

# Prices, markups and product portfolio

By RÉMI MONIN AND MILENA SUAREZ CASTILLO\*

*[Preliminary and incomplete]*

*How do firms spread markups across products? Are there reduced markups on new products thanks to profit on core or established products? In this paper, we derive per-product markup and marginal cost following (De Loecker et al. 2016) on a large panel of French manufacturers over 2009-2016. We confront marginal costs' estimates to out-of-sample cost shocks to assess their relevancy. We then describe within-firms markups along several dimensions of firms characteristics but also product dynamics and how do they interact.*

*JEL: D2; D4; L1*

*Keywords: Markups; multiproduct firms; product dynamics; production function*

## I. Introduction

Within-firm product switching is increasingly recognized as a major source of resource reallocation and industry dynamics. For the US, (Bernard, Redding and Schott 2010) find that newly created or about to be dropped products represent a share of output comparable to firms exit and entry. Firm entry and exit churning process has been the focus of considerable attention, in particular questioning whether selection operates on productivity or profitability. (Foster, Haltiwanger and Syverson 2008) find that profitability (partly determined by productivity) explains firms selection. As for product churning within firms, fewer studies exist. Across its set of products, a firm decision to maintain, create or drop a product may depend heavily on its profitability, hence on the markups and marginal costs across its range of products. For instance, the profit made on some products may be used to launch new products, as a form of cross subsidization. It may play a part in the innovation process within firms.

This paper examines how markups across products interact with product switching dynamics. The goal is to shed light on the role of markups on firm choices over product dynamics. Prices heterogeneity across homogeneous products may reflect a number of factors related to either market power (markups) or production efficiency (productivity, marginal costs of production). Being able to observe

\* INSEE-CREST, remi.monin@insee.fr, milena.suarez-castillo@insee.fr

both physical output and prices at a very detailed product level, and leveraging production function estimation literature, we may adequately approximate production efficiency at the product-level, hence marginal costs. Subsequently, the wedge between marginal cost and prices would reflect markups. We first analyse how markups are spread across products, and quantify their heterogeneity. In particular, our results suggest that markups are higher on core products, with this profitable position increasingly salient as the number of products rises. Markups are lower on products which are about to be dropped.

In order to estimate the range of markups of firms across their products, we rely on the methodology of (De Loecker et al. 2016) which we apply to a large panel of French manufacturers over the period 2009-2016. This method allows to recover markups and quantity-based productivity estimates from production data, where per-product quantity are observed, under conditions which are discussed below. From there, dividing prices by markups, marginal costs are recovered. The panel dimension and the very detailed level of disaggregation allow to carefully examine product portfolio and product switching from one year to the next. The analysis is here related to the work by (Bernard, Redding and Schott 2010), which describe product switching dynamics in US manufacturing.<sup>1</sup>

To assess the estimates consistency, we confront marginal cost estimates to cost shocks from the labor market and from trade, with data which are not used in the markups and marginal costs estimations. The first cost shock is related to a large tax credit based on firms' wage bill, the *CICE*. Over our period, it amounts to a percentage (4 or 6) of the wage of each worker paid under  $2.5\times$  the minimum wage, and began in 2013. Due to this threshold and depending on the share of the wage bill in total costs, some firms were more exposed than others to this tax credit. If not used as pure cash flows or redistributed in wages, it may be considered as a decrease in marginal cost of production at the firm level; and therefore may be confronted to our estimates. Second, we use an arguably exogenous shock from trade: the exchange rates sensitivity through imports. This shock is restricted to importers from outside the eurozone. Namely, we check that the estimated marginal costs of importers respond to import-weighted exchange rates. Third, we follow (Amiti, Itskhoki and Konings 2018) in building a proxy for product-specific european-partners marginal costs, using the product-level export prices of the main France euro partners, excluding export to France. Possibly, these exports prices would reflect movement in European marginal costs and should not be related to the product-specific demand in France. They may reflect as well european competitors prices for French firms producing the same product. As opposed to the first two shocks which vary at the firm-level, this shock varies at the product level. By confronting marginal costs estimates' to a variety of cost

<sup>1</sup>We test one of their model prediction: productivity estimates are positively correlated to the number of products.

shocks, we provide evidence on their consistency before the main analysis.

While the empirical literature on international firms' product portfolio is dense, it is less the case for multiproduct domestic firms.<sup>2</sup> The focus of the paper is on the interaction between markups and product portfolio. We may think as productivity as a firm-specific characteristics which applies similarly to all its products, while the product-specific markup reflects market power or customer taste, hence profitability.

The remaining of the paper goes as follows: the second part describe the data, related to the period 2009-2016. The third review the main points in (De Loecker et al. 2016) which are applied here to a large set of French manufacturers. Results on production function and markups estimation are reported in section four. The fifth part confront these estimates to out-of-sample cost shocks, and then describe how markups and product dynamics interact. Future work will entail using exogenous cost shocks (from trade, but also from the labor cost, through firm-exposition to a large tax credit in 2013) estimates pass-through of cost shocks in markups, according to product position in firm portfolio.

## II. Data

We gather four distinct datasets relative to the period 2009-2016 at annual frequency. The first is firm-product-level production data (*Enquête annuelle de production*) collected by the French National Statistical Institute Insee for the PRODCOM regulation at yearly frequency. It covers the manufacturing sector, except the agri-food firms, and surveys about 35 000 firms (legal units). The exhaustive strata of the sample comprises firms with more than 20 workers or with sales revenues over 5 millions euros. The other firms are sampled. A distinctive feature of these data is to record both quantities and sales at a very detailed product level (PRODFRA, 10 digits levels). Observation of physical output (instead of revenue output alone) has proven very helpful for neat production function estimation. Moreover, the very detailed features of the data allows to monitor closely products portfolio changes. Table 1 provides examples of the product notion used hereafter.

To accomodate product classification changes, we aggregate products within the smallest products' envelope which is stable over our time period.<sup>3</sup> From the 3789 products in our sample defined with a year-specific nomenclature, we get 3131 products with our 2009-2016 stable nomenclature on product envelope. In the remaining of the paper, this is the concept of product which we follow.

<sup>2</sup>For multiproduct firms selling to customer, see (Hottman, Redding and Weinstein 2016)

<sup>3</sup>Derived from a simple connected components algorithm, see appendix for more details

1812125000	Advertising and similar printed matter (excluding commercial catalogs)
1812199010	Administrative or commercial printed matter, flat or continuous, customized or not, and directories
2511235040	Industrial boiler products: not including tanks, boilers, nuclear equipment
3102100010	Wooden kitchen furniture: by mounted elements, including custom
310912502B	Dining and living room furniture other than tables: buffets, credenzas and livings, bookcases, cabinets by element.

TABLE 1—EXAMPLES OF PRODUCTS IN EAP (PRODFRA NOMENCLATURE)

The second is FARE *Fichier Approché des Résultats d'Esane* data, firm-level compulsory tax files recording firm balance sheet which cover the manufacturing sector (but not only). These data are used in production function estimation, as they contain materials, employment and capital information among other. Employment is computed in full-time equivalent and is very close to the number of worked hours. It is therefore a volume of work rather than payroll information. Materials include merchandises (that are sold as bought) and raw or source materials, that are destroyed in the production process. We also include in intermediate consumption (and materials), the other and external expenses, as they notably include energy expenses (electricity, gas), or outsourcing expenses. These material expenses are deflated with a sectoral intermediate consumption price index (2 digits, 88 sectors). Capital measure is also derived from the tax record files. Measuring capital volume is difficult because assets are recorded at their acquisition price in the books. We hence need to estimate the average age of the assets in order to deflate by the investment price index which was current at the acquisition date. We calculate the average age of fixed assets, multiplying the depreciated portion of fixed assets by the usual depreciation period. Firms report both the gross acquisition value of fixed assets and the cumulated depreciated value of the assets, because each year, companies can recognize the depreciation of their investment as operating expense according to strict accounting rules. Tangible assets on the assets side of the balance sheet are broken down into four categories: land, buildings, technical and industrial equipment (which account for most of the assets of industrial enterprises), and other tangible assets (including vehicles and IT equipment). Once the assets age is recovered, the asset book values are deflated with the sectoral price index (construction for building assets, machinery and equipments, NACE 28 for technical and industrial equipment and electronical industries NACE 27 for other tangible assets) at the estimated date of acquisition.

Our main sample merges EAP and FARE datasets (EAP-FARE). The two remaining datasets are used to assess the relevancy of marginal cost estimates, by confronting them to two types of out-of-sample cost shocks: (1) labor cost shocks, (2) trade cost shocks. One dataset, the DADS, *Déclarations Annuelles de Données Sociales*, provide enough details on firms' wage bill to reconstitute

an *ex ante* exposure to a massive labor cost shock introduced in 2013, the *CICE*. In total, it represents about 1% of GDP per year. Each wage paid under  $2.5\times$  the national minimum wage entitled the firm to a tax credit of 4% (in 2013) or 6% (from 2014 to 2016) of the given wage. The other dataset is firm-to-firm exporting transactions, from French customs, which is used to compute cost shock from trade. The four datasets can be merged based on the unique identifier of the firm legal entity (SIREN).

Table 2 describes our main sample EAP-FARE. We kept observations with both non missing quantity and sales to be able to compute a unit price. We exclude as well two concentrated sectors, with few firms: pharmaceutical industry and petroleum processing and coking. Per year, in-sample firms account for about 350 billions of sales and 2900 distinct products. Multiproduct firms (with more than one product) represent slightly more than 30% of the sample. There is on average 1.8 products per firm a given year, but the median is at 1. Only 1% of firms produce more than 9 products.

TABLE 2—MANUFACTURING FIRMS: SALES AND NUMBER OF PRODUCTS

Year	Firms	Product	Total sales (Billions)	Multiproduct	Products per firm				
					Med	p80	p90	p99	Mean
2009	22025	2898	313.719	0.36	1	2	4	10	1.95
2010	24630	2898	343.024	0.34	1	2	4	9	1.88
2011	26641	2911	367.203	0.34	1	2	4	9	1.87
2012	28409	2939	361.808	0.33	1	2	4	9	1.84
2013	31237	2956	355.469	0.32	1	2	3	9	1.80
2014	31036	2959	353.792	0.32	1	2	3	9	1.80
2015	31584	2950	361.508	0.31	1	2	3	9	1.78
2016	31262	2951	361.823	0.31	1	2	3	9	1.77

*Note:* EAP-FARE sample

In Table 3, we report product dynamics when the sample is restricted to firms which are present the eight years. In 2010, about 4% of firms both dropped a product and introduce a new product, 5% dropped a product and 5% introduced a new product. From 2013 onward, the dynamics is slightly slower: 3% of firms change their product-mix by addition and deletion, and new products are introduced by only 3% of firms in 2016. See (Bernard, Redding and Schott 2010) for a US comparison (where periodicity is 5 years, product are at 5 digits level).

Finally, Figure 1 shows the dynamics of product portfolio for firms starting with 1, 2, 3 or 4 product in 2009, and staying in the sample until 2016.

TABLE 3—PRODUCT-MIX CHANGES PER YEAR, RELATIVE TO PREVIOUS YEAR.

Product-mix changes	2010	2011	2012	2013	2014	2015	2016
Both	0.04	0.04	0.04	0.03	0.03	0.03	0.03
Drop	0.05	0.04	0.04	0.04	0.04	0.05	0.04
New	0.05	0.05	0.05	0.04	0.04	0.04	0.03
None	0.87	0.87	0.87	0.89	0.89	0.87	0.90

*Note:* The sample is restricted to 8-year-present firms. *Both* refers to firms which both drop at least one product and introduce at least one new product (as observed in the survey).

### III. Estimation

This section largely builds on (De Loecker et al. 2016) and thereby on (Hall 1988). We reproduced here the main elements of (De Loecker et al. 2016) estimation methods for the reader not familiar with the method. We clarify some estimation details. Firms are assumed to minimize costs and thus to choose optimally their inputs under on a production level objective. In this context, markups can be expressed as the ratio of the output elasticity with respect to one input (production efficiency) to the share of the same input cost in output revenue (cost in revenue). Importantly, the analysis is conducted at the product level: the goal is to derive markups and marginal costs per product (and per firm). A firm  $f$  producing product  $j$  at time  $t$  has the following production function:

$$(1) \quad Q_{fjt} = \Omega_f F_j(M_{fjt}, L_{fjt}, K_{fjt})$$

$Q$  is physical output,  $\Omega_f$  is firm productivity and  $F_j$  is the production technology which takes as inputs materials  $M$ , labor  $L$  and capital  $K$ . For our purpose, output elasticities are defined once  $F_j$  is estimated, and inputs must be spread out by product (this breakdown is typically unobserved): inputs are indexed by  $j$ .

The estimation procedure proceeds as follows. First,  $F_j$  is estimated on the sample of monoproducer firms with production function estimation following (Wooldridge 2009) and (Akerberg, Caves and Frazer 2015). By industry, the coefficients of a translog production function are derived. For monoproducer firms, no assumption on the input allocation across product are needed. These production features are assumed representative: they apply to products in multiproducer firms. Namely, the production function estimates of a multiproducer firm consists in (1) overall productivity  $\hat{\Omega}_f$  and (2) translog coefficients for each of its products  $\hat{F}_j$ . The latter is given by the corresponding estimates in monoproducer firms. The former is then estimated: it allows multiproducer firms to be more efficient than monoproducer firms although the production technology is product-specific. In addition, per-product output elasticities are varying by firms as with a translog production

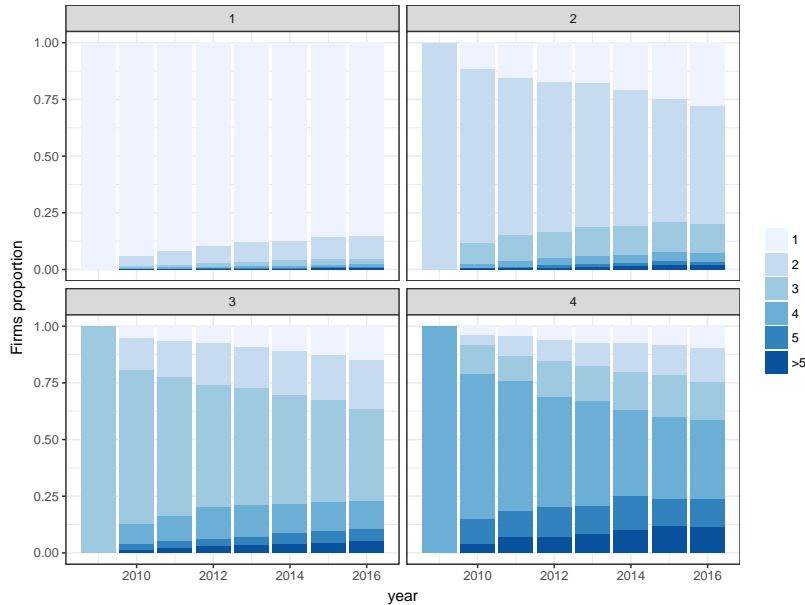


FIGURE 1. PRODUCT PORTFOLIO DYNAMICS (NUMBER OF PRODUCTS) FOR FIRMS STARTING WITH 1, 2, 3 OR 4 PRODUCTS.

*Note:* Among 8-year-present firms.

function, the output elasticities are a function of the set of inputs.

However, a challenge remains: allocating inputs across products in multiproduct firms. For this last step, for each multiproduct firms producing  $J_f$  products, to determine its  $J_f$  production processes (one per product) we shall estimate (1) its productivity, invariant across product (1 unknown), (2) how its inputs are spread over products ( $J_f - 1$  unknown shares, as shares sum to one). This boils down to  $J_f$  unknown in  $J_f$  production equations, which can be solved approximately.

We detail in this section the firm problem, the estimation of production functions on the sample of monoproducer firms and finally the estimation of last production features in multiproduct firms.

#### A. Firm optimization problem

Firms are assumed to minimize their cost  $C(M_{fjt}, L_{fjt}, K_{fjt}) = W_{fjt}^m M_{fjt} + W_{fjt}^l L_{fjt} + W_{fjt}^k K_{fjt}$ , where  $W_{fjt}$  is the vector of input prices faced by the firm for a given product. The firm pursue an output objective:  $Q_{fjt} = Q_{fjt}(V_{fjt}, K_{fjt})$ , which is a constraint in the optimization problem. Thus, the Lagrangian associated

to its choice of inputs  $(M_{fjt}, L_{fjt}, K_{fjt})$  is:

$$\mathcal{L} = W_{fjt}^m M_{fjt} + W_{fjt}^l L_{fjt} + W_{fjt}^k K_{fjt} + \lambda_{fjt} [Q_{fjt} - Q_{fj}(V_{fjt}, K_{fjt})]$$

Optimal input choice verifies the first order condition, for a given input, here  $M$ :

$$(2) \quad \frac{\partial \mathcal{L}}{\partial M_{fjt}} = 0 = W_{fjt}^m - \lambda_{fjt} \frac{\partial Q_{fj}(\cdot)}{\partial M_{fjt}}$$

The lagrange multiplier, at the optimal choice of inputs, is by the envelope theorem equal to

$$\lambda_{fjt} = \frac{dC(M_{fjt}^*, L_{fjt}^*, K_{fjt}^*)}{dQ_{fjt}}$$

It is the marginal cost of a unit of output. In this setting, if prices are observed, markups are defined with:

$$(3) \quad \mu_{fjt} = \frac{P_{fjt}}{\lambda_{fjt}}$$

Combined with Equation 2, it is easy to show that

$$(4) \quad \mu_{fjt} = \left( \frac{M_{fjt}}{Q_{fjt}} \frac{\partial Q_{fj}(\cdot)}{\partial M_{fjt}} \right) \times \left( \frac{P_{fjt} Q_{fjt}}{W_{fjt}^m M_{fjt}} \right)$$

which is the product of an output elasticities with respect to materials in the production of product  $j$  and of the inverse of the share of material cost (for this product) over firm revenues (on this product).

Equation 4 is the basis of the econometric approach in (De Loecker et al. 2016), which we implement here.

### B. Production function of mono-product firms

In this section, we detail the estimation of  $f_j = \log(F_j)$ , restricting to single-product firms. Taking the logs of equation 1, where lower cases indicates the logs,

$$(5) \quad q_{ft} = \omega_{ft} + f_j(m_{ft}, l_{ft}, k_{ft}; \beta) + \epsilon_{ft}$$

We drop the subscript  $j$  in inputs as  $J_f = 1$  for all firms considered. We assume a flexible translog form for  $f_j$ , which can be seen as a second order approximation



of the production function.<sup>4</sup>  $\beta$  is the parameter we wish to estimate. In this equation, we link physical quantities. However, we observe physical quantities only for output and labor. We denote  $\tilde{m} = m + \log(W^m) - \log(I^m)$  and  $\tilde{k} = k + \log(W^k) - \log(I^k)$  the deflated materials and capital which are observed (because material costs are observed, and  $I$  is a sector-specific deflator). Production can be written:

$$(6) \quad q_{ft} = \omega_{ft} + f_j(\tilde{m}_{ft}, l_{ft}, \tilde{k}_{ft}; \beta) + \frac{B(.)}{f_j(m_{ft}, l_{ft}, k_{ft}; \beta) - f_j(\tilde{m}_{ft}, l_{ft}, \tilde{k}_{ft}; \beta)} + \epsilon_{ft}$$

$B$  quantify the bias of not observing input prices (ideally, we should deflate by a firm-specific input price index). But as noted by (De Loecker et al. 2016), if we assume the errors in input prices to be proportional across inputs,<sup>5</sup>

$$(7) \quad B(.) = \frac{w_{ft}}{\text{Error in input price}} \times a(w_{ft}, \tilde{m}_{ft}, l_{ft}, \tilde{k}_{ft})$$

This remark is important as it provides an estimation strategy to dampen the input price bias, while identifying the parameters of  $f_j$ . In Equation 6, all the terms due to the input price bias appear in interaction with the error in input prices. For instance, eventhough  $\tilde{m}$  enters both  $f_j$  and  $B$ , it does in  $B$  only in interaction with the input price control, which insure identification here of  $\beta_m$ . The strategy is therefore as follows: (1) assume a control proxy for  $w_{ft} = \log(W_{ft}) - \log(I)$ , (2) estimate Equation 6 by substituing for  $w_{ft}$ . In fact, if we approximate  $B$  at first order, we get:

$$(8) \quad B(.) \approx -w_{ft} \times (\beta_l + \beta_k + \beta_m)$$

The deviation of firms input prices with respect to the sector deflator is assumed to reflect output quality. To proxy for unobserved quality, we assume

$$(9) \quad w_{ft} = \alpha p_{ft} + \beta m s_{ft} + \zeta \text{EXP}_{ft} + \xi \text{COM}_{ft} + \mu \text{Age}_{ft} + \gamma R_{ft} + \delta_j + \nu_{ft}$$

where  $p_{jt}$  is final product price,  $m s_{ft}$  are firm market shares, which are completed with dummies: at  $t$ , is the firm (1) exporter, (2) having retail activities, (3) which category of age it belongs, (4) its regional location. Finally, we introduce product dummies. In what follows, we denote  $z_{ft} = (p_{ft}, m s_{ft}, \text{EXP}_{ft}, \text{COM}_{ft}, \text{Age}_{ft}, R_{ft}, \delta_j)$

<sup>4</sup>Namely,  $f_j(m, l, k) = \beta_l l + \beta_m m + \beta_k k + \beta_{ll} l^2 + \beta_{mm} m^2 + \beta_{kk} k^2 + \beta_{lk} lk + \beta_{mk} mk + \beta_{ml} lm + \beta_{lmk} klm$

<sup>5</sup>That is  $w_{ft} = \log(W^k) - \log(I^k) = \alpha_j + \log(W^m) - \log(I^k)$ . For instance, the distance between the firm pricing and the sector pricing is due to both inputs' quality which is reflected in their higher prices. See (De Loecker et al. 2016) for a discussion.

and  $B(\cdot) = z_{ft}\alpha$ .<sup>6</sup>

After its detour to tackle input price bias, we combine Equations 6, 8 and 9 to get

$$(10) \quad q_{ft} = \omega_{ft} + f_j(\tilde{m}_{ft}, l_{ft}, \tilde{k}_{ft}; \beta) + z_{ft}\alpha + \tilde{\epsilon}_{ft}$$

We then follow the literature on production function estimation, starting from (Olley and Pakes 1996),(Levinsohn and Petrin 2003) to deal with unobserved productivity. We use a control function inverting the demand for input, more specifically the demand for materials. The demand for materials is assumed to reflect productivity level and to be adjusted by the firm which observes its productivity and other variables:

$$\tilde{m}_{ft} = m_t(\omega_{ft}, \tilde{k}_{ft}, l_{ft}, z_{ft})$$

Inverting this equation gives the control function:

$$\omega_{ft} = h_t(\tilde{m}_{ft}, \tilde{k}_{ft}, l_{ft}, z_{ft})$$

Now, we follow (Akerberg, Caves and Frazer 2015) and more precisely the one step GMM version in (Wooldridge 2009) and estimates the parameters in 10 by forming moments on the innovation  $\xi_{ft}$  in the productivity process:

$$\xi_{ft} = \omega_{ft} - E[\omega_{ft}|\omega_{f,t-1}]$$

Here, we use that  $\omega_{ft} = \omega_{ft}(\alpha, \beta)$  where  $(\alpha, \beta)$  is the vector of parameter to estimate, as

$$(11) \quad \omega_{ft} = q_{ft} - (f_j(\tilde{m}_{ft}, l_{ft}, \tilde{k}_{ft}; \beta) + z_{ft}\alpha + \tilde{\epsilon}_{ft})$$

and that  $E[\omega_{ft}|\omega_{f,t-1}] = g(\omega_{f,t-1}) = g(h_t(\tilde{m}_{f,t-1}, \tilde{k}_{f,t-1}, l_{f,t-1}, z_{f,t-1}))$  can be approximated by a flexible function in its argument. The identification strategy is complete once we have assumed that

$$(12) \quad E[\xi_{ft} + \tilde{\epsilon}_{ft} | \tilde{k}_{ft}, z_{ft}, \tilde{m}_{f,t-1}, \tilde{k}_{f,t-1}, l_{f,t-1}, z_{f,t-1}, \tilde{m}_{f,t-2}, \tilde{k}_{f,t-2}, l_{f,t-2}] = 0$$

Here, the contemporaneous state variables  $(\tilde{k}_{ft}, z_{ft})$  acts as their own instruments, and  $\tilde{m}_{f,t-1}, l_{f,t-1}$  acts as an instruments for  $m_{ft}, l_{ft}$ . In practice, to identify all the terms in the translog, we introduce the corresponding squares and interaction

<sup>6</sup> $\alpha_1 = -(\beta_l + \beta_k + \beta_m) \times \tilde{\alpha}_1$  etc..

terms. Equation 12 is estimated with a GMM procedure which allows to recover  $\alpha$  and  $\beta$ , by industry.

*C. Share of inputs attributable to each products in multi-product firms*

For multiproduct firms, there is an additional challenge: spreading inputs across products. For firm  $j$  producing  $J_{ft}$  products, its  $J_{ft}$  production process are as follows for  $j \in J_{ft}$ , which mobilize a share  $\exp \rho_j$  of each inputs:

$$q_{fjt} = \omega_{ft} + f_j(\tilde{m}_{ft}, l_{ft}, \tilde{k}_{ft}; \beta) + \underbrace{f_j(m_{ft}, l_{ft}, k_{ft}; \beta) - f_j(\tilde{m}_{ft}, l_{ft}, \tilde{k}_{ft}; \beta)}_{B(.)} + \underbrace{f_j(\rho_j + m_{ft}, \rho_j + l_{ft}, \rho_j + k_{ft}; \beta) - f_j(\tilde{m}_{ft}, l_{ft}, \tilde{k}_{ft}; \beta)}_{A(.)} + \epsilon_{ft}$$

If we assume the technology to be product-specific, in this equation,  $\beta$  and  $B(.)$  are recovered from the previous section method. The remaining unknowns of these  $J_{ft}$  equations are  $\rho_j$  and  $\omega_{ft}$  which is assumed to be constant over time and therefore becomes an additional unknown. In total, we have  $J_{ft} + 1$  unknowns for the same number of equations (if we add that  $\sum_{j=1}^{J_{ft}} \exp \rho_j = 1$ ). We approximately<sup>7</sup> solve this problem for each firm-year pairs.

#### IV. Estimation results

In this section, we detail the results we obtain by applying the methodology of (De Loecker et al. 2016) to our large sample of French manufacturers. Table 4 reports the output elasticities for both multiproducts and monoproductions firms. They are a function of estimated  $\beta$ ,  $\rho_j$ ,  $w_{ft}$  and observed inputs. For instance, the output elasticities for materials is equal to

$$\hat{\beta}_m + 2\hat{\beta}_{mm}m_{fjt} + \hat{\beta}_{mk}k_{fjt} + \hat{\beta}_{ml}l_{fjt} + \hat{\beta}_{mlk}l_{fjt}k_{fjt}$$

where physical inputs are unobserved at the product levels, but can be recovered by taking into account (1) the estimated input price correction and (2) the estimated input shares. It clearly appears that output elasticities vary by firms (and across product within firms) eventhough technology does not, so we report the mean output elasticities and their standard errors over firms. Returns to scale are the sum of the three elasticities: with respect to labor, materials and capital. Across all firms, the average output elasticities with respect to labor, materials and capital are respectively 0.23, 0.64, and 0.07. Among the highest

<sup>7</sup>Note that the problem is not linear (it contains a polynomial of order three in  $\rho_j$ ).

labor elasticities, we find textile, cloth and shoes industries. Among the highest capital elasticities, we find metal and paper industries. The highest elasticity with respect to materials is found in the manufacture of other transport equipment industry. We find slightly decreasing returns to scale, but constant returns to scale cannot be rejected at our level of precision.

TABLE 4—AVERAGE OUTPUT ELASTICITIES BY SECTOR

Sector (NACE code)	Labor	Materials	Capital	Returns to scale
13	0.35 [0.10]	0.59 [0.12]	0.00 [0.05]	0.95 [0.07]
14	0.29 [0.20]	0.72 [0.20]	0.04 [0.03]	1.06 [0.16]
15	0.54 [0.18]	0.48 [0.16]	-0.05 [0.07]	0.96 [0.14]
16	0.26 [0.13]	0.58 [0.16]	0.06 [0.07]	0.90 [0.12]
17	0.23 [0.12]	0.70 [0.07]	0.05 [0.08]	0.98 [0.06]
18	0.26 [0.10]	0.59 [0.10]	0.09 [0.06]	0.93 [0.08]
20	0.11 [0.22]	0.58 [0.09]	0.18 [0.08]	0.86 [0.21]
22	0.30 [0.14]	0.64 [0.14]	0.04 [0.02]	0.98 [0.02]
23	0.18 [0.17]	0.62 [0.27]	0.09 [0.11]	0.88 [0.11]
24	0.19 [0.18]	0.65 [0.19]	0.11 [0.09]	0.95 [0.17]
25	0.25 [0.12]	0.55 [0.12]	0.11 [0.04]	0.92 [0.08]
26	0.19 [0.13]	0.70 [0.05]	0.03 [0.04]	0.92 [0.10]
27	0.33 [0.16]	0.55 [0.23]	0.08 [0.08]	0.96 [0.06]
28	0.26 [0.15]	0.59 [0.15]	0.07 [0.04]	0.91 [0.09]
29	0.40 [0.17]	0.57 [0.22]	-0.05 [0.09]	0.91 [0.19]
30	0.18 [0.17]	0.79 [0.21]	-0.07 [0.18]	0.90 [0.18]
31	0.11 [0.19]	0.71 [0.11]	0.05 [0.07]	0.87 [0.14]
32	0.25 [0.23]	0.44 [0.15]	0.10 [0.10]	0.79 [0.20]

*Note:* This table reports output elasticities from the production function estimates, for both monoproducers and multiproducers firms. Average are across firms within sectors, as well as standard deviations in brackets.

Table 5 provides the results for markups. In column (1), we show markups over all product-firm pairs by industry. The mean markup across all product-firm is 1.74, with a standard deviation of 3.12. The median markup is 1.01.<sup>8</sup> In some sector, the median markup is below 1, which mean that for half of the product in this sector, prices are set below marginal costs. However, if we restrict the sample to a specific product per firm, the product where the maximal markup is realized (column (3) of Table 5, which comprises single-product firms where the maximal markup is achieved on its only product), the median is above one and the mean markup considerably higher. Column (2) shows the mean and median markups for core product (with maximal revenue) within multiproduct firms. Here as well, markups are higher and clearly above 1. We interpret these findings as supporting the idea that revenue is borne by some products (core product, or product with maximal markups), and firms accept markups under 1 for some of their products, whose production is *de facto* sustained by the other products in firm portfolio. Several explanations can be put forward to explain marginal costs above prices. In the first place, these could be products recently introduced by the company, for which one can imagine that the production processes are not yet fully optimized. Unfortunately, the time lag available in the data does not allow us to conduct a full analysis of margin behavior over the life cycle of a product. Second, the measurement of our price is an average price. Companies could adopt more strategic pricing behavior (discounts, markdowns, two part tariffs), which could imply that the average price is actually lower than the marginal cost. This qualitative information which depends on customer portfolios is not observed. Another example of behavior that could explain margins below unity is the limit pricing strategy, with which companies agree to reduce their profits in the short term in the hope of deterring market entry and maintain a favorable oligopolistic structure in the long run. Finally, note that a marginal cost above the price does not in itself imply a financial loss for the company. A company only loses profit on a product if the selling price is lower than the average cost.

Finally, we check a final stylized fact in Figure 2. Our estimates of firm productivity is increasing with the number of products produced by the firm. In the next section, we study more in detail the breakdown of prices between markups and marginal cost.

## V. Empirical analysis of markups

### A. *Pass-through of cost shocks*

We confront the breakdown of price between markup and marginal cost estimates to various type of cost shocks.

<sup>8</sup>Note that these results are not weighted by sales.

TABLE 5—MARKUPS BY SECTOR

Sector	All product-firms (1)		Core products within multiproduct firms (2)		Product with maximal markup (3)	
	Mean	Median	Mean	Median	Mean	Median
13	1.61	0.99	2.71	1.50	2.02	1.10
14	1.99	1.06	3.67	2.20	3.68	1.86
15	1.50	0.83	2.98	1.43	1.94	0.97
16	1.48	0.97	2.23	1.45	1.99	1.13
17	1.69	1.08	3.01	1.93	2.10	1.22
18	1.39	1.01	2.57	1.71	1.84	1.13
20	2.05	0.78	3.92	1.74	3.87	1.38
22	1.80	1.06	2.75	1.58	2.11	1.13
23	1.94	1.10	3.02	1.54	2.53	1.26
24	1.53	0.98	2.49	1.60	2.13	1.22
25	1.40	0.97	2.11	1.31	1.59	1.02
26	2.50	1.30	3.23	1.38	2.89	1.44
27	1.91	0.95	2.95	1.11	2.29	1.08
28	1.85	0.99	2.75	1.31	2.19	1.07
29	1.60	0.91	2.63	1.33	1.79	0.97
30	2.07	1.18	2.58	1.50	2.38	1.29
31	1.94	1.22	2.86	2.02	2.89	1.73
32	1.51	0.95	2.07	1.00	1.62	1.00

*Note:* This table reports markups recovered from production function estimates, input price correction and shares attribution. These statistics are computed first for all firm-products-years estimates in columns (1), only for the year-specific core product within multi-product firms in columns (2) and only for the year-specific product where maximal markup is realized in each firm, be it because it is the only product (single-product firms) or because its markups is higher than on other products (3). They are computed excluding both extreme percentiles.

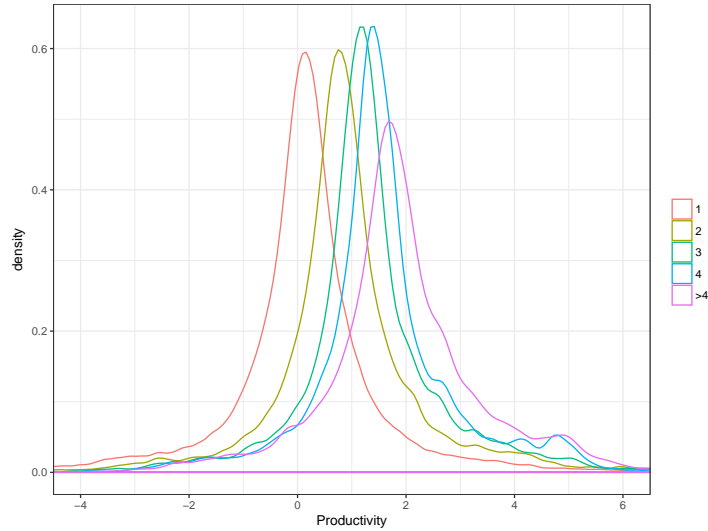


FIGURE 2. PRODUCTIVITY OF FIRMS WITH 1, 2, 3, 4 OR MORE THAN 4 PRODUCTS

**Labor cost shocks.** We use a large labor cost shock which occurred in 2013, was extended in 2014 and then remained the same until 2016. This major labor cost reduction is the french Tax Credit for Competitiveness and Employment<sup>9</sup>, introduced in 2013, in order to tackle a high level of unemployment in France. This public policy is particularly significant as the benefits for firms is equal to approximately 1% of France GDP. The amount of the tax credit is based on the wage paid a given year, and amounts to a percentage (4% in 2013 and 6% in 2014-2016) of each wage paid under  $2.5 \times$  the national minimum wage. Firms differ with respect to the repartition of the wage bill across the eligibility threshold of  $2.5 \times$  NMW, and have therefore a variable exposure to the tax credit. We compute an ex-ante exposure to the tax credit from *past* wage bill: this ex-ante exposure is defined as the share of eligible bill in 2012 times the rate of the tax credit, 4% in 2013 and 6% in 2014-2016, which measures the percentage cut in wage bill if wage bill had remained the same as in 2012).<sup>10</sup> Table 6 shows the results of a first set of regressions: over the full sample, after controlling for firm and product-year fixed effects, prices are lower by 0.6% per percentage point of tax-credit exposure. We do not observed any significant effect over markup, but a significant decrease in marginal cost. For non exporter firms (panel OLS 2), the pass-through of the tax credit into the prices is even stronger. This particularly strong effect among non-exporters could come from the fact that this subpopulation is likely to include a large number of subcontractors of large industrial exporting groups,

<sup>9</sup>CICE : Crédit d'impôt pour la compétitivité et l'emploi

<sup>10</sup>DADS data is used here.

very economically dependent on them. Their contractors may have been able to extract all the surplus related to the tax credit. Indeed, in mid-2013, small businesses complained to the Minister of Industry that their clients had wanted to retroactively renegotiate their contracts in such a way that prices would be revised downward to include the lower cost of labor from the tax credit.

TABLE 6—PASS-THROUGH OF LABOR COST SHOCKS IN MARGINAL COST, MARK-UPS AND PRICES

	<i>Dependent variable:</i>		
	log price (1)	log markup (2)	log marginal cost (3)
<i>OLS 1 - Full sample</i>			
Tax credit exposure	-0.006* (0.003)	0.005 (0.005)	-0.011** (0.005)
Product x year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	340,129	339,360	339,360
R <sup>2</sup>	0.939	0.405	0.862
<i>OLS 2 - Sample: Non exporters</i>			
Tax credit exposure	-0.018*** (0.005)	0.005 (0.009)	-0.023*** (0.009)
Product x year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	90,850	90,448	90,448
R <sup>2</sup>	0.944	0.464	0.879
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01		

**Trade shocks.** First, we restrict the sample to firms with at least one import from the 30 first France non-euro trade partners, to capture evolution of imported good marginal costs due to exchange rate variations. We weight these 30 log exchange rates (foreign currencies per euro, an increase means an appreciation of the euro) with firm-specific weights, which are proportional to the lagged imported value (known from the custom data) by the firm from the foreign country with the given currency. The first panel of Table 7 shows the pass-through of the foreign exchange rates (at the firm-level) to its product prices, and the estimates markups and marginal costs. We introduce product-year fixed effects to capture product-specific trends and shocks. We observe a significant pass-through, namely marginal costs decreases when foreign currencies depreci-



ate against the euro, with half of the pass-through being in lower prices and half in higher markups. Note that a currency shock is most likely affecting a minor part of the firm costs (those related to import with non-euro partners).<sup>11</sup> Second, we follow (Amiti, Itskhoki and Konings 2018) by proxying product-specific european-partners marginal costs, using the product-level export prices of the main France’s euro partners, excluding export to France. These data are available at the CN8-level  $\times$  countries pair  $\times$  year on Eurostat website. Possibly, these exports prices would reflect movement in European marginal costs and should not be related to the product-specific demand in France. This shock varies at the product  $\times$  year level. The second panel of Table 7 report the results. If foreign prices are understood as a proxy for European-level marginal cost shocks at the product level, we indeed observe a positive correlation between foreign prices and firm marginal costs.

We see these different results, taken together, as providing preliminary evidence of the consistency of marginal costs estimates.

#### *B. Within-firm markups distributions*

Figure 4 shows how markups are spread across product within multiproduct firms. Here log markups are demeaned by product. The larger is the size of the product portfolio increases, the larger is the difference between the markup on the main product (the product with maximal sales value) and the markup on the other products. In diversified firms, markups on secondary products are much more spread than in firms with a few products.

#### *C. Within-firm markups and product dynamics*

Finally, Figure 4 shows the distribution of markups depending on whether the product is about to be dropped (it is dropped the following year) or not (it remains in firm’s portfolio the following year). We represent both markups distribution for respectively new and stable (which were in firm’s portfolio the year before) products. Among new products, products which are dropped are characterised by lower markups. It is also the case, eventhough slightly less pronounced, for stable product (which were here the year before).

<sup>11</sup>We try as well to confront marginal cost estimates to firm-level import prices, and found no significant pass-through of import prices into marginal costs.

TABLE 7—PASS THROUGH OF TRADE SHOCKS

<i>Exchange rate</i>						
	$\Delta \log$ price	$\Delta \log$ markup	$\Delta \log$ marginal cost	$\Delta \log$ price	$\Delta \log$ markup	$\Delta \log$ marginal cost
$\Delta \log$ Foreign currencies per euro	-0.121 (0.074)	0.062 (0.089)	-0.183* (0.094)	-0.155** (0.073)	0.059 (0.095)	-0.212** (0.098)
Industry x year	yes	yes	yes	no	no	no
Product x year	no	no	no	yes	yes	yes
Observations	123,463	123,343	123,343	123,463	123,343	123,343
R <sup>2</sup>	0.040	0.025	0.040	0.325	0.201	0.242
<i>Foreign prices</i>						
	$\Delta \log$ price	$\Delta \log$ markup	$\Delta \log$ marginal cost	$\Delta \log$ price	$\Delta \log$ markup	$\Delta \log$ marginal cost
$\Delta \log$ Foreign product prices	-0.015 (0.011)	-0.044*** (0.012)	0.029** (0.013)	-0.013 (0.010)	-0.049*** (0.011)	0.035*** (0.012)
Industry x year	yes	yes	yes	no	no	no
Sector x year	no	no	no	yes	yes	yes
Observations	174,568	174,247	174,247	174,568	174,247	174,247
R <sup>2</sup>	0.081	0.024	0.065	0.019	0.002	0.012

*Note:* Source: EUROSTAT, French customs. Product: envelope of 10-digits PRODCOM; Industry: 4-digits PRODCOM; Sector: 2-digits PRODCOM. Note that in the second panel, the explanatory variable varies at the product  $\times$  year level. \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

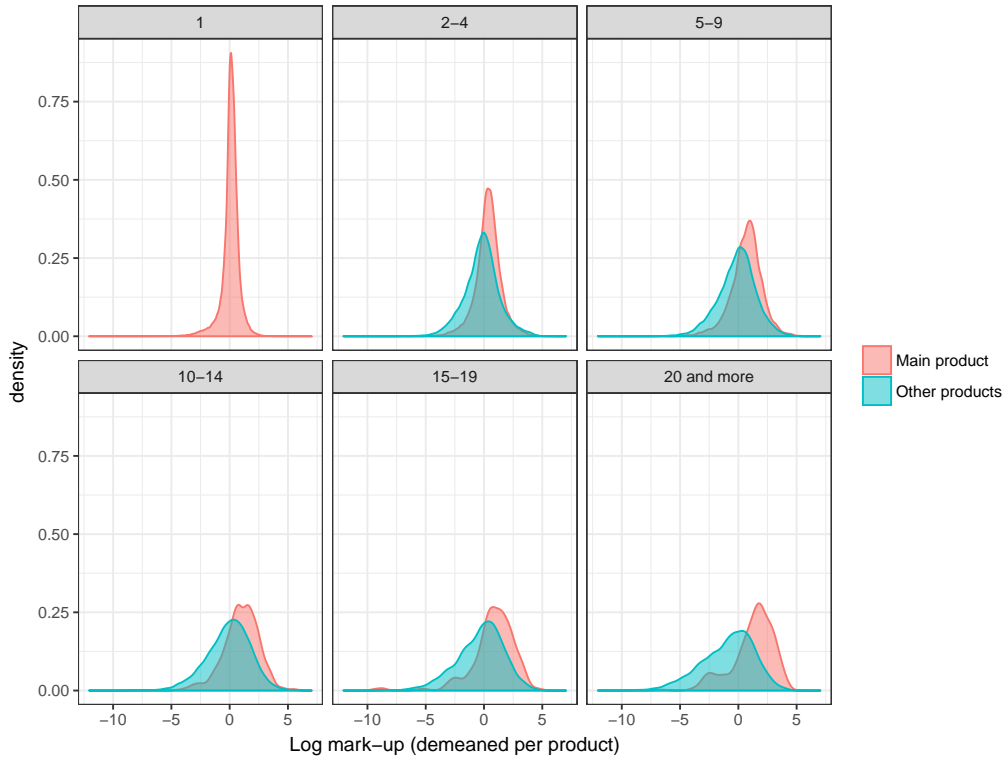


FIGURE 3. MARK-UP WITHIN MULTIPRODUCT FIRMS, BY PRODUCT PORTFOLIO SIZE

*Note:* The product with maximal sales value is the main product. Log mark-up are demeaned by product. The markup (relative to the product market) are generally higher on the main product.

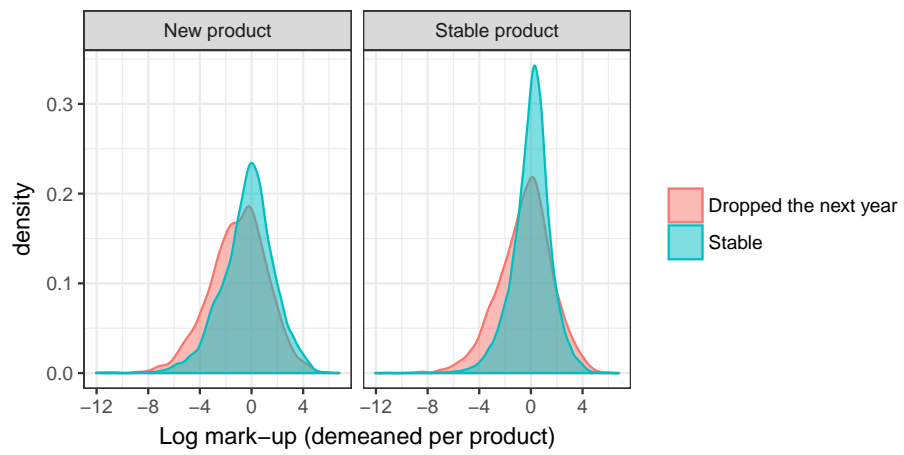


FIGURE 4. MARK-UP WITHIN MULTIPRODUCT FIRMS, ACROSS NEW AND STABLE (INCUMBENT) PRODUCT WHICH WILL BE DROPPED OR NOT NEXT YEAR

*Note:* Multiproduct firms only. Log mark-up are demeaned by product.

## REFERENCES

- Akerberg, Daniel A, Kevin Caves, and Garth Frazer.** 2015. "Identification properties of recent production function estimators." *Econometrica*, 83(6): 2411–2451.
- Amiti, Mary, Oleg Itskhoki, and Jozef Konings.** 2018. "International Shocks, Variable Markups and Domestic Prices."
- Bernard, Andrew B, Stephen J Redding, and Peter K Schott.** 2010. "Multiple-product firms and product switching." *American Economic Review*, 100(1): 70–97.
- De Loecker, Jan, Pinelopi K Goldberg, Amit K Khandelwal, and Nina Pavcnik.** 2016. "Prices, markups, and trade reform." *Econometrica*, 84(2): 445–510.
- Foster, Lucia, John Haltiwanger, and Chad Syverson.** 2008. "Reallocation, firm turnover, and efficiency: Selection on productivity or profitability?" *American Economic Review*, 98(1): 394–425.
- Hall, Robert E.** 1988. "The relation between price and marginal cost in US industry." *Journal of political Economy*, 96(5): 921–947.
- Hottman, Colin J, Stephen J Redding, and David E Weinstein.** 2016. "Quantifying the sources of firm heterogeneity." *The Quarterly Journal of Economics*, 131(3): 1291–1364.
- Levinsohn, James, and Amil Petrin.** 2003. "Estimating production functions using inputs to control for unobservables." *The Review of Economic Studies*, 70(2): 317–341.
- Olley, G Steven, and Ariel Pakes.** 1996. "The dynamics of productivity in the telecommunications equipment industry." *Econometrica*, 64(6): 1263.
- Wooldridge, Jeffrey M.** 2009. "On estimating firm-level production functions using proxy variables to control for unobservables." *Economics Letters*, 104(3): 112–114.

## APPENDIX

### *A1. Classification concurring procedure*

The product data we use in the empirics are tabulated against two distinct classifications :

- The "PRODFRA" classification, coded onto 10 positions, corresponding to about 4 000 products, which is similar although more comprehensive than the PRODCOM classification (coded onto 8 positions), because it includes products which are not included in the european program.
- The Combined nomenclature for custom data, CN8, coded onto 8 positions, corresponding to roughly 10 500 products.

A common feature of these three classification is that they experience small evolution each year (from 3 to 5% of product classification are changed). These variability sources are to be taken into account for research at the product level since the classification evolutions are to generate considerable noise and misattribute product switching to firms.

The goal of the concurring procedure is twofold. First, it is to define a classification stable over time, to avoid spurious product switching, exiting or introducing. Second, it is to define a coherent bundle of product for custom products, which are more disaggregated than the production survey classification. We use

- Evolutions over time of PRODCOM classification (available on RAMON)
- Evolutions over time of CN8 classification (available on RAMON)
- Evolution over time of PRODFRA classification (provided by Insee)
- Correspondance between CN8 and PRODCOM, each year (available on RAMON)
- Correspondance between PRODCOM and PRODFRA, each year (provided by Insee)

These five data information give us links between well identified codes, over time and between classifications. These links can be seen as edges of a graph. The product envelopes (or bundle) correspond to the isolated subgraphs, or more technically, connected components. A very quick algorithm of connected components research gives the bundles of stable products stable over time and classification and solves the problem of classification concurring. Figure A1 gives three examples of stable bundle products. Bundle (A) is the most simple bundle product : the product E1 is unambiguously linked to Prodcom P1, and only one custom product corresponds. This represents more than 40% of the Prodfra products.

Case (B) could represent one product PRODFRA associated with one prodcom P2, which is linked to two custom products N2 and N3; and a code change without reassignment of E2 in E3 at a time. Case (C) is a complex case of two (P3 and P5) Prodcom merging into a new one (P4), and one renaming (N4 into N5). Two thirds of prodfra bundles have strictly less than 6 nodes. Only 3% of bundles have more than 15 nodes (up to more than a hundred). For very large bundles, two patterns can be identified : agri-food products, which include a very detailed classification sublevel for customs (typically a prodcom is "Fruit, prepared or preserved", and the correspondong NC8 codes are split into all imaginable fruits), note that agri-food industries are out of the scope of the study; and an extensive evolution of the PRODCOM and PRODFRA classification (Typically, for chemical bactericide and fungicides, classification was split in order to account for the different active agents like dithiocarbamates or benzimidazoles).

FIGURE A1. EXEMPLES OF CONNECTED COMPONENTS

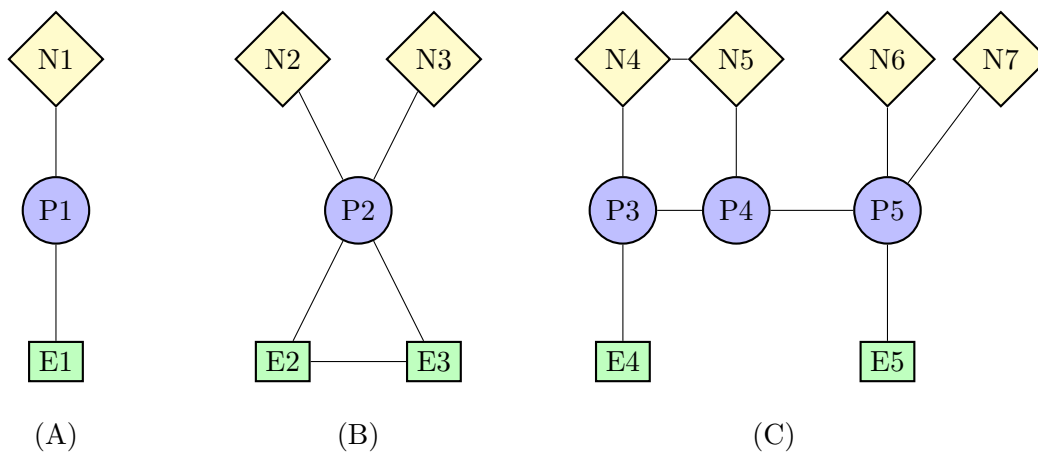


TABLE A1—MONOPRODUCT AND MULTIPRODUCT FIRMS: DESCRIPTIVE STATISTICS (AFTER PARTIALLYING OUT INDUSTRY FIXED EFFECTS)

variable	1 product	2-4 products	5 products
Firm size : <20 workers	4,92	-6,11	-13,57
>=20 and <100	0,05	0,43	-1,90
>=100 and <250	-2,80	4,05	5,72
>=250	-2,17	1,63	9,74
Labor productivity (in k)	-0,09	-0,34	1,87
Economics profitability	0,42	-0,47	-1,27
Financial profitability	0,48	-0,51	-1,65
Export rate	-0,40	-0,02	2,89
Investment rate	-0,21	0,19	0,85
Margin rate	0,25	-0,56	0,18
Corporate group	-2,15	2,50	6,55
Workers <30 yo	0,35	-0,34	-1,26
Workers >=30 yo and <50 yo	0,12	-0,15	-0,33
Workers >=50 yo	-0,46	0,49	1,60
Managers and professionals	-0,04	-0,13	0,76
Intermediate professions	-0,10	-0,16	1,31
Prop. CS 15	-0,02	-0,02	0,22
Prop. CS 16	0,05	0,48	-2,05
Women	-0,21	0,19	0,81
Techies	0,01	-0,10	0,30

TABLE A2—

	N products	Mean log productivity	Mean log markups
<i>Age group</i>			
1	1.6	0.49	0.00
2	1.6	0.50	0.04
3	1.7	0.51	0.06
4	1.8	0.49	0.07
5	2.1	0.48	0.01
<i>Is exporter</i>			
0	1.6	0.47	0.05
1	2	0.51	0.04

Note: Log markups are demeaned by product, and exclude both extreme percentiles.



TABLE A3—MARKUPS, MARGINAL COSTS, QUANTITY AND PRODUCT SHARE

	<i>Dependent variable:</i>			
	Log markups	Log marginal costs	Log markups	Log marginal costs
	(1)	(2)	(3)	(4)
Quantity	0.567*** (0.002)	-0.778*** (0.001)		
Product share			2.253*** (0.016)	-3.009*** (0.013)
Product-year FE	Yes	Yes	Yes	Yes
Firm-year FE	Yes	Yes	Yes	Yes
Observations	356,694	356,694	356,694	356,694
R <sup>2</sup>	0.685	0.979	0.610	0.949

*Note:* This table replicates the results found in (De Loecker et al. 2016) for Indian manufacturing firms.  
\*p<0.1; \*\*p<0.05; \*\*\*p<0.01