\mu^{dom}_{ipt} = uv^{dom}_{ipt} / \mathrm{mc}_{ipt} \tag{8}$$

and

$$\mu^{for}_{ipt} = uv^{for}_{ipt} / \mathrm{mc}_{ipt} \tag{9}$$

Note that this paper uses product-level information defined at the very detailed 8-digit level. This contrasts with Blum *et al*. (2018) who use information at the 3-digit level or Georgiev (2016) who uses information at the 6-digit level. By contrast, I rely on 8-digit product-level data in order to avoid as far as possible composition bias in the comparison of prices, markups and marginal costs across firms and markets. To give an idea of the difference it makes, within the 6-digit code 10.82.22, “Chocolate and food preparations containing cocoa (except sweetened cocoa powder), other than in bulk forms”, there are no less than eleven different 8-digit categories, with very different contents, from chocolate blocks to sugar confectionery containing cocoa (such as chocolate nougat) and preparations containing cocoa for making beverages.[6]

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[6] In more detail, the CPA category 10.82.22 contains the following sub-categories: 10.82.22.33, “Filled chocolate blocks, slabs or bars consisting of a center (including of cream, liqueur or fruit paste; excluding chocolate biscuits)”; 10.82.22.35, “Chocolate blocks, slabs or bars with added cereal, fruit or nuts (excluding filled, chocolate biscuits)”; 10.82.22.39, “Chocolate blocks, slabs or bars (excluding filled, with added cereal; fruit or nuts, chocolate biscuits)”, 10.82.22.43, “Chocolates (including pralines) containing alcohol (excluding in blocks, slabs or bars)”; 10.82.22.45, “Chocolates (excluding those containing alcohol, in blocks, slabs or bars)”; 10.82.22.53, “Filled chocolate confectionery (excluding in blocks, slabs or bars, chocolate biscuits, chocolates)”; 10.82.22.55, “Chocolate confectionery (excluding filled, in blocks, slabs or bars, chocolate biscuits, chocolates)”; 10.82.22.60, “Sugar confectionery and substitutes therefor made from sugar substitution products, containing cocoa (including chocolate nougat) (excluding white chocolate)”; 10.82.22.70, “Chocolate spreads“;10.82.22.80, “Preparations containing cocoa for making beverages”; 10.82.22.90, “Food products with cocoa (excluding cocoa paste, butter, powder, blocks, slabs, bars, liquid, paste, powder, granular, other bulk form in packings > 2 kg, to make beverages, chocolate spreads)”.

A further difference from other papers is that I assume marginal costs are firm-product-specific but do not vary across markets. Although estimating marginal costs by product and market enables us to potentially capture the part of costs related to trade activities and quality differentiation on foreign versus domestic markets, this comes at a cost. In doing so, one also allows for differences in the allocation of firm inputs for the same product depending on the market. Such flexibility may be hard to reconcile with the idea that it is the same product sold on both markets. In sum, assuming that marginal cost may vary slightly across markets but not by a large extent, I opt for a methodology that constraints marginal costs to be equal across markets rather than allowing them to fluctuate without bounds.

In order to estimate the production function, the data is trimmed for outliers by excluding firm-observation values of apparent labour productivity, the intermediate input share and the capital-labour ratio that lie below their median minus 3 times the interquartile range or above their median plus 3 times the interquartile range, where moments have been estimated by 2-digit sector and year, as before. Furthermore, output prices (firm-product unit values) are trimmed according to the same criteria where moments in the price distribution are defined by 8-digit product and year. In addition, intermediate inputs to sales ratios that are above 1 or below 0.10 are excluded. Last, firm-year observations for which the sum of industrial products sales to firm total sales is below two-thirds or above 1.33 are dropped.[7]

After trimming the dataset has 116 706 observations over 1996-2016, for 5 613 firms, covering 2 569 products. 20% of firm-product-year observations refer to single-product firms, so that 23 173 observations are available for estimation of the production function.

Table 2 below reports information on firm-year observations by number of product and internationalisation status. Firms with one or two products account for 37% of the firm-year observations. Exporters and multinationals are more frequent among companies that have many products; firms with more than five industrial products are exporters in 88% of the cases and belong to a multinational in 28% of the cases. These numbers are high relative to the sample average of 69% and 12% respectively.

Table 2: Sample description – firm-year observations of multi-product firms

	% obs	# obs	% exporters	% multinationals
single-product firms	0.51	23162	0.68	0.10
multi-product firms				
• 2 products	0.22	10072	0.58	0.09
• 3 products	0.10	4351	0.75	0.14
• 4 products	0.05	2502	0.78	0.15
• 5 products	0.03	1477	0.82	0.18
• >5 products	0.09	4085	0.88	0.28
total		45649	0.69	0.12

To keep the number of observations sufficiently large, estimates are performed by broad sector

7 This may occur because manufacturing firms do not only sell industrial goods they have produced but also goods that have been bought from other companies (e.g. this issue was raised in the case of export and named “carry-along trade”, Bernard *et al*., 2019), or services (see Blanchard *et al*., 2017). Further, this may be due to reporting issues because information on industrial production and firms’ total sales come from two different sources: a survey in the first case, VAT declarations in the second case.

of economic activity. Still, sectors 20-21, 26, 27 and 29-30 are excluded because this leaves less than 1 000 observations for estimating the production function.

A first look at markup estimates suggests that there is still substantial heterogeneity. Outliers may impact estimates of internationalisation effects on markups, but also on marginal costs. Therefore, before turning to the examination of export premia, markups are trimmed, removing observations where estimated markups and output elasticities lie below the median minus 3 times the interquartile and their median plus 3 times the interquartile, where moments are computed at the broad sector and year level. Table C.1 in the Appendix reports trimmed estimated markups by broad sector. Table C.2. in the Appendix reports mean and median estimates of output elasticities.

As a primary description of estimated variables, table C.3 reports least squares regressions of output prices on marginal costs and wages. All regressions include year dummies. In columns (1) and (2), the results indicate that a firm encountering a 10% higher product marginal cost has a 2% higher price than the price charged by its competitors. A 10% higher average firm wage translates into a 1% higher price. Considering firm-product effects, the results in columns (3) and (4) indicate that a 10% increase in marginal costs leads to a 2% increase in firm-product unit value. Wage changes have limited but positive impact on firm-product unit values variations. This may be due, among other things, to little heterogeneity across firms compared to heterogeneity of marginal costs across firms and products. This result may be due to the centralised wage bargaining system used in Belgium. It is also consistent with evidence in Carlsson and Nordstrom Skans (2012) and Loupias Sevestre (2013) pointing to wage changes have a smaller impact on price changes than variations in intermediate input costs.

In the absence of observed product-level data on both output and inputs, input allocation to each firm product is observed for single-product firms but has to be estimated from multi-product firms. De Loecker *et al*. (2016) propose to recover the share allocated to each product from a theoretical model where the structure derived from the function controlling for unobserved input prices for single-product firms can be used to infer the product allocation for multi-product firms. An alternative to this theoretically sounded input allocation is to allocate inputs across products using the firm 's product revenue shares. This has been used by Foster *et al*. (2008), for example. In our sample, the correlation between the two is 0.79. Table C.4. in the Appendix reports the average input shares using both methods, by broad sector of economic activity. Although output elasticities are relatively close to the main results, the allocation of inputs based on revenue shares has a dramatic effect on estimated markups. The correlation between markups estimated in these two ways is rather low, 0.10, but naturally goes up when excluding firm-year observations for which some products account for a very small share of revenues (the correlation rises to 0.18 if no product accounts for less than 1% of revenues and reaches 0.45 if no product accounts for less than 25% of revenues).

3.b. Export premia revisited at the firm-product-market level.

Using the data constructed as described above, this section proceeds in three steps. Table 3 describes the structure of the data and the empirical exercises that are performed. Three types of export dummies are defined, at the firm-year level, DX_{it}, at the firm-product-year level, DX_{ipt}, and at the firm-product and market-year level, DX_{ipmt}. The previous section considers firm export status and the export dummy as defined in the first column.

In this section, unit values are computed at the firm-product level and markups are constructed by the difference between these unit values and estimated marginal costs. The export dummy considered is the one defined in the third column, DX_{ipt}. Actually, exporters may have two types of products on their production portfolio, those that they sell on the domestic market only (for which DX_{ipt}=0) and those that they (also) sell on the foreign market (for which DX_{ipt}=1). Analysing the export premia at firm-product level enables an examination of whether exporters obtain higher margins and lower marginal costs from exported products than from non-exported products.

Last, thanks to data on firm-product unit values on foreign transactions, a distinction is made between domestic and foreign markets. Since marginal costs are estimated at the firm-product level, the interest of this exercise rests on comparing unit values and markups across markets, the domestic versus the foreign market. Focusing on firm-product-market dummies, DX_{ipmt}, the analysis seeks to understand where exporters obtain their margins from. Indeed, for a given exported firm-product variety (for which DX_{ipt}=1), unit values are constructed separately for the domestic market (DX_{ipmt}=0) and foreign market (DX_{ipmt}=1). Accordingly, markups charged on the domestic market and markups charged on foreign markets can be evaluated separately.

To end up with the description of the econometric analysis, it should be noted that, in each of these three cases, the specification includes firm-product effects. It thereby captures variation across time for a given firm-product variety. Note that a firm-year dummy for multinational membership is included as control variable, *inter alia* to control for transfer pricing. Variables are expressed in logarithmic terms.

Table 3 –Structure of the dataset and econometric exercises

firm export status		firm-product export status		market where the product is sold	
$DX_{it} = 0$	domestic	$DX_{ipt} = 0$	firm-product not exported	$DX_{ipmt} = 0$	domestic market only
$DX_{it} = 1$	exporter	$DX_{ipt} = 0$	firm-product not exported	$DX_{ipmt} = 0$	domestic market only
		$DX_{ipt} = 1$	firm-product exported	$DX_{ipmt} = 0$	domestic market also
				$DX_{ipmt} = 1$	foreign market also

Notes:

DX_{it}=1 if firm i exports in year t;

DX_{ipt}=1 if firm i exports product p in year t;

DX_{ipmt}=1 if firm i sell product p on foreign markets in year t;

The econometric analysis described above is now reported in the following two tables. Table 4 shows regressions of firm-product-level estimates of marginal costs, unit values and markups on an export dummy, DX_{ipt}, that is equal to one when firm *i* exports product *p*. The analysis focuses on products exported by at least one firm, because non-exported products, i.e. products that no firm sells abroad, are irrelevant for the identification of DX_{ipt}. All equations include firm-product and year effects. The results therefore indicate that, compared to its firm-product average, an exported product reaches a 14.4% lower marginal cost once the firm exports it. This cost advantage does not translate into lower prices. So, this advantage gives firms a 15.5% higher markup on exported products than when they do not export that product.

The analysis in table 4 is conducted at the firm-product level. Therefore, results for unit values and markups may be contaminated by a market composition effect. The pricing-to-market literature has shown that prices actually vary across markets, according to local demand conditions, and so will markups. This does not hold for marginal costs which can reasonably be assumed to be firm-product-specific and thereby constant across markets.

Table 4: Export premia, firm-product level estimates

	$\ln(mc_{ipt})$	$\ln(uv_{ipt})$	$\ln(\mu_{ipt})$
DX_{ipt}	-0.144***	0.011	0.155***
	(0.034)	(0.013)	(0.030)
$DFDI_{it}$	-0.034	0.010	0.045
	(0.062)	(0.019)	(0.059)
Observations	72,846	72,846	72,846
R-squared	0.913	0.983	0.797
Fixed effects			
year	Yes	Yes	Yes
firm-product	Yes	Yes	Yes

Notes: firms active in the manufacturing sectors over 1996-2016.

$DFDI_{it}$=1 is firm i is or belongs to a multinational in year t;

DX_{ipt}=1 if firm i exports product p in year t

Markups estimated using De Loecker et al. (2016), trimmed for outliers.

Clustered (at the firm level) standard errors in brackets,

*** p<0.01, ** p<0.05, * p<0.1

Therefore, in table 5, the analysis is based on data that decomposes firm-product unit values by market, uv_{ipmt}; the difference with respect to firm-product marginal costs yields firm-product-market markups, μ_{ipmt}. As before, the regressions include a multinational dummy as control. The main interest for the firm-product-market-level analysis is to compare prices charged and markups obtained on the domestic and foreign markets. For that purpose, the export dummy is accordingly defined at the firm, product and market level. DX_{ipmt} is equal to one when firm *i* sells product *p* on foreign markets, and zero for sales on the domestic market.

Table 5: Export premia, firm-product-market estimates

	$\ln(uv_{ipmt})$	$\ln(\mu_{ipmt})$
DX_{ipmt}	0.005	0.028***
	(0.004)	(0.007)
$DFDI_{it}$	-0.006	0.005
	(0.019)	(0.077)
Observations	77,148	77,148
R-squared	0.973	0.770
Fixed effects		
year	Yes	Yes
firm-product	Yes	Yes

Notes: firms active in the manufacturing sectors over 1996-2016

$DFDI_{it}$=1 is firm i is or belongs to a multinational in year t

DX_{ipmt}=1 if firm i sells product p on market m (domestic vs foreign) in year t;

Markups estimated using De Loecker et al. (2016), trimmed for outliers.

Clustered (at the firm level) standard errors in brackets,

*** p<0.01, ** p<0.05, * p<0.1

The estimates reported in table 5 suggest that, for exported products, when selling a product abroad, the difference between the unit values charged abroad and on the domestic market is small and not significant, implying a small although significant difference in markups compared to the times when the firm sells the same product on the domestic market.

The above analysis is a first step to understanding why firms export their products, whether the main motivation is to widen their scope by accessing a larger market to sell their output or obtaining higher prices on foreign markets. Considering external markets as an aggregate foreign market was sufficient for that purpose.

Differences in prices and markups could nevertheless be observed across foreign markets varying between distant and close markets, high-income and low-income economies, or countries with specific linkages with the domestic country, such as those related to language, trade union or currency area membership, to cite a few characteristics. In order to investigate this, one last exercise is carried out to distinguish between market types. Several foreign market aggregates are considered: the euro area (for the period starting in 1999), EU (with time-varying definition), OECD countries, and high-income countries as classified by the Wold Bank.

Note that, the definition of exported product, exported dummies and export unit values are all based on export data that is corrected for re-export activities. This correction cannot be applied to trade data split by destination as there is no convincing way of identifying from what country of origin the re-exported volumes come from, nor to what destination country they go to. To get round this issue, I define export dummies and export unit values restricted to firm-product observations where net export is observed.[8] To be clear, the EU firm-product export dummy is set as equal to one if the firm exports that product towards the EU and net export is positive for that firm product. In the same vein, the EU firm-product export unit value is computed for firm products exported to the EU if net exports of that firm product are positive.

Table 6 reports results of the same regression as in table 4, adding a dummy by specific foreign market, each panel considering one variable, marginal cost, unit values and markups. The first column reports the results from table 4. Table 7 reports similar results to table 5 where the domestic market is compared to each of the foreign markets.

In the vast majority of the cases, most export transactions take place with an EU country. In fact, 92% of firm-product-year observations refer to exports to the EU, and 95% to an OECD or high-income country. Export to the EU (OECD) account, on average, for 92% (96%) of a firm's exports. Therefore, unsurprisingly, exports to these countries drive the results. However, the finding of lower marginal costs and higher markups is reinforced when considering the broader set of OECD and high-income countries, suggesting that firms make an additional effort on product costs when exporting there. They thereby benefit from a slightly higher markup compared to the domestic market.

[8] The volume of re-export by firm and product is identified as the identical volume of the same product that the firm imports over the same period. Exports (imports) and then cleaned for re-export, and the values of net export (net import) are reconstructed based on observed export (import) unit values. When correcting for re-export, some firm-product exports are entirely due to re-export. Net export is equal to zero for these firm-product pairs. Therefore, these observations are dropped, by construction, from the exported products.

Table 6: Export premia by market type, firm-product level estimates

	$\ln(mc_{ipt})$	$\ln(mc_{ipt})$	$\ln(mc_{ipt})$	$\ln(mc_{ipt})$	$\ln(mc_{ipt})$
DX_{ipt}	-0.144***	0.002	-0.009	0.068	0.033
	(0.034)	(0.055)	(0.054)	(0.067)	(0.070)
DX^{EU}_{ipt}		-0.177***			
		(0.058)			
DX^{EA}_{ipt}			-0.196***		
			(0.057)		
DX^{OECD}_{ipt}				-0.238***	
				(0.070)	
DX^{high}_{ipt}					-0.199***
					(0.073)
Observations	72,846	72,846	62,884	72,846	72,846
R-squared	0.913	0.913	0.921	0.913	0.913
	$\ln(uv_{ipt})$	$\ln(uv_{ipt})$	$\ln(uv_{ipt})$	$\ln(uv_{ipt})$	$\ln(uv_{ipt})$
DX_{ipt}	0.011	0.031	0.029	0.027	0.020
	(0.013)	(0.021)	(0.021)	(0.025)	(0.025)
DX^{EU}_{ipt}		-0.024			
		(0.025)			
DX^{EA}_{ipt}			-0.025		
			(0.023)		
DX^{OECD}_{ipt}				-0.018	
				(0.027)	
DX^{high}_{ipt}					-0.010
					(0.028)
Observations	72,846	72,846	62,884	72,846	72,846
R-squared	0.983	0.983	0.984	0.983	0.983
	$\ln(\mu_{ipt})$	$\ln(\mu_{ipt})$	$\ln(\mu_{ipt})$	$\ln(\mu_{ipt})$	$\ln(\mu_{ipt})$
DX_{ipt}	0.155***	0.029	0.039	-0.041	-0.013
	(0.030)	(0.050)	(0.046)	(0.063)	(0.064)
DX^{EU}_{ipt}		0.153***			
		(0.051)			
DX^{EA}_{ipt}			0.171***		
			(0.048)		
DX^{OECD}_{ipt}				0.219***	
				(0.064)	
DX^{high}_{ipt}					0.189***
					(0.066)
Observations	72,846	72,846	62,884	72,846	72,846
R-squared	0.797	0.797	0.819	0.797	0.797

Notes: firms active in the manufacturing sectors over 1996-2016

All regressions include a multinational dummy, firm-product effects and year dummies.

The estimates with the EA dummy are run on 1999-2016.

$DFDI_{it}$=1 is firm i is or belongs to a multinational in year t. DX_{ipt}=1 if firm i exports product p in year t; DX^{m}_{ipt}=1 if firm i exports product p in year t to market m, where m = EA, EU, OECD, high (for high-income countries).

Markups estimated using De Loecker et al. (2016), trimmed for outliers.

Clustered (at the firm level) standard errors in brackets.

*** p<0.01, ** p<0.05, * p<0.1

Table 7: Export premia by market type, firm-product-market estimates

	$\ln(uv_{ipmt})$	$\ln(uv_{ipmt})$	$\ln(uv_{ipmt})$	$\ln(uv_{ipmt})$	$\ln(uv_{ipmt})$
DX_{ipmt}	0.005				
	(0.004)				
DX^{EU}_{ipmt}		0.012***			
		(0.004)			
DX^{EA}_{ipmt}			0.011**		
			(0.005)		
DX^{OECD}_{ipmt}				0.013***	
				(0.004)	
DX^{high}_{ipmt}					0.019***
					(0.004)
Observations	77,148	78,492	67,943	79,377	79,332
R-squared	0.973	0.972	0.974	0.972	0.972
	$\ln(\mu_{ipmt})$	$\ln(\mu_{ipmt})$	$\ln(\mu_{ipmt})$	$\ln(\mu_{ipmt})$	$\ln(\mu_{ipmt})$
DX_{ipmt}	0.028***				
	(0.007)				
DX^{EU}_{ipmt}		0.036***			
		(0.007)			
DX^{EA}_{ipmt}			0.038***		
			(0.008)		
DX^{OECD}_{ipmt}				0.035***	
				(0.006)	
DX^{high}_{ipmt}					0.039***
					(0.007)
Observations	77,148	78,492	67,943	79,377	79,332
R-squared	0.770	0.774	0.794	0.774	0.774

Notes: firms active in the manufacturing sectors over 1996-2016

All regressions include a multinational dummy, firm-product effects and year dummies. The estimates with the EA dummy are run on 1999-2016.

$DFDI_{it}$=1 is firm i is or belongs to a multinational in year t.

DX_{ipmt}=1 if firm i sells product p on market m (domestic vs foreign) in year t;

DX^{m}_{ipt}=1 if firm i exports product p in year t to market m, where m = EA, EU, OECD, high (for high-income countries).

Markups estimated using De Loecker et al. (2016), trimmed for outliers.

Clustered (at the firm level) standard errors in brackets.

*** p<0.01, ** p<0.05, * p<0.1

To sum up, the estimates in table 4 suggest that exported firm-product varieties have a marginal cost advantage over the product average. Exported products are sold at a slightly lower price than non-exported products and yield much higher margins. The results in table 5 indicate that the decisive difference in terms of price and markups works for exported varieties as opposed to non-exported varieties rather than on the market on which the export product is sold. The markup gains originate mostly from lower marginal costs; that yields higher margins both on the domestic and foreign markets, although there is a slight additional gain in foreign markets.

4. Conclusion

This paper verifies that export activity provides internationalised firms with a markup premia. After checking that this is true for exporters as compared to non-exporters, the analysis goes beyond firm-level evaluation and examines the nature of this markup premia from two further dimensions, the product and the market. It analyses the nature of the exported products in terms of cost efficiency, and it investigates whether margins come from foreign or domestic markets.

This is made possible thanks to a unique dataset for Belgian manufacturing firms over 1996-2016 that enables output and unit values to be obtained at the firm, product and market level. This makes it possible to measure firm-product unit values not only by export destination, but also those charged on the domestic market. This enables new light to be shed on export premia by comparing the markups that exporters obtain on the domestic market with those achieved on foreign destinations.

The empirical evidence confirms that exporters choose to ship their best products abroad, the ones with lowest marginal costs, consistent with the theoretical predictions of Mayer *et al*. (2014). Decomposing firm unit values into unit values charged on the domestic market and unit values obtained on foreign markets, the paper further provides evidence that most of the margins are obtained from this cost-efficient advantage. Last, when comparing the firm pricing strategies of exporters and non-exporters, when they operate on the same market, i.e. the domestic market, the results confirm that although exported products benefit from a cost advantage, this is only partly passed on through to lower prices and mainly provides exporters with substantially higher margins. The firm-product marginal cost advantage is actually 14.4% lower on average; but these products are sold at similar prices, leading to a markup advantage of 15.5%.

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Appendix A: Harmonisation of Trade and Prodcom data classification and construction

Data on firm total production by product are provided in the Survey of Industrial Production (Prodcom) for total values PX^{tot}_{ipt} and total volumes, X^{tot}_{ipt}. Data on exports (imports) by firm *i*, product *p* and country *c* are given in the Transaction Trade dataset, for values, PX^{c}_{ipt} (PM^{c}_{ipt}), and quantities, X^{c}_{ipt} (M^{c}_{ipt}). These are used to construct firm-product unit values, uv_{ipt}, and firm-product unit values by market (domestic vs foreign), uv^{dom}_{ipt} and uv^{for}_{ipt}. Before explaining the construction of these variables, this Appendix explains how the product classification is harmonised across the various data sources, and how account is taken of re-export activities.

Harmonisation of trade and Prodcom classifications

To be compared, CN8 trade classification and 8-digit Prodcom classifications need to be harmonised. This has been done in three steps. First, since the product classification changes regularly, the classifications of each data source have been harmonised over time.[9]

Second, a correspondence between CN codes and Prodcom codes is made, focusing on one-to-one conversion. This avoids complications and errors related to weighting export values and volumes to convert them into several Prodcom codes.[10] The price to pay is that unconverted export codes will lead to missing export information that will not subtract from production information. In Eurostat conversion tables, over 1996-2016, 97% of export codes have a one-to-one correspondence with Prodcom codes.

Third, both values and quantities need to be converted into the same classification and units to compute domestic and export unit values. In this case, the analysis focus on products for which trade and Prodcom units are the same.

Accounting for re-export activities

Before using the export data to construct unit values, an additional correction has been made to export variables to account for re-export activities. Re-export activities are identified as import of product *p* by firm *i* in year *t* that firm *i* exports within the same year. More precisely, re-export volumes are defined as $reX^{export}_{ipt} = \min(X^{export}_{ipt}, M^{export}_{ipt},)$. Reexport values and net export values are adjusted accordingly, applying the export unit value aggregated across destination countries: $PX^{export}_{ipt} \,.\, reX^{export}_{ipt}$. Firm export, sales and intermediate input purchases are then cleaned for re-export.

Construction of unit values on the domestic and foreign market

To obtain unit values on the export and domestic markets, net export values are subtracted from total sales and net export volumes from total quantities sold. For this purpose, additional cleaning of export data is performed. Export data for which either values or volumes are missing are dropped.

9 When a product is split into several categories, the new production (export) structure is applied to the past. If the firm no longer produces the product, the average production (export) structure over the sample of firms is applied.

10 One-to-many conversion is possible provided weights are computed for each of the many products. For example, firm total sales of each product (from Prodcom) can be used to allocate export into several Prodcom products. However, this implicitly assumes some proportionality between unit values, which is not suitable for the analysis of this paper that considers differences across unit values.

Then exports are aggregated across destination to obtain export values and export volumes at the firm-product-year level, PX^{export}_{ipt} and X^{export}_{ipt},. Accordingly, Prodcom data is cleaned by excluding observations where total volumes or total values are not reported. Further, export and domestic observations where total values (volumes) are smaller than export values (quantities) are excluded.

Based on this information, one can now construct firm-product unit values as $PX^{tot}_{ipt} / X^{tot}_{ipt}$. Then domestic values are obtained as $PX^{dom}_{ipt} = PX^{tot}_{ipt} – PnetX^{export}_{ipt}$, and domestic volumes as $X^{dom}_{ipt} = X^{tot}_{ipt} – \text{net}X^{export}_{ipt}$. We end up with two sets of unit values: firm-product unit values, uv_{ipt}, and firm-product unit values by market, distinguishing between the domestic market, uv^{dom}_{ipt} and unit values on the foreign market, uv^{for}_{ipt}.

Appendix B – De Loecker *et al*. (2016) methodology

This Appendix explains the methodology developed by De Loecker *et al*. (2016) that is used to estimate markups and marginal costs at the firm and product level. The method relies, as in De Loecker and Warzynski (2012), on the fact that markups can be expressed as the output elasticity with respect to intermediate inputs over the share of intermediate inputs in firm sales. The difference with De Loecker and Warzynski (2012) is twofold. First, the estimate of the output elasticity is based on estimates of the production function from production data, rather than revenue data. This makes it possible to purge the output price bias discussed by Griliches and Mairesse (1995), i.e. the fact that firm-specific demand shocks contaminate estimated TFP in revenue-based production function estimates. Second, De Loecker *et a*l. (2016) carry out their analysis at the firm-product level. This implies that the allocation of firm-level inputs across inputs has to be recovered, and also offers the opportunity to correct the estimates for unobserved firm-level input price bias.

Let us consider the following firm-product production function

$$q_{ipt} = f\,(x_{ipt}\ \beta) + \omega_{it} + \varepsilon_{ipt} \qquad \text{(B.1)}$$

where q_{ipt} is firm-product production, x_{ipt} are input quantities and ω_{it} is firm-specific productivity. While q_{ipt} can be obtained from production data, firm-product quantities have to be recovered from nominal firm-level input expenditure. This raises two issues, recovering input allocation across firm products and correcting for unobserved input prices. What is typically observed is firm-level input expenditure for input *x*, $W_{it}^{x}X_{it}$, possibly deflated by sector-level deflator, $\frac{W_{it}^{x}}{W_{st}}X_{it}$. What should enter the production function is the quantity of inputs allocated to the production of product *p*

$$X_{ipt} = r_{ipt}.\frac{W_{it}^{x}X_{it}}{W_{it}^{x}} = r_{ipt}.\frac{W_{it}^{x}X_{it}}{W_{st}}\frac{W_{st}}{W_{it}^{x}} \qquad \text{(B.2)}$$

where r_{ipt} is the share of input *x* allocated to the production of product *p,* or in logarithmic term:

$$x_{ipt} = \rho_{ipt} + \overline{x_{it}} - w_{ipt}^{x} \qquad \text{(B.3)}$$

where ρ_{ipt} = log(r_{ipt}), $\overline{x_{it}}$ is sector-level deflated firm-level input and w_{ipt}^{x} firm-level input prices in deviation from sector-level deflator. Inserting expression (B.3) for firm-product input into the production function (1) yields

$$q_{ipt} = f\,(\overline{x_{it}}\ \beta) + A(\rho_{ipt}\overline{x_{it}}\ ,\ \beta) + B(W_{ipt}, \rho_{ipt}\overline{x_{it}}\ \beta) + \omega_{it} + \varepsilon_{ipt} \qquad \text{(B.4)}$$

where the function A(.) corrects for unobserved input allocation and is a function of deflated inputs and input allocation scheme. B(.) corrects for unobserved firm-specific input prices, and depends on the product-firm input prices, the input allocation scheme and deflated input expenditures.

The estimation of the production function coefficients rests on single-product firms. For firms that produce one single product, r_{ipt}=1 and the term A(.) is equal to zero. The production function simplifies to

$$q_{it} = f\,(\overline{x_{it}}\ \beta) + B(W_{it}\ ,\ \overline{x_{it}}\ \beta) + \omega_{it} + \varepsilon_{it} \qquad \text{(B.5)}$$

Generally, B(.) is approximated by a flexible polynomial of variables capturing firm input prices variables in level and interacted with terms that enter the production function f(.). As in De Loecker *et al*. (2016), I consider firm-product output prices, p_{ipt}, market shares, ms_{ipt}, and interaction between the two, in addition to product and year dummies, as determinants of unobserved input prices. Note that the control function for unobserved input prices is assumed to be identical for capital, labour and intermediate input prices. As is usual in production function estimates, unobserved productivity is proxied by a control function.

For multi-product prices, the predicted input prices, $\widehat{W_{ipt}}$, can be recovered from function B(.). Then, the relationship between firm-specific input prices and input allocation is used to recover input allocation scheme, r_{ipt}, under the constraint that $\sum_p r_{ipt}$ = 1. Note that this latter stage assumes that the input allocation across products is identical for capital, labour and intermediate inputs.

Estimating the input allocation scheme, ρ_{ipt}, is crucial for recovering intermediate input shares, $PY_{ipt}/P^M M_{ipt}$, by firm-product for all firms, which is an essential component of firm-product markups. The production function parameters obtained for single-product firms in (B.1) can then be applied to all firms to obtain the estimated output elasticity with respect to intermediate inputs and the firm-product markup:

$$\mu_{ipt} = \varepsilon_{YM}.PY_{ipt}/P^M M_{ipt}. \tag{B.6}$$

which, combined with firm-product unit value, yields the firm-product marginal cost

$$mc_{ipt} = uv_{it} / \mu_{ipt} \tag{B.7}$$

To illustrate the procedure, the Cobb-Douglas production function gives an interestingly simplified example. In that case, the production function writes:

$$q_{ipt} = \beta_L l_{ipt} + \beta_K k_{ipt} + \beta_M m_{ipt} + \omega_{it} + \varepsilon_{ipt} \tag{B.8}$$

and the output elasticity simplifies to $\varepsilon_{YM} = \beta_M$. Taking into account the fact that the econometrician observes sector-level deflated inputs only, the production function becomes:[11]

$$q_{ipt} = q_{it} = \beta_L \overline{l_{it}} + \beta_K \overline{k_{it}} + \beta_M \overline{m_{it}} + \beta_L(l_{it}-\overline{l_{it}}) + \beta_K (k_{it}-\overline{k_{it}}) - \beta_M (m_{it}-\overline{m_{it}}) + \omega_{it} + \varepsilon_{it} \tag{B.9}$$

Assuming that the control function for unobserved input prices is identical for capital, labour and intermediate input prices and depends on output prices, p_{ipt}, market shares, ms_{ipt}, and product dummies, δ_p, $B((p_{ipt}, ms_{ipt}, p_{ipt} . ms_{ipt}, \delta_p), \gamma)$, one obtains the estimable production function for single-product firms:

$$q_{it} = \beta_L \overline{l_{it}} + \beta_K \overline{k_{it}} + \beta_M \overline{m_{it}} + (\beta_L + \beta_K + \beta_M) B(z_{it}, \gamma) + \omega_{it} + \varepsilon_{it} \tag{B.10}$$

For multi-product firms, equation (B.4) for a Cobb-Douglas production function becomes:

$$q_{ipt} = \beta_L \overline{l_{it}} + \beta_K \overline{k_{it}} + \beta_M \overline{m_{it}} + \beta_L(l_{ipt}-\overline{l_{it}}) + \beta_K (k_{ipt}-\overline{k_{it}}) + \beta_M (m_{ipt}-\overline{m_{it}}) + \omega_{it} + \varepsilon_{it} \tag{B.11}$$

11 Note that there are no interaction terms with production factors in the Cobb-Douglas case on the contrary to translog production functions.

where using equation (B.3) for production inputs at the firm-product level, and assuming that the allocation of inputs across products is identical for capital, labour and intermediate inputs, simplifies to

$$q_{ipt} = \beta_L \overline{l_{\iota t}} + \beta_K \overline{k_{\iota t}} + \beta_M \overline{m_{\iota t}} + (\beta_L + \beta_K + \beta_M)\ (\rho_{ipt} - w_{ipt}) + \omega_{it} + \varepsilon_{ipt} \tag{B.12}$$

which can also be written as

$$q_{ipt} = \beta_L \overline{l_{\iota t}} + \beta_K \overline{k_{\iota t}} + \beta_M \overline{m_{\iota t}} + (\beta_L + \beta_K + \beta_M)\ (\ln(r_{ipt} \frac{W_{ipt}}{W_{st}})) + \omega_{it} + \varepsilon_{ipt} \tag{B.13}$$

Using the first-stage regression, $q_{ipt} = f_1(\overline{x_{\iota t}}\ ,\ \beta_M \overline{m_{\iota t}}\ ,\ z_{it}\ \gamma,\ \omega_{it}) + \varepsilon_{ipt}$, to clean for measurement errors, ε_{ipt}, yields a system of linear equations that simplifies in the Cobb-Douglas case to :

$$\widehat{\omega_{\iota pt}} - \widehat{\omega_{\iota t}} = (\beta_L + \beta_K + \beta_M) \ln(\boldsymbol{r_{ipt}}) \tag{B.14}$$

where $\widehat{\omega_{\iota pt}}$ is obtained from the control function approach for productivity at the firm-product level and $\widehat{\omega_{\iota t}}$ is aggregated at the firm level.

Appendix C – Estimation of firm-product marginal costs

Table C.1. – Firm-product markups, De Loecker *et al*. (2016) methodology, 1996-2016

broad sector	sector	# obs	average	std	P25	median	P75
Food, beverage and tobacco	10,11, 12	28070	1.42	2.01	0.15	0.79	1.57
Textiles, wearing apparel and leather	13, 14, 15	11420	0.99	1.09	0.18	0.72	1.27
Wood, paper and printing	16,17, 18	6569	1.67	2.97	0.23	0.92	1.30
Rubber, plastic and other non-metallic mineral products	22, 23	11100	1.66	2.70	0.37	0.93	1.30
Basics metals and fabricated metal products	24, 25	10965	1.17	1.28	0.40	0.90	1,36
Manufacture of machinery and equipment n.e.c.	28	3316	0.98	0.96	0.23	0.73	1.41
Furniture; other manufacturing; Repair and installation of machinery and equipment	31,32, 33	4691	1.04	1.08	0.23	0.77	1.41

Notes: Firms active in the manufacturing sectors over 1996-2016.
Markups estimated using De Loecker et al. (2016).

Table C.2. – Median estimates of output elasticities – 1996-2016

broad sector	2-digit sectors	θ_M	θ_L	Θ_K	Returns to scale
Food, beverage and tobacco	10, 11, 12	0.94	0.23	0.04	1.21
Textiles, wearing apparel and leather	13, 14, 15	0.73	0.05	-0.01	0.79
Wood, paper and printing	16, 17, 18	0.76	0.12	-0.03	0.86
Rubber, plastic and other non-metallic mineral products	22, 23	0.79	0.11	0.01	0.90
Basics metals and fabricated metal products	24, 25	0.76	0.19	-0.01	0.94
Manufacture of machinery and equipment n.e.c.	28	0.71	-0.02	-0.04	0.80
Furniture; other manufacturing; Repair and installation of machinery and equipment	31, 32, 33	0.70	0.19	-0.01	0.90

Table C.3 - Relationship between firm-product unit values, markups, marginal cost and wages

	(1)	(2)	(3)	(4)
	$\ln(uv_{ipt})$	$\ln(uv_{ipt})$	$\ln(uv_{ipt})$	$\ln(uv_{ipt})$
$\ln(mc_{ipt})$	0.211***		0.158***	
	(0.006)		(0.008)	
$\ln(wage_{it})$		0.079		0.032
		(0.053)		(0.021)
Observations	76,131	76,131	76,131	76,131
R-squared	0.945	0.923	0.987	0.984
Fixed effects				
Year	Yes	Yes		
Product	Yes	Yes		
firm-product			Yes	Yes

Table C.4. – Estimated input share by sector De Loecker *et al*. (2016) estimates, ρ_{ipt}, and product sales shares, s_{ipt}.

broad sector	2-digit sectors	average ρ_{ipt}	average s_{ipt}	median ρ_{ipt}	median s_{ipt}	$corr(\rho_{ipt},s_{ipt})$
Food, beverage and tobacco	10,11,12	0.34	0.27	0.17	0.07	0.70
Textiles, wearing apparel and leather	13,14,15	0.37	0.33	0.20	0.11	0.82
Wood, paper and printing	16,17,18	0.59	0.47	0.67	0.31	0.71
Rubber, plastic and other non-metallic mineral products	22,23	0.59	0.50	0.83	0.40	0.80
Basics metals and fabricated metal products	24,25	0.66	0.57	0.99	0.68	0.81
Manufacture of machinery and equipment n.e.c.	28	0.54	0.51	0.50	0.40	0.85
Furniture; other manufacturing; Repair and installation of machinery and equipment	31,32,33	0.52	0.48	0.48	0.38	0.77

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