Markups and Markdowns in the French Dairy Market

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Abstract

This paper quantifies upstream and downstream market power (MP) of French dairy manufacturers. These firms exert monopsony power when purchasing raw milk, and monopoly power when selling dairy products. The analysis is based on a plant-level database covering French dairy firms for the 2003-2018 period, which provides prices and quantities of raw milk input by origin and of outputs by product. We rely on a production function approach to estimate total margins. The existence of a commodity, substitutable as an input or as an output, and exchanged on global markets where firms do not have any price-setting power, then allows to separately estimate firm-origin-level markdowns and firm-product-level markups. Markdown estimates imply that dairy firms on average purchase raw milk at a price 16% below its marginal contribution to their profits, while markup estimates indicate that firms sell dairy products at a price exceeding their marginal costs by 46%. We document substantive variations in the exploitation of buyer and seller power across firms, products, and time. Variations over time notably explain incomplete and non-constant pass-throughs of commodity price shocks through the supply chain. Our results thus call for methodologies authorizing both sources of MP and such heterogeneity, as the suggested approach does. Our results finally show the dependence of farmers' revenues on manufacturers' price-setting power and variations in commodity prices, advocating for a price floor on raw milk which could (i) raise farmers' revenues without harming consumers and (ii) replace subsidies paid to farmers but captured by manufacturers.

Keywords: Industrial Organization, Market Power, Agricultural Economics, Vertical Chains, Markups, Markdowns.

JEL Classification: L11, L13, D21, D43

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1 Introduction

Market power (MP) has detrimental consequences for economies. It reduces consumers' welfare, generates resource misallocation, and distorts value-added sharing in supply chains. MP comes from firms' ability to sell outputs at a high price (*i.e., imposing a markup*) as well as their ability to purchase inputs at a low prices (*i.e., imposing a markdown*). Public authorities need to assess MP and its origins to design efficient policies. However, due to the difficulty of disentangling both sources of MP, the literature often only partially analyzes it, allowing firms to set prices on one side and assuming them to be price-takers on the other. This assumption may be misleading in two ways. On the one hand, if markups *or* markdowns are well estimated while the others are present but disregarded, then the total magnitude of MP is understated. On the other hand, if total MP is accurately quantified but falsely attributed to markups *or* markdowns only, then attention is partly diverted from the true inefficiency.

This paper addresses these challenges by quantifying French dairy manufacturers' MP during the 2003-2018 period, disentangling their monopsony and monopoly powers.[1] Manufacturers are central in the dairy supply chain: they purchase raw milk from farmers and process it in products sold to retailers or to the food industry. In this setting, described in Section 2, dairy manufacturers' buyer power has long been a major concern, due to the market asymmetry between atomistic farmers and concentrated manufacturers, and raw milk transportation costs creating segmented local markets in which manufacturers can exert monopsony power. Downstream, the extent to which dairy firms may exploit seller power varies across dairy product markets, depending on the market structure and products differentiation.[2]

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[1]Throughout the paper, and with a small abuse of language, we indifferently refer to buyer or monopsony power, and to seller or monopoly power respectively, regardless of the number of firms active on the considered market.

[2]Some dairy products are differentiated (yoghurts, cheese) while others appear to be relatively homogeneous, most notably intermediates products (such as milk powder, bulk butter or bulk cream).

Guided by these features of the French dairy market, we build a structural model of multi-source and multi-product dairy firms, exploiting buyer and seller power. The model is introduced in Section 3. It allows us to characterize firm-product-origin level margins of dairy manufacturers, and to decompose them into firm-origin level markdowns and firm-product level markups. This decomposition relies on three definitions. The *margin* is the wedge between the price of a given product and its *accounting marginal cost* of production using milk from a given origin, and results from overall MP. The *markdown* is the wedge between the net marginal revenue generated by milk and the price paid by the firm, arising from buyer power. Finally, the *markup* is the wedge between the price of a product and its (economic) marginal cost, and is the consequence of seller power.

In order to estimate the model, we exploit a *cost-side approach*, building on pioneer work by Hall (1988) and De Loecker and Warzynski (2012) who analyze markups assuming no markdowns. In line with recent papers by Morlacco (2019) and Rubens (2021), we incorporate in this framework the possibility of buyer power on input markets. Similarly to Rubens (2021), we assume perfect complementarity in the production process between the raw material and its processing, but depart from this framework by incorporating *multi-source* and *multi-product* firms, which are salient features of the dairy industry. This modeling is suitable for studying MP in industries where manufacturers process a necessary input (hop, beans, wheat, milk...), which typically characterizes food industries (beer, chocolate, coffee, pasta, dairy products...). In most of them, and as pointed out by Sexton (2013), processors' monopsony and monopoly powers are a concern given a supply chain structure similar to the industry considered here (asymmetric concentration, segmented local markets, increasing product differentiation along the supply chain).

The empirical analysis detailed in Section 4 relies on three main datasets: production, balance sheet, and technical data. Our production data provide prices and quantities at the firm-product level for output and at the firm-origin level for raw milk intermediate consumption.[3] Balance sheet data contain manufacturers' labor and capital expenses at the firm-level. In the technical data, we observe the dry matter content of milk intermediate consumption

[3] A raw milk origin/market will in the analysis be one of the 85 French departments producing milk.

and processed output at the product-level.[4] Importantly, this information reveals which quantity of milk input is needed to process a unit of each dairy product.

Our estimates are first based on the estimation of marginal costs, which in our setting are the sum of (i) purchasing costs of raw milk and other pre-processed milk-inputs and of (ii) processing costs. On the one hand, together production and technical data allow us to estimate milk-input buying costs at the firm-origin-product level. On the other hand, we use production and balance sheet data to estimate marginal processing costs at the firm-level, following seminal papers estimating production functions.[5] Having quantity and price data on both the input and output sides helps us overcoming issues stressed by the literature, such as the revenue data bias, input price bias, or prices endogeneity due to MP upstream and downstream.[6] Overall, we recover *marginal costs at the firm-origin-product level*, which is to the best of our knowledge new in this literature.[7]

In order to separately identify markdowns and markups, we complement the aforementioned production function approach by leveraging the existence of a *commodity*, namely whole milk powder (WMP), which (i) dairy firms purchase (resp. sell) without buyer (seller) power, and (ii) is substitutable with raw milk (with other dairy products sold). The price of WMP is fixed on global markets, so that price-setting power of French dairy firms can be assumed away. Given substitutability, firms buying WMP optimally equalize the marginal costs of sourcing raw milk and WMP. Similarly, WMP sellers optimally trade-off between producing an additional unit of a given dairy product or of the commodity. In such multi-input and multi-product setting, the international price of the commodity thus offers an empirical moment that helps separately identify markups and markdowns. The identifying procedure thus differs from Rubens' (2021) who imposes additional structure on the input supply before estimating it.[8] Conversely, our estimating framework allows us to remain ag-

[4] Milk intermediate consumption encompasses raw milk from a specific origin, but also milk powder, bulk butter or bulk cream. Milk processed products and their dry matter content are observed at the CN8 level.

[5] Seminal papers include Olley and Pakes (1996), Levinsohn and Petrin (2003), De Loecker and Warzynski (2012) and Ackerberg et al. (2015).

[6] Respectively stressed out by Bond et al. (2020), De Loecker et al. (2016) and Morlacco (2019).

[7] Following various methodologies discussed in Section D.2.1, De Loecker et al. (2016), Valmari (2016) and Dhyne et al. (2017) estimate marginal costs at the firm-product level, but without heterogeneity by input.

[8] It also differentiates our approach from the *demand approach* (Berry et al., 1995) to estimate markups

nostic on the exact competition structures, both upstream and downstream, which is crucial in our analysis as competition faced by dairy manufacturers widely varies across markets and time.[9]

The results presented in Section 5 indicate that dairy firms generate an average margin rate of 62%. This margin comes from the aggregation of a markup rate of 46% and a markdown rate of 19% implying that dairy firms on average purchase raw milk at a price 16% ($1/1.19 \approx 0.84$) below its marginal contribution to their profits, while selling a dairy product at a price exceeding its marginal cost by 46%. These weighted averages however hide substantial heterogeneity across firms, products and time. The product dimension notably is far from being negligible, even when focusing on a specific sector as we do. The average markup rate is equal to 70% on final consumption goods, going above 100% for differentiated products such as yoghurts or cheeses, whereas the markup rate on homogeneous intermediary products is close to 0%. Most importantly, and although the average total margin is relatively stable over time, the average contributions of markups and markdowns vary a lot over the period. The average markdown rate fluctuates between 4% and 40% while the average markup rate lies between 27% and 61%. We use our theory and these results to analyze how shocks on the prices of the commodity, both used as an input and an output by manufacturers, spread through the dairy supply chain. A reduced-form analysis reveals *incomplete pass-throughs* on raw milk and dairy products prices, which the theory rationalizes with endogenous markups and markdowns adjustments.[10] Such *adjustments* ultimately suggest *non-constant elasticities* along the underlying supply and demand curves, and empirically translate into markup and markdown fluctuations across time.

The paper's contributions are highlighted in Section 6. The first contribution is methodological and twofold. We first show the importance of taking into account buyer power of manufacturers, often disregarded in the literature. In particular, our estimates imply that we would have overestimated markup rates by 35%, had we ignored buyer power and attributed

through the estimation of demand elasticities, which similarly requires stronger assumptions on competition.

[9] We especially detail regulatory changes in the Appendix A.2.

[10] This prediction relates to a broad literature studying pass-throughs to assess competition imperfection. See Weyl and Fabinger (2013) for instance.

the entire margin to seller power, as the production function approach traditionally does.[11] Although the magnitude of this bias is highly context-specific, our findings thus suggest that such estimated *markups* shall be more safely viewed as *margins*, coming from price-setting power *on both sides*, as soon as one suspects the existence of buyer power in the sector of study. We then suggest *a new solution to disentangle buyer and seller power*, flexible enough to be applicable in other contexts. As aforementioned, our approach relies on the existence of an input/output that (i) is substitutable with the input/output of interest, and (ii) on which firms do not have any price-setting power. As such, our methodology relates to papers relying on a *flexible input* (Dobbelaere and Mairesse, 2013; Wong, 2019; Yeh et al., 2022) where monopsony power is assumed away on a whole *type* of input (e.g materials).[12] The methodology suggested here applies a similar logic at a more disaggregated level and to both the input and output sides. It thus allows leveraging the existence of commodity markets where price-setting power can be assumed absent in a less *ad hoc* way.[13], such markets being commonly present in many industries in which manufacturers' buyer and/or seller power(s) is often a concern.[14] Importantly, our methodology does not rely on estimating supply or demand elasticities, which would raise additional issues.[15]

Our second contribution is to quantify both buyer and seller power of French dairy manufacturers, which constitute a significant concern for regulating authorities but had, to the best of our knowledge, never been estimated in a unified framework.[16] Our results demon-

[11]This is notably the case of De Loecker and Warzynski (2012); De Loecker and Scott (2016); De Loecker et al. (2016); De Ridder et al. (2021), to which we extensively compare in Section 6.1.1.

[12]Morlacco (2019) applies similar arguments to domestically purchased materials in order to isolate buyer power on imported ones. M. Morlacco and E. Guigue are however currently working on a revision of Morlacco (2019), relying on a different estimation methodology.

[13]This point and the applicability of the methodology to other sectors is further discussed in Section 6.1.3.

[14]Such markets include other food commodities like wheat, corn, soybeans, livestock, coffee, tea, rice, sugar, or bananas, but also different products including metals, minerals, fertilizers, natural gas...

[15]Remaining agnostic on competition allows us to cope with the aforementioned variations in competition across markets and time, but also to accommodate potential vertical cooperation between farmers and processors, as well as collusion among processors. Finally, our results reveal non-constant markups and markdowns along the supply and demand curves, which would challenge any alternative *demand/supply estimation*. These points are further discussed in Section 6.1.2.

[16]Related papers studying MP in dairy supply chains consider processors' oligopsony power (Perekhozhuk et al., 2017; Grau and Hockmann, 2018) *or* oligopoly power (Cakir and Balagtas, 2012; Bonnet and Bouamra-Mechemache, 2016) in isolation, under varying assumptions on manufacturers-retailers relationships.

strate that dairy firms exploit both buyer and seller power, and neither of them is negligible.[17] Importantly, we show how the price of raw milk in France, and thus farmers' revenues, are ultimately determined by (i) the price-setting power of dairy manufacturers on both sides and (ii) fluctuations on the global WMP market. In particular, manufacturers' buyer power prevents farmers from benefiting from positive downstream demand shocks, as markdowns endogenously increase in response, making the pass-through to prices of raw milk far from complete. Our results thus call for policies aiming at promoting farmers' countervailing seller power or even for a price floor on raw milk.[18] According to our theoretical setting, producers' and final consumers' interests are aligned, as these policies would raise farmers revenues without harming final consumers.[19] Importantly, a price floor could replace public subsidies that are paid to farmers, but, as our results suggest, are captured by manufacturers.

Our work contributes to the literature analyzing MP in food supply chains, extensively reviewed by Sheldon (2017), to whom we refer for more detail. Importantly, he explains that, if this literature has long theoretically identified the importance of jointly studying buyer and seller powers exertion in such contexts (Sexton, 2000), it has however found "little empirical evidence for exertion of buyer power in either the United States or the EU".[20] Our work also relates to the broader literature quantifying MP in various contexts. On the input side, a strand of the literature focuses on labor MP. As Wong (2019) and Yeh et al. (2022), Tortarolo and Zarate (2018) explicitly authorize and quantify both markups and labor markdowns.[21] A recent development literature also studies MP issues, often relying on natural experiments and focusing on one source of MP (oligopoly or oligopsony) in specific contexts.[22]

[17]Buyer power was expected given the industry setting. Our results however also demonstrate manufacturers' ability to generate high markups despite retailers' countervailing buyer power, extensively studied by the literature reviewing retailers' mergers. See Loertscher and Marx (2019) among others.

[18]Complementing Russo et al. (2011), theoretically showing the interest of price floors in similar contexts.

[19]This challenges the conventional wisdom of regulating authorities that increasing producers' seller power or a price floor on input markets harm final consumers, through increasing prices along the supply chain.

[20]Sheldon (2017) attributes this to technical reasons (methodology, lack of data) but also to "vertical coordination between downstream food processors and suppliers of raw agricultural commodities". We believe the present paper tackles these challenges. See Section 6.1.2 for more detail.

[21]Tortarolo and Zarate (2018) estimate total MP through a production function approach similar to ours but pins down labor markdowns with an estimation of labor supply elasticities. Other work focusing on labor MP includes Berger et al. (2022) and Card et al. (2018).

[22]See Cajal-Grossi et al. (2019); Brooks et al. (2021); Bartkus et al. (2021); Leone et al. (2021) for instance. Zavala (2020) in particular relates to our work as he quantifies buyer power exerted by exporters on farmers

2 Data and Key Facts on the French Dairy Market

We first introduce our data, before detailing here general facts on the French dairy market in order to provide the reader with some important background suggesting the existence of manufacturers' market power.[23] Appendix A complements this static picture with recent evolutions on the market motivating our competition-agnostic approach.

2.1 Data

Our analysis rests on the exploitation of several datasets.

We first use data provided by the French Ministry of Agriculture[24]: the *Enquête Annuelle Laitière* (EAL, 1995-2018), the *Enquête Mensuelle Laitière* (EML, 2013-2018), and the PRODCOM data for dairy products (2003-2018). They contain firm-level data regarding the production of dairy products and the collection of raw milk. All these data are available at a yearly frequency level.

In the EAL, and regarding the output side, we observe for each dairy firm in France the quantity produced, for each dairy product (slightly more disaggregated than CN8). Thanks to our *PRODCOM* data, we are able to observe revenues and production at the firm-CN8-year level, for French dairy firms with more than 10 employees. This allows us to recover *unit values*, which we will use as a proxy for *factory-gate* prices in the analysis.[25] These price data are only available for the 2003-2018 period, which will thus be our period of analysis.

Regarding the input side, we also observe in the EAL the quantity of raw milk collected by each firm and in every French department. Thanks to the EML, we are able to observe firm-department prices paid for raw milk, for a subsample of firms and over 2013-2018. To complement these firm-level raw milk prices, we use data from a survey made by *FranceAgrimer*, which gives us average raw milk prices by French regions, covering the period 2000-2018.

in Ecuador, through the estimation of a structural model of farmers' buyers and crops switching, but ignoring exporters' seller power.

[23]Figures presented in this Section rely on our own computations and figures from the CNIEL website.

[24]We are thankful to Corinne Prost and FranceAgrimer for making this data available through the CASD.

[25]We discuss the validity of this proxy in Appendix B.2.

We also use *dry matter content* (DMC) data jointly produced by the *Centre national interprofessionnel de l'économie laitière* (CNIEL), *FranceAgrimer* and the *Institut de l'élevage* (Idele), three institutes in charge of elaborating statistics on the French dairy market.[26] This information allows us to build an input-output matrix, by retrieving the quantity of milk needed to produce a dairy product, for each dairy input-product pair.

Finally, we complement this production and raw milk collection data with balance sheet data for French dairy firms, coming from FICUS and FARE databases of the French Institute of National Statistics (INSEE). These data contain the yearly firm-level expenses on labor and capital (among others) needed for the production function estimation.

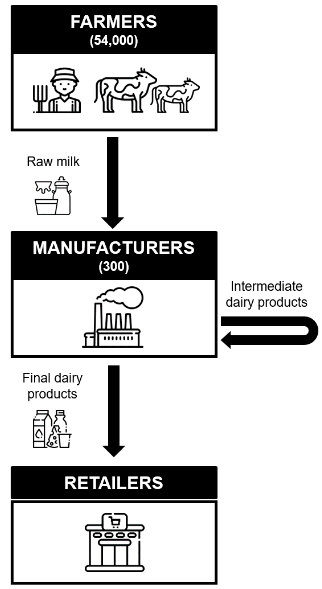
2.2 Industry Setting

The French dairy industry remains an important industry within the French economy, generating around 40 billions euros of revenues in 2018. As such, France is the 2^{nd} milk producer in Europe (after Germany), and 8^{th} in the world. Throughout the empirical analysis, we only consider cow milk, which represents 97% of the overall milk production. We also exclude Protected Designation of Origin (PDO) and organic milk, as our methodology relies on the assumption that milks from different origins are substitutable, which is not the case for these two labeled products.[27] The share of PDO milk (10%) is constant during the period whereas organic milk share increases from 0.5% in 2000 to 3.5% in 2018.

[26]We are grateful to Jean-Noël Depeyrot for providing us these data.
[27]As explained in Section 4.2.

The French dairy supply chain is typically organized along a vertical structure described by Figure 1. At the top of the chain, 54,000 atomistic farmers[28] produce raw milk. They sell milk to manufacturers which process milk and other dairy intermediates (bulk products like cream, butter, skimmed or whole milk powder) to produce dairy products. Although the industry counts 300 manufacturing groups, this stage of the chain is dominated by a handful of them, the top 5 alone representing 63% of purchases of raw milk. Manufacturers then reach final consumers through wholesalers and retailers. Both manufacturers and distributors are thus necessary intermediaries for most farmers to sell their production, direct sales of dairy products by fully integrated structures remaining marginal.

Figure 1: The Dairy Value Chain (2018)



The dairy supply chain features specificities which are important to have in mind when studying competition along the chain. Upstream, farmers generally milk cows twice a day and store raw milk in a cooling tank up to the collection by a single manufacturing plant which (in many instances) owns the tank. The manufacturer is in charge of the collection which is done using a refrigerated truck every day or two, the same truck being used to collect raw milk from several farms. Due to conservation constraints of raw milk, this operation is costly, which explains why raw milk is always collected from farms close to the manufacturing plant (less than 60 kilometers on average).

More downstream, raw milk is then processed by manufacturers in order to produce either final goods (milk, cheese, butter, cream, yoghurts) sold to retailers (75% of processed

[28]The average farm counts 66 cows in 2018.

milk) or intermediate products (milk powder, butter, cream) used in the dairy industry or in other food industries (25%). Such intermediate products are traded through global commodity markets, where prices are determined by quotations. 99% of the milk processed in France was first produced within the country. In contrast, 40% of it ends up being exported as dairy products. Dairy manufacturers are either private (45% of processed milk) or cooperative companies (55%). While most of the private firms are gathered into important groups, some cooperatives have also become prominent actors in this industry.[29]

2.3 Key Facts Suggesting the Existence of Buyer and Seller Power

We describe here various features of the French dairy industry fostering the existence of unbalanced bargaining relationships between raw milk producers and dairy firms.

2.3.1 Buyer Power: Asymmetric Concentration and Local Markets

As aforementioned, the production of milk remains very dispersed in France (54,000 farms in 2018) while the number of downstream manufacturers is much smaller (about 300 groups). Furthermore, the downstream stage is dominated by a handful of big groups, the top 3 representing 52% of the raw milk purchased in 2018, while the top 10 represents 75%. The French dairy value-added chain is thus characterized by an asymmetric setting where an atomistic raw milk supply faces a demand emanating from very concentrated actors, favoring the emergence of buyer power.

[29] The 2^{nd} leading French group representing 20% of French milk collection is for instance a cooperative.

Table 1: Competition on the Raw Milk Market (2018)

	Number of ...		Purchasing share (%) of the k largest buyers					
	Buyers	Farms	1	2	3	4	5	10
At the national level	300	54,000	21	41	52	58	63	75
At the departmental level								
Median	8	406	46	73	88	95	98	100
Average[a]	13	1,588	43	67	81	89	93	98

Departments representing less than 0.1% of the milk collection are dropped.

[a] Quantity weighted average. A buyer is defined as a dairy manufacturing group.

Aforementioned characteristics of the raw milk collection process imply that the French raw milk market has to be considered as a collection of segmented local markets, where the potential for monopsony power is exacerbated. At the local level, the average farmer indeed faces a limited number of potential buyers (13) within a department. This (observed) department-level quantity-weighted average is an imperfect approximation of the relevant potential buyers' set for a given seller, which essentially depends on the distance to the plant of each of the surrounding buyers in the department and in the neighboring ones. It remains however instructive on the order of magnitude of buyers' competition at the local level. More strikingly, the local dairy markets are most of the time dominated by a handful of buyers. Table 1 above shows that the locally biggest group represents 46% of the median market, the top 2 constituting 73% of it, while the 4 biggest buyers typically represents 95% of the local raw milk collection. Consequently, the average departmental Herfindahl-Hirschman Index (HHI) is above 0.25.[30] Local milk markets can thus be considered as *highly concentrated*, according to US Antitrust Department' or European Commission' guidelines.

[30]See Figure 20 for evidence on recent concentration trends on the raw milk market.

2.3.2 Seller Power

Table 2: Competition on the Dairy Products Market (2018)

	Number of ...	Market share (%) of the k largest sellers					
	Sellers	1	2	3	4	5	10
At the national level	300	21	41	52	59	66	79
At the product-level							
Median	40	24	42	56	65	72	92
Average[a]	58	25	44	56	66	74	89

[a] Revenue weighted average. A seller is defined as a dairy manufacturing group.

Unsurprisingly reflecting their importance on the raw milk market, dairy manufacturers also represent highly concentrated *sellers*, the top 5 manufacturers alone accounting for two third of the national market, and 72% of the median product market.[31])

French dairy firms may exploit market power when selling differentiated dairy products as they are very concentrated, with a few global players.[32] This seller power can however be mitigated by the existence of countervailing buyer power emanating from downstream retailers, which are (i) highly concentrated in France and (ii) often grouped into purchasing alliances. Negotiations between these two types of actors can take various complex forms, which are beyond the scope of this paper.[33]

[31] The definition of a product market is here relatively loose, as we aggregate CN8 products into 7 categories: cheese, butter, cream, milk, milk powder, yoghurt.

[32] The biggest French group, Lactalis defines itself as the first world leading dairy company.

[33] We refer interested readers to Villas-Boas (2007); Allain et al. (2020) among many other papers. Our theory cope acknowledge such complexity by remaining agnostic on the nature of the competition between firms, thus encompassing various types of negotiations.

3 A Theory of Margins, Markups and Markdowns

We develop a theory which rely in its basic version on two assumptions on manufacturers: (i) they produce dairy products according to a Leontief production function and (ii) they maximize their variable profits internalizing their effects on prices up- and downstream. This set-up authorizes us to define markdowns, markups and (total) margins.

3.1 Production Function

Technology Assumptions

To produce y_{fj} kilograms of dairy product j, a dairy firm[34] f combines milk intermediate consumption m_{fij} - possibly coming from various markets i - with its processing technology. The production function is given by:

$$y_{fj} = \min \left\{ \underbrace{\sum_{i \in \mathcal{I}_f} e_{ij} m_{fij}}_{\text{required milk inputs}} \quad , \quad \underbrace{F_j \left(L_f, K_f; \Omega_f \right)}_{\text{processing capacity}} \right\} \tag{1}$$

Through the Leontief form, we assume perfect complementarity between the required milk inputs quantity and the processing capacity. This reflects the fact that a given dairy product has to contain a minimal quantity of milk inputs. We define $e_{ij} \equiv \dfrac{e_i}{e_j}$, the required quantity of milk input i to produce a kilogram of dairy product j. Output heterogeneity in milk input contents is product-specific and captured by the scalar e_j, whereas input quality is market-specific and denoted e_i. We further assume that milk inputs from various markets i are perfect substitutes.

The processing technology is common to all manufacturers and represented by the function $F_j(.)$ which is assumed to be twice differentiable in each argument. For now we assume a general product-specific processing function $F_j(.)$, defined as a function of firm's use of labor L_f and capital K_f, expressed in quantities. Finally, Ω_f characterizes firm's f ability to

[34] Throughout the paper, a *dairy firm* or a *manufacturer* indifferently refers to any firm processing milk inputs to produce dairy products.

process goods.[35] Writing $F_j(.)$ as a function of firm-level labor and capital quantities enables us to authorize *economies of scope* when processing several goods.

Input Assumptions

A dairy firm sources milk inputs from various markets i in its accessible set $\mathcal{I}_f$. It encompasses direct purchases of raw milk from farmers on local markets and/or intermediary dairy products from other manufacturers. The latter are traded through global and regulated markets, as we extensively explain later. These pre-processed dairy products notably include milk powder (whole, half-skimmed, skimmed) and we discuss its substitutability with raw milk in greater details in Section 4.2.2. We assume milk inputs to be variable in the sense that sourcing and processing occur at the same period. This rules out the possibility for the manufacturer to store milk inputs, which is a natural assumption for perishable raw milk, but a stronger one for intermediary dairy products such as milk powder. We also assume milk inputs to be static, to the extent that they only affect current profits, thus ruling out adjustment costs. We similarly assume labor to be variable, implying costless labor adjustment.[36]

Finally and as standard in this literature, capital is assumed to be dynamic and fixed, which means that the capital stock at time t K_{ft} is determined by previous investments I_{ft-1} and depreciation of the capital stock of $t-1$, K_{ft-1}. Formally, denoting δ the depreciation rate of capital, we have :

$$K_{ft} = (1-\delta)K_{ft-1} + I_{ft-1}.$$

Note that we ignore non-milk intermediary inputs (e.g energy, fruits for yoghurt...) which would enter the production function as perfect complements. We argue that they are small in comparison with milk inputs cost. Including them would not affect estimated processing coefficients but could marginally increase the estimation of marginal costs of production. We

[35] At this stage, L_f and K_f can be defined as vectors of labor and capital quantities used for every product, while Ω_f can similarly be a vector of firm-product level efficiencies.

[36] This assumption is relatively strong. However, dairy processing mainly requires low skilled work which reduces hiring cost, firing costs, and facilitates turnover.

discuss this point in Appendix C.3.1.

3.2 Variable Profit Maximization

A manufacturer f maximizes its current variable profit. Firm f can be multi-source and multi-product: milk inputs i's are sourced from a market set $\mathcal{I}_f$ and products sold j's belong to $\mathcal{J}_f$. Both sets are defined one period ahead by firm f and dropped from notations hereafter.[37]

For each pair (i, j), firm f optimally chooses which quantity m_{fij} of input i to dedicate to product j. Firm f also chooses the optimal quantity of labor L_f to hire at unit cost z_f to process these products.[38] This yields the following program:

$$
\begin{aligned}
\max_{\{m_{fij}\}_{(i,j)\in\mathcal{I}_f\times\mathcal{J}_f},\, L_f} \quad & \sum_j p_{fj}(y_{fj})y_{fj} - \sum_i w_{fi}(m_{fi})m_{fi} - z_f L_f \\
\text{s.t.} \quad & y_{fj} = \min\left\{\sum_i e_{ij} m_{fij}\, , F_j\left(L_f, K_f; \Omega_f\right)\right\}\, , \forall\, j, \\
& m_{fi} = \sum_j m_{fij}\, , \forall\, i
\end{aligned}
$$

Firm f can exploit MP by internalizing its quantity effects on prices through its demand for product j, denoted $p_{fj}\left(y_{fj}\right)$ and its inverse supply curve on market i, denoted $w_{fi}(m_{fi})$.

Assuming concavity of the variable profit function, optimal purchases and production decisions are given by a first order condition with respect to m_{fij} for every (i, j), which yields:

$$
\underbrace{\left(1+\varepsilon_{fj}^{D\;-1}\right)p_{fj}}_{\text{marginal revenue } MR_{fj}} \quad = \quad \underbrace{\left(1+\varepsilon_{fi}^{S\;-1}\right)\frac{w_{fi}}{e_{ij}} + \lambda_{fj}}_{\text{marginal cost } MC_{fj}}\,. \tag{2}
$$

[37]See Appendix C for a more detailed description of the underlying timing.

[38]Capital is determined by past and current investments according to inter-temporal decisions which are separated from the program discussed here.

where the demand price-elasticity of j is

$$\varepsilon^D_{fj} \equiv \frac{\partial y_{fj}}{\partial p_{fj}} \frac{p_{fj}}{y_{fj}},$$

the supply price-elasticity is

$$\varepsilon^S_{fi} \equiv \frac{\partial m_{fi}}{\partial w_{fi}} \frac{w_{fi}}{m_{fi}}.$$

and λ_{fj} is the marginal processing cost (MPC) of product j.

Equation 2 states the equality between marginal revenue and marginal costs. Due to the existence of seller power, the marginal revenue differs from the downstream price, by a *wedge* equal to $1 + {\varepsilon^D_{fj}}^{-1}$.

Due to the existence of buyer power on market i, the marginal cost MC_{fj} writes:

$$MC_{fj} = \left(1 + {\varepsilon^S_{fi}}^{-1}\right) \frac{w_{fi}}{e_{ij}} + \lambda_{fj}$$

and thus differs from what we hereafter refer to as the *accounting marginal cost*:

$$AMC_{fj} = \frac{w_{fi}}{e_{ij}} + \lambda_{fj}$$

The distinction between both objects appears due to the firm internalizing its effect on price when buying an additional unit of milk. As a consequence, the term $1 + {\varepsilon^S_{fj}}^{-1}$ scales up the price of a raw milk in the marginal cost expression. In contrast, the *accounting* marginal cost is computed taking the price as given. Both objects feature an additive structure due to the Leontief production function: any unit of milk input purchased needs to be processed, requiring an additional marginal processing cost λ_{fj}.

One can note that first order conditions imply equality between the marginal revenue of producing an additional unit of product j (MR_j), and the marginal revenue of sourcing and processing the required milk from market i MC_{fij} for every couple (i, j). We thus have for every i:

$$MC_{fij} = MC_{fj}.$$

As extensively explain in Section 4, these arbitrage conditions, together with the existence of a commodity market where dairy firms do not have any price-setting power, will be the cornerstone of our identification strategy.

3.3 Markups, Markdowns and Margins

In this section, and based on the first order conditions derived above, we define markups, markdowns, and total margins.

3.3.1 Markups

Definition 1. *The markup measures the ability of a firm to set a price above its marginal cost. The markup of firm f on product j is:*

$$\mu_{fj} \equiv \frac{p_{fj}}{\left(1 + \varepsilon_{fi}^{S\ -1}\right) \frac{w_{fi}}{e_{ij}} + \lambda_{fj}} = \frac{1}{1 + \varepsilon_{fj}^{D\ -1}}.$$

This expression is derived from Equation (2). It links the ratio between price and the marginal cost of production with the demand elasticity : the more inelastic is the demand (higher ε_{fj}^{D}) the higher is the markup.

3.3.2 Markdowns

Definition 2. *The markdown measures the ability of a firm to purchase a milk input at a price below the input's marginal contribution to profit. The markdown of firm f on input i is:*

$$\nu_{fi} \equiv \frac{e_{ij} \left(p_{fj} \left(1 + \varepsilon_{fj}^{D\ -1}\right) - \lambda_{fj}\right)}{w_{fi}} = 1 + \varepsilon_{fi}^{S\ -1}.$$

This definition is derived from Equation (2), similarly to Definition 1. As expected, firm's upstream market power depends on the supply elasticity: the more inelastic is the supply, the higher is the markdown. Due to perfect complementarity between milk and other inputs, the production of an additional unit of output j requires an extra processing cost λ_{fj}. This marginal processing cost cuts what is left to remunerate milk input i. Hence, $p_{fj}\left(1+\varepsilon_{fj}^{D\,-1}\right)-\lambda_{fj}$ is the marginal contribution to profit of an additional unit of *output* j. Adjusting by e_{ij}, we finally have at the numerator the marginal contribution to profit of an additional unit of *input* i to product j. Note that despite the multi-product setting, firms' optimizing behavior requires markdowns on a given market i to be product-invariant.

3.3.3 Margins

Definition 3. *The (total) margin measures the ability of a firm to set a price above its accounting marginal cost. We define the margin of firm f on product j sourcing milk from input market i as:*

$$M_{fij} \equiv \frac{p_{fj}}{\frac{w_{fi}}{e_{ij}} + \lambda_{fj}}.$$

Using our definitions of markups and markdowns, the margin can be rewritten:

$$M_{fij} = \left(\theta_{fij}\nu_{fi} + (1-\theta_{fij})\right)\mu_{fj} \tag{3}$$

where $\theta_{fij} \equiv \frac{w_{fi}}{w_{fi}+e_{ij}\lambda_{fj}}$ is the share of milk from i in the *accounting* marginal cost of producing j. The total margin on a unit of milk input i used in product j is thus a combination of the markdown on milk input i and the markup on product j, thus reflecting overall market power of a firm. Due to the Leontief structure, the importance of the markdown on milk i is modulated by the importance of milk input i in the total marginal cost of processing product j, which translated into θ_{fij}. Finally, note that the term $(1-\theta_{fij})$ enters without any multiplicative term as we assumed no MP on labor, the only other variable input.[39]

[39]We discuss this assumption, which can be relaxed in theory but is needed for estimation, in Appendix C.

This definition encompasses special cases which have been studied in the literature. If $\theta_{fij} = 1$, we have $M_{fij} = \nu_{fi}\mu_{fj}$, implying that the margin is equal to the product of the markdown and the markup. This is the result of Morlacco (2019) who assumes substitutability between materials and labor and capital. As a consequence, the markdown proportionally scales up the total margin, similarly to the markup.

Ignoring buyer power ($\nu_{fi} = 1$), the margin reduces to $M_{fij} = \mu_{fj}$, *i.e* the total margin equalizes the markup. This is the classical result of various papers (De Loecker and Warzynski (2012); De Loecker and Scott (2016); De Loecker et al. (2016); De Ridder et al. (2021) among others) ignoring buyer power on intermediates/materials. By assumption, the existence of total margins is thus attributed to seller power only.

Finally, in the absence of seller power (μ_{fj}=1), the margin is equal to $M_{fij} = \nu_{fi}\theta_{fij} + (1 - \theta_{fij})$, which tends towards ν_{fi} when θ_{fij} is close to unity. This for example relates to Zavala (2020), estimating markdowns of exporters when purchasing crops to Ecuadorian farmers, but taking (international) output prices as given.

3.4 Assumptions

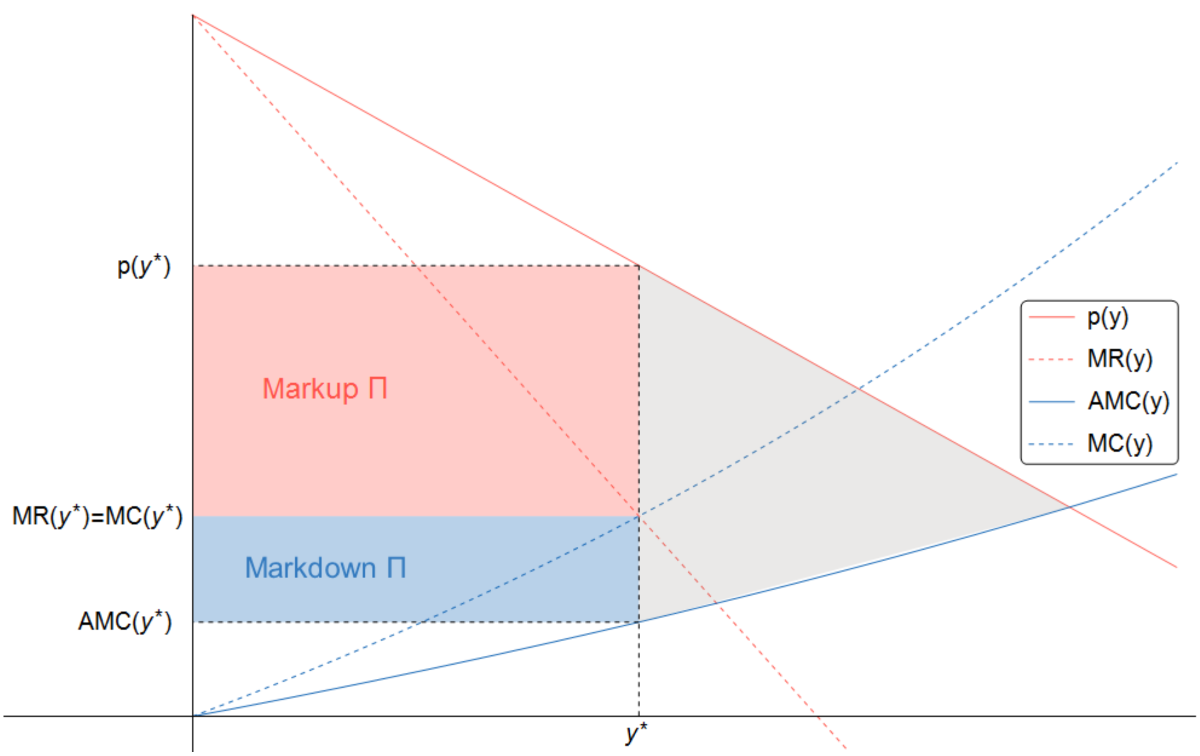
For the sake of simplicity, the theoretical framework presented here is kept to the strict necessary in order to derive markups, markdowns and margins, in a context-consistent way. It relies on some simplifying assumptions that are relaxed in Appendix C where we show how (i) we can rely on cost minimization only, (ii) we can incorporate intra-brand competition or (iii) horizontal collusion or vertical cooperation can be allowed.[40] Importantly, these extensions would not change empirical results. The key intuition behind this robustness is that we do not rely on an estimation of the implied elasticities, so that underlying marginal revenue and marginal cost are free to encompass any economic cost of adjusting raw milk and dairy products prices perceived by the firm. Firms behaviors can thus take more complex forms than outlined here, as further explained in Appendix C.1.2.

[40]This last aspect allowing us to think about the behavior of vertically integrated cooperatives.

3.5 Graphical Representation

Figure 2 represents the equilibrium of a single milk input and output firm, allowing us to drop subscripts. For the sake of representation, we here assume particular functional forms. Demand $p(.)$ and marginal revenue curves $MR(.)$ differ due to the existence of seller power. Accounting marginal costs $AMC(.)$ and marginal cost $MC(.)$ curves differ due to the existence of buyer power.

Figure 2: Equilibrium - Single Input/Output Firm



The equilibrium quantity (of input and output) is determined by the equality between marginal revenue and marginal costs. This simple representation stresses two important aspects: both buyer and seller power similarly (i) reduce equilibrium input and output quantities, and (ii) pull down input prices and inflate final prices. As such, they both decrease total welfare and induce redistributing effects from farmers and consumers towards manufacturers. The total rent captured by manufacturers is thus the sum of markdown and markup rents, respectively represented by the blue and red rectangles.

In the empirical analysis that follows, we will be able to identify equilibrium objects $p(y^*)$, $MR(y^*) = MC(y^*)$, and $AMC(y^*)$, allowing us to quantify markups, markdowns and margins, as well as associated rents. As our framework purposely remains agnostic on the exact competition contexts, and thus on the exact shapes of red and blue curves on Figure 2, we do not aim at computing the deadweight loss (in grey), nor at generating counterfactuals. However, variations of estimated equilibrium objects across time and markets will help us having a sense of the underlying shape of demand and supply curves, and drawing important policy implications.

4 Estimation

We are ultimately interested in estimating margins, markups and markdowns, provided that we directly observe prices p_{fj} and w_{fi} in the data. From definition 3, repeated below for convenience,

$$M_{fij} \equiv \frac{p_{fj}}{\frac{w_{fi}}{e_{ij}} + \lambda_{fj}},$$

we see how we can recover total margins from the estimation of *accounting* marginal costs, which are the sum of the cost of buying at cost w_{fi} the quantity e_{ij} of milk input i present in a unit of output j, and marginal processing cost λ_{fj}. In Section 4.1.1, we argue that e_{ij} can be summarized using dry matter contents of milk input i and product j, which we observe in the data. We then show in Section 4.1.2 how we can estimate marginal processing costs, following a standard production function approach relying on our production data.

We then explain in Section 4.2 how we take advantage of the presence of dairy firms on multiple markets, including a commodity market where they do not have any price-setting power (be it as a buyer or as a seller), to disentangle both sources of MP and estimate firm-origin-level markdowns and firm-product-level markups.

4.1 Recovering Margins through Marginal Costs Estimation

4.1.1 Dry Matter Contents of Milk Inputs and Outputs

We explain here how we identify e_i and e_j and thus $e_{ij} = \frac{e_i}{e_j}$, the quantity of milk input i needed to produce a unit of output j. Together with our raw milk price data, this provides us marginal buying costs at the firm-origin-product level.

In practice, raw milk and dairy intermediates are bundles of multiple sub-inputs (water, fat, protein, lactose, minerals) which are also present in different proportions in various dairy outputs j. The two main sub-inputs are fat and proteins, which we treat indifferently by summing them to get *dry matter contents* e_i *and* e_j. This methodology is commonly used by practitioners in the industry, which guarantees the quality and the availability of the data. On the output side, we observe dry matter contents at the CN8-level (and for some products slightly more disaggregated). On the input side, we observe it at the department-year level for raw milk and at the CN8-level for dairy intermediates.

Table 3: Example of Dry Matter Contents in Dairy Inputs and Outputs

DMC data	Butter	Comté	Yoghurt	Raw Milk ($i =$*Doubs, 2018*)
Content (in g/100g)				
Fat	82.00	31.20	2.69	3.95
Proteins	0.75	27.97	3.60	3.38
Dry Matter (e_j or e_i)	82.75	59.17	6.29	7.33
Quantity of milk needed (in g/g)				
e_{ij}	11.29	8.07	0.85	

Table 3 shows concrete examples of e_i and e_j measurements. For example, 100 grams of butter contain 82 grams of fat and 0.75 grams of proteins so that $e_{butter} = 82.75$, whereas 100 grams of yoghurt contain 2.69 grams of fat and 3.6 grams of proteins so that $e_{yoghurt} = 6.29$. Similarly, in the Doubs department in 2018, $e_{Doubs} = 7.33$. Using these characteristics, producing a kilogram of butter would require 11.29 kilograms (82.75/7.33) of milk from the *Doubs* department, while producing a kilogram of *Comté* cheese would require 8.07 kilograms (59.17/7.33) of such milk.

In our data, e_i are time-varying[41], while e_j are not. Table 3 illustrates the substantial heterogeneity in milk requirements e_j across dairy products[42] and the importance of taking it into account. Dry matter contents e_i exhibit less variation across departments (and time), lying between 5.60 and 8.19 grams per 100 grams, for every French department during the 2003-2018 period.

Using these data, we assume that there is no waste of dry matter contents in the production process. This assumption appears credible and even necessary in our context as manufacturers use fat or proteins leftovers from the production of a given product in the production of other products. Doing so, they exploit complementarities in the production of several dairy products regarding the use of milk. Assuming an optimal use thus seems reasonable, which the goodness of fit we find between the reconstituted demand for French raw milk and the actual raw milk collection confirms. We underestimate the demand for raw milk by 2 to 8% over the period, as shown in Appendix D.1), a gap that can be explained by wastes in the production process that we do not allow.

4.1.2 Milk Processing Costs Estimation

We describe here our identification and estimation methodology for milk processing costs. In the theoretical part of the paper, we allow processing costs to be firm-product specific. In the empirical analysis which follows, we restrict them to be homogeneous within a firm across products, assuming that: $\forall j, \lambda_{fj} = \lambda_f$. This assumption makes sense in our context, as extensively explained in Appendix D.2.1.

Identification of Milk Processing Marginal Costs λ_f

We assume that a firm f processes milk using variable labor l_f, and fixed capital k_f, in log terms. Firms differ in their ability to process milk ω_f. In our favorite specification, we

[41]Time subscript are dropped here in order to alleviate notations.

[42]Interested readers can further explore this dimension in this public (and slightly more aggregated) version of the dry matter content data we use here.

assume the following translog milk processing function:[43]

$$\ln y_f = \ln F(.) = \beta_l l_f + \beta_k k_f + \beta_{ll} l_f^2 + \beta_{kk} k_f^2 + \beta_{kl} k_f l_f + \omega_f. \tag{4}$$

The implied output elasticity of labor is firm-time specific and equal to:

$$\varepsilon_{ft}^{Y,L} \equiv \varepsilon^{Y,L}(l_{ft}, k_{ft}) = \beta_l + 2\beta_{ll} l_{ft} + \beta_{kl} k_{ft} \tag{5}$$

Dropping time subscript again to alleviate notations, the minimization of the variable cost function given the desired processing level of Y_f implies:

$$\begin{aligned} \min_{L_f} \quad & Z_f L_f \\ \text{s.t.} \quad & F(L_f, K_f, \Omega_f) - Y_f^* \geq 0, \end{aligned}$$

At the optimum, we have:

$$\lambda_f = \frac{Z_f L_f^*}{\varepsilon_f^{Y,L} Y_f^*}. \tag{6}$$

The marginal processing cost is thus equal to the expenditure on labor L_f divided by the labor elasticity of output $\varepsilon_f^{Y,L}$ times the quantity of output produced. Identifying the firm-product-specific marginal costs thus requires estimating $\varepsilon_f^{Y,L}$.

Estimation Procedure In order to estimate the processing function, we follow the seminal literature. In particular, we follow Olley and Pakes (1996), Levinsohn and Petrin (2003) and Ackerberg et al. (2015) in order to deal with firm-specific efficiencies that are unobserved sources of endogeneity. We also incorporate methodologies of De Loecker et al. (2016) and Rubens (2021) to deal with unobserved exogenous input prices and quantities, and with (observed) endogenous prices upstream and downstream, *ie* firms exploiting MP on both sides of the market. We extensively describe this standard approach in Appendix D.2.2.

[43] In the Results section, we compare the resulting estimated elasticities with the ones obtained with a Cobb-Douglas specification and to the empirical labor shares.

Estimates We present in Appendix D.2.3 our processing functions estimates for several specifications, including plain OLS and GMM, and for Translog and Cobb-Douglas production functions. All coefficients (i) are close to typical findings in the literature and (ii) confirm the importance of correcting for endogeneity. Translog estimates imply an average output elasticity of labor of 0.79, and the average output elasticity of capital of 0.14, as shown in Table 4. Reassuringly, all quantiles of the distribution of elasticities align well with their counterparts in the empirical distributions of labor, and capital shares in total processing costs (labor and capital costs), as shown in Table 13.

Table 4: Distribution of Elasticities obtained with a Translog Specification

	Average	Median	P5	P25	P75	P95	Obs.
Labor Elasticity	0.79	0.79	0.65	0.73	0.86	0.95	2,736
Capital Elasticity	0.14	0.14	0.01	0.09	0.19	0.24	2,736

Notes: Distributions winsorized at 1% and 99%.

The median labor elasticity of output is above the one found by Rubens (2021) (0.591) - who assume a similar Leontief production function, though applied in different context - and De Loecker and Scott (2016) (0.75), who have a Cobb-Douglas specification. Capital elasticities are less stable in the literature and ours differs from Rubens (2021)' (0.59) but are closer to De Loecker and Scott (2016)' (0.30)[44]. Using these estimates of $\varepsilon_f^{Y,L}$ now indexed by firm subscript f, and equation (6), we can recover marginal costs at the firm-level.

In the rest of the empirical analysis hereafter, we thus write marginal costs (λ_f) at the firm-level rather than at the theoretical firm-product level (λ_{fj}), consistently with our estimation procedure. Based on these estimates and definition 3, we have margin estimates:

$$M_{fij} = \frac{p_{fj}}{\frac{w_{fi}}{e_{ij}} + \lambda_f}.$$

[44] Our estimates of the capital elasticity may be downward biased due to measurement error, as suggested by Collard-Wexler and De Loecker (2016). Note that this capital elasticity does not directly affect subsequent results as estimating marginal processing costs only requires knowledge of the labor elasticity. In the translog production function, capital measurement, however, can contaminate our measured labor elasticity.

4.2 Disentangling Markups and Markdowns

Having margin and marginal cost estimates in hands, we show how we can recover a firm's markups and markdowns through its sales or purchases on a global commodity markets. We then detail and discuss the practical implementation of this methodology, relying on a particular commodity, namely whole milk powder (WMP).

4.2.1 Intuition for Identification

The intuition for identification of markups and markdowns is based on Equation 3, repeated here for convenience:

$$M_{fij} = \left(1 + \theta_{fij}\left(\nu_{fi} - 1\right)\right)\mu_{fj} \tag{3'}$$

where $\theta_{fij} \equiv \frac{w_{fi}}{w_{fi}+e_{ij}\lambda_{fj}}$ is the share of milk from i in the *accounting* marginal cost of producing j. As aforementioned, once λ_{fj} approximated by λ_f, M_{fij} and θ_{fij} are estimated. As Equation 3 holds for every source market i and product j on which firm f is present, we can exploit the underlying arbitrage conditions and the fact that firms trade inputs or outputs on markets where they do not systematically have price-setting power.

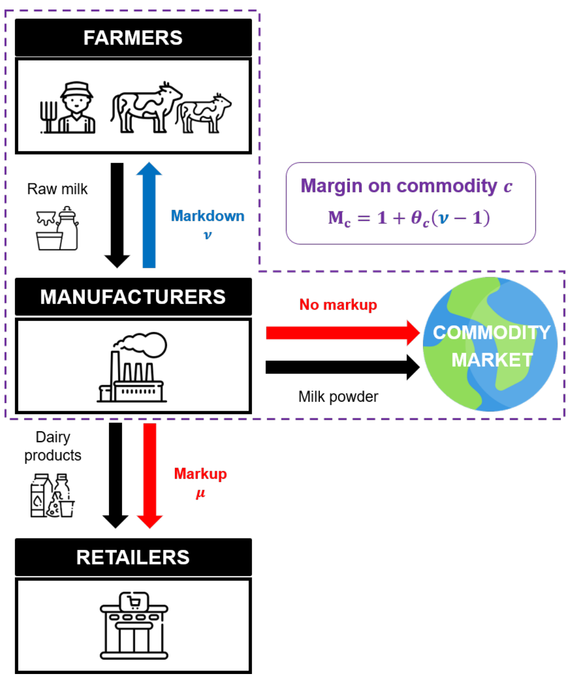
Figure 3 provides identification intuitions for manufacturers selling on at least two markets, including one where they do not have seller power. For simplicity, we take a particular firm sourcing milk on a single market, allowing to drop corresponding subscripts. This firm has buyer power and a markdown ν on its milk market. Such a firm sells on a market c where it has no seller power ($\mu_c = 1$), its margin M_c is only fueled by the markdown:

$$M_c = 1 + \theta_c\left(\nu - 1\right).$$

As M_c has previously been estimated, inverting the equation above allows the identification of the markdown v. Using again Equation 3, we can then recover markups μ_j for all other products j sold by the firm:

$$M_j = \left(\theta_j\nu + \left(1 - \theta_j\right)\right)\mu_j.$$

Figure 3: Identification - Commodity Sellers



(a) Markdown (b) Markup

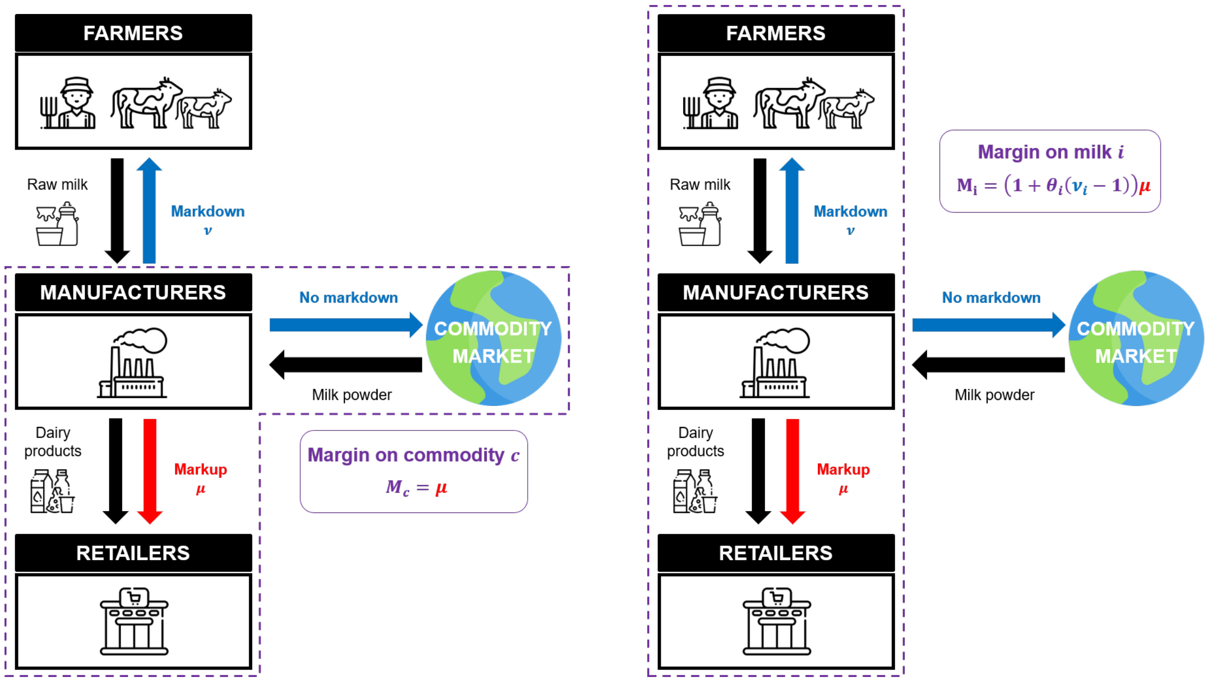
Figure 4 provides similar identification intuitions for manufacturers buying on at least two markets, including one where they do not have buyer power. For simplicity, we take a particular firm selling on a single market, allowing to drop corresponding subscripts. This firm has seller power and a markup μ on its output market. If such a firm purchases on a market c where it has no buyer power ($\nu_c = 1$), its margin M_c is only fueled by the markup:

$$M_c = \mu_c.$$

As M_c has been estimated, the equation above directly delivers the markup μ_c. Using again Equation 3, we can then recover markdowns ν_i for all other milk inputs i the firm purchases:

$$M_i = (1 + \theta_i (\nu_i - 1)) \mu_c.$$

Figure 4: Identification - Commodity Buyers



(a) Markup (b) Markdown

4.2.2 Practical Implementation

We are thus able to identify markups and markdowns of firms that either buy or sell at least one commodity. According to our theory, a firm can either be a seller or a buyer of commodities, or none of the two, but cannot simultaneously be both a seller and a buyer. The latter would imply losses on this trading activity, as the firm would buy and sell the same product, but would incur an additional marginal processing cost. Our theory rationalizes the fact that some firms sell commodities while some do not, as it reflects the ability of the former to process commodities at a marginal cost lower than commodity market prices.

The Commodity as a Competitive Output

In practice, we observe firm-level sales and price p_{fc} of WMP. By assumption, we have $\mu_{fc} = 1$, implying the following markdowns and markups estimates for WMP sellers:[45]

[45] These results and their equivalent for WMP buyers are derived from first order conditions of the variable profit maximization program. See Appendix D.3 for the formal derivation.

$$\nu_{fi} = \frac{e_i}{e_c}\frac{(p_{fc} - \lambda_f)}{w_{fi}}, \ \forall\ i \quad \text{and} \quad \mu_{fj} = \frac{p_{fj}}{\frac{(p_{fc}-\lambda_f)}{e_{cj}} + \lambda_f}, \ \forall\ j.$$

A firm that has the opportunity of producing and selling the commodity trades-off between (a) producing and selling it at exogenous price p_{fc} and (b) producing and using it in its production process. Using WMP in the production process rather than selling it implies an opportunity cost $(p_{fc} - \lambda_f)$. As a consequence, the markdown is the wedge between the opportunity cost of not selling WMP, and the observed price w_{fi} or raw milk, pondered by their respective dry matter contents. The wedge only exists due to the existence of buyer power on raw milk, and reflects the magnitude of this price-setting power upstream.

A firm that has the opportunity of selling the commodity also trades-off between (a) using milk to process and selling the commodity at exogenous price p_{fc} and (b) processing and selling another product j, on which it has seller power. The marginal cost of producing an additional unit of product j thus takes into account the marginal processing cost λ_f but also the opportunity cost $(p_{fc} - \lambda_f)$ of renouncing to producing and selling the commodity. The wedge only exists due to the existence of seller power on market j, and reflects the magnitude of downstream price-setting power.

The Commodity as a Competitive Input

Contrary to sales, we do not observe firm-level purchases and price of WMP, leading us to assume that firms which do not sell WMP are purchasers of the commodity at a common market price w_c. We use market prices for France provided by the European Commission.[46] Similarly to what we do for local markets i, we define $e_{cj} = \frac{e_c}{e_j}$ using the observed dry matter content data of the commodity and dairy products. Doing so, and as λ_f has been estimated, $AMC_c(.)$ is observed.

By assumption, we have $\nu_{fc} = 1$, implying the following markdowns and markups esti-

[46] These data can be found here.

mates for WMP purchasers:

$$\nu_{fi} = \frac{e_i}{e_c}\frac{w_c}{w_{fi}}, \ \forall\ i \quad \text{and} \quad \mu_{fj} = \frac{p_{fj}}{\frac{w_c}{e_{cj}} + \lambda_f}, \ \forall\ j.$$

The firm prefers to buy raw milk from market i - where it exerts buyer power - as long as the marginal costs of buying and processing it is below the marginal costs of buying - at exogenous price w_c - and processing the commodity. For the optimal quantity of milk i, both are equalized, allowing to identify the markdown. Eventually, the markdown on market i of a firm buying on the commodity market simply is the ratio between prices of the commodity c and of milk i, adjusted for their respective dry matter contents. The wedge between both prices exists reflects the fact that the firm prefers to buy the commodity at a price higher than the price of raw milk. This comes from the firm's internalization of its buyer power on market i, $i.e$ which thus takes into account that purchasing an additional unit of raw milk on market i requires paying a higher price for every milk unit purchased.

The firm then relies on commodity c to produce a given dairy product j as long as the marginal revenue of j is above the marginal costs of buying and processing the commodity. For the optimal quantity of product j, both are equalized, and the ratio between the price of product j and the (accounting) marginal cost of using commodity c delivers the markup. As the firm does not have buyer power on commodity c, this wedge is solely due to the existence of seller power.

Appendix D.3 provides more details on the separate identification of markups and markdowns, with the exact derivations of both objects for WMP buyers and sellers respectively, as well as graphical representations illustrating the main aforementioned intuitions.

The Choice of the Commodity: Whole Milk Powder

As other dairy commodities (butter, cream, or skimmed milk powder), (bulk) WMP is sold on global markets at a price fixed by a quotation. WMP however feature specificities that makes it the most relevant commodity to back up our empirical analysis. First, WMP is the most internationally traded dairy commodity in the world. The European Union production and consumption shares are however relatively small, about 11 and 15% in 2018.[47] Around 70% of the global production comes from New Zealand, China and Brazil, New Zealand alone representing 70% of total WMP exports. We can thus credibly assume that French manufacturers do not have seller nor buyer power on this product, and consider its price as exogenous. Second, among all commodities used in the dairy industry, WMP is the most similar (in terms of fat and protein contents) to raw milk, given that it is basically dry raw milk. As a consequence, WMP is commonly used as a substitute for raw milk in the production process, and typically enters the composition of many dairy products like yoghurts, milk or cheese.

Discussion of the Competitive Input and Output Assumptions

We view the competitive output assumption as quite natural. WMP is the adjustment output used by dairy firms to dispose of short-term overproduction. The drawback of this assumption is that WMP is generally not produced by small and medium producers. We instead use the competitive input assumption for such manufacturers. This assumption relies on WMP as a substitute for raw milk. In practice, intermediary inputs can (almost) always be replaced by raw milk, but the reverse is not always true (e.g. for raw milk cheese). In the theoretical part of the paper, we assume that this substitution is valid for processing every output. In fact, the competitive input assumption is relevant as long as WMP is a perfect substitute for raw milk used for at least one product processed by the firm, which is a much less restrictive assumption. Processing yoghurts or industrial cheeses for instance with such milk powder is a common practice in the dairy industry. In order to avoid concerns on the substitutability between inputs, we exclude PDO and organic milk of our analysis.

[47] Source: USDA

5 Results

In this section, we show that dairy manufacturers exploit both markups and markdowns. On average, dairy firms' margins mostly come from markups but the relative contributions significantly vary across time and products. With a complementary pass-through analysis, we show that variations across time are indicative of how manufacturers endogenously adjust the degree of monopsony and monopoly powers exertion following variations in the price of the commodity.

5.1 Average and Median Markdowns, Markups and Margins

Table 5 displays average and median markdowns, markups and margins, over the whole period of analysis (2003-2018) and for different samples.[48]

The average markdown is 1.19, meaning that dairy firms on average purchase raw milk at a price 16% ($1 - 1/1.19 \approx 0.16$) below its marginal contribution to their profits.

The weighted average markup equals 1.46, implying that, on average, the unit price of a dairy product sold by a French dairy firm exceeds the marginal cost by 46%. This weighted average markup inflates to 68% when we restrict to final consumption goods, which are relatively more differentiated. Both of these weighted averages are significantly higher than the corresponding median and simple averages, implying that bigger firms tend to enjoy higher markups, suffering relatively less than smaller sellers from the existence of countervailing buyer power emanating from concentrated retailers.

[48]For all aggregated statistics in this section, we use raw milk prices at the regional level, which we have over the entire period. Using individual raw milk prices for the subsample of firms and years (2013-2018 deliver similar aggregated results for the corresponding period.

Table 5: Margins, Markdowns and Markups - Estimates

	Markdowns	Markups		Margins	
Sample	All	All Prod.	Final goods	All Prod.	Final goods
Average	1.18	1.24	1.55	1.51	1.91
Weighted Average	1.19	1.46	1.68	1.62	1.88
Median	1.16	1.08	1.44	1.38	1.89
Observations	8,049	6,004	3,787	71,787	43,486

Notes: Sample restricted to firms for which we manage to link raw milk collection and production. Markdowns computed based on raw milk prices at the regional level. Weighted averages based on quantity (dry matter content) shares upstream and downstream. Markdowns at the group-department-time level, markups at the group-product-time level, margins at the group-department-product-time level.

The industry's weighted average margin amounts to 1.62. It means that, on average, the unit price of a dairy product sold by a French dairy firm exceeds the accounting marginal cost by 62%. The difference with the weighted average markup shows the non-negligible contribution of buyer power. Moreover, this weighted average margin goes up to 88% when focusing on final consumption goods only, naturally reflecting the existence of higher markups on such products.

Overall, these results suggest that, on average, markdowns are relatively low compared to markups and that dairy firms' margins mainly come from the exploitation of seller power, especially for bigger firms with high seller power. However, these averages hide a substantial amount of heterogeneity we discuss below.

5.2 Market Power Exertion across Time and Pass-Through

In this subsection, we first show that while dairy manufacturers' margins are relatively stable, markups and markdowns contributions significantly vary over time. With a pass-through analysis, we then show that these variations actually reflect adjustments of manufacturers' MP exertion to non-constant price elasticities along the underlying supply and demand curves.

5.2.1 Variations in Market Power Exertion across Time

Defining margin rates $\tilde{M}_{fij}$, markup rates $\tilde{\mu}_{fj}$ and markdown rates $\tilde{\nu}_{fj}$ with $\tilde{x} = x - 1$ for $x = \{\nu_{fi}, \mu_{fj}, M_{fij}\}$, we can rewrite Equation (3) and get:

$$\tilde{M}_{fij} = \underbrace{\theta_{fij}\tilde{\nu}_{fi}}_{\text{Markdown contrib.}} + \underbrace{\tilde{\mu}_{fj}}_{\text{Markup contrib.}} + \underbrace{\theta_{fij}\tilde{\nu}_{fi}\tilde{\mu}_{fj}}_{\text{Joint contrib.}} \tag{7}$$

This decomposition shows that the difference between total margins and markups comes from two terms. First, the markdown rate directly contributes to the margin rate up to $\theta_{fij}\tilde{\nu}_{fi}$, *i.e.* proportionally to the share of milk in total marginal costs. Second, the markdown rate also contributes together with the markup rate, again proportionally to the share of milk in total marginal costs.

Figure 5: Average Markdowns and Markups Contributions to the Margin

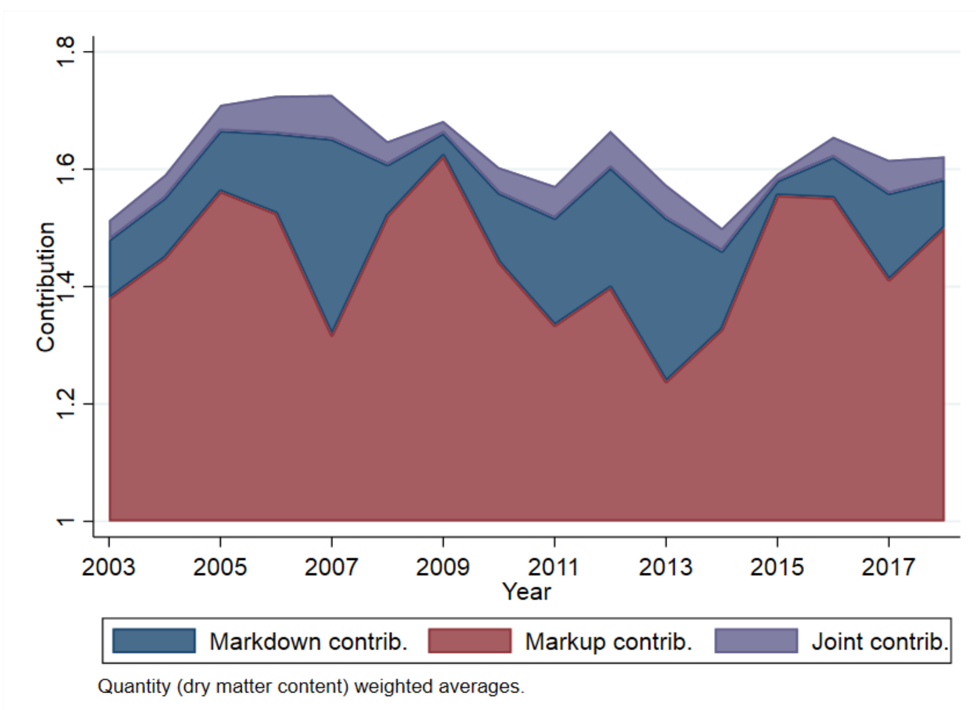
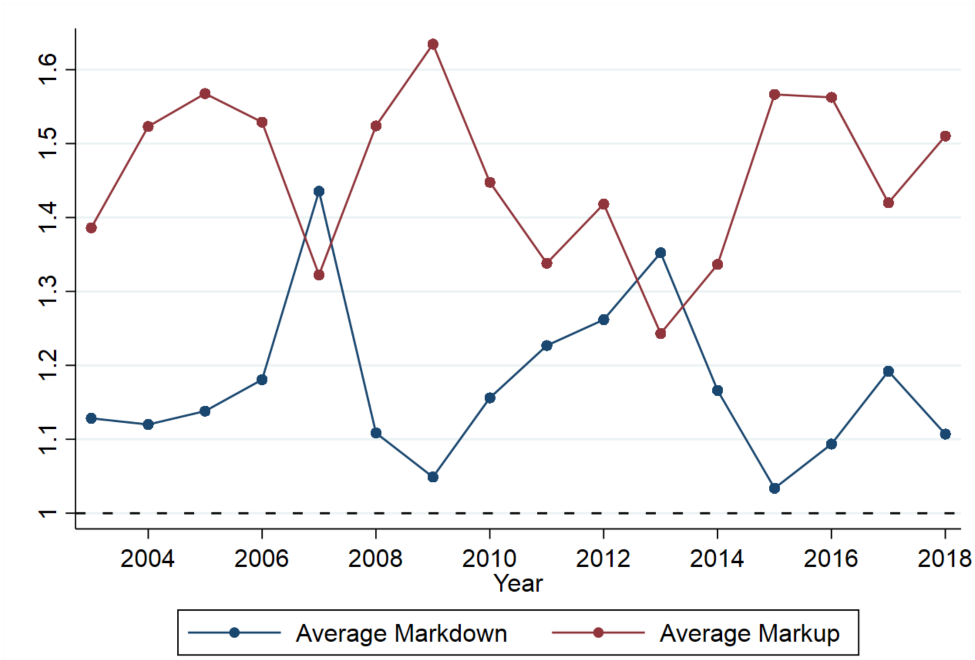


Figure 5 plots the different terms of Equation 7 across time. While the average margin rate remains somewhat stable, around 60% over the period, the relative contribution of markups and markdowns vary during the period. This reflects the variation of markups and markdowns over time, as shown on Figure 6. Over the period, the average markdown rate fluctuates between 4% and 40%, while the average markup rate lies between 27% and 61%. Our estimates indicate that markdowns are higher than markups for two years of the period of analysis (2007 and 2013). Overall, we do no find any particular trends in the evolution of markups and markdowns. Markups and markdowns, however, appear to be strongly negatively correlated. This relationship is governed by (i) variations in the price of WMP but also (ii) endogenous adjustments of MP exertion by manufacturers.

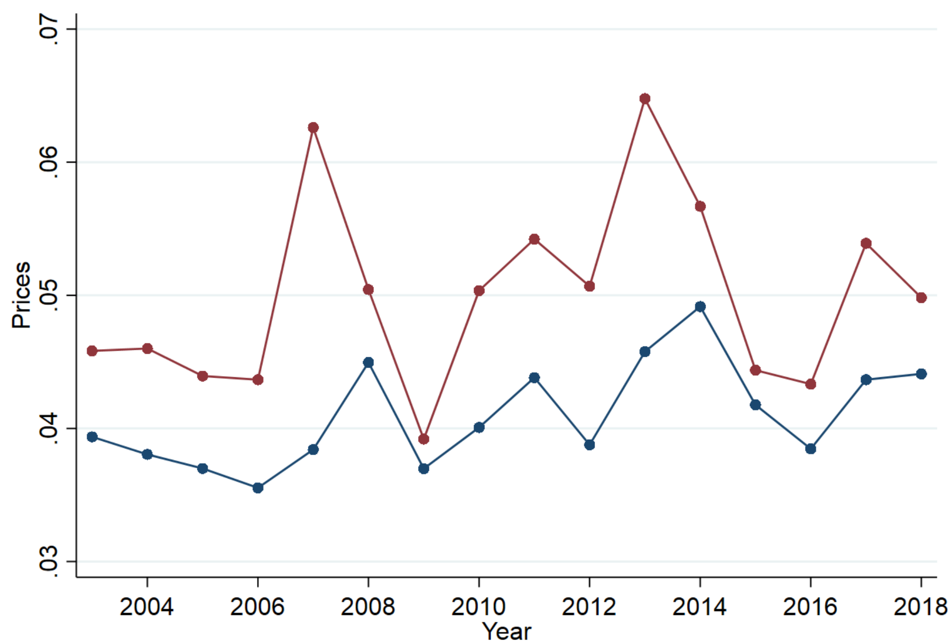
Figure 6: Markdowns and Markups - Estimated Weighted Averages



Quantity (dry matter content) weighted averages.

Figure 7 shows how markdown fluctuations actually follow variations of the commodity price. Under perfect competition, the markdown and the markup would have been stable and equal to 1. Variations in dairy products and raw milk prices would have then perfectly reflected WMP price variations. Our results instead show that markups and markdowns fluctuate over time due to a (i) varying and (ii) incomplete *pass-through*. Upstream, when the price of WMP increases, the price of raw milk increases as well, but less than proportionally. We view it as indicative that above a given quantity threshold, raw milk supply becomes inelastic as farmers' productions bind on capacity constraints. Manufacturers thus do not have any reason to increase more raw milk prices, and markdowns increase to reach relatively high levels (1.42 in 2007, 1.34 in 2013). Conversely, when the price of WMP decreases, the price of raw milk also decreases but again less than proportionally. During such downturns, the average markdown comes even close to unity: 1.05 in 2009 or 2015. This relatively *more incomplete* pass-through actually reflects an increase in milk supply elasticity due to declines in farm's profitability. In the aforementioned context of supply preservation, manufacturers compress their markdowns in order to avoid too many exits of local farms.

Figure 7: Whole Milk Powder and Average Raw Milk Prices



Dry Matter Content (DMC) prices. Quantity (DMC) weighted average raw milk price.

In what follows, we theoretically and empirically describe such pass-through adjustments, showing how dairy products and raw milk prices ultimately depend on (i) commodity prices and (ii) markups and markdowns adjustments.

5.2.2 Pass-Through Analysis

In this section, we analyze how shocks on the price of WMP, denoted w_c and which we view as exogenous, pass through on prices of dairy products. Reduced-form results confirm the existence of monopsony and monopoly powers of French dairy manufacturers, providing an external validation to our estimation results.

Theoretical Pass-Through

We start from the definition of the margin as the ratio of price and accounting marginal costs:

$$M_{fij}(w_c) = \frac{p_{fj}(w_c)}{\frac{w_{fi}(w_c)}{e_{ij}} + \lambda_{fj}}$$

All equilibrium objects are endogenous, which we make explicit here by writing them as functions of w_c.[49]

Passing the equation above to the log, taking the derivative with respect to w_c, and rearranging, our model predicts the following pass-through of the commodity price to the price of a given product j sold by firm f:

$$\varepsilon_{w_c}^{p_{fj}} = \varepsilon_{w_c}^{M_{fij}} + \theta_{fij}\varepsilon_{w_c}^{w_{fi}}, \tag{8}$$

where we, here and hereafter, note $\varepsilon_{w_c}^{x} \equiv \dfrac{\partial x}{\partial w_c}\dfrac{w}{x}$ for $x = \{M_{fij}, p_{fj}, \mu_{fj}, w_{fi}\}$, remembering that $\theta_{fij} = \frac{w_{fi}}{w_{fi}+e_{ij}\lambda_{fj}}$ is the share of milk purchased in market i in the *accounting* marginal cost.

We thus see how an increase of the commodity price spreads along the supply chain

[49]For simplicity we here consider the marginal processing cost (MPC) λ_{fj} as unresponsive to w_c, which is consistent with (i) our estimation assumption of the same MPC for raw milk and WMP, and (ii) our results indicating near-constant returns to scale. Reduce-form results presented in the following subsection confirm this prior. In Appendix E.2, we nevertheless additionally derive the formulas presented here authorizing MPC to adjust.

depending on manufacturers' reactions. The shock is pass through to upstream and downstream prices but also possibly partly absorbed by margin adjustments.

We can further decompose underlying adjustments of the margin to see how markups and markdowns respectively adjust. To do so, we proceed in a similar way but starting from the definition of the markup (or equivalently from the first order condition of the variable profit maximization program), repeated here for convenience:

$$\mu_{fj}(w_c) = \frac{p_{fj}(w_c)}{\nu_{fi}(w_c)\dfrac{w_{fi}(w_c)}{e_{ij}} + \lambda_{fj}}$$

This yields:

$$\varepsilon_{w_c}^{p_{fj}} = \varepsilon_{w_c}^{\mu_{fj}} + \tilde{\theta}_{fij}\left(\varepsilon_{w_c}^{\nu_{fi}} + \varepsilon_{w_c}^{w_{fi}}\right), \tag{9}$$

where $\tilde{\theta}_{fij} = \frac{w_{fi}\nu_{fi}}{w_{fi}\nu_{fi}+e_{ij}\lambda_{fj}}$ is the share of milk purchases from i in the marginal cost of product j. As expected, the margin adjustment $\varepsilon_{w_c}^{M_{fij}}$ appearing in (8) decomposes into a proportional markup adjustment $\varepsilon_{w_c}^{\mu_{fj}}$ and an adjustment $\varepsilon_{w_c}^{\nu_{fi}}$ of the markdown on raw milk that affect the margin proportionally to the share $\tilde{\theta}_{fij}$ of milk purchases in marginal costs.

In the absence of upstream and downstream MP (*i.e* if $\nu_{fi} = \mu_{fj} = 1$ and $\varepsilon_{w_c}^{\mu_{fj}} = \varepsilon_{w_c}^{\nu_{fi}} = 0$), Equation (9) would collapse to:

$$\varepsilon_{w_c}^{p_{fj}} = \theta_{fij}\varepsilon_{w_c}^{w_{fi}}. \tag{10}$$

Importantly, comparing Equations (9) and (10) shows how the pass-throughs of variations in the commodity price to upstream and downstream prices crucially depend on the ability of manufacturers to *adjust* their markups and markdowns, *i.e* on the terms $\varepsilon_{w_c}^{\nu_{fi}}$ and $\varepsilon_{w_c}^{\mu_{fj}}$. Note that through $\tilde{\theta}_{fij}$, it also *directly* depends on the markdown *level.* Markdown and markup *levels* otherwise only matter *to the extent that they impact the ability of manufacturers to* *adjust MP exertion.* It echoes a result well-identified by the literature: pass-through rates crucially depend on the curvature of supply and demand curves.[50]

One can dig further in the theoretical pass-through predictions by relying on our assumption allowing to separately estimate markups and markdowns, thus starting from markup and markdown definitions of WMP buyers:[51]

$$\nu_{fi}(w_c) = \frac{e_i}{e_c}\frac{w_c}{w_{fi}(w_c)},\ \forall\ i \quad \text{and} \quad \mu_{fj} = \frac{p_{fj}(w_c)}{\frac{w_c}{e_{cj}} + \lambda_f},\ \forall\ j,$$

Proceeding as above yields two separate expressions for the pass-throughs of WMP prices to the upstream raw milk price paid by firm f on market i:

$$\varepsilon_{w_c}^{w_{fi}} = 1 - \varepsilon_{w_c}^{\nu_{fi}} \tag{11}$$

and to the downstream price of product j:

$$\varepsilon_{w_c}^{p_{fj}} = \varepsilon_{w_c}^{\mu_{fj}} + \theta_{fcj} \tag{12}$$

where $\theta_{fcj} = \frac{w_c}{w_c + e_{cj}\lambda_{fj}}$ is the share of WMP purchases in the marginal cost of product j. Equation (11) shows that markdown adjustments weaken the pass-through of WMP price shocks to the price of raw milk, making it incomplete. In the absence of monopsony power, shocks to the commodity price would translate one for one to the price of raw milk ($\varepsilon_{w_c}^{w_{fi}} = 1$), purely reflecting the perfect substitutability between both inputs (dry matter contents). Equation (12) similarly shows that markup reactions attenuate the pass-through to downstream prices. In the absence of monopoly power, the pass-through would be *complete*, to the extent that it would be proportional to the share of the commodity in in the accounting marginal cost of product j ($\varepsilon_{w_c}^{p_{fj}} = \theta_{fcj}$).[52]

[50]See for instance Weyl and Fabinger (2013).

[51]In Appendix E.2, we derive similar expression for WMP sellers.

[52]One can note that, by definition, $w_{fi}\nu_{fi} = \frac{e_i}{e_c} w_c$ and thus $\tilde{\theta}_{fij} = \theta_{fcj}$, consistently linking (9), (11) and (12).

Reduced-Form Pass-Through

In order to assess the magnitude of the various adjustments, we estimate the elasticities $\varepsilon^x_{w_c}$ for $x = \{M_{fij}, p_{fj}, \mu_{fj}, \lambda_{fj}, w_{fi}\}$ in a reduced-form way. Regressing the log of the different equilibrium objects on the log of the WMP price and relevant interacted fixed-effects, we rely on the variations of WMP prices over time (2003-2018) to identify the *average* elasticities in Table 6.

Estimated elasticities from Panel A confirm the mechanisms previously outlined. In order to simply interpret the reduced-form results, we consider a 1% increase in the price of WMP.

On the upstream side, such increase lead manufacturers relying on WMP as an input to adjust their sourcing mix. They substitute away from WMP in favor of raw milk. In doing so, they move up along the increasing raw milk supply curve, leading to increases in the price paid for raw milk, of 0.39% on average. This purely reduced-form result indicates an incomplete pass-through from the price of WMP to the price of raw milk, in line with the existence of monopsony power and the theoretical results derived above. The theory and Equation (11) provides a rationale for this pattern: the pass-through incompleteness comes from the existence of buyer power and more precisely from endogenous markdown adjustments by manufacturers, which increase their monopsony power exertion by 0.64% on average. The strongly positive and significant coefficient on markdowns confirms the intuition aforementioned: manufacturers face supply curves featuring non-constant elasticities. They increase (resp. decrease) their markdowns when moving up (down) along the raw milk supply curve following a surge (decrease) in the price of the alternative WMP input. Overall, an increase in the price of the commodity thus increases the marginal cost of manufacturers, in a way that is smoothed by (i) input substitution and (ii) markdown adjustments on the raw milk markets.[53]

The increase in marginal costs however very partially pass through to output prices, a 1% WMP price increase leading to an increase in prices of final consumption goods limited to

[53] As expected, the insignificant coefficient of the marginal processing cost (MPC) indicates that it plays no role here.

0.14% on average. Again, this result is purely reduced-form, but the model helps interpreting. First, Equation (12) shows that a we have an incomplete pass-through on downstream prices, as $\varepsilon_{w_c}^{p_{fj}} < \theta_{fcj}$ (and not because $\varepsilon_{w_c}^{p_{fj}} < 1$). The share of raw milk purchases in marginal cost $\tilde{\theta}_{fij}$ ($= \theta_{fcj}$) being on average around 0.8, this confirms the existence of monopoly power. Further relying on Equation (12), this incomplete transmission to downstream prices is essentially explained by adjustments in the exertion of monopoly power by manufacturers. Markups on average endogenously decrease by 0.54%, thus absorbing a big part of the shock to marginal cost. Mirroring mechanisms at work upstream, the strongly negative coefficient on markups indicate that manufacturers on average face demands for final consumption goods that are increasingly elastic with prices.

Table 6: Pass-Through: Reduced-Form Estimates

	(1)	(2)	(3)	(4)	(5)	(6)
	Output Price	Markup	MPC	Markdowns	Milk Price	Margin
	p_{fj}	μ_{fj}	λ_f	ν_{fi}	w_i	M_{fij}
A) Final Consumption Goods – WMP Buyers only						
WMP Price	0.138***	-0.537***	0.062	0.639***	0.393***	-0.110***
	(0.021)	(0.036)	(0.068)	(0.012)	(0.021)	(0.031)
Obs.	3,135	3,135	3,135	6,256	1,343	26,547
R-squared	0.971	0.859	0.925	0.626	0.416	0.865
B) Final Consumption Goods – WMP Sellers only						
WMP Price	0.218***	-0.313*	-0.043	0.484***	0.386***	-0.109
	(0.061)	(0.144)	(0.176)	(0.034)	(0.016)	(0.086)
Obs.	581	581	581	1,437	1,121	16,806
R-squared	0.960	0.751	0.821	0.559	0.420	0.760
C) Commodities - All Manufacturers						
WMP Price	0.695***	0.046	0.033	0.595***	0.392***	0.523***
	(0.047)	(0.060)	(0.084)	(0.025)	(0.024)	(0.060)
Obs.	2,165	2,165	2,165	6,953	1,377	27,972
R-squared	0.931	0.782	0.900	0.637	0.414	0.699
FE	$f \times j$	$f \times j$	f	$f \times i$	i	$f \times i \times j$

Standard errors are in parenthesis

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

Overall, manufacturers relying on WMP as an input are able to adjust their degree of

[53] See Table 14 of the Appendix for more figures on the share of milk purchases in marginal cost.

MP exertion on both sides so as to limit pass-through rates to upstream and downstream prices. Doing so allows them to preserve relatively stable margins despite the cost shock, as they on average only decrease by 0.11% following a 1% in increase in WMP prices.

Panel B shows how WMP sellers adjust to variations of the price of WMP. For a simple interpretation, we consider again a 1% increase in the price of the commodity they sell. This causes a partial transmission to downstream prices - which our reduce-form results indicate - increase by 0.22%, on average. The theory suggests that underlying arbitrage conditions lead WMP sellers to sell more WMP and less final consumption goods, pushing prices to increase as we move up along the demand curves. However, the model also explains that this increase is mitigated due to a markups compression (by -0.31%), suggestive of non-constant demand elasticities, increasing with prices. Both adjustments are respectively bigger and smaller (in absolute values) than adjustments of output prices and markups by WMP buyers. This possibly reflects the fact that WMP sellers are on average larger firms and have more seller power. Upstream, the shock inflates markdowns and raw milk prices - as (as rationalized by the model) we move up the increasing raw milk supply curves - in a similar way than for WMP buyers.[54]. Thus, and as already anticipated, positive demand shocks only partially pass-through to raw milk prices, due to endogenous markdowns increases. As a consequence, farmers only partially benefit from positive shocks, while manufacturers selling WMP are able to maintain their margins unchanged.

Finally, Panel C shows how manufacturers selling commodities benefit from surges in international prices. Prices variations on the different global commodity markets are highly correlated. A 1% increase in the WMP price is thus accompanied by an average increase of 0.7% of all commodities prices. The insignificant coefficient in column (2) confirms that French dairy manufacturers are essentially price-takers when selling commodities and do not have (or have limited) markup adjustments possibilities. [55] However, dairy firms selling such

[54]Partly due to the fact that raw milk prices are here observed at the regional level.

[55]We ruled out monopoly power when selling WMP, but do not need nor want to completely rule it out for other commodities. However, similar arguments can apply.

commodities take advantage of surges in their prices as they allow them to inflate their total margin (+0.52%), by increasing their markdowns (+0.59%), following mechanisms similar to the aforementioned ones. In doing so, they again incompletely pass through increases in downstream prices (of commodities here) to raw milk farmers. Given that margins on such commodities essentially comes from monopsony power, they strongly increase.

The empirical findings presented here are thus in line with our theoretical predictions. In particular, the incomplete average pass-throughs observed from WMP price shocks to upstream and downstream prices confirms the presence of monopsony and monopoly powers. The theory rationalizes these partial transmissions by adjustments in MP exertion on both sides.[56] Such adjustments ultimately rationalize markup and markdown variations observed across time.

5.3 Other Heterogeneity Dimensions

5.3.1 Heterogeneity Across Products

Computing weighted averages by product category shows how markups vary across final consumption goods and the importance of taking this dimension into account

Figure 8 shows that the average markup broadly lies between 1.5 and 2.5 for relatively differentiated products (yoghurt, cheese), whereas less differentiated products (cream, butter) have relatively low markups, close to unity.

Among commodities, and as shown on Figure 9, milk powder features an average markup of around one. The milk powder category encompasses whole milk powder - on which our methodology imposes a markup equal to one for a subsample of firms - but also skimmed milk powder. Markup estimates on commodity markets are noisier than on final consumption goods, as only a few French manufacturers sell on such markets. Interestingly, markups are close to or below one on other commodities, sold on similar global markets, on which our estimating procedure does not impose a constraint. We view this feature as supporting the

[56] Additional graphical representations of theoretical adjustments taking place following variations in WMP prices and illustrating aforementioned mechanisms can be found in Appendix E.1.

idea that French manufacturing firms are price takers on bulk dairy products sold on global markets.

Figure 8: Markups on Final Consumption Goods - Product Category Averages

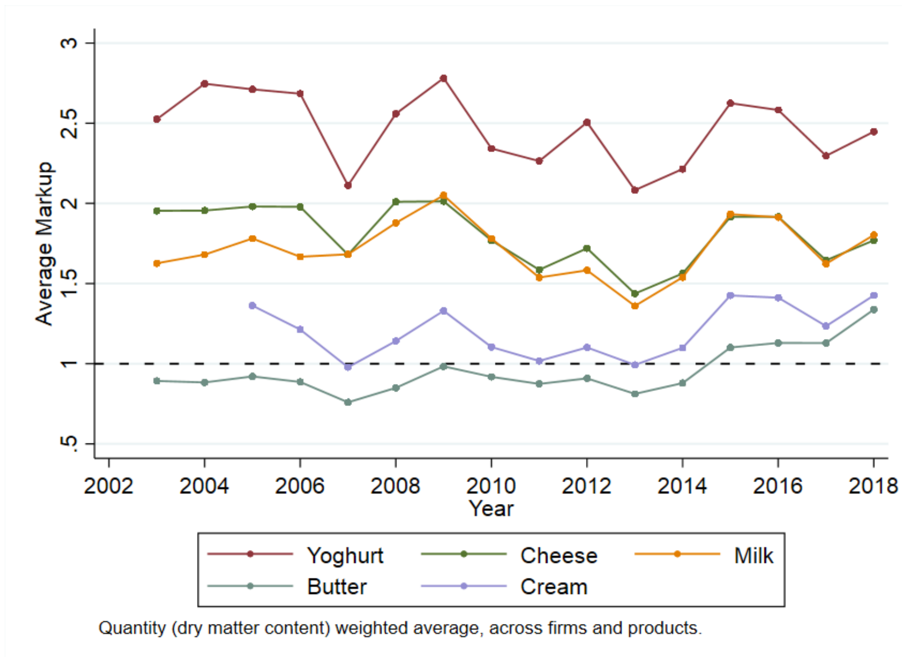
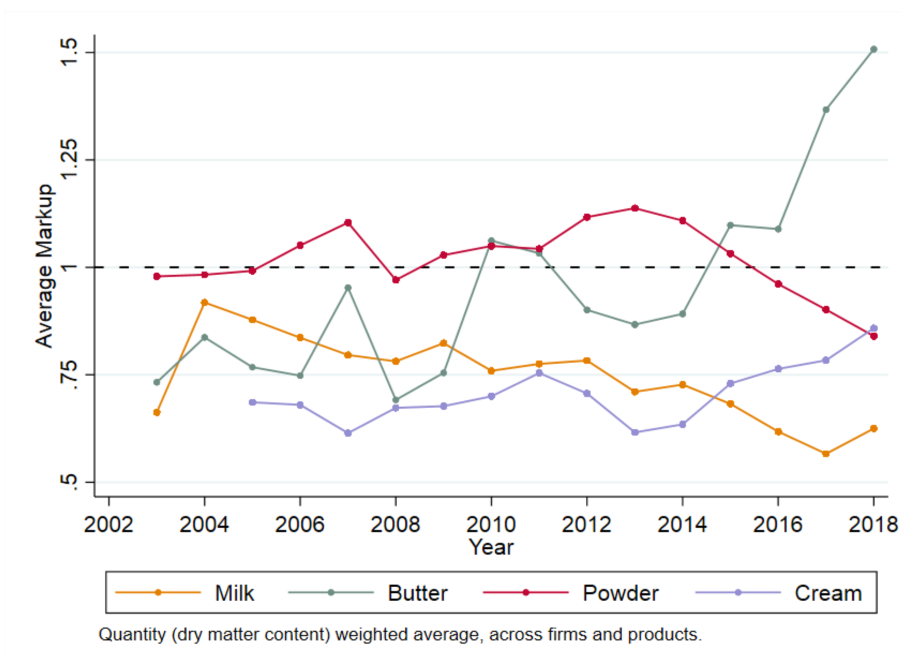


Figure 9: Markups on Commodities - Product Category Averages

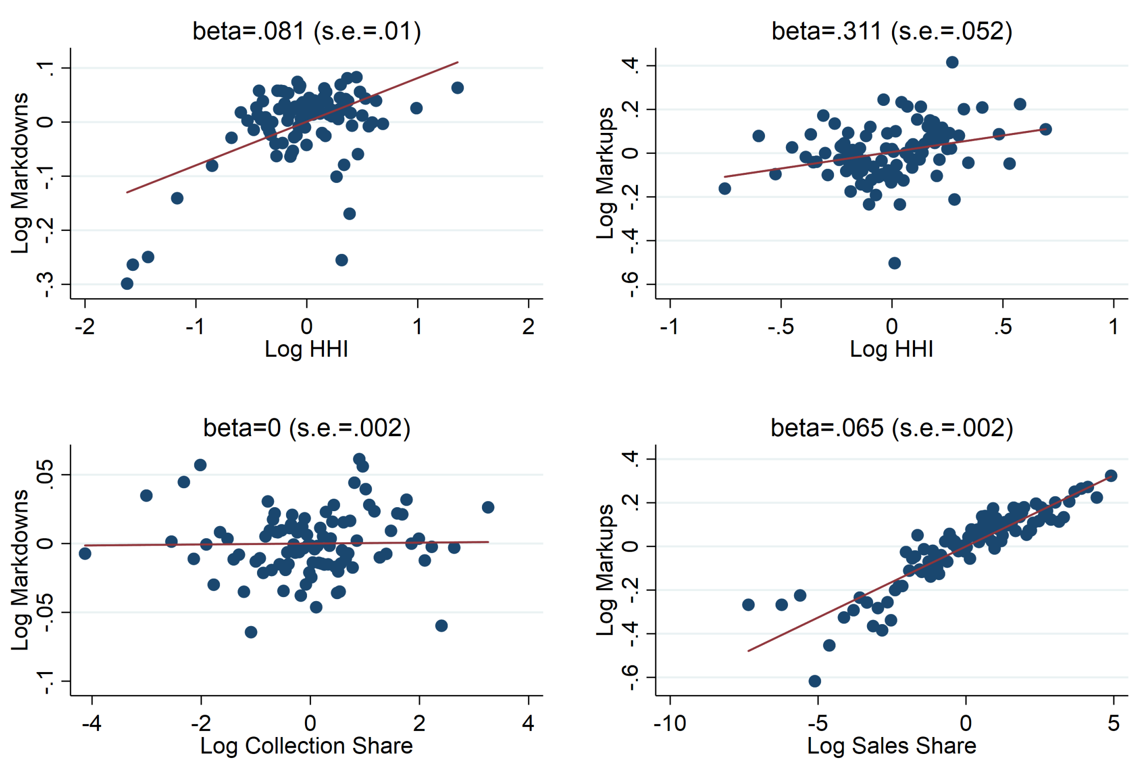


5.3.2 Heterogeneity Across Firms and Markets

Panel 10 plots our estimated measures of market power against usual variables, such as concentration measures (HHI) at the market-level or market shares at the firm-market-level. Both graphs at the top show how average markups and markdowns are higher on more concentrated markets, consistently with many theories such as Cournot or monopolistic competition. At the bottom right, we see that markups positively correlate with dairy firms' sales shares within the market. These results are consistent with our interpretation we do measure market power and not other frictions, as alternative explanations would not generate such patterns.

However, we do not find evidence of markdowns correlating with dairy firms' milk collection shares. We view this result as indicative that upstream prices are rather determined at the market-level, with possible bench-marking effects.

Figure 10: Market Power and Competition



Obs. at the market-time (up) and group-market-time level (bottom), grouped into 100 equal-sized bins in terms of the X-axis var. Variables de-meaned by time on the up left-hand graph, by market and time on the up right-hand graph, and by market-time on the two bottom graphs.

6 Implications

6.1 Methodological Implications

In this subsection, we emphasize two methodological implications based on our results. First, we show the challenge of estimating MP when both buyer and seller power are present. In particular, we stress the importance of authorizing buyer power when quantifying seller power following a production function approach. Second, we show the difficulty of properly estimating MP relying on an estimation of the implied supply and demand elasticities when these objects of interest vary along the corresponding curves. In both cases, we compare our findings on markups and markdowns with the literature's.

6.1.1 Buyer Power, Seller Power, and the Production Function Approach

In theory, any wedge between a firm's revenues and a firm's expenses on a given input can emanate from buyer power, seller power, or both. We show that erroneously assuming one of both sources of MP away when following a *production function approach* can lead to falsely attribute the entire wedge to the considered source.

To fix ideas, and in order to ease comparison with the production function approach literature, assume a profit-maximizing firm with technology $y = f(m)$, facing an inverse input supply $w(m)$ and an inverse output demand. The firm chooses m (or equivalently y) to maximize variable profit $p(y)y - w(m)m$. Rewriting the objective function in terms of output quantity y, and then deriving and rearranging the first order condition directly lets the total margin appear:

$$M \equiv \theta \frac{py}{wm} = \frac{1 + \varepsilon_S^{-1}}{1 + \varepsilon_D^{-1}} \tag{13}$$

where $\theta_m = \dfrac{\partial f(m)}{\partial m} \dfrac{m}{f(m)}$ is the output elasticity with respect to the input. (13) directly delivers the total *margin*. The margin can then be empirically recovered from the left hand side thanks to an estimation of θ_m, conditional on observing revenues py and input expenses wm. This is the approach we followed throughout the paper.

If buyer power (on materials) is assumed away, the following first order condition and markup definition is derived instead:

$$\mu \equiv \theta \frac{py}{wm} = \frac{1}{1 + \varepsilon_D^{-1}} \tag{14}$$

The so-called *markup* is then similarly empirically recovered from the left hand side. Equations (13) and (14) are the basis for the discussion below.

If buyer power is present, wedges estimated through a production function approach emanate from both seller and buyer powers, and shall be defined as (total) margins rather than markups. The expressions above aim at easing intuitive comparisons with the literature and differ in their shapes from our theoretical framework, mainly due to the Leontief production function that is assumed, creating an additive structure in the marginal costs.[57] However, in our context, assuming buyer power would have similarly lead to assume markups and margins to be equal. Following our wording, it would have implied confounding marginal costs and *accounting* marginal costs. Importantly, we would have similarly estimated marginal processing costs, which allows direct comparisons.

The *production function approach* literature typically assumes buyer power away, relying on equations similar to (14).[58] Reasons to do so include (i) data availability or simply (ii) a focus on seller power and estimating final consumption goods markups. As explained above, following such an approach, a total margin can be well estimated but is - *sometimes erroneously* - attributed to the sole seller power. Indeed, margins and markups are by assumption equalized. Had we done so, we would have assessed an average markup rate of 62% (instead of 46%), falsely equal to the margin rate. This amounts to an average markup rate overestimation of 35%. Moreover, in a context as ours where costs pass-through to prices upstream and downstream adjust over time, the bias vary accordingly. Hence, while we would have

[57]As explained in Section 3 or in De Loecker and Scott (2016).

[58]See for instance De Loecker and Warzynski (2012); De Loecker and Scott (2016); De Loecker et al. (2016); De Ridder et al. (2021).

overestimated the annual markup rate by a factor of 6% in 2015, the bias would have been of 129% in 2013. Finally, our results (see Table 5) show that margins and markups sometimes vary in opposite directions, due to the presence of markdown adjustments, underlining the importance of authorizing market power on both sides.

Of course, the magnitude of the bias is highly context-specific, and its size is not surprising in the French milk market where the presence of buyer power was expected. It however indicate that, at least in sectors where buyer power is a possibility, *markups* estimated through such methodology may be more safely reinterpreted as *total margins*, emanating from seller power and buyer power.

Table 7: Margins and Markups in the Production Function Approach Literature

Paper	Margin	Markup	Industry
Tortarolo and Zarate (2018)	2.02^m	1.78^m	Manufacture
De Loecker et al. (2016)		1.78	Food & Beverages
This paper	**1.62**	**1.45**	**Dairy**
De Loecker et al. (2020)		1.61	Manufacture, Retail & Wholesale
De Loecker and Scott (2016)		1.59	Beer
Wong (2019)		1.38	Manufacture
De Ridder et al. (2021)		1.34	Manufacture
De Loecker and Warzynski (2012)		1.28	Manufacture
Yeh et al. (2022)		1.20	Various
Rubens (2021)	n.c	0.52	Cigarettes

Notes: Average margins are reported if a distinction with the markup is made (blank otherwise) and if communicated by the author(s) ("n.c." otherwise). Median margin and markdown - which is stressed by a "m" subscript - are reported when the average for at least one of both is not disclosed by the author(s). Yeh et al. (2022) and Wong (2019) distinguish the markup from the total margin on labor, but compute it as a margin which can also partly emanate from buyer power on materials.

Having this in mind, we compare our paper's estimates with markups estimated in the production function approach literature in Table 7. To the exception of Tortarolo and Zarate (2018) and Rubens (2021) (and us), all other papers here potentially confound markups and margins emanating from buyer power *on materials* and seller power, if both are present. Tortarolo and Zarate (2018) and Rubens (2021) rely on a production function approach to recover margins and an estimation of the supply elasticity of the input of interest, respectively labor and tobacco, to isolate markdowns from markups.[59] We discuss in Section 6.1.2 such way of identifying markdowns. Yeh et al. (2022) and Wong (2019) allow for and measure a markdown on labor, but not on materials, similarly to most papers cited here. This assumption allows them to identify markups and labor markdowns - relying on (14) to pin down markups and dividing it by a labor version of (13) to get markdowns (on labor). Their estimates of markups *and* markdowns are thus subject to a similar bias if firms have buyer power on materials.

For comparison fairness' sake, the reader can note that we assumed away labor MP. We do so as we think the extent to which dairy firms can exploit labor MP is limited, for reasons further discussed in Appendix D.4. Moreover, and as shown in the same Appendix, labor MP - if any - would affect our estimates to a limited extent. It would leave margin estimates unchanged. These would in such case be interpreted as resulting from the three implied MP forces. Interestingly, given the estimation framework relying on the price of WMP as an empirical moment, markdown estimates for WMP buyers would also be unaffected. Remaining markdown (of WMP sellers) and markups estimates would be only affected by labor MP through the induced bias in the estimation of marginal *processing* costs, which on average only represent (absent labor MP) 30% of total marginal costs. Overall, this point further stresses the difficulty of distinguishing different coexisting sources of MP. As shown in Section 6, we hereby contribute to the distinction between seller power and *buyer* power, leaving labor monopsony power out of the scope of this paper.

Regarding the rest of the papers cited here, the relevant comparison to be made thus is between our *margin* estimates and their *markup* estimates. Comparison exercises are made difficult by differences in the context or in the period of study. Our margin estimates nevertheless align with markup estimates of De Loecker et al. (2016); De Loecker and Scott (2016); De Loecker et al. (2020), in contexts which are the closest to ours. Their estimates are however above our average markup estimate (1.45). Among other reasons, this can possibly be driven by the existence of some buyer power in the studied sectors. Although disregarded

[59] Doing so, Rubens (2021) estimates a very low markup for Chinese cigarettes manufacturers which he explains by the presence of a monopsonistic buyer further downstream.

by the authors for practical concerns, manufacturers in the "Food and Beverages" industries may in particular have some degree of buyer power for reasons similar to the ones outlined in our specific context.[60] Our markup estimates align more with the literature's markups in the broader manufacturing sector (De Ridder et al., 2021; De Loecker and Warzynski, 2012), a possible interpretation being that these estimates may be less contaminated by buyer power, as it may be less of a concern in some manufacturing industries.

On a different note, notice that we included in Table 7 the weighted average levels of markups and margins on *all products* in the French dairy markets. This is typically the relevant point of comparison with other papers presented here, which most of the time do not distinguish between *final* and *intermediate* products. An exception is De Loecker and Scott (2016), who found - ignoring buyer power - an average markup of 1.59 on final beers.

Conversely, one can assume away markups and attribute the entire estimated margins to buyer power markdowns. In our context, this would have implied a 244% overestimation of markdown rates. Such an assumption would not have made sense in many contexts, but one can note that it could have been defended in our context, especially given the concentration levels observed at the retailers level.

Overall, markups and markdowns have similar first order consequences on welfare. They lead to a reduction of quantities, an increase of prices faced by final consumers, and a decrease of the input price, so that total margins that a *production function approach* appear as the appropriate measures of the overall distortion. Such an approach however can misname the origin of the inefficiency, if buyer (or seller) power is erroneously assumed away. Confounding both can thus severely bias assessments and policy advises, which we view as an important concern.

[60] De Loecker et al. (2020) study manufacturers, but also retailers and wholesalers, which can also have buyer power, depending on the concentration at this stage of the chain.

6.1.2 Markdowns, Markups, and the Elasticity Approach

In this subsection, we highlight the challenges and caveats raised by any MP quantification relying on the estimation of demand or supply elasticities, and show their particular prevalence in the French dairy market context.

Although disregarded in the estimation, Definitions 1 and 2 also implied the following equations:

$$\mu_{fj} = \frac{1}{1 + {\varepsilon^{D}_{fj}}^{-1}} \quad \text{and} \quad \nu_{fi} = 1 + {\varepsilon^{S}_{fi}}^{-1}.$$

An alternative method to obtain markups and markdowns could thus have been to estimate demand and supply elasticities to recover markups and markdowns, following a so-called demand approach[61]. In contrast, we decided (i) to exploit a production function approach to recover marginal costs and margins, and (ii) to leverage the existence of the commodity markets to disentangle markups and markdowns. Following such a methodology, we *reveal* the implied *equilibrium elasticities*, rather than *assuming* possible mechanisms at work by putting more theoretical structure on the model to be able to estimate the implied elasticities. This has several advantages, which we show below are particularly appealing in our context but also relevant in broader ones.

Our estimates of markups and markdowns are robust to numerous theoretical deviations regarding firms behavioral assumptions, which would not have been the case of an approach based on supply and demand elasticities estimation. In Appendix C.1.2, we show how we can accommodate a wide range of firms' behaviors, such as (i) intra-brand competition internalization, (ii) collusion, (iii) vertical cooperation... Some dairy manufacturers are likely deviating from the simple theory outlined in Section 3 in such ways. Nonetheless, since our estimating framework does not rely on estimating demand and supply elasticities, marginal revenue and marginal cost functions are free to take more complex forms than outlined in Section 3. In particular, they can respectively encompass any economic cost of adjusting raw milk and dairy products prices perceived by the firm. Markup

[61] Following Berry et al. (1995), the literature has long applied the suggested methodology to estimate demand elasticities. However, a similar approach can be and has been used to estimate *supply* elasticities.

and markdown estimates thus remain valid under a wide range of theoretical behaviors, while estimates based on demand/supply elasticities would have been biased. Pursuing such an approach would have lead us to impose more structure on firms' behaviors, which would have both make (i) the identification more complex and (ii) lose theoretical flexibility.

Related to this point and in the particular context of agricultural markets, Sexton (2013) points out the trade-off faced by manufacturers between exploiting MP and preserving local supply.[62] This can alleviate MP and in particular generate a wedge between the true markdown and the one predicted by approaches relying on supply elasticities.[63] Considering the literature, we view such a mechanism as potentially partly explaining the strong magnitude of the markdown estimated by Rubens (2021) using a supply elasticity approach.[64] Finally, the hypothesis of supply-preserving considerations reducing the markdown is consistent with low markdowns estimates found by an older literature which has tried to assess buyer power in various (U.S.) agricultural markets, exploiting other approaches, as summarized and explained in Crespi et al. (2012).[65]

Moreover, *elasticity approaches typically rely on estimating reduced-form elasticities, which generally differ from structural elasticities.* This distinction, pointed out by Berger et al. (2022) who estimate markdowns on labor, is due to the fact that structural elasticities are a *partial equilibrium concept*, where a given firm takes its competitors' behavior as fixed. This is akin to our approach, relying on Nash equilibrium concept. On the contrary, any reduced-form elasticity estimates would encompass other firms' adjustments and more general equilibrium effects.[66]

Finally, even omitting aforementioned caveats and willing to rely on (reduced-form) elasticities, *estimating demand and/or supply elasticities with the required level of flexibility raise practical challenges.* Upstream and downstream, our results outline an important heterogeneity in MP exertion across firms and markets, which the demand approach (as the production

[62] Which is crucial due to the existence of transportation and transaction costs.

[63] See Appendix C.1.2 for a formal derivation.

[64] The specific context also strongly supports the existence of an important buyer power. We refer the interested reader to the paper for more details.

[65] These papers however assume constant MP exertion across time, and may have missed the type of underlying variations we document.

[66] We refer the interested reader to section 2.1 of Berger et al. (2022) for further explanations.

Table 8: Markdowns on Materials in the Literature

Paper	Markdown	Industry	Input
Rubens (2021)	4.37	Cigarettes	Tobacco leaf
Morlacco (2019)	2.11	Food & Beverages	Materials
Zavala (2020)	2.04	Agri-Food	Various crops
Wong (2019)	1.61	Manufacture	Labor
Yeh et al. (2022)	1.53	Various	Labor
Berger et al. (2022)	1.35	Various	Labor
This paper	**1.18**	**Dairy**	**Raw milk**
Azar et al. (2019)	1.17	Various	Labor
Tortarolo and Zarate (2018) [a]	1.12	Manufacture	Labor
Crespi and Sexton (2005)	1.10	Agri-Food	Cattle. Potato & Rice
Various papers (90's-00's)[b]	1.00-1.03	Cattle ind.	Cattle

[a]Median markdown, as the average is not disclosed by the authors.

[b]Schroeter and Azzam (1991); Azzam and Park (1993); Koontz et al. (1993); Muth and Wohlgenant (1999); Crespi et al. (2005)

function approach) literature has come up with solutions to deal with.[67] Our findings however also highlight the importance of variations in MP exertion across *time*. First, this heterogeneity dimension remains empirically difficult to tackle, as (i) data are not always available at a high frequency level, and (ii) estimating methodologies often rely on the panel dimension. Moreover, the demand (and supply) approaches typically require variables to instrument endogenous prices, which are similarly not always available at a high frequency level.[68] Second, and more important, the variations in markdowns and markups from a year to the other we document reflect (i) changes in the competition contexts and (ii) *non-constant elasticities along dairy products demand and milk supply curves*.[69] From a theory viewpoint, the latter point relates to the curvature of these functions, *i.e* to their second derivatives, and remains a not-yet answered challenge for the *demand* approach, which directly aims at identifying

[67]See Berry and Haile (2021) for a recent review.

[68]An exception is Döpper et al. (2021) who estimate manufacturers' markups across 100 products at the year-level following a demand approach and using high frequency scanner data. Estimation and identification is based on MacKay and Miller (2022) relying on covariance restrictions on demand and supply shocks. However, doing so, they crucially rely on a constant marginal costs assumption, ruling out the possibility of buyer power.

[69]We refer the interested reader to Appendix A.2 for more details on the first point.

such functions.[70]

We thus view our framework, which remains agnostic on exact supply and demand functions and rather (partly) reveals their shapes, as circumventing the aforementioned challenges to buyer and seller power estimation. Applying this methodology to the French dairy market, we are able to disentangle markups and markdowns, and reveal their endogenous adjustments to demand and costs shocks, as well as the implied pass-throughs to upstream and downstream prices. Furthermore, we think such an approach to monopsony and monopoly powers estimation can be applicable to other contexts, as discussed in what follows.

6.1.3 Applicability of the Estimating Framework to Other Settings

Overall, we suggest in this paper a new approach to disentangle buyer and seller power, easily applicable to the study of MP in other sectors, and especially suitable to quantify buyer and seller power in food supply chains.

First, we estimate firms' total margins with a production function approach. As aforementioned, it requires increasingly available data and is fairly standard, and we refer the reader to the corresponding literature for more details.[71] In doing so, we acknowledge the possibility of buyer power, participating, as seller power, to margins estimated this way.

Second, we suggest a new way of disentangling markups and markdowns, relying on the existence of at least one *competitive product* that is *substitutable* with the input (resp. output) on which there is monopsony (monopoly) power. In using an input where firms do no exert monopsony power, we follow the recent production function approach literature relying on the existence of so-called *flexible inputs*.[72] However, in doing so, such papers rely

[70] As pointed out by Berry and Haile (2021), which we cite here: "For example, "pass-through" (e.g., of a tariff, tax, or technologically driven reduction in marginal cost) depends critically on second-derivatives of demand. It is not clear that a mixed-logit model is very flexible in this dimension. An alternative is nonparametric demand estimation, as in Compiani (2022), although many off-the-shelf nonparametric approaches lack the parsimony necessary to estimate demand systems with a large number of products or product characteristics."

[71] See Olley and Pakes (1996), Levinsohn and Petrin (2003), De Loecker and Warzynski (2012) and Ackerberg et al. (2015), among others. Putting aside the critique by Bond et al. (2020), the minimal data requirement for estimating total margins through a production function approach is to observe firm-level revenues and expenses on a variable input, available in many datasets.

[72] A flexible input is defined as freely-adjustable input on which firms do not exert monopsony power. See Dobbelaere and Mairesse (2013), Morlacco (2019), Wong (2019) and Yeh et al. (2022) for different

on somewhat *ad hoc* assumptions that monopsony power is absent on one aggregate type of variable inputs, typically assuming away buyer power on overall materials, an assumption that is likely to be violated for at least some inputs. Our methodology has a similar spirit, but (i) goes one step further in disaggregation and (ii) applies the same logic to output markets. Doing so, one can rely on the existence of products on which buyer or seller power can be *safely* assumed away. In our application to the French dairy market, we use the existence of the WMP commodity market. Such commodity markets, as listed by the World Bank, are also present in many other industries: energy (coal, oil, gas), beverages (cocoa, coffee, tea), oils and meals (coconut/soybean/palm/sunflower oil...), grains (maize, rice, wheat...), food (bananas, beef/chicken/sheep meat, oranges, shrimps, sugar...), raw materials (cotton, rubber, tobacco...), metals and minerals (aluminum, steel, nickel...)...[73] In many of these industries, notably food and beverages ones, buyer and seller power are a concern, for reasons akin to the ones outlined in the analysis of the French raw milk market. This concern is particularly important in emerging economies, where local or international intermediaries' price-setting power, can largely impede development (Sexton et al., 2007). In such contexts, our approach provides a useful tool to disentangle monopsony and monopoly power.

This is particularly true given that the suggested tool is especially practical to quantify buyer power in a context of limited data. Based on firms' arbitrage conditions, our theoretical model indeed microfounds a markdown imposed by French dairy manufacturers that, for most of them, simply is the ratio of the substitutable commodity (here WMP) price and of the price of the raw material, adjusted for their elasticity of substitution (here the respective dry matter contents). This implies that one can gauge buyer power in broader applications, without prior marginal processing cost estimation, only relying on the corresponding prices data. Commodity prices data are directly available online, while unit prices of the input

applications. M. Morlacco and E. Guigue are however currently working on a revision of Morlacco (2019), relying on a different estimation methodology.

[73]More generally, Rauch (1999) provide a systematic classification of internationally traded products in *commodities* (referred to as products trade obeying an *organized exchange*), *reference priced* products (whose prices could similarly be exploited), and *differentiated* products, which could be helpful in a broader applications of our methodology.

considered can be found at a level of disaggregation which depends on the data availability. To the least, one can rely on average prices of the raw material, scrutinized and made available by local authorities or international institutions. The elasticity of substitution between the commodity and the raw material can be assumed equal to one when a homogeneous product is considered, as in most aforementioned food industries. For others, an adjustment similar to what we do with dry matter contents data, can be implemented.

6.2 Economic Implications

In this subsection, we first show the dependence of raw milk prices on (i) commodity prices, and (ii) markups and markdowns adjustments, has important implications for farmers' revenues in particular, before suggesting policy remedies.

6.2.1 Manufacturers' Market Power and Farmers' Revenues

We find what one could consider as "low" markdown levels, 18% on average. However, farmers' profits at the end of the day essentially depend on the prices set by manufacturers for raw milk, and thus not only on the markdown level, but on both buyer and seller market powers. Their joint exploitation by manufacturers indeed generates a wedge between the prices of processed products and the price of raw milk. This wedge, which translates into what we defined as the total margin, is remarkably important - 62% on average - and stable over time. Both sources of market power thus largely contribute to (i) diminishing the value added created in the dairy market and (ii), distorting its allocation in favor of manufacturers to the detriment of farmers.

Second, fluctuations in the degree of buyer power exerted by manufacturers have important consequences on farmers' revenues. Overall, markdowns' adjustments by manufacturers smooth raw milk prices. On one hand, during dairy market downturn phases (2009, 2015), dairy firms compress their markdowns, *almost* pushed down to the competitive level (1), but still above it, in order to avoid too many exits among their suppliers. On the other hand, manufacturers conversely increase markdowns to remarkably high levels (1.4) when facing positive demand shocks (2007, 2013). The presence of buyer power *alone* thus largely impede farmers from benefiting of good conjecture times, while remaining present, though limited, during downturns.[74]

Overall, absent buyer power, farmers would thus (i) earn a bigger share of the value added generated in the supply chain and (ii) be able to benefit from good conjecture times to reconstitute financial buffers undermined during downturns. This is an important concern as French dairy farmers are notoriously suffering from weak revenues. According to the French Livestock Institute, in 2021, 42% of dairy farms are in a critical financial situation, *i.e* indebted on the medium and long run and without cash flow. To cope with this structural imbalances, the Common Agricultural Policy (CAP) massively subsidizes dairy farmers. As a consequence, CAP subsidies to farmers represent around 80% of their revenues, and 42% of farmers would have negative revenues absent the subsidies.

Our simple model provides a rationale through which manufacturers eventually capture these subsidies, thanks to their buyer power. Indeed, any exogenous revenue supplement granted to farmers in theory affect farmers' milk supply elasticities. In turn, manufacturers internalize their suppliers' profitability increases and, *in fine*, decrease in milk supply elasticity, and strategically increase their markdowns. Back of the envelop computations show that annual markdown rents of French manufacturers amount to about about 1 billion a year over our period of analysis. This grossly corresponds to the subsidies from the Common Agricultural Policy annually perceived by French dairy farmers. We thus view the manufacturers' buyer power we document as a major policy concern, and suggest more adequate remedies below.

6.2.2 Policy Recommendations

Our findings call for setting up a price floor on raw milk, which could replace inefficient subsidies to farmers. In the context described above, a price floor would correct the value added distortion, redistributing revenues from manufacturers to farmers. It

[74] As such, buyer power only continuously decrease farmers' revenues compared to the revenues they would have had in a competitive setting, thus more than canceling any (possible) positive revenue-smoothing effects for (potentially) risk-averse farmers.

could replace direct subsidies to farmers which are in practice inefficient, as revealed by our simple model and estimates.

Importantly, and maybe explaining why such a policy has never been implemented in France, such a price floor on an input price would be in opposition with the conventional wisdom of regulating authorities. Indeed, such an idea is typically perceived as likely to harm consumers' welfare through increased final prices and an additional deadweight loss. As already evoked in the theoretical work of Russo et al. (2011), who suggest similar policy remedies for agricultural markets based on a simple model, this prior partly merely results from the predominance of theoretical work relying on constant manufacturers' marginal costs, thus by assumption ruling out the possibility of a monopsony power source of inefficiencies.[75]

Such reasoning for instance motivated the removal of the price recommendation for standardized raw milk in France in 2008. Until then, the CNIEL (National Interprofessional Center for the Dairy Economy) was regularly updating this *recommended price*, resulting from negotiations between farmers and manufacturers representatives, a recommendation in practice closely followed by manufacturers. This functioning was then abandoned following a decision of the French regulation authority, which declared the practice as anti-competitive. Our results, which do not indicate a stark increase in markdowns after 2008 may suggest that the policy was insufficient, either due to the price-level fixed, or simply because it was only a *recommended* price, and not a constraining price-floor as we suggest here.

Up to 2003 (before the period of analysis) the European dairy industry was further supported through *intervention prices* on the various commodities (milk powder, butter, cream), aiming at maintaining a decent price for raw milk further upstream. When the commodity price fell below a certain threshold level (the *intervention price*), the European Union purchased the necessary quantity to restore the price level. Purchased quantities were then stored and later resold and/or exported at a loss.[76] Our model shows this policy was - at least partially - ineffective, since partly captured by manufacturers through MP adjustments.

In contrast to the type of work which motivated the removal of the *recommended price*,

[75]We view our work, empirically showing the existence of the type of distortions assumed in the theoretical work of Russo et al. (2011), as usefully complementing their work in this aspect.

[76]See Appendix A.2 for further detail.

our model and estimates show that a price floor on raw milk would correct value added sharing and increase farmers' profits without harming consumers' welfare. The existence of the commodity market actually creates a dichotomy between raw milk and downstream dairy product markets, explaining why the latter are not affected. Absent this dichotomy, a price floor would have been even more profitable. In such case, reducing manufacturers' possibilities of exerting MP, be it buyer and/or seller power, would indeed increase equilibrium input *and* output quantities and decrease final prices. The main intuitions regarding the positive impact of a price floor are gathered in Figures 19 and 20 of Appendix E.4, showing its effects for firms that initially buy and sell WMP respectively.

In practice, such a price floor would have to be regularly adjusted, following farmers' cost indexes - already computed by institutes scrutinizing the industry - and commodity price fluctuations, in line with our model. Our model deliver a good benchmark-level for such a price floor, which, to be effective and efficient, would have to be just below the easily observable price of WMP (adjusted for respective dry matter content) on commodity markets.

An alternative policy remedy could be to promote farmers' countervailing seller power, for instance by authorizing farmers to regroup into producers organizations to bargain with manufacturers. After having long been forbidden, since perceived as anti-competitive, such organizations have been authorized by French regulating authorities (2012), but the take-up, for institutional reasons beyond the scope of the paper, so far remain modest.[77]

Downstream, our results question the efficiency of policies regulating manufacturers-retailers negotiations. Despite the authorization of several retailers' mergers and purchasing alliances during the period of analysis, supposedly improving retailers' countervailing buyer power and consumers' welfare, our results show dairy manufacturers are able to charge important markups. Having in mind that an additional margin can actually be imposed on final prices by retailers, effects on consumers' welfare are likely to be significant. To the least, mergers between important dairy manufacturers shall thus be (more) carefully scrutinized.

[77]We refer the interested (French-reading) reader to the Ministry of Agriculture's report on the "Mise en œuvre de la contractualisation dans la filière laitière française", available online.

7 Conclusion

In this paper, we show how total margins made by firms in imperfectly competitive markets rely on their exploitation of market power both when selling products but also when purchasing inputs. We quantify the respective contributions of buyer and seller power to manufacturers' margins in the French dairy market. To do so, we rely on a production function approach exploiting (i) the technical relationship between raw milk and dairy products and (ii) the existence of a commodity market where firms do not have any price-setting power. Our results indicate that dairy manufacturers exploit both buyer and seller power: on average, dairy firms purchase raw milk at a price 16% below its marginal contribution to their profits, while selling a dairy product at a price exceeding its marginal cost by 46%. Markups and markdowns aggregate to generate a global margin rate of 62%.

These results imply that we would have overestimated markups rates by 35%, had we ignored buyer power, as is often done in the *production function approach* literature. Our paper also demonstrates the importance of implementing estimation methods which take firms, products and time heterogeneity into account, as markdowns and markups highly vary across these dimensions, even within the specific industry we consider. In particular, the markdown and markup variations we document indicate that manufacturers face supply and demand curves characterized by *non-constant price elasticities*, thus challenging any alternative *demand approach*. Overall, our methodology (i) circumvents challenges to buyer *and* seller power estimation in supply chains, and (ii) remains flexible enough to be applicable to the study of market power in other industries.

Our findings ultimately highlight the dependence of farmers' revenues on manufacturers' price-setting power and variations in commodity prices. Our results in particular call for policies promoting farmers' countervailing seller power and/or for setting a price floor on raw milk, which would raise farmers' revenues without harming consumers' welfare. Such policies could in particular supplant farmers' subsidies from the Common Agricultural Policy, which our findings suggest are fully captured by manufacturers through their buyer power.

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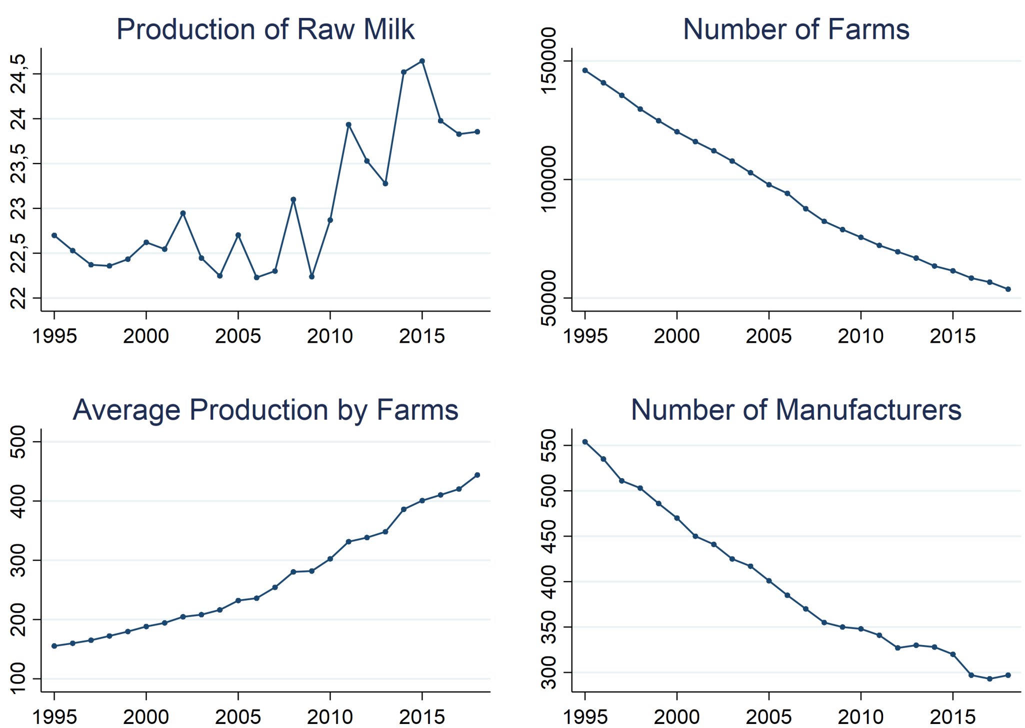
Appendix

A Recent Changes on the French Dairy Market

In this Section, we detail structural and regulatory changes the French dairy market experienced over the last 20 years. They motivate our (quasi-)competition-agnostic approach.

A.1 Trends

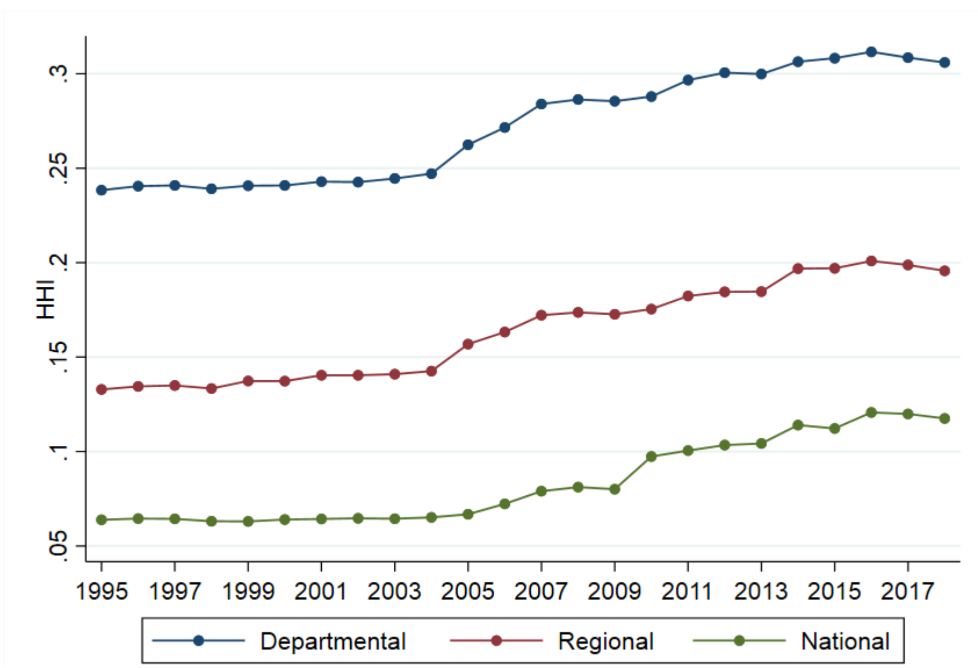
Figure 11: Dairy Industry Trends



The number of farms producing raw milk has steadily decreased since 1995, from around 150,000 to 54,000. Concomitantly, and naturally reflecting the increase of the national production, the yearly milk production of the average farm tripled to reach 450,000 liters. The average farm nevertheless remains relatively small (66 cows) and mostly organized around a familial nucleus, the controversial *farm of a thousand cows* remaining a short-lived exception (2014-2020).

One stage downstream, the processing of raw milk into dairy products is made by increasingly concentrated manufacturing groups (300 in 2018 against 550 in 1995). 4 of them are among the top 15 groups at the world level, including the world leading dairy group. Figure 20 shows the consequences of these ongoing concentration of raw milk market over the 20 last years, a phenomenon that has accelerated over the last years. The concentration results from a structural trend but also from various events, such as mergers of big dairy firms or the relocation of the milk activity following the quotas removal. The declining number of manufacturing groups is reflected in the Herfindahl-Hirschman Index (HHI), growing at national but also at regional scales since 2006, to attain substantially high levels, especially at the local (department) level.

Figure 12: Raw Milk Collection HHI



HHI from group-level market shares. Quantity weighted averages for regional and national HHI.

A.2 Regulatory and Structural Changes

A.2.1 Regulatory Changes

During the 2003-2018 period, the French dairy industry's regulatory context regularly changed. Upstream, the market has long been highly regulated before being liberalized. Downstream, the commercial negotiations between manufacturers and concentrating has also undergone notable changes.

From 1984 to 2015, the European Union (EU) raw milk market was regulated by production quotas. Each member state was endowed with a maximum amount of production decided at the EU level, which it could freely allocate among its national farmers. In 2003, the Common Agricultural Policy officially engaged towards a progressive liberalization of the dairy industry, following a so-called *soft landing* (Bouamra-Mechemache et al., 2008) strategy in order to leave the quotas regime and foster greater competition. Quotas were increased by 2% (2008) and 1% (2009-2015) every year before being definitively removed in 2015. Consequently, as regards France, the production of raw milk by farms is since then not administratively determined anymore but the result of bilateral contracts linking manufacturers and farmers. Moreover, raw milk prices have also been liberalized. Up to spring 2008, the CNIEL (National Interprofessional Center for the Dairy Economy) was regularly publishing a recommended price resulting from negotiations between farmers and manufacturer representatives, a recommendation in practice closely followed by manufacturers. This functioning was abandoned after the French regulation authority declared the practice as anti-competitive. There are concerns that these institutional changes may have been to the detriment of farmers, rarely organized and less used to bargain than manufacturing groups.[78]

The European dairy industry was further supported through *intervention prices* on bulk products (milk powder, butter). When a commodity price dropped below a certain threshold level (the *intervention price*), the European Union purchased the necessary quantity to

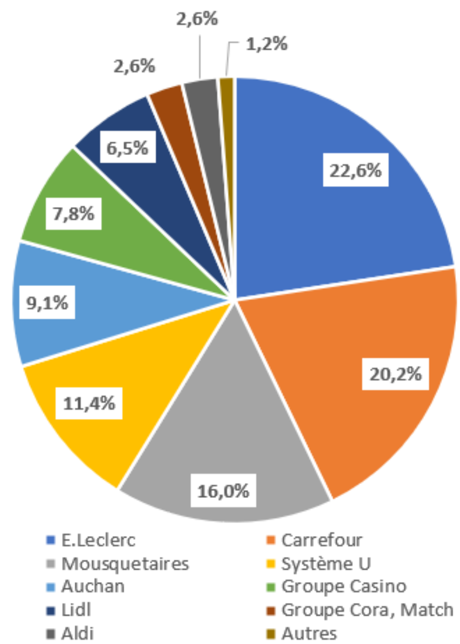
[78] See for instance this study summary: Study of Measures against Market Imbalance:What Perspectives after Milk Quotas in the European Dairy Sector?.

maintain a decent price. Purchased quantities were then stored and later resold and/or exported at a loss. Following the Common Agricultural Policy (CAP) reforms of 1999 and 2003, these intervention levels were progressively reduced, until becoming in practice ineffective. More generally, after the 2003 CAP reform, price support policies - because pushing to more production - were progressively replaced by less-distortive direct subventions to farmers.

A.2.2 Commercial Relations between Manufacturers and Retailers

In France, the 2000s were marked by debates about the regulation of the retail sector. In 2008, the Economic Modernization Act (*Loi de Modernisation de l'Economie*, in French) removed the non-discriminatory price obligation imposed on manufacturers since the *Galland Act* (1996). The Galland Act was constraining manufacturers to sell a given product to different retailers at a similar price, which in practice had effects akin to prices floors (Biscourp et al., 2013). More recently, two waves of purchasing alliances formations (2014, 2018) have been scrutinized by competition authorities and economists for their possible anti-competitive effects (Caprice and Rey, 2015; Allain et al., 2020). As striking on Figure 13, retailers are highly concentrated in France, with the 7 dominating players representing 94% of the food market. Purchasing alliances may thus have reinforced their countervailing buyer power.

Figure 13: Food Retail Shares (2018)



Source: www.kantarworldpanel.com

Overall, these changes soundly modified commercial relations and bargaining power along the entire dairy supply chain, *i.e* between farmers and manufacturers on the upstream side, and between manufacturers and retailers further downstream. We acknowledge and take into account these important policy changes in our analysis by remaining agnostic on competition structures both up- and downstream.

B Measurement

B.1 Labor and Capital

This section describes how we build our measures of labor and capital quantities, using FICUS, FARE and OECD STAN data.

Wage Bill We measure the wage bill as the sum of wages and social security payments, under variables names *saltrai* and *charsoc* in FICUS, and *redi_r216* and *redi_r217* in FARE. In doing so, we follow De Ridder et al. (2021).

Capital We measure capital as the tangible fixed assets, under variable names *immocor* in FICUS, and *immo_corp* in FARE. We here follow De Ridder et al. (2021) and Wong (2019) among others using similar data. De Ridder et al. (2021) in particular explains why this approach is better than the *perpetual inventory* method in this data context, while delivering similar capital measures.

Deflators In order to estimate the production function, we need to recover labor and capital *quantities*. To do so, we deflate wage bill and capital variables with industry-level deflators from the OECD STAN database. The industry is here defined as the "Foods products, beverages and tobacco" industry, which is the finest level for which we have data for the entire period of analysis. Both labor and capital are deflated using the industry-level Gross Output deflator. As highlighted by De Ridder et al. (2021), this is consistent with the assumption that dairy firms operate on competitive labor and capital markets with equal prices.

B.2 Output Prices and Quantities

Data used here come from the *Enquête Annuelle Laitière* (EAL, 1995-2018), the *Enquête Mensuelle Laitière* (EML, 2013-2018) and the PRODCOM database for dairy products (2003-2018). They contain firm-level data regarding the production of dairy products and the collection of raw milk. In the EAL, and regarding the output side, we observe for each dairy firm in France the quantities of dairy products produced, by product (slightly more disaggregated than CN8). Thanks to our *PRODCOM* data, we are able to observe revenues and production at the firm-CN8-year level, for French dairy firms with more than 10 employees. This allows us to recover *unit values*, which we use as proxy for *factory-gate* prices in the analysis. These price data are only available for the 2003-2018 period, which will as a consequence be our period of analysis.

The unit values observed are thus firm-product-level weighted averages of more disaggregated unit values. On one hand, a product is defined at the CN8 level, which is typically the most disaggregated level observed in such data, but may have some heterogeneity at a more disaggregated level. Our estimates can thus be subject to composition effects if such heterogeneity is present. However, we do no find particular structural changes in markups estimated which could be driven by such composition effects. Moreover, our classification allows us to distinguish bulk products sold as intermediates from final consumption goods. On the other hand, we do not observe heterogeneity in prices charged by a given manufacturer for a given product for different buyers.

In the estimation, we only use quantities and unit values from the PRODCOM database. We solely use the EAL data and their more disaggregated products classification to identify (and drop) PDO and organic products, which we disregard for now, as they do not align with our assumption of substitutability of milk inputs of different origins.

To avoid inconsistencies, we harmonize units of counts in our quantity data, which are eventually all expressed in kilograms. In the original dataset, quantities are either expressed in kilograms of fat, or in kilograms of dry equivalent, which we convert into kilograms using our dry matter content data. When expressing output at the firm-level to perform the production function estimation, we sum the quantities, expressed in kilograms, of the different processed products.

B.3 Input Prices and Quantities

Raw Milk

In the EAL, we observe the quantity of raw milk collected by each firm and in every department. Thanks to the EML, we are able to observe firm-department prices paid for raw milk, for a subsample of firms and only for the 2013-2018 period. Importantly, these data are price data and not *unit values*. To complement this firm-level raw milk prices, we use data from a survey made by *FranceAgrimer*, which gives us average raw milk prices by French regions, covering the period 2000-2018.

Whole Milk Powder Prices

We use Whole Milk Powder market prices for France provided online by the European Commission (link).

B.4 Firms and Groups

Firms The production function estimation is done at the firm-level, where a firm is a SIREN. We match PRODCOM with FICUS and FARE data thanks to this unique firm identifier.

Groups Some results are then presented at the business group level. We recover these groups using the *Liaisons Financières entre Sociétés* (LIFI) data which allows us to observe financial relationships between French firms, including dairy firms. In order to more accurately describe the French dairy market reality, we complemented these financial links by a substantial amount of research online to find out additional business relationships in the market. Doing so, we marginally adjusted groups as defined by LIFI, including business relationships which are not necessarily translated into ownership relationships.

B.5 Cleaning

In the spirit of cleanings described in Dhyne et al. (2017), we compute the median ratios of capital over wage bill, milk usage respectively over capital and over labor, and wage bill over labor (average wage), then excluding observations more than five times the interquartile range below or above the median. This leads us to drop 649 observations (firm-year couples), leaving us with 7,996 observations for the estimation (see Table 12).

C Discussing Theoretical Assumptions

C.1 Variable Profit Maximization

C.1.1 Timing

In this Section, we consider a timing that microfounds the variable profit maximization on which our model relies. In the first stage, dairy firms take long term decisions which determine the competitive environment for their purchases of each input i and for the sales of each output j. On the downstream side, these decisions encompass for example, the choice of dairy products produced by the firm $\mathcal{J}_f$, the corresponding quality levels and distribution networks. On the upstream side, among other choices, firms decide the set of markets in which they source their milk-input $\mathcal{I}_f$. In the second stage, dairy firms maximize their current variable profit, competing upstream and downstream. On both sides, competition can take any usual form (Cournot, Bertrand, Monopolistic competition, etc). A Nash equilibrium of these two-stage game defines all the relevant information that affects firms' individual supply and demand curves (quantities, prices, varieties, etc...), respectively denoted by A_{fj} and A_{fi}. Then, in equilibrium, each firm maximizes its variable profit knowing which individual demand and supply curves it faces, anticipating that all other firms play Nash equilibrium. This two-stage game yields first order conditions linking firms' marginal cost, markups and markdowns.

In doing so, the product-specific demand faced by firm f on product j would rewrite $p_{fj}(y_{fj}, A_{fj})$ and its market-specific supply would rewrite $w_{fi}(m_{fi}, A_{fi}$. In Section 3, we simply respectively summarize them by $p_{fj}(.)$ and $w_{fi}(.)$, where indices fj and fi encompass competitive environments.

C.1.2 Generalization

We here show how the simple setting of Section 3 can be generalized in multiple (and compatible) ways, without having any impact on the empirical analysis.

Vertical Cooperation A lot of French dairy manufacturers are cooperatives. They represent about half of the milk collection in France. The term "cooperatives" however hides a variety of functioning, which makes their proper modelization difficult. Some of them (mostly small ones) are fully vertically integrated, and the value added sharing within them can take various forms. Some cooperatives are not fully integrated but rather regroup distinct manufacturing firms and long-serving suppliers. As such, some have evolved towards a more private structure. The biggest cooperative, which represents 20% of the French milk collection is for instance owned for half of it by private actors. Its functioning is based on an additional premium paid to its milk suppliers for every ton of milk furnished.[79]

We propose here a simple of modelization of this wide range of possible (vertically) cooperative behaviors. Denoting α_f the parameter characterizing firm f interest in its suppliers revenues, firm's f objective function writes:

$$O_f = \sum_j p_{fj}(y_{fj})y_{fj} - (1-\alpha_f)\sum_i w_{fi}(m_{fi})m_{fi} - z_f L_f$$

$0 \leq \alpha_f \leq 1$, and the bigger the α, the more important the cooperation, $\alpha_f = 0$ bringing us back to the non-cooperative behavior. The corresponding first order condition yields:

$$\underbrace{\left(1+{\varepsilon^D_{fj}}^{-1}\right)p_{fj}}_{\text{marginal revenue } MR_{fj}} = \underbrace{(1-\alpha_f)\left(1+{\varepsilon^S_{fi}}^{-1}\right)\frac{w_{fi}}{e_{ij}} + \lambda_{fj}}_{\text{marginal cost } MC_{fj}}. \tag{15}$$

Importantly, authorizing such cooperative behaviors does not alleviate the markdown defini-

[79] Which is included in the price we observe in the data.

tion (nor the markup and the margin definitions):

$$\nu_{fi} \equiv \frac{e_{ij}\left(p_{fj}\left(1+\varepsilon_{fj}^{D\ -1}\right)-\lambda_{fj}\right)}{w_{fi}} \tag{16}$$

However, at the equilibrium we now have the equality between the markdown and a product of the supply elasticity and the cooperative distortion terms:

$$\nu_{fi} = (1-\alpha_f)\left(1+\varepsilon_{fi}^{S\ -1}\right).$$

Given that our empirical analysis hinges on (17) rather than on the equality between the markdown and the supply elasticity, our results are robust to any cooperative behaviors taking such forms. In particular, it can include supply preserving behaviors by dairy firms, be they private or cooperative actors. Such behaviors even provide a rationale for markdowns below one (high values of α_f).

Collusion In a similar manner to the one used for modeling vertical cooperation, one can extend the model to allow for possible collusive behaviors. We present here a version allowing downstream collusion, but we could similarly allow for upstream collusion. Being able to allow for collusion downstream is particularly important as cartels have actually been deterred during the period of analysis. Between 2006 and 2012, 11 firms belonging to the so-called "yoghurt cartel" have for instance collude in determining prices when selling yoghurts to retailers.

We propose here a simple modelization of such collusive behaviors wide range of possible (vertically) cooperative behaviors. Denoting γ_f the parameter characterizing firm's f interest in some of its competitors profits (for instance belonging to a cartel C), firm's f objective function writes:

$$O_f = \sum_j p_{fj}(y_{fj})y_{fj} + \gamma_f \sum_{f'\in C}\sum_{j'} p_{f'j'}(y_{fj})y_{f'j'} - \sum_i w_{fi}(m_{fi})m_{fi} - z_f L_f$$

$0 \leq \gamma_f \leq 1$, and the bigger the γ, the more important the collusion, $\gamma_f = 0$ bringing us back to the non-collusive behavior. The corresponding first order condition yields:

$$\underbrace{\left(1+\varepsilon_{fj}^{D\,-1}\right)p_{fj}++\gamma_f\sum_{f'\in C}\sum_{j'}\varepsilon_{f'j'j}^{D\ \ -1}p_{f'j'}\frac{y_{f'j'}}{y_{fj}}}_{\text{marginal revenue } MR_{fj}} \;=\; \underbrace{\left(1+\varepsilon_{fi}^{S\,-1}\right)\frac{w_{fi}}{e_{ij}}+\lambda_{fj}}_{\text{marginal cost } MC_{fj}}. \tag{17}$$

Importantly, authorizing such collusive behaviors does not alleviate the markup definition (nor the markdown and the margin definitions):

$$\mu_{fj} \equiv \frac{p_{fj}}{\left(1+\varepsilon_{fi}^{S\,-1}\right)\frac{w_{fi}}{e_{ij}}+\lambda_{fj}}. \tag{18}$$

However, at the equilibrium we now have the equality between the markup and a Lerner index authorizing collusion:

$$\mu_{ff} = \frac{1}{\left(1+\varepsilon_{fj}^{D\,-1}\right)p_{fj}+\gamma_f\sum_{f'\in C}\sum_{j'}\varepsilon_{f'j'j}^{D\ \ -1}p_{f'j'}\frac{y_{f'j'}}{y_{fj}}}.$$

Given that our empirical analysis hinges on (17) rather than on the equality between the markup and the demand elasticity, our results are robust to any colluding behaviors taking such forms.

Intra-Brand Competition Internalization Generalize the variable profit maximization introduced in Section 3 to allow for intra-brand competition is straightforward.

We first rewrite firm's f objective function to incorporate its vector Y_{f-j} of quantities of products other than j produced, in order to make explicit the internalization of intra-brand competition:

$$\Pi_f = \sum_j p_{fj}(y_{fj}, Y_{f-j})y_{fj} - \sum_i w_{fi}(m_{fi})m_{fi} - z_f L_f$$

The corresponding maximization program yields a first order condition very similar to

(2):

$$\underbrace{\left(1+\varepsilon_{fjj}^{D}{}^{-1}\right)p_{fj}+\sum_{j'\neq j}\varepsilon_{fj'j}^{D}{}^{-1}p_{fj'}\frac{y_{fj'}}{y_{fj}}}_{\text{marginal revenue } MR_{fj}} \quad = \quad \underbrace{\left(1+\varepsilon_{fi}^{S}{}^{-1}\right)\frac{w_{fi}}{e_{ij}}+\lambda_{fj}}_{\text{marginal cost } MC_{fj}}.$$

We accordingly define the marginal processing cost (MPC) of product j as

$$\lambda_{fj} \equiv \sum_{j'} \frac{\partial c_{fj'}(.)}{\partial y_{fj}},$$

where $c_{fj}\left(y_{fj}, Y_{f-j}\right)$ is firm f's processing cost for product j, which is obtained by the minimization of the total processing cost.

We also define the own (cross) demand price-elasticity of j for $j=j'$ (for $j\neq j'$) as

$$\varepsilon_{fj'j}^{D} \equiv \frac{\partial y_{fj}}{\partial p_{fj'}}\frac{p_{fj'}}{y_{fj}},$$

and we still have the supply price-elasticity as

$$\varepsilon_{fi}^{S} \equiv \frac{\partial y_{fi}}{\partial w_{fi}}\frac{w_{fi}}{m_{fi}}.$$

The implied markup is:

$$\mu_{fj} \equiv \frac{p_{fj}}{MC_{fj}} = \frac{1}{1+\sum_{j'}\varepsilon_{fj'j}^{D}{}^{-1}\frac{p_{fj'}y_{fj'}}{p_{fj}y_{fj}}}.$$

This expression is quite similar to the classical single product markup expression. Again, the more inelastic is the demand (higher ε_{fjj}^{D}) the higher is the markup. However, the markup here also takes into account intra-brand competition (through $\varepsilon_{fjj'}^{D}$ for $j\neq j'$) which affects the marginal revenue of selling an extra unit of product j. Whenever product j and j' are substitutes (resp. complements), a reduction of p_{fj} to sell an extra unit of j decreases.

Again, it stresses out the flexibility of our estimates based on cost rather than elasticities estimation.

Cost Minimization We show here that we can relax the profit maximization assumption and only rely on variable costs minimization to similarly define our three objects of interest: markdown, markup and total margin. This has the advantage of not having to define any demand function that manufacturers face when selling to retailers. Thus, negotiations between both types of actors are free to take any form.

Each dairy firm solves the following variables costs minimization program:

$$\begin{aligned} \min_{m_{fij}} \quad & \sum_i w_{fi}(m_{fi})m_{fi} + c_{fj}(y_{fj}) \\ \text{s.t.} \quad & y_{fj} = \min \left\{ \sum_i e_{ij} m_{fij} \, , F_j \left(L_f, K_f; \Omega_f \right) \right\} \, , \forall \, j \end{aligned}$$

where we *only* assume an increasing firm-dept specific supply curve $w_{fi}(.)$.

Denoting λ^y_{fj} the associated Lagrange multiplier, the first order condition yields:

$$MC_{fj} \equiv \lambda^y_{fj} = \left(1 + \varepsilon^{S\ -1}_{fi}\right) \frac{w_{fi}}{e_{ij}} + \lambda_{fj}$$

By definition, the Lagrange multiplier associated to the cost minimization program is equal to marginal costs.

We thus similarly recover markdowns, markups and margins definitions: $\mu_{fj} \equiv \frac{p_{fj}}{MC_{fj}}$, $\nu_{fi} \equiv e_{ij} \frac{MC_{fj} - \lambda_{fj}}{w_{fi}}$ and $M_{fij} \equiv \frac{p_{fj}}{AMC_{fij}}$.

As logical since totally abstracting from the demand side, we do not have anymore the equality between marginal revenue and marginal costs. As a consequence, (i) markups do not relate to any underlying demand elasticity and (ii) the markdown has to be interpreted as the wedge between the *shadow cost* of a unit of milk (rather than its marginal contribution to profit) and its price.

C.2 Milk Supply Microfoundation [TBA]

We are currently working on a milk supply functions micro-foundation along the following lines:

- Each manufacturer faces a continuum of potentially active farms in each source market.
- Farms feature (i) heterogeneous productivities and (ii) constant marginal costs with capacity constraints or increasing marginal costs.

The induced heterogeneity in profitability of farms thus determines the number of existing farms for each pric and yield an increasing supply curve.

C.3 Static and Dynamic Inputs

Correlations shown in Table 9 are reassuring evidence that labor, milk and materials are all variable and statically chosen, while capital is more dynamic.

Table 9: Correlations between Yearly Growth Rates

	Labor (wage bill)	Capital	Milk Inputs
Output $\%\Delta_t$	0.20	0.09	0.68
Output $\%\Delta_{t+1}$	0.08	0.10	0.06

C.3.1 Ignoring Materials other than Milk Inputs

We exclude non-milk intermediary inputs from marginal costs estimation. We argue that this restriction is unlikely to have a significant impact on our marginal costs estimates. We compute the ratio between the raw milk expenses declared in the production data (*i.e* EAL) over total intermediary expenses recorded in balance sheet data (*i.e* FICUS-FARE). The remaining gap between this ratio and 1 is at least partly explained by intermediary dairy inputs purchases (such as WMP and other commodities), which we do not observe but which are however taken into account in our theory. Any residual gap would result from non-milk intermediary inputs purchases, which seem to be insignificant. The sample used for this ratio is restricted to firms and years for which we observe prices at the firm-department-year level.

Table 10: Milk to Materials Expenses Ratio

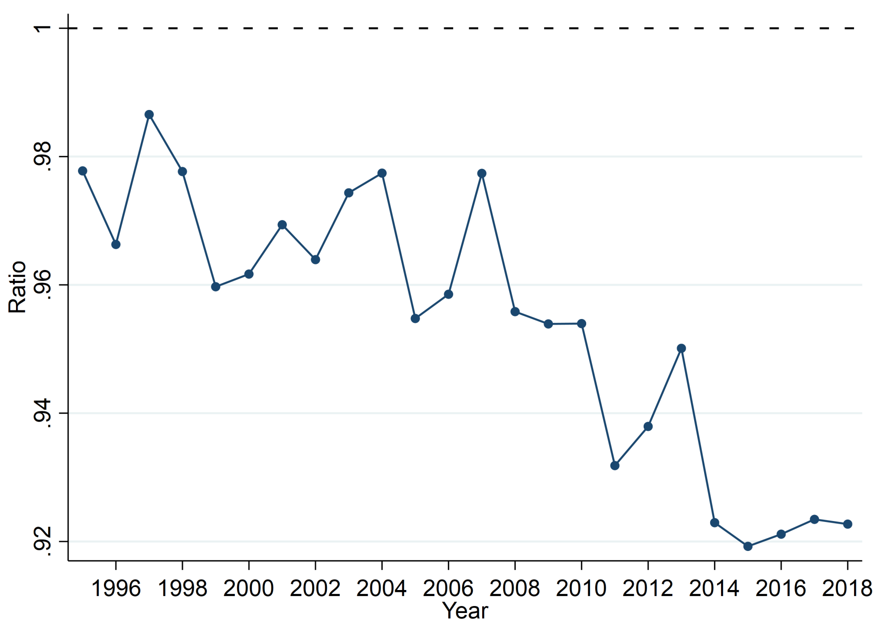
Average	Median	P25	P75	Obs.
0.78	0.88	0.65	0.95	980

D Discussing Identification

D.1 Dairy Input/Output Matrix

We plot here the ratio between the simulated manufacturers' needs, in raw milk, generated from production data using our dry matter content data, and the actual raw milk production. Over the period, the underestimation of the demand is contained between 2 and 8 percent which can be explained by a waste in the processing process which is assumed to be zero when dry matter content data are constructed.

Figure 14: Estimated DMC needs vs. Real demand (Collection + Imports)



D.2 Processing Function

D.2.1 Specification

Estimating marginal processing costs at the product-level is challenging and requires strong assumptions. There are few papers dealing with multi-product production function estimation.[80] The main issue is that inputs are generally reported at the firm-level. As a consequence, papers coping with multi-product production function estimation rely on 2 sets of important assumptions. On the one hand, some impose an allocation rule of inputs observed at the firm-level to each product (see De Loecker et al. (2016) and Valmari (2016)). Despite their methodological differences, these papers ultimately consider multi-product production function as a sum of mono-product production functions, once having allocated inputs to the different products. This amounts to assuming no complementarity in producing various products, an assumption that does not seem well-suited for our analysis. As we mentioned before, milk inputs are a bundle of a sub-inputs split during the processing of different products. Moreover, we cannot implement De Loecker et al.'s (2016) methodology as it relies on mono-product firms, which are very rare in the French dairy industry context, even at a relatively aggregated product-level (see Table 11 in Appendix D.2.1). On the other hand, Dhyne et al. (2017, 2021) develop a general multi-product production function which presents the advantage of not having to allocate inputs to be estimated. The drawback of this specification is that it requires at least as many variable inputs as products to identify marginal costs at the product level, something we do not have. Overall, it appears reasonable to assume a firm-level processing function in our case. Our scope of analysis is limited to the industry of "Operation of Dairies and Cheese Making" (NC4-level), which is the level at which De Loecker et al. (2016) estimate production functions. Within this industry, firms seem to have a fairly similar mix in labor and capital regardless of their product specialization, as we show in Table 11 in Appendix D.2.1). Labor cost shares in firms' total processing costs (defined as labor and capital costs) indeed turn out to be very close to 0.8 for each product-group we consider. Finally, in our estimates, processing costs (estimated at the firm-level)

[80] In this paragraph, we follow the literature's vocable about *production* function, but the reader shall keep in mind that we here want to estimate what we refer to as the *processing* function.

on average only represent 30% of firms' accounting marginal costs, milk input purchases at the firm-origin-*product*-level constituting the remaining 70%.

Empirically, the labor shares displayed in Table 11 are supportive of a firm-level production technology, as labor shares distribution of specialized firms are remarkably constant across product categories. Moreover, the small number of monoproduct firms in the dairy industry reflected by the number of observations in Table 11 also motivates our choice of not implementing a production function estimation relying on them *à la* De Loecker et al. (2016).

Table 11: Labor Shares by Product Category, Monoproduct Firms

	Butter	Cream	Cheese	Milk	Powder	Yoghurt
Average	0.79	0.77	0.80	0.83	0.78	0.84
Median	0.79	0.73	0.78	0.77	0.83	0.81
P5	0.62	0.65	0.57	0.57	0.60	0.64
P25	0.74	0.70	0.71	0.71	0.75	0.74
P75	0.86	0.81	0.88	0.84	0.93	0.89
P95	0.94	1.00	0.97	1.00	1.00	0.96
Obs.	91	54	1,878	188	110	383

Notes: Specialized firms here defined as firms for which at least 80% of milk purchased are transformed into that product. Labor shares computed assuming a constant depreciation rate of capital over 10 years.

D.2.2 Estimation

Adding time t and dropping firm f subscripts to Equation (4), the estimating equations are:

$$y_t = \beta_l l_t + \beta_k k_t + \beta_{ll} l_t^2 + \beta_{kk} k_t^2 + \beta_{kl} k_t . l_t + \epsilon_t \,,$$

where the technical efficiency term ϵ_t is assumed to split into two parts: $\epsilon_t = \omega_t + \eta_t$.

η_t is an i.i.d. error which the firm does not influence (e.g., measurement/specification errors). ω_t reflects firm-specific technical efficiency, observed by the firm but not by the econometrician. We now describe how we deal with three issues typically encountered in such contexts.

(i) Unobserved Firm-Specific Efficiencies

ω_t is assumed to be first-order Markov and is the source of the well-known simultaneity problem as firms observe it before choosing labor l_t. By assumption, k_t responds to ω_t with a lag as investments made in period $t-1$ take effects in period t. Thus, k_t is possibly correlated with the expected value of ω_t given ω_{t-1} ($E[\omega_t|\omega_{t-1}]$) - but this assumption guarantees that the innovation in the productivity shock, $\xi_t = \Omega_t - E[\omega_t|\omega_{t-1}]$ is unknown at time $t-1$ the investment was made and therefore uncorrelated with current k_t.

Following Olley and Pakes (1996) and Levinsohn and Petrin (2003), we use the existence of a proxy variable h_t for the technical efficiency shock, which is assumed to be a function of unobserved productivity ω_t, capital k_t, and other variables z_t, which we denote $h_t(k_t, \omega_t, z_t)$. Assuming this function is a bijection in ω_t - conditional on k_t and other variables z_t - we can then invert the proxy variables to get $\omega_t = g(k_t, h_t, z_t)$. We thus include a function of k_t, h_t and z_t in the estimation to control for ω_t. We define z_t later as it will also address problems (ii) and (iii), among others. Following Wooldridge (2009), and as commonly done in the literature, we use a single index restriction so that:

$$\omega_t = g(k_t, h_t, z_t) = c(k_t, h_t, z_t)'\gamma, \tag{19}$$

where we choose $c(.)$. In practice we use multivariate 2^{nd} order polynomials. We can now rewrite $E[\omega_t|\omega_{t-1}] = f\left(c(k_t, h_t, z_t)'\gamma\right)$, where we impose a similar single index restriction on $f(.)$. Using our assumptions to re-express (19) yields:

$$y_t = \beta_l l_t + \beta_k k_t + \beta_{ll} l_t^2 + \beta_{kk} k_t^2 + \beta_{kl} k_t.l_t + E[\omega_t|\omega_{t-1}] + \xi_t + \eta_t,$$

where remember that $\xi_t = \omega_t - E[\omega_{jt}|\omega_{t-1}]$. For a given set of parameters $\beta = (\beta_l, \beta_k, \beta_{ll}, \beta_{kk}, \beta_{kl})$ to be estimated, the error is:

$$[\xi_t + \epsilon_t](\beta) = y_t - \beta_l l_t + -\beta_k k_t - \beta_{ll} l_t^2 - \beta_{kk} k_t^2 - \beta_{kl} k_t.l_t - f\left(c(k_t, h_t, z_t)'\gamma\right)$$

Denoting $\tilde{\beta}$ the true parameters values, the conditional moment restriction $[\xi_t + \epsilon_t]\left(\tilde{\beta}\right) = 0$ identifies β.

(ii) Unobserved Exogenous Input Prices and Quantities

Following De Loecker et al. (2016), we acknowledge the existence of a potential input price bias, as we use labor[81] and capital in monetary terms. To reduce this bias, we use industry-level labor and capital deflators. We further include average wage per worker (a proxy for labor quality) and downstream market shares in the control function $g(.)$. The latter are good proxies for output quality, as they positively correlate with input quality in a large class of theoretical models. We refer to De Loecker et al. (2016) for a more formal explanation.[82]

(iii) Endogenous Prices Upstream and Downstream

We choose firm's milk demand as our proxy for ω_t, as both shall be positively correlated. With endogenous prices downstream and upstream, high milk input demand can also result from low markups and/or low markdowns rather than high productivity. As highlighted by De Loecker et al. (2016) and Rubens (2021), a large class of competition models can deliver markdowns and markups as functions of markets shares on the corresponding market, upstream and downstream, respectively.[83] We thus incorporate these variables in the control function z_{ft} for ω_t and define:[84]

$$z_{ft} = \left(s_{ft}^m, s_{ft}^y\right)$$

[81] We also have total employment in our data, which less accurately reflects the number of hours worked.

[82] Contrary to De Loecker and Warzynski (2012), we do not include downstream prices (observed from 2003) here, as it would reduce the estimating sample and time window, which spans from 1995 to 2018.

[83] In such models, markdowns and markups also depend on prices, plus an additional elasticity parameter. We do not include prices, as they would drastically reduce the estimating sample. Given that we use quantities of products and milk in the estimation, we think this is not a major concern.

[84] Using again a 2^{nd} order polynomial for flexibility concerns.

where s^m_{ft} and s^y_{ft} are firm's f average market shares in milk input and output markets.

D.2.3 Estimates

Table 12: Processing Function Estimates - firm-level

	OLS	GMM - CD	GMM - TL
β_l	0.534***	0.739***	0.585***
	(0.035)	(0.035)	(0.145)
β_k	0.252***	0.138***	0.121
	(0.027)	(0.021)	(0.083)
β_{ll}			0.098***
			(0.029)
β_{kk}			0.066***
			(0.018)
β_{kl}			-0.149***
			(0.044)
Obs.	7,996	7,996	7,996
R2	0.974		
Labor Quality corr.	No	Yes	Yes
Market Power corr.	No	Yes	Yes
Firm and Year F.E.	Yes	Yes	Yes

Notes: For comparison purposes, OLS sample is restricted to be the same as GMM samples, further reduced due to the presence of lagged variables. Labor quality is corrected for by introducing firm-level average wage control. Market power is controlled by introducing upstream and downstream market shares. Standard errors are in parenthesis. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

We present in Table 12 our processing functions estimates for several specifications. Assuming a translog production function, the average estimate of the output elasticity of labor is

0.79, and the average output elasticity of capital is 0.14. These estimates are close to the Cobb-Douglas estimates (0.74 for labor and 0.14 for capital). Moreover, all quantiles of the distribution of elasticities resulting align well with their counterparts in the empirical distributions of labor, and capital shares in total processing costs (labor and capital costs), as shown in Table 13. Correcting for endogeneity seems to be important as GMM Cobb-Douglas elasticities differ significantly from those obtained by plain OLS regressions with firm and year fixed effects.

Robustness

Table 13 shows how all quantiles of the distribution of elasticities resulting from the translog specification relatively well align with their counterparts in the empirical distribution of respectively labor and capital shares in total processing costs (labor and capital costs).

Table 13: Translog Elasticities and Input Shares

	Average	Median	P5	P25	P75	P95	Obs.
Labor Elasticity	0.79	0.79	0.65	0.73	0.86	0.95	2,736
Capital Elasticity	0.14	0.14	0.01	0.09	0.19	0.24	2,736
Labor Share in Processing Costs	0.73	0.73	0.57	0.66	0.80	0.90	2,736
Capital Share in Processing Costs	0.27	0.27	0.10	0.20	0.34	0.43	2,736

Notes: Distributions winsorized at 1% and 99%. Labor shares computed assuming a constant depreciation rate of capital over 10 years.

As a robustness check, we conducted the estimation exercise using two alternatives for the elasticity of output to labor required to retrieve marginal costs: (i) using the Cobb Douglas elasticity of about 0.74 presented in Table 12, and (ii) using observed labor shares as firm-level output elasticities of labor. All results presented in the paper are robust to these alternative methodologies.

Table 14: Share of Milk Purchases in Marginal Costs

	Ignoring buyer power
	θ_{fij}
Average	0.69
Weighted Average	0.64
Median	0.72
Observations	43,486

Notes: Sample restricted to firms for which we manage to link raw milk collection and production.

Table 14 shows the average and median shares θ_{fij} of raw milk purchases in marginal costs. These shares appear in several structural equations throughout the theoretical and pass-through analysis.

D.3 Disentangling Markups and Markdowns

D.3.1 Identification

WMP Buyers When considering a WMP buyer, we notably have the two following first order conditions:[85]

$$\underbrace{\left(1+\varepsilon_{fj}^{D\,-1}\right)p_{fj}}_{\text{marginal revenue } MR_{fj}} = \underbrace{\left(1+\varepsilon_{fi}^{S\,-1}\right)\frac{w_{fi}}{e_{ij}}+\lambda_f}_{\text{marginal cost } MC_{fij}} \tag{20}$$

and

$$\underbrace{\left(1+\varepsilon_{fj}^{D\,-1}\right)p_{fj}}_{\text{marginal revenue } MR_{fj}} = \underbrace{\frac{w_c}{e_{cj}}+\lambda_f}_{\text{marginal cost } MC_{fcj}} \tag{21}$$

[85] Here and in the following subsection, we write marginal processing cost λ_f at the firm-level, consistently with the estimating assumption.

From (21), we directly get the markup:

$$\mu_{fj} = \frac{p_{fj}}{\frac{w_c}{e_{cj}} + \lambda_f}, \ \forall \ j.$$

From (20) and (21), *i.e* exploiting the underlying arbitrage between using an additional unit of WMP or of raw milk for producing product j, we get the markdown:

$$\nu_{fi} = \frac{e_i}{e_c} \frac{w_c}{w_{fi}}, \ \forall \ i$$

.

WMP Sellers When considering a WMP seller, we notably have the two following first order conditions:

$$\underbrace{\left(1 + \varepsilon_{fj}^{D\ -1}\right) p_{fj}}_{\text{marginal revenue } MR_{fj}} = \underbrace{\left(1 + \varepsilon_{fi}^{S\ -1}\right) \frac{w_{fi}}{e_{ij}} + \lambda_f}_{\text{marginal cost } MC_{fij}} \tag{22}$$

and

$$\underbrace{p_{fc}}_{\text{marginal revenue } MR_{fc}} = \underbrace{\left(1 + \varepsilon_{fi}^{S\ -1}\right) \frac{w_{fi}}{e_{ic}} + \lambda_f}_{\text{marginal cost } MC_{fic}} \tag{23}$$

From (23), we directly get the markdown:

$$\nu_{fi} = \frac{e_i}{e_c} \frac{(p_{fc} - \lambda_f)}{w_{fi}}, \ \forall \ i$$

From (22) and (23), *i.e* exploiting the underlying arbitrage between producing and selling an additional unit of WMP or of product j, we get the markup:

$$\mu_{fj} = \frac{p_{fj}}{\frac{(p_{fc} - \lambda_f)}{e_{cj}} + \lambda_f}, \ \forall \ j.$$

D.3.2 Intuition for Identification - Toy Examples

WMP Sellers A firm that is observed selling WMP trades-off between producing dairy products and WMP. Figure 15 conveys the main general intuitions, representing the equilibrium for a stylized firm sourcing milk on a given market i, and selling a given dairy product j and commodity c. Without loss of generality and for simplicity, we also assume here that $e_{ij} = e_{cj} = 1$, $i.e$ that milk and the commodity transform one for one into product j and commodity c, so that $y_i = y_j + y_c$.

In such simple example, combining both underlying firm's first order conditions amounts to equalize marginal revenues of each output with the marginal costs of milk input i, implying that:

$$p_c = MR_j(y_j^*) = MC_i(y_i^*)$$

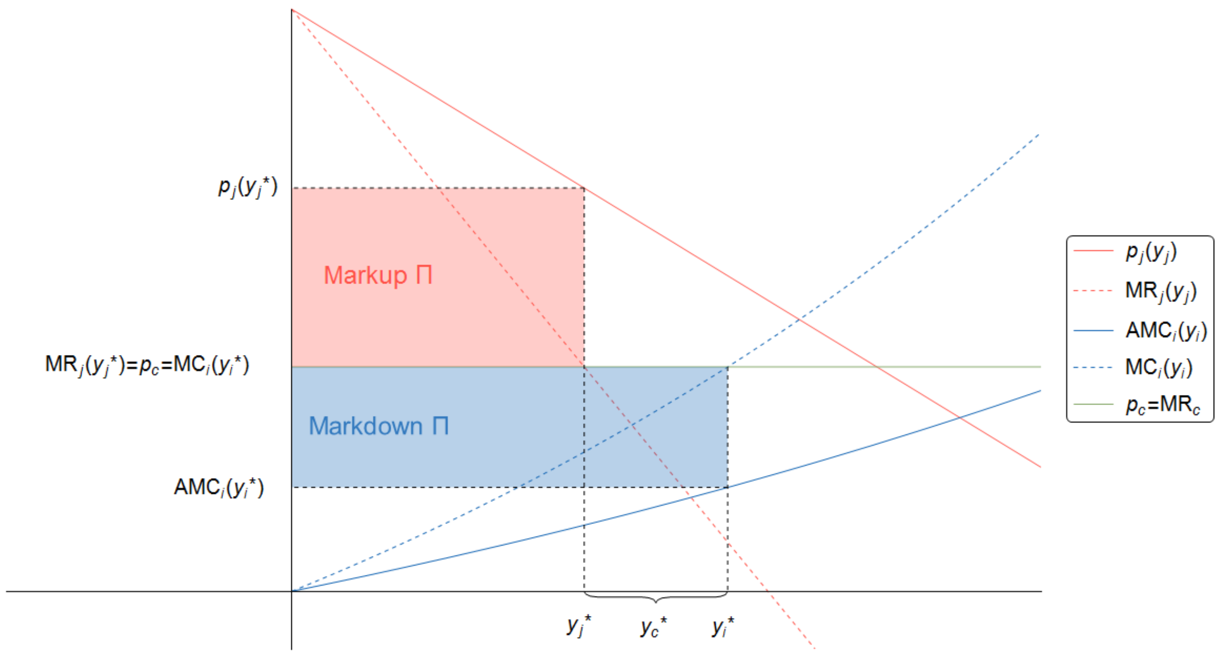
Arbitrage conditions and the commodity price thus allow identifying marginal revenue of product j and marginal costs of input i.

The firm produces and sells output j rather than commodity c as long as the marginal revenue MR_j of product j is above the commodity price p_c. For the optimal quantity of output j, MR_j and p_c are equalized, and the ratio between the price of product j and p_c delivers the markup.[86]

The firm produces and sells commodity c as long as the commodity price p_c is above the marginal costs MC_i of processing milk i into the commodity. For the optimal quantity of milk input i (and thus for optimal quantities of both outputs j and c), p_c and MC_i are equalized, allowing us to identify the markdown. This stresses out that firms selling commodities must be efficient enough (λ_f low enough) to do so. Our data confirms this intuition, as we observe a small number of larger firms selling WMP.

[86] Noticing that the markup estimates for a commodity seller collapses to $\mu_{fj} = \frac{p_{fj}}{p_{fc}}$ when $e_{cj} = 1$.

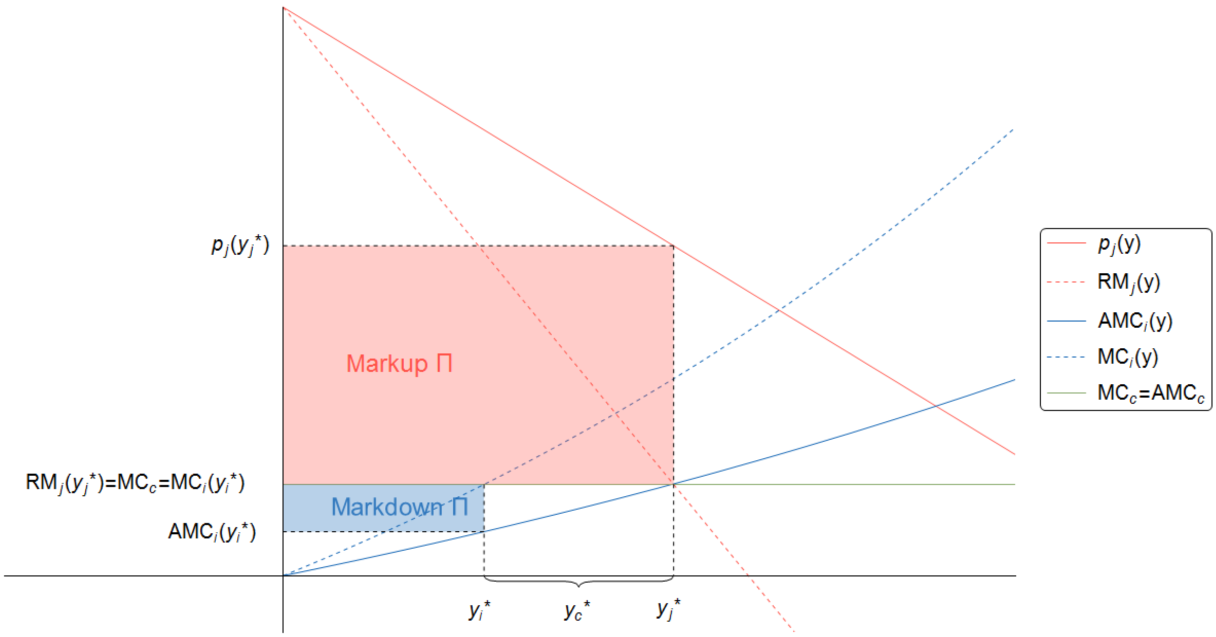
Figure 15: Equilibrium for Commodity Sellers



WMP Buyers Figure 16 displays general intuitions for a firm assumed producing and selling one product j, processing milk i and commodity c. It thus illustrates intuitions for identification of markups and markdowns of WMP buyers, evoked in subsection 4.2.2. Underlying firm's first order conditions, $i.e$ equalizing marginal revenue of output j with the marginal cost of each input i and c, implies that:

$$MR_j(y_j^*) = AMC_c(y_c^*) = MC_i(y_i^*)$$

Figure 16: Equilibrium for Commodity Buyers



D.3.3 Estimates - WMP Buyers vs. WMP Sellers

Table 15: Markdowns and Markups - WMP Buyers vs. WMP Sellers

	Markdowns		Markups	
Sample	WMP Buyers	WMP Sellers	WMP Buyers	WMP Sellers
Average	1,20	1,10	1,21	1,37
Weighted Average	1,22	1,12	1,52	1,38
Median	1,17	1,07	1,04	1,17
Observations	6,610	1,439	4,943	1,061

Notes: Sample restricted to firms for which we manage to link raw milk collection and production. Markdowns computed based on raw milk prices at the regional level. Weighted averages based on quantity (dry matter content) shares upstream and downstream. Markdowns at the group-department-time level, markups at the group-product-time level, margins at the group-department-product-time level.

Table 15 shows summary statistics for markups and markdowns estimates of WMP buyers and WMP sellers respectively. Median and simple average markdowns (resp. markups) estimated for WMP buyers are slightly above (below) markdowns (markups) estimated for WMP sellers. Given the identification methodology, this comes from the fact that on average:

$$p_{fc} - \lambda_f < w_c$$

This corresponds to the idea that the opportunity cost of renouncing to sell WMP for WMP sellers is below the price of WMP on the commodity market. This result can partly come from a limitation of our methodology. Throughout the empirical analysis, we assumed a firm-level processing cost. A marginal processing cost of commodities that would be lower than the marginal processing cost of final goods - within a same firm - could for instance drive the pattern observed.

D.4 Competitive Labor

D.4.1 Discussion

Throughout the analysis, we assume away labor market power because we think it is likely limited in this industry, for three main reasons. First, dairy firms are (i) relatively smaller on labor market(s) than they are on milk markets, which imply both that they are likely to have a limited labor MP, and if any, it would be of a second order magnitude compared to buyer power on raw milk. Second French manufacturers are confronted to regulation, especially when hiring low skilled workers. An important part of such workers are hired at the minimum wage, a level a which the labor supply is inelastic, implying no room for wage-setting power. Finally, dairy firms may not necessarily operate in a monopsony environment when recruiting high skilled workers. For such workers, given the rural places where dairy firms essentially operate, high skilled workers may be a relatively rare resource, balancing the relationship in their favor.

D.4.2 Theoretical Impact of Labor Market Power

That being said, we examine in the following what would be the impact of the existence of labor MP on our theoretical results, before turning to its impact on empirical estimates.

Adding an additional source of MP would affect the first order condition of the variable profit maximization, and consequently some definitions of our objects of interests. The first order conditions would rewrite:

$$\underbrace{\left(1+\varepsilon_{fj}^{D\,-1}\right)p_{fj}}_{\text{marginal revenue } MR_{fj}} = \underbrace{\left(1+\varepsilon_{fi}^{S\,-1}\right)\frac{w_{fi}}{e_{ij}} + \left(1+\varepsilon_{L}^{S-1}\right)\lambda_{fj}}_{\text{marginal cost } MC_{fj}}. \tag{24}$$

Due to the existence of monopsony power on the labor market, the marginal cost MC_{fj} would additionally feature the supply elasticity of labor ε_L^S. This would imply redefining markups and markdowns in Definitions 1 and 2, replacing λ_{fj} by $\left(1+\varepsilon_L^{S-1}\right)\lambda_{fj}$. Doing so would be necessary to acknowledge the contribution to the total margin of a markdown on the labor market, which, starting from (24), would be defined in the following way:

$$\nu_L \equiv \frac{\left(1+\varepsilon_{fj}^{D\,-1}\right)p_{fj} - \left(1+\varepsilon_{fi}^{S\,-1}\right)\frac{w_{fi}}{e_{ij}}}{\lambda_{fj}} \tag{25}$$

The markdown on labor market would have an interpretation akin to the markdown on raw milk markets, as being the wedge between the marginal contribution of labor to profit, and its shadow cost.

While the theoretical definitions of markups and markdowns would be affected by the presence of labor MP, the margin definition would be left unchanged, as the *accounting marginal cost* remains identical.

D.4.3 Impact of Labor Market Power on the Estimation

If firm f had wage-setting power, its variable cost minimization program would be:

$$\begin{aligned} \min_{L_f} \quad & Z_f(L_f)L_f \\ \text{s.t.} \quad & F(L_f, K_f, \Omega_f) - Y_f^* \geq 0, \end{aligned}$$

Given labor monopsony power, the implied marginal processing cost (MPC) would be:

$$\tilde{\lambda}_f = \left(1 + \varepsilon_L^{S^{-1}}\right) \frac{Z_f L_f^*}{\varepsilon_f^{Y,L} Y_f^*}.$$

It would differ from our original definition of $\lambda_f = \frac{Z_f L_f^*}{\varepsilon_f^{Y,L} Y_f^*}$, which in such context would have to be interpreted as the *accounting* MPC. If there was labor monopsony power, then $1 + \varepsilon_L^{S^{-1}} > 1$, implying $\tilde{\lambda}_f > \lambda_f$.

As aforementioned, *the presence of such labor MP would not affect the margin estimates.* It would however impact our markups and markdowns estimates in different ways, depending on the firm's status. If firm f is a WMP buyer, its markups and markdowns have been estimated as:

$$\nu_{fi} = \frac{e_i}{e_c} \frac{w_c}{w_{fi}}, \; \forall \; i \quad \text{and} \quad \mu_{fj} = \frac{p_{fj}}{\frac{w_c}{e_{cj}} + \lambda_f}, \; \forall \; j.$$

From these definitions and the discussion above, it is straightforward to see that *the presence of labor MP would leave unchanged our markdowns estimates for WMP buyers*. It would however lead to an overestimation of their markups, which should have featured $\tilde{\lambda}_f$ instead of λ_f. In such case, a part of the margin that is due to the existence of markdown on wages would have been falsely attributed to monopoly power.

If firm f is a WMP seller, its markups and markdowns have been estimated as:

$$\nu_{fi} = \frac{e_i}{e_c} \frac{(p_{fc} - \lambda_f)}{w_{fi}}, \; \forall \; i \quad \text{and} \quad \mu_{fj} = \frac{p_{fj}}{\frac{(p_{fc} - \lambda_f)}{e_{cj}} + \lambda_f}, \; \forall \; j.$$

For similar reasons as aforementioned, the markdown would be overestimated. The bias in the estimated markup on product j depends on its dry matter content and the WMP one (the commodity c). The markup would be overestimated (resp. underestimated) if $e_j < e_c$ (if $e_j > e_c$), $i.e$ if product j is less (more) dry matter intensive than WMP.

Quantitatively, such biases would however remain limited, as the estimated MPC λ_f (to be inflated by the potential wage markdown) only represents around 30% of the total marginal costs, the remaining part being constituted by raw milk or WMP purchases.

E Additional Results

E.1 Pass-Through Analysis - Graphical Representation

Figure 17: Impact of a Decrease of the Commodity Price for Commodity Buyers

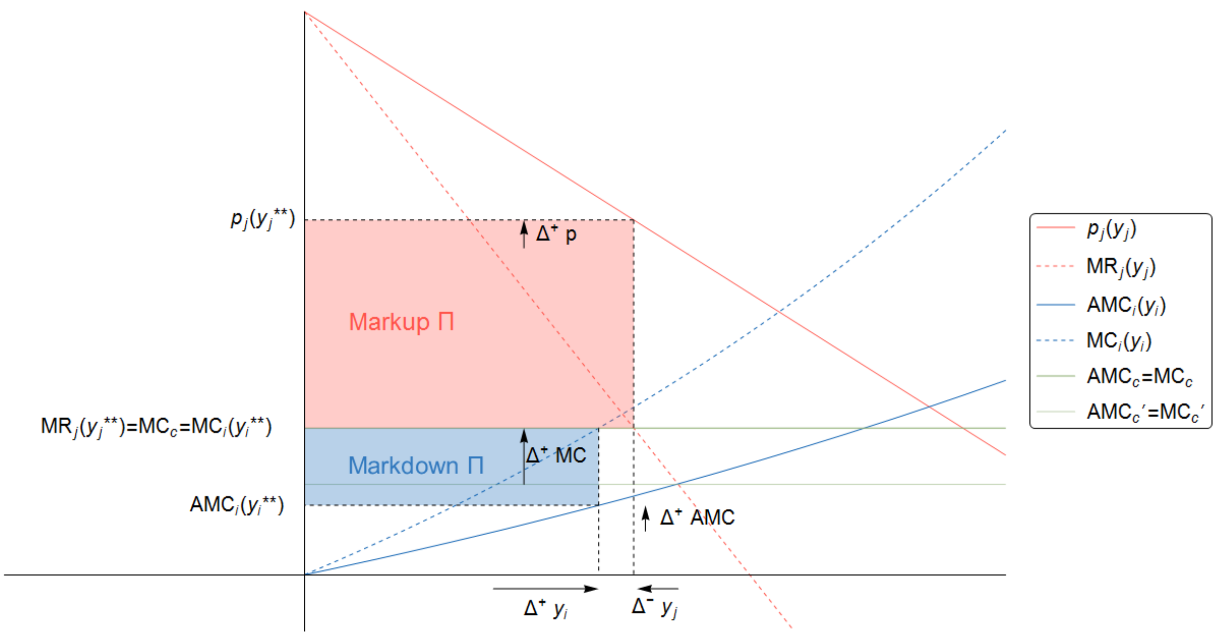
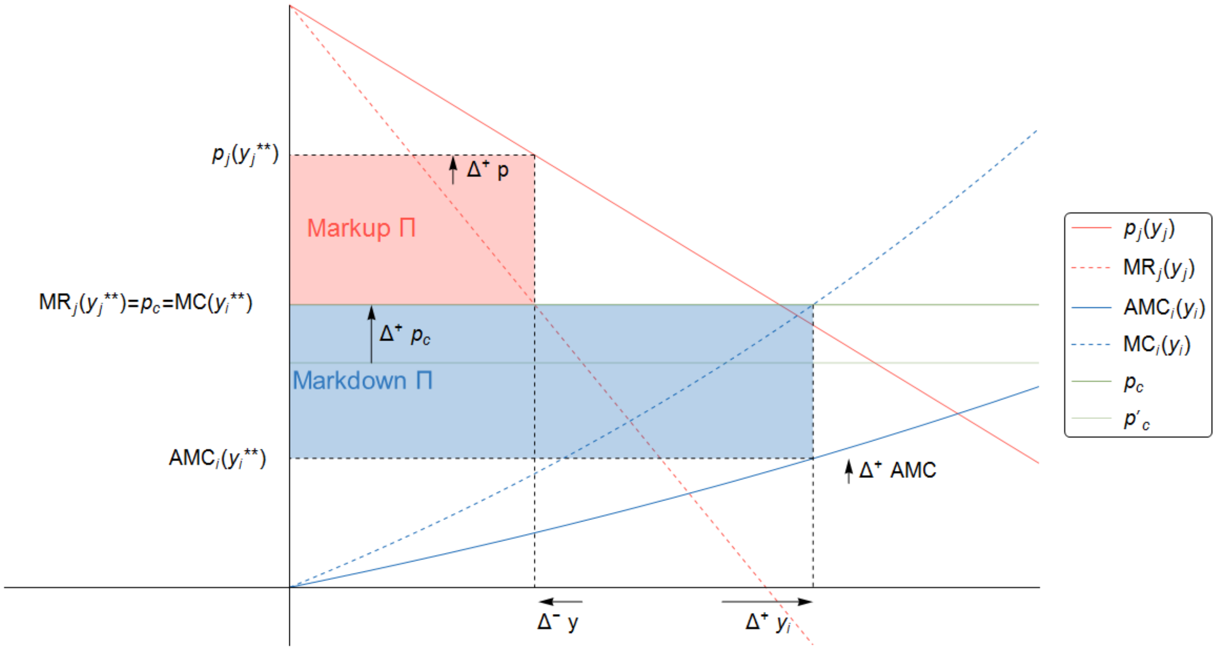


Figure 18: Impact of a Decrease of the Commodity Price for Commodity Sellers



E.2 Additional Theoretical Pass-Through Derivations

E.2.1 Pass-Through for WMP Sellers

Under the identifying assumption that WMP sellers do not have seller power on the WMP market, their markdowns and markups are defined as follows:

$$\nu_{fi} = \frac{e_i}{e_c}\frac{(p_{fc} - \lambda_f)}{w_{fi}}, \ \forall\ i \quad \text{and} \quad \mu_{fj} = \frac{p_{fj}}{\frac{(p_{fc}-\lambda_f)}{e_{cj}} + \lambda_f}, \ \forall\ j.$$

We consider here variations in the price p_{fc} at which they are able to sell WMP. Proceeding as in Section 5.2.2, both definitions yield the following pass-throughs on upstream prices:

$$\varepsilon_{p_{fc}}^{w_{fi}} = \tilde{\theta}_{fic}^{-1} - \varepsilon_{p_{fc}}^{\nu_{fi}}, \tag{26}$$

and downstream prices

$$\varepsilon_{p_{fc}}^{p_{fj}} = \varepsilon_{p_{fc}}^{\mu_{fj}} + \frac{e_j}{e_c}\frac{p_{fc}}{p_{fj}}\mu_{fj}. \tag{27}$$

E.2.2 Pass-Through with Endogenous Marginal Processing Cost

We proceed in a similar way as in Section 5.2.2 but authorizing λ_{fj} to adjust, $i.e$ considering it as an endogenous object $\lambda_{fj}(w_c)$.

Starting from the margin definition, (8) rewrites:

$$\varepsilon_{w_c}^{p_{fj}} = \varepsilon_{w_c}^{M_{fij}} + \theta_{fij}\varepsilon_{w_c}^{w_{fi}} + (1-\theta_{fij})\,\varepsilon_{w_c}^{\lambda_{fj}}, \tag{28}$$

Starting from the markup definition, (9) rewrites:

$$\varepsilon_{w_c}^{p_{fj}} = \varepsilon_{w_c}^{\mu_{fj}} + \tilde{\theta}_{fij}\left(\varepsilon_{w_c}^{\nu_{fi}} + \varepsilon_{w_c}^{w_{fi}}\right) + \left(1-\tilde{\theta}_{fij}\right)\varepsilon_{w_c}^{\lambda_{fj}},$$

or, in the absence of MP (rewriting (10)):

$$\varepsilon_{w_c}^{p_{fj}} = \theta_{fij}\varepsilon_{w_c}^{w_{fi}} + (1-\theta_{fij})\,\varepsilon_{w_c}^{\lambda_{fj}}.$$

Finally, (11) is unchanged:

$$\varepsilon_{w_c}^{w_{fi}} = 1 - \varepsilon_{w_c}^{\nu_{fi}}$$

while (12) rewrites:

$$\varepsilon_{w_c}^{p_{fj}} = \varepsilon_{w_c}^{\mu_{fj}} + \theta_{fcj} + (1-\theta_{fcj})\,\varepsilon_{w_c}^{\lambda_{fj}}$$

E.3 Additional Reduced-Form Pass-Through Estimates

Table 16: Pass-Through: Reduced-Form Estimates

	(1)	(2)	(3)	(4)	(5)	(6)
	Output Price	Markup	MPC	Markdowns	Milk Price	Margin
	p_{fj}	μ_{fj}	λ_f	ν_{fi}	w_i	M_{fij}
A) Final Consumption Goods – All Manufacturers						
WMP Price	0.147***	-0.503***	0.049	0.600***	0.392***	-0.136***
	(0.019)	(0.038)	(0.065)	(0.022)	(0.017)	(0.051)
Obs.	3,723	3,723	3,723	7,705	1,380	43,590
R-squared	0.969	0.848	0.920	0.627	0.414	0.828
B) Commodities – WMP Buyers only						
WMP Price	0.654***	-0.022	0.057	0.637***	0.393***	0.395***
	(0.057)	(0.066)	(0.082)	(0.016)	(0.024)	(0.103)
Obs.	1,688	1,688	1,688	5,504	1,338	17,369
R-squared	0.932	0.789	0.922	0.640	0.416	0.777
FE	$f \times j$	$f \times j$	f	$f \times i$	i	$f \times i \times j$

Standard errors are in parenthesis

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

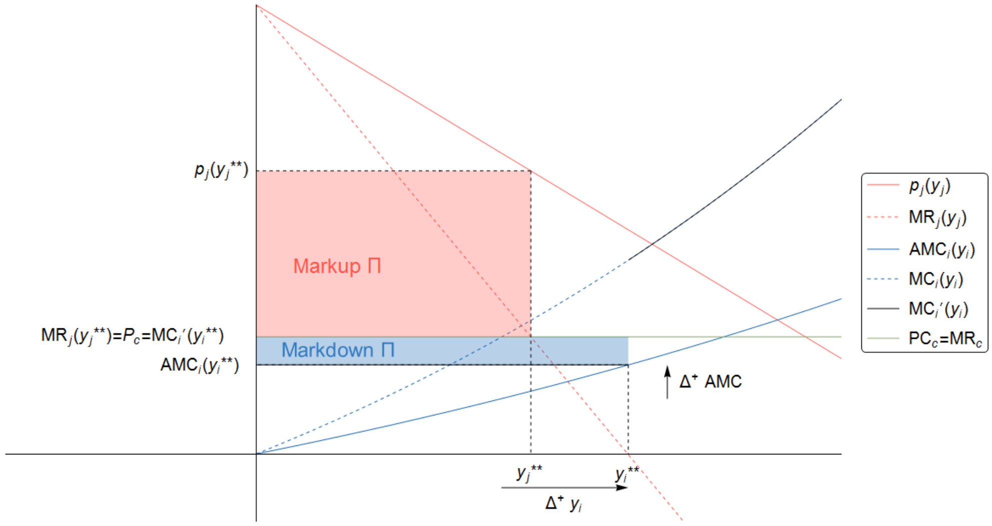
E.4 Illustrating the Role of a Price Floor

The main intuitions regarding the impact of a price floor are gathered in Figures 19 and 20 of Appendix E.4, showing its effects for firms that initially buy and sell WMP respectively,

As aforementioned, the price floor would in our theory have no impact on downstream dairy product markets, because firms sell the same quantity in both equilibria with and without a price floor.

Upstream, the price floor induces similar effects for both types of firms: increasing prices and quantities on raw milk markets. Setting a price floor – at an efficient level - mechanically modifies the milk supply curve faced by manufacturers. At the price floor level, milk supply becomes flat, and so does the marginal cost of manufacturers. This implies that manufacturers' buyer power is diminished: they become price takers on the first units of raw milk purchased, at a price equal to the price floor. At some point, raw milk supply intersects with the price floor level, and the marginal cost curve jumps and becomes increasing again. This intersection determines the new and larger quantity of milk purchased by manufacturers.

Figure 19: Price Floor - WMP Buyers



The surplus of milk purchased is - in this simple world - sold on commodity markets. This implies that firms that were initially purchasing WMP have substituted it with raw milk, and are now WMP sellers.

As the rest of the analysis, partial equilibria described on Figures 19 and 20 rely on the exogeneity of the commodity price. One could consider that setting a price floor on raw milk in France, leading - according to our theory - every French manufacturer to produce and sell WMP, has the potential of decreasing the WMP world-price. In such case, French manufacturers would endogenously adjust their behaviors downstream, selling more final dairy products to equalize again marginal revenues on such product with the commodity price. These adjustments would suppress the dichotomy between upstream raw milk markets and downstream dairy product markets, making the price floor on raw milk even more welfare-enhancing. Indeed, it would then decrease dairy products prices as well as increasing raw milk prices. In such case, both markdowns and markups would be decreased.

Figure 20: Price Floor - WMP Sellers