# Markups and Markdowns in the French Dairy Market

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November 15, 2022

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**Abstract**

Separately measuring firm buyer and seller power is important for policy-making, but challenging. In this paper, we suggest a new methodology to do so and apply it to French dairy processors. These firms exert buyer power when purchasing raw milk, and seller power when marketing dairy products. The analysis is based on plant-level data on dairy firms, with observations on prices and quantities of raw-milk input by origin and output by product from 2003 to 2018. We rely on a production function approach to estimate total margins. The existence of a commodity, (i) substitutable as an input or as an output, and (ii) exchanged on global markets where firms are price-takers, allows us to separately estimate firm-origin markdowns and firm-product markups. We show this methodology can also be useful in other contexts, with more limited data. 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 41%. Our results show substantial variations in the exploitation of buyer and seller power across firms, products, and time. We analyze how exogenous farmer and processor cost shocks pass through the supply chain. Processors partially absorb such shocks by adjusting markups and markdowns, thus smoothing variations in farmer revenues. It further implies that 65% of subsidies are currently diverted from farmers due to processor buyer power. A price floor on raw milk could be an alternative welfare-improving policy.

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

**JEL Classification:** L11, L13, D21, D43

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We are grateful to Marie-Laure Allain, Claire Chambolle and Francis Kramarz for their advice. We also thank Philippe Choné, Gregory Corcos, Basile Grassi, Samuel Kortum, Isabelle Méjean, Monica Morlacco, Michael Rubens, Frederic Warzynski, and Horng Wong. The paper also benefited from feedback from participants at CREST, INRAE, and Sciences Po seminars, and at BECCLE, EARIE, EEA-ESEM, JEI, and RES 2022 conferences. This research benefited from financial support from the ANR "Investissements d'avenir" program under the ANR grant ANR-18-EURE-0005 (EUR DATA EFM).

# 1 Introduction

Market power (MP) has detrimental consequences for economies. It reduces consumer welfare, generates resource misallocation, and distorts value-added sharing in supply chains. MP comes from a firm's ability to sell outputs at a high price (*i.e., imposing a markup*) as well as its ability to purchase inputs at a low price (*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 other is 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 (i) suggesting a new methodology to separately identify buyer and seller power, and (ii) applying it to French dairy processors. The suggested approach is especially relevant to study processor MP in food supply chains. In most such chains, processors are central: they purchase raw material from farmers and process it in final products sold to retailers or intermediate products sold to other processors. In such contexts, and as pointed out by Sexton (2013), processor buyer and seller power are a concern given supply chain structures favorable to their joint emergence. Indeed, most food industries feature at least one of the following characteristics: (i) asymmetric concentration between atomistic farmers and concentrated processors, (ii) transportation costs creating segmented local markets, and (iii) increasing product differentiation along the supply chain. In Section 2, we show the prevalence of all these features in the French dairy market.

Guided by these features, we build a structural model of multi-source and multi-product processors, exploiting buyer and seller power. The model is introduced in Section 3. It allows us to identify firm-origin-product level margins of French dairy processors, 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. This margin arises from overall MP. The *markdown* is the wedge between the net marginal revenue generated by the raw material (milk in our application) and the price paid by the firm. This markdown arises from buyer power. Finally, the *markup* is the wedge between the price of a product and its (economic) marginal cost. This markup arises from seller power. Due to buyer power, margins and markups differ. This difference stems from the fact that buyer power creates an *opportunity cost* of buying an additional unit of raw material (milk), appearing in the marginal cost but not in the accounting marginal cost.[1]

In order to estimate the model, we exploit a *cost-side approach*, building on pioneering 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.

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 input.[2] Balance sheet data contain labor and capital expenses of processors at the firm-level. In the technical data, we observe the dry matter content of milk intermediate consumption and processed output at the product-level.[3] Importantly, this information reveals what quantity of milk input is needed to process a unit of each dairy product. This is a crucial point as allocating inputs observed at the firm-level is the main challenge to multi-product production function estimation.[4] Our estimates are first based on the estimation of accounting marginal costs, which in our setting are the sum of (i) purchasing costs of raw milk and other pre-processed

[1]The distinction is analogous to the one between price and marginal revenue in presence of seller power.

[2]A raw milk origin/market in the analysis will be one of the 85 French *départements* producing milk.

[3]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.

[4]We view the use of such technical coefficients, which can be easily obtained, as an interesting tool for similar multi-product production function estimation in food processing.

milk-inputs and of (ii) processing costs. Together production and technical data first allow us to estimate milk-input buying costs at the firm-origin-product level. We then use production and balance sheet data to estimate marginal processing costs at the firm level, following the literature estimating production functions.[5] Having quantity and price data on both the input and output sides helps us overcome issues stressed by the literature, such as revenue data bias, input price bias, or price endogeneity due to MP upstream and downstream.[6] Overall, we recover *margins and accounting 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 suggest an approach hinging on firm arbitrage conditions and the existence of international commodity markets. In our application, we use the whole milk powder (henceforth WMP) market. WMP is (i) bought (resp. sold) by dairy firms without buyer (seller) power and (ii) substitutable with raw milk (with other dairy products sold). The price of WMP is set in global markets, so that the 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 WMP. In such multi-input and multi-product settings, the international price of a relevant commodity thus offers an empirical moment that helps separately identify markups and markdowns. The identifying assumption thus differs from Rubens' (2021) who relies on input supply estimation.[8] Conversely, our estimating framework allows us to remain agnostic on the exact competition structures upstream and downstream. This element of our analysis is crucial, as competition faced by dairy firms varies across markets and time.[9] Such variation is also an interesting feature of a broad set of applications.

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

[9]Regarding the evolution of competition in the French dairy market, we especially detail regulatory changes in Appendix A.2.

The results presented in Section 5 indicate that dairy firms generate an average margin rate of 56%.[10] This margin consists of a markdown rate of 19% and a markup rate of 41% implying that dairy firms on average 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 41%. These weighted averages however hide substantial heterogeneity across firms, products, and time. The product variability is far from 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, although the average total margin is relatively stable over time, the average contributions of markups and markdowns vary substantially over time. The average markdown rate fluctuates between 4% and 40% while the average markup rate lies between 27% and 61%.

We explore this time variation by analyzing how shocks (i) to the international WMP price and (ii) to French dairy farmer costs, spread differently through the supply chain. A reduced-form analysis reveals *incomplete pass-through* on raw milk and dairy products prices, that our model rationalizes by processor MP. Processors partly absorb such exogenous shocks affecting farmer revenues through adjustments in raw milk prices. Induced markdown variations reveal changes in the ability of processors to extract rent from farmers due to a *non-constant raw-milk supply elasticity*. Shocks then differently spread down the supply chain depending on the nature of competition in the output market, highlighting again the role of MP in shock transmission. On competitive intermediary products, processors cannot increase prices to transmit local farmer cost shocks. On final products, processors are able to transmit cost increases to retailers via markup increases. Overall, margin variations are mitigated through compensating markdown and markup adjustments.[11]

[10] Margin, markup, and markdown rates correspond to percentage deviations of each of these objects from 1, which would be their value prevailing in the absence of MP. The average rates presented here are weighted averages, based on dry matter content quantity weights.

[11] We here contribute to the literature studying pass-throughs to assess seller power (Nakamura and Zerom, 2010; Weyl and Fabinger, 2013; Bergquist and Dinerstein, 2020) *or* buyer power (Zavala, 2020). An important implication of the joint exploitation of buyer and seller power is that complete pass-through to downstream prices occurs (i) under no or constant markups *and* markdowns, but also if (ii) markups and markdowns adjust in fully offsetting ways. Both points show the importance of disentangling buyer and seller power.

The paper's contributions are highlighted in Section 6. Our first contribution is methodological and twofold. We first show the importance of taking into account processor buyer power. In particular, we would have overestimated markup rates by 37%, had we ignored buyer power and attributed the entire margin to seller power, as the production function approach traditionally does.[12] Our findings suggest that such estimated *markups* should be viewed as *margins*, coming from price-setting power *on both sides*, if there is reason to suspect buyer power in the sector of study. We demonstrate that distinguishing both is crucial (i) for understanding pass-throughs along supply chains, as markups and margins differently react to costs shocks, and (ii) because markdown adjustments alone make some support policies, e.g. farmer subsidizing, largely inoperative.

We also suggest *a new solution to disentangle buyer and seller power*, flexible enough to be applicable in other contexts. As mentioned, our approach relies on the existence of an input *or* output that (i) is substitutable with the input or 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) to recover its importance on another (e.g labor).[13] The proposed approach follows a similar logic but at a more disaggregated level and *can be applied* to both input and output sides. It exploits the existence of commodity markets where price-setting power can be assumed absent in a less *ad hoc* way. As such, the methodology can be applied in many industries where similar commodity markets exist and in which processor buyer and/or seller power is a concern.[14] Finally, our - to this extent - *sufficient-statistic* approach does not require estimating supply or demand, making it suitable for many industries in setting with varying competition.[15]

[12]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), in contexts in which buyer power is less a prevalent concern (but could be present), to which we compare in Section 6.1.1.

[13]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.

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

[15]These points are further discussed in Section 6.1.2.

Our second contribution is to quantify both buyer and seller power of French dairy processors, which constitute a significant concern for regulating authorities but had never been estimated in a unified framework.[16] Our results demonstrate that dairy firms exploit both buyer and seller power, and neither is negligible.[17] It has important implications. First, through sole markdown adjustments, processors partially absorb shocks to commodity prices and to farm costs, smoothing variations in farmer profits but also impeding farmers from benefiting from positive downstream demand shocks. Second, also due to buyer power alone, 65% of the subsidies currently paid to farmers are diverted through raw milk price adjustments. Our results thus call for alternative policies aiming at promoting farmer countervailing seller power or for a price floor on raw milk, as such policies could be welfare-improving.[18]

Our work contributes to the literature analyzing MP in food supply chains, reviewed by Sheldon (2017). Importantly, he explains that, if this literature has long theoretically identified the importance of jointly studying buyer and seller power 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".[19] 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. [20] A recent development literature also studies MP issues, often relying on randomized or natural experiments for identification and focusing on one source of MP (buyer or seller power) in specific contexts.[21] Our work can thus contribute to evaluating/understanding both MP forces exerted by intermediaries in global food value chain sourcing in developing countries.

[16]Related papers studying MP in dairy supply chains consider processor 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 processors-retailers relationships.

[17]Buyer power was expected given the industry setting. Our results however also demonstrate processors' ability to generate high markups despite retailer countervailing buyer power.

[18]We thus complement Russo et al. (2011), theoretically showing the value of price floors in similar settings.

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

[20]Most relatedly, as Wong (2019) and Yeh et al. (2022), Tortarolo and Zarate (2018) explicitly authorize and quantify both markups and labor markdowns. They estimate total MP through a production function approach similar to ours but pin down labor markdowns with an estimation of labor supply elasticities.

[21]See Cajal-Grossi et al. (2019); Bergquist and Dinerstein (2020); 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 in Ecuador, however ignoring exporter seller power.

# 2 Data and Key Facts on the French Dairy Market

We first introduce our data before detailing general facts on the French dairy market in order to provide the reader with some important background suggesting the existence of processor market power.[22] Appendix A complements this static picture with the recent evolution of the market motivating our approach, which is agnostic about the form of competition.

## 2.1 Data

Our analysis rests on several key datasets.

We first use data provided by the French Ministry of Agriculture[23]: 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.

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.[24] 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 *département*. Thanks to the EML, we are able to observe firm-*département* prices paid for raw milk, for a subsample of firms and from 2013 to 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.

We also use *dry matter content* (DMC) data jointly produced by the *Centre national in-*

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

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

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

*terprofessionnel 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.[25] 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.

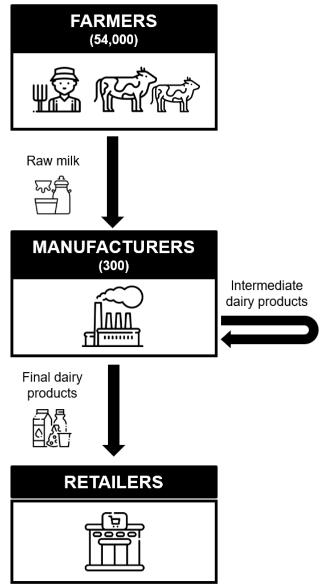
## 2.2 Industry Setting

The dairy industry remains an important sector of the French economy, generating around 40 billion euros in 2018. 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.[26] The share of PDO milk (10%) is constant during the period whereas the organic milk share increased from 0.5% in 2000 to 3.5% in 2018.

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

The French dairy supply chain is typically organized along a vertical structure described in Figure 1. At the top of the chain, 54,000 farmers[27] produce raw milk. They sell milk to processors 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. Processors then reach final consumers through wholesalers and retailers. Both processors and distributors are thus necessary intermediaries for most farmers to sell their production, as direct sales of dairy products by fully integrated structures are rare.

**Figure 1: The Dairy Value Chain (2018)**




The dairy supply chain has unique features 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 until it is collected by a single manufacturing plant which (in many instances) owns the tank. The processor is in charge of collection via 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 processed by processors in order to produce either final goods (milk, cheese, butter, cream, yoghurts) sold to retailers (75% of processed milk) or intermediate products (milk powder, butter, cream) used in the dairy industry or in other

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

food industries (25%). These intermediate products are directly exchanged between firms or traded through global commodity markets, where prices are determined by quotations. Over 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 processors are either private (45% of processed milk) or cooperative companies (55%). While most of the private firms are gathered into large business groups, some cooperatives have also become prominent actors in this industry.[28]

## 2.3 Key Facts Suggesting the Existence of Buyer and Seller Power

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

### 2.3.1 Buyer Power: Asymmetric Concentration and Local Markets

As mentioned, milk production remains very dispersed in France (54,000 farms in 2018) while downstream manufacturing is concentrated (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 extreme asymmetry; atomistic raw milk supplier face demand from very concentrated actors, favoring the emergence of buyer power.

[28] 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 département level* | | | | | | | | |
| Median | 8 | 406 | 46 | 73 | 88 | 95 | 98 | 100 |
| Average[a] | 13 | 1,588 | 43 | 67 | 81 | 89 | 93 | 98 |

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

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

Characteristics of the raw milk collection process imply that the French raw milk market should 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 *département*. This (observed) *département*-level quantity-weighted average is an imperfect approximation of the relevant potential set of buyers for a given seller, which essentially depends on the distance to the plant of each of the surrounding buyers in the *département* and in the neighboring ones. It remains however instructive on the order of magnitude in competition between buyers 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 *département* Herfindahl-Hirschman Index (HHI) is above 0.25.[29] Local milk markets can thus be considered as *highly concentrated*, according to US Antitrust Department' or European Commission' guidelines.

[29]See Figure 21 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 processors also represent highly concentrated *sellers*, the top 5 processors alone accounting for two third of the national market, and 72% of the median product market.[30])

French dairy firms may exploit market power when selling differentiated dairy products as they are very concentrated, with a few global players.[31] 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.[32]

[30]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.

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

[32]We refer interested readers to Villas-Boas (2007); Allain et al. (2020) among many other papers. Our theory acknowledges 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 relies, in its basic version, on two assumptions about processors: (i) they produce dairy products according to a Leontief production function and (ii) they maximize their variable profits by internalizing their effects on prices up- and downstream. This setup enables 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[33] $f$ combines milk intermediate consumption $m_{fij}$ - possibly coming from various markets $i$ - with its processing technology. The production function is given by:

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

The production technology is a combination of two extremes. Through the *Leontief form*, we assume perfect complementarity between the required milk input 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 $e_{ij}$ as the required quantity of milk input $i$ to produce a unit of dairy product $j$. Through *linearity* in combining milk inputs from various markets $i$, we assume that they are perfect substitutes for producing product $j$, given technical coefficients $e_{ij}$. A processor thus only needs one type of milk input, but may use a variety of perfectly substitutable inputs.

The processing technology is common to all processors and is 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 a firm's use of labor $L_f$ and capital $K_f$. Finally, $\Omega_f$ characterizes the ability of firm $f$ to process goods. More precisely, $L_f$ and $K_f$ can be defined as vectors of labor and capital quantities used for

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

every product, while $\Omega_f$ can similarly be a vector of firm-product level efficiencies. Writing $F_j(.)$ as a function of firm-level labor and capital quantities enables us to capture *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 processors. The latter are traded through global and regulated markets, as we 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 detail in Section 4.2.4. 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 processor 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, in the sense that they only affect current profits, thus ruling out adjustment costs. We similarly assume labor to be variable, implying costless labor adjustment.[34]

Finally, and standard in this literature, capital evolves from previous investments $I_{ft-1}$:

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

$\delta$ is the depreciation rate.

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 discuss this point in Appendix C.2.1.

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

## 3.2 Variable Profit Maximization

A processor $f$ maximizes its current variable profit. Firm $f$ can be multi-source and multi-product: milk inputs $i$ are sourced from a market set $\mathcal{I}_f$ and products sold $j$ belong to $\mathcal{J}_f$. Both sets are defined one period ahead by firm $f$.[35]

For each pair $(i,j)$, firm $f$ optimally chooses the 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.[36] This yields the following program:

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

where $L_f$, $K_f$ and $\Omega_f$ respectively are vectors of $l_{fj}$, $k_{fj}$ and $\omega_{fj}$ , $\forall j \in \mathcal{J}_f$, other terms being simple scalars.

Firm $f$ can exploit market power by internalizing its quantity effects on prices through the inverse demand it faces for product $j$, denoted $p_{fj}\left(y_{fj}\right)$, and the inverse supply curve it faces 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

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

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

yields:

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

where the demand price-elasticity of $j$ is

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

the supply price-elasticity is

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

and $\lambda_{fj}$ is the marginal processing cost (MPC) of product $j$. This MPC stems from variable processing cost minimization for a given production level.[37] We provide derivation detail in Appendix C.1.2.

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 $1+\varepsilon_{fj}^{D\;-1}$.

Due to the existence of buyer power on market $i$, the marginal cost $MC_{fij}$ can be written as:

$$MC_{fij} = \left(1+\varepsilon_{fi}^{S\;-1}\right)w_{fi}e_{ij}+\lambda_{fj}. \tag{3}$$

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

$$AMC_{fij} = w_{fi}e_{ij}+\lambda_{fj}. \tag{4}$$

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 $1+\varepsilon_{fj}^{S\;-1}$ scales up the price of a unit of raw milk in the marginal cost expression. In contrast, the

[37] It can also be defined as the Lagrangian multiplier, associated to the processing capacity constraint, of the reduced profit-maximization problem, in which milk capacity constraint is already satisfied.

*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 $\lambda_{fj}$.

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

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

As extensively explained 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:*

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

This expression is derived from Equation (2). It links the ratio between price and the marginal cost of production with the demand elasticity: the less elastic is the demand (higher $\varepsilon^{D}_{fj}$) the higher is the markup. Under perfect competition on output $j$, the markup would be equal to one.

#### 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:*

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

This definition is derived from Equation (2), similarly to Definition 1. As expected, a firm's upstream market power depends on the supply elasticity: the less elastic is the supply, the higher is the markdown. Under perfect competition on input $i$, the markdown would be equal to one. Due to perfect complementarity between milk and other inputs, the production of an additional unit of output $j$ requires an extra processing cost $\lambda_{fj}$. 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, in the numerator, the marginal contribution to profit of an additional unit of *input* $i$ to product $j$. Note that despite the multi-product setting, firm optimizing behavior requires markdowns on a given input 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:*

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

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

$$M_{fij} = \left(\theta_{fij}\nu_{fi} + (1-\theta_{fij})\right)\mu_{fj} \tag{5}$$

where $\theta_{fij} \equiv \frac{w_{fi}e_{ij}}{w_{fi}e_{ij}+\lambda_{fj}}$ 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 the overall market power of a firm. Under perfect competition on input $i$ and output $j$, the margin would be equal to one. Deviations from perfect competition on either the input or the output market lead the margin to deviate from one. 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 translates into $\theta_{fij}$. 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.[38]

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

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

## 3.4 Assumptions

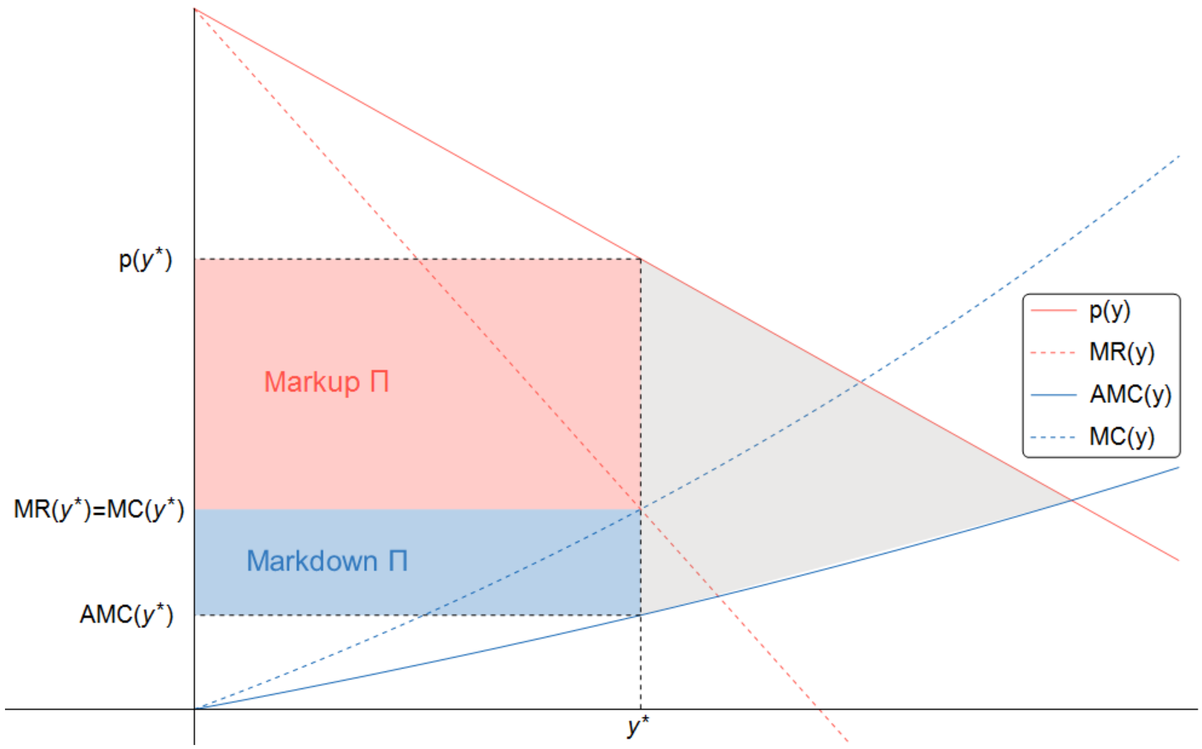
For the sake of simplicity, the theoretical framework presented here is kept as simple as possible in order to derive markups, markdowns, and margins, in a consistent way. It relies on some assumptions that are relaxed in Appendix C where we show how (i) we can rely on cost minimization only, (ii) we can incorporate intra-brand competition or (iii) horizontal collusion or vertical cooperation can be allowed.[39] Importantly, these extensions would not change our 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. Firm behaviors can thus take more complex forms than outlined here, as further explained in Appendix C.1.3.

## 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, here we 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.

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

**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 (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 redistribute from farmers and consumers to processors. The total rent captured by processors 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 in Figure 2, we do not aim to compute the deadweight loss (in grey), nor to generate counterfactuals. However, variations of estimated equilibrium objects across time and markets will give a sense of the underlying shape of demand and supply curves, and imply 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,

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

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 $\lambda_{fj}$. 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 $e_{ij}$, 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 sum to get *dry matter* *contents*. This methodology is commonly used by practitioners in the industry, which guarantees the quality and availability of the data. These measures give us $e_j$, the dry matter per unit of output $j$, observed at the CN8-level (and for some products slightly more disaggregated). These measures also give us $e_i$, the dry matter per unit of input $i$, observed at the *département*-year level for raw milk and at the CN8-level for dairy intermediates. Together, $e_j$ and $e_i$ allow us to construct $e_{ij} = \frac{e_j}{e_i}$, which represents the quantity of input $i$ needed per unit of product $j$ produced.

**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 | 1 |

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 *département* 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 département*, 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[40] while $e_j$ are not. Table 3 illustrates the substantial heterogeneity in milk requirements $e_j$ across dairy products[41] and the importance of taking it into account. Dry matter contents $e_i$ exhibit less variation across *départements* (and time), lying between 5.60 and 8.19 grams per 100 grams, for every French *département* during the

[40] Time subscripts are dropped here to simplify notations.

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

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 processors use fat or protein leftovers from the production of a given product in the production of other products. In doing so, they exploit complementarities in the production of several dairy products regarding the use of milk. Assuming 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 Marginal Processing Costs Estimation

We describe here our identification and estimation methodology for milk marginal 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 explained in Appendix D.2.1.

**Identification of Milk Marginal Processing Costs** 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 $\omega_f$. In our preferred specification, we assume the following Cobb-Douglas milk processing function:[42]

$$\ln y_f = \ln F(.) = \beta_l l_f + \beta_k k_f + \omega_f, \tag{6}$$

where we drop time subscript again to simplify notation.

[42] In Appendix D.2.3, we compare the resulting estimated elasticities with the ones obtained with a Translog specification and to the empirical labor shares. We rely on the Cobb-Douglas functional form as a baseline as the coefficients estimated with a Translog exhibit very high (bootstrapped) standard errors. All empirical results however pertain using both specifications.

The firm-level quantity is obtained by summing quantities produced across products, where all quantities are expressed in the same unit (kilograms).[43] We thus have:

$$y_f = \sum_j y_{fj}.$$

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:

$$\lambda_f = \frac{Z_f L_f^*}{\beta_l y_f^*}. \tag{7}$$

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

**Estimation Procedure** In order to estimate the processing function, we follow the seminal literature, Olley and Pakes (1996), Levinsohn and Petrin (2003), and Ackerberg et al. (2015), who 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, *i.e.* firms exploiting MP on both sides of the market. We describe this approach in Appendix D.2.2.

[43] Note that this is equivalent to summing revenues across products and deflating by a price index that is the weighted average price. Indeed:

$$\frac{\sum_j p_{fj} y_{fj}}{\overline{p}_f} = \sum_j y_{fj} \iff \overline{p}_f = \sum_j p_{fj} \frac{y_{fj}}{\sum_j y_{fj}}.$$

**Estimates** We present in Table 11 in the Appendix our processing functions estimates for several specifications, including plain OLS and GMM, for our preferred Cobb-Douglas processing function specification.[44] All coefficients (i) are close to findings in the literature and (ii) confirm the importance of correcting for endogeneity.

The labor elasticity of output (0.739) is between the one found by Rubens (2021) (0.591) - who assumes a similar Leontief production function, though applied in a different context - and De Loecker and Scott (2016) (0.75), who have a Cobb-Douglas production function. Capital elasticities are less stable in the literature. Ours differs from Rubens (2021), who estimates 0.59 but is closer to De Loecker and Scott (2016), who estimate 0.30.[45] Using our estimates of $\beta_l$ and equation (7), we can recover marginal costs at the firm-level.

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

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

Having marginal processing cost and thus margins estimates in hands, we show here how we recover markups and markdowns of French dairy processors.

## 4.2 Disentangling Markups and Markdowns

In this section, we first highlight intuitions on how to separately recover a firm's markups and markdowns through its sales or purchases on a global commodity market. We then formally explain the identification, before detailing its empirical implementation using the whole milk powder (WMP) market. We conclude this section by discussing identification robustness.

[44]Appendix D.2.3 also presents results for a Translog specification, conducted as a robustness check.

[45]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.

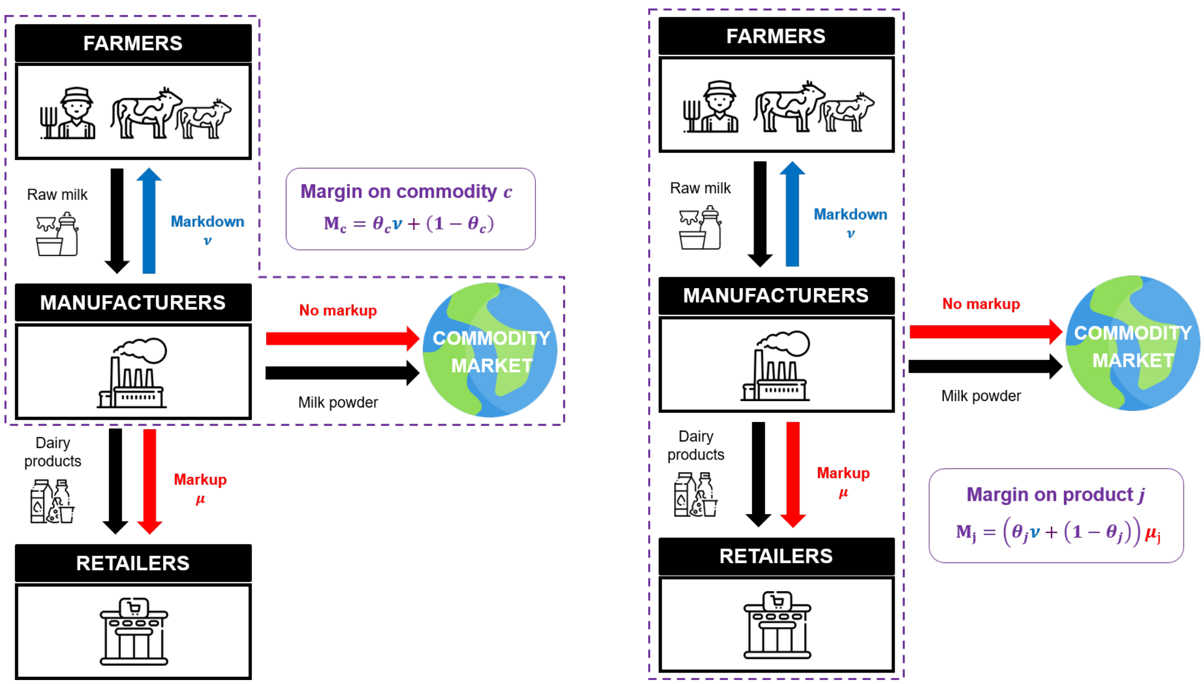
### 4.2.1 Intuition

The intuition for identification of markups and markdowns is based on Equation 5, repeated here for convenience:

$$M_{fij} = (1 + \theta_{fij} (\nu_{fi} - 1)) \mu_{fj} \tag{5'}$$

where $\theta_{fij} \equiv \frac{w_{fi} e_{ij}}{w_{fi} e_{ij} + \lambda_{fj}}$ is the share of milk from $i$ in the *accounting* marginal cost of producing $j$. As mentioned, once $\lambda_{fj}$ is approximated by $\lambda_f$, we obtain estimates of $M_{fij}$ and $\theta_{fij}$. As Equation 5 holds for every source market $i$ and product $j$ in 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 have price-setting power.

**Figure 3: Identification Intuition - Commodity Sellers**




(a) Markdown (b) Markup

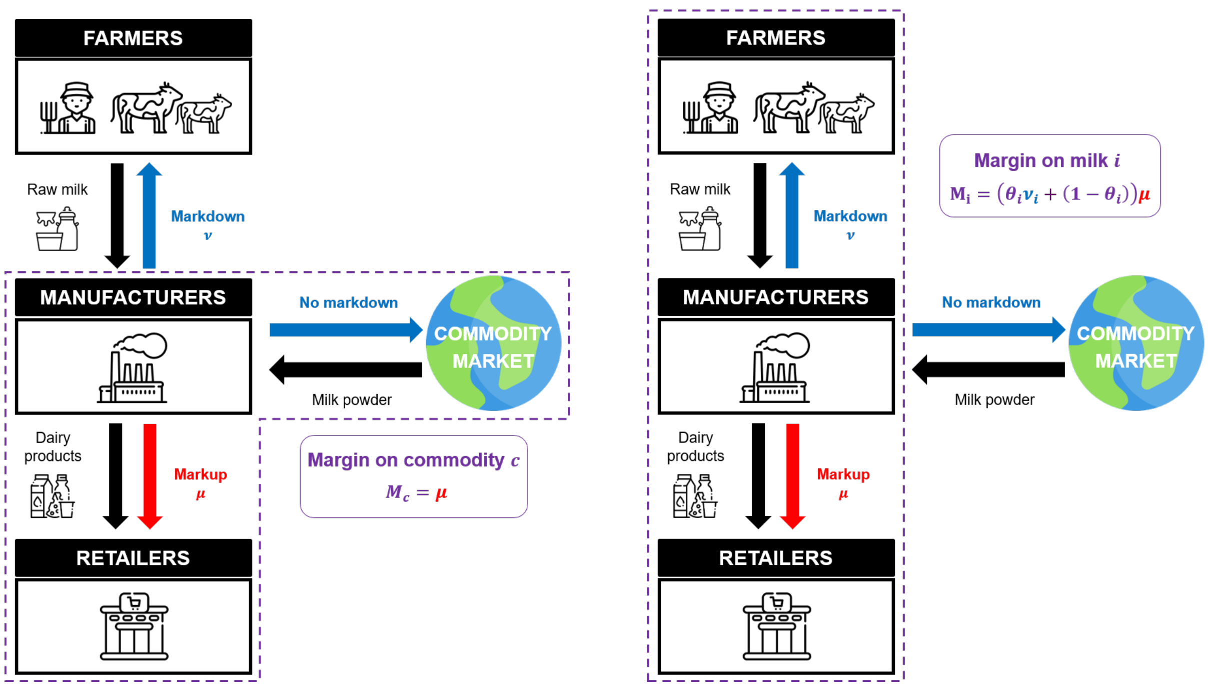
Figure 3 provides the intuition for identification in the case of processors selling on at least two markets, including one where they do not have seller power. For simplicity, we take a particular firm sourcing milk on a single market, allowing us to drop the corresponding subscripts. This firm has buyer power and a markdown $\nu$ on its milk market. In contrast, when such a firm sells on a market $c$, where it has no seller power ($\mu_c = 1$), its margin $M_c$ is only determined by the markdown:

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

As $M_c$ has previously been estimated, inverting the equation above allows the identification of the markdown $v$. Using Equation 5, we can then recover markups $\mu_j$ for all other products $j$ sold by the firm, by inverting:

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

**Figure 4: Identification Intuition - Commodity Buyers**




(a) Markup (b) Markdown

Figure 4 provides similar intuition for identification in the case of processors 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 us to drop the corresponding subscripts. This firm has seller power and a markup $\mu$ 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 determined by the markup:

$$M_c = \mu_c.$$

As $M_c$ has been estimated, the equation above directly delivers the markup $\mu_c$. Using again Equation 5, we can then recover markdowns $\nu_i$ for all other milk inputs $i$ the firm purchases, by inverting:

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

#### 4.2.2 Identification

We here detail the exact identification of markups and markdowns for firms that either buy or sell a commodity, namely whole milk powder (WMP), on which they are price-takers. Identification relies on processors trading off between using (resp. producing) WMP or using raw milk (producing another dairy product) on which they exert buyer (seller) power.[46]

According to our theory, a firm can either be a seller or a buyer of WMP, 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 WMP while some do not, as it reflects the ability of the former to process WMP at a marginal cost lower than the WMP price.

In what follows, the WMP price is denoted $w_c$. Similarly to what we do for technical coefficients $e_{ij}$, we also define $e_{ic} = \frac{e_c}{e_i}$ and $e_{cj} = \frac{e_j}{e_c}$, where $e_c$ is the dry matter content of WMP, observed in the data.

**Identification for WMP Sellers** Here, identification stems from the fact that a firm is indifferent, for the marginal unit of milk purchased in a given market $i$, between using it to produce WMP, sold at exogenous price $w_c$, and using it to produce another product.

[46] In Section 4.2.4, we explain to what extent we can extend the identification to firms that are inactive on the commodity market.

Formally, identification relies on two first order conditions: with respect to the use of milk input $i$ for producing and selling WMP,

$$\underbrace{w_c}_{\text{marginal revenue } MR_{fc}} \quad = \quad \underbrace{\nu_{fi} w_{fi} e_{ic} + \lambda_f}_{\text{marginal cost } MC_{fic}} , \tag{8}$$

and with respect to the use of the same milk input $i$ for producing another product $j$,

$$\underbrace{p_{fj} \mu_{fj}^{-1}}_{\text{marginal revenue } MR_{fj}} \quad = \quad \underbrace{\nu_{fi} w_{fi} e_{ij} + \lambda_f}_{\text{marginal cost } MC_{fij}} . \tag{9}$$

We directly get markdowns from (8), while (8) and (9) together identify markups:

$$\nu_{fi} = \frac{(w_c - \lambda_f)}{w_{fi} e_{ic}}, \ \forall\, i \quad \text{and} \quad \mu_{fj} = \frac{p_{fj}}{(w_c - \lambda_f)\, \frac{e_{ij}}{e_{ic}} + \lambda_f}, \ \forall\, j.$$

By definition, the markdown is the wedge between the marginal contribution to profit of milk and its price. As apparent in (8), a firm does not have seller power when selling WMP. The exogenous price of WMP ($w_c$), together with marginal processing cost ($\lambda_f$) and technical coefficients ($e_{ic}$), thus directly identifies the marginal contribution to profit of a unit of raw milk from $i$. The wedge between this marginal contribution to profit ($\frac{w_c - \lambda_f}{e_{ic}}$) and the observed price of raw milk ($w_{fi}$) is solely due to buyer power and identifies the markdown.

By definition, the markup is the wedge between the price and the marginal cost of a product. As a firm has buyer power on the raw milk market $i$, an opportunity cost arises from allocating milk from $i$ to produce product $j$ rather than to produce WMP. This opportunity cost, determined by arbitrage conditions stemming from (8) and (9), is proportional to the marginal profit lost when renouncing to selling an additional unit of WMP ($w_c - \lambda_f$).[47] This opportunity cost also shifts depending on relative milk requirements, an additional unit of $j$ requiring $e_{ij}$ units of milk from $i$ that could have been otherwise used to produce $\frac{e_{ij}}{e_{ic}}$ units of WMP. The wedge between the output price ($p_{fj}$) and the implied marginal cost, featuring this opportunity cost ($(w_c - \lambda_f)\, \frac{e_{ij}}{e_{ic}}$) and the marginal processing cost ($\lambda_f$), is solely due to

[47] For every unproduced and unsold unit of WMP, a firm loses $w_c$ but saves marginal processing cost $\lambda_f$.

seller power and identifies the markup.

**Identification for WMP Buyers** Here, identification stems from the fact that a firm is indifferent, for producing the marginal unit of a given product $j$, between using WMP, purchased at exogenous price $w_c$, and using raw milk. Formally, identification relies on two first order conditions: with respect to the use of WMP to produce a given product $j$,

$$\underbrace{p_{fj}\mu_{fj}^{-1}}_{\text{marginal revenue } MR_{fj}} = \underbrace{w_c e_{cj} + \lambda_f}_{\text{marginal cost } MC_{fcj}}, \tag{10}$$

and with respect to the use of milk input $i$ to produce the same product $j$,

$$\underbrace{p_{fj}\mu_{fj}^{-1}}_{\text{marginal revenue } MR_{fj}} = \underbrace{\nu_{fi} w_{fi} e_{ij} + \lambda_f}_{\text{marginal cost } MC_{fij}}. \tag{11}$$

We identify markdowns from (10) and (11), while we directly get markups from (10):

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

By definition, the markdown is the wedge between the marginal contribution to profit of milk and its price. As a firm has buyer power when purchasing raw milk from $i$, an arbitrage arises between using milk from $i$ or using WMP to produce product $j$, stemming from (10) and (11). A firm prefers to buy and use raw milk from market $i$ - where it exerts buyer power - as long as the corresponding marginal cost is below the marginal cost of using WMP. At the optimum, a firm equalizes both marginal costs. It further implies a three-term equality between the marginal contribution to profit of a unit of $j$ ($MR_{fj} - \lambda_f$), the marginal sourcing cost using raw milk ($\nu_{fi} w_{fi} e_{ij}$), and the marginal sourcing cost using WMP ($w_c e_{cj}$). Adjusting by technical coefficients $e_{ij}$ eventually allows us to identify the marginal contribution to profit of a unit of milk from $i$. The wedge between this marginal contribution to profit ($\frac{w_c e_{cj}}{e_{ij}}$) and the observed price of raw milk ($w_{fi}$) is solely due to buyer power and identifies the markdown.

By definition, the markup is the wedge between the price and the marginal cost of a product. As apparent in (10), a firm does not have buyer power when purchasing WMP. The exogenous price of WMP ($w_c$), together with marginal processing cost ($\lambda_f$) and technical coefficients ($e_{cj}$), thus directly identifies the marginal cost of product $j$. The wedge between the output price ($p_{fj}$) and the implied marginal cost is solely due to seller power and identifies the markup.

Appendix D.3 provides additional graphical representations illustrating the main intuitions mentioned here.

#### 4.2.3 Implementation

In our data, we observe and identify which firms sell bulk WMP, and at what price. We take the price on the commodity market as the market price for France, denoted $w_c$ in the equations above, provided by the European Commission (EC) at the yearly level.[48] Contrary to sales, we do not observe firm-level purchases and prices of WMP, leading us to assume that firms which do not sell WMP are purchasers or, as discussed in Section 4.2.4, *potential* purchasers of WMP at the common market price $w_c$.

**The Choice of Whole Milk Powder** As other dairy commodities (butter, cream, or skimmed milk powder), WMP is sold on global markets at a price fixed by a quotation. WMP however features specificities that make it the most relevant commodity to back up our empirical analysis. First, WMP is one of the most internationally traded dairy commodities in the world. The European Union production and consumption shares are however relatively small, about 11 and 15% in 2018.[49] Around 70% of the global production comes

[48] These data can be found here. Alternatively, we could have used the firm-level price at which these firms sell WMP. However, our data do not provide the buyer's identity nor the destination market. As a consequence, we do not know if these firms sell WMP (solely) through the commodity market $c$. In particular, such sales of bulk WMP potentially also encompass sales to other (French) firms in the food industry, that do not go through the commodity market. In order to avoid any identification issues, and maintain consistency with what we do for the identification of WMP buyers' markups and markdowns, we rely on EC market prices. Reassuringly, robustness checks based on the latter deliver similar results, as EC market prices and firm-level prices of WMP are on average very similar over time.

[49] Source: https://apps.fas.usda.gov/psdonline/circulars/dairy.pdf.

from New Zealand, China, and Brazil, New Zealand alone representing 70% of total WMP exports. We can thus credibly assume that French processors have neither 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 essentially dry raw milk. As a consequence, WMP is commonly used as a substitute for raw milk in the production process and enters the composition of many dairy products like yoghurts, milk, or (industrial) cheese.

#### 4.2.4 Discussion

We view the identification for WMP sellers as quite natural. However, WMP is generally not produced by smaller processors, for which we instead rely on the identification based on the use or potential use of WMP as an input.

Such identification relies on WMP as a substitute for raw milk. In practice, WMP can almost always be replaced by raw milk, while using WMP in place of raw milk is not possible for every product (e.g. for raw milk cheese). However, the identification of markups and markdowns of a given firm remains valid as long as this firm relies on WMP as a substitute for raw milk for at least one product, which is a much less restrictive assumption. Processing yoghurts or industrial cheeses with such milk powder is for instance a common practice in the dairy industry. Moreover, substitution between raw milk and WMP only has to be possible on a positive part (and not on the entire part) of the milk input requirement. Finally, in order to avoid concerns about the substitutability between raw-milk inputs, we exclude labeled products (organic and Protected Designation of Origin) from our analysis.

Moreover, and importantly, markdown and markup expressions similar to the ones established for WMP buyers can be derived for firms that are *potential* WMP purchasers but are inactive on the WMP commodity market in equilibrium. The implied micro-foundation hinges on processors and farmers (Nash-)bargaining over the price of raw milk, where processors can rely on WMP to replace local raw milk in case of negotiation breakdown.[50]

[50]See Appendix D.3.2 for further detail.

# 5 Results

In this section, we first show that dairy processors exploit both markups and markdowns, and that, *on average*, processor margins mostly come from markups. We then show that the relative contributions significantly vary across firms, products, and time. Finally, with a complementary pass-through analysis, we connect variations over time to changes in processor ability to exploit buyer and seller power in response to cyclical shocks.

## 5.1 Average and Median Markdowns, Markups and Margins

Table 4 displays average and median markdowns, markups, and margins, over the whole period of analysis (2003-2018) and for different samples.[51]

The weighted 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.[52] While this figure appears relatively low, we document in subsequent analyses that it hides a substantial heterogeneity over time, which has important implications for farmer revenues, as well as for policy.

The weighted average markup equals 1.41, implying that, on average, the unit price of a dairy product sold by a French dairy firm exceeds the marginal cost by 41%. This weighted average markup inflates to 63% 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 are able to impose higher markups, suffering relatively less than smaller sellers from the existence of countervailing buyer power emanating from concentrated retailers.

[51] 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 delivers similar aggregated results for the corresponding period.

[52] Over the rest of the analysis, the weighting scheme is based on dry matter contents of raw milk and of dairy products. Doing so, weighted average markdowns, markups, and margins reflect the weighted average market power imposed on a unit of dry matter content produced in France. Thus, they are to be interpreted as the MP consequences from the French dairy farmer's point of view.

**Table 4: Margins, Markdowns, and Markups - Estimates**

| | Markdowns | Markups | | Margins | |
|---|---|---|---|---|---|
| Sample | All | All Prod. | Final goods | All Prod. | Final goods |
| Average | 1.18 | 1.21 | 1.50 | 1.44 | 1.82 |
| Weighted Average | 1.19 | 1.41 | 1.63 | 1.56 | 1.81 |
| Median | 1.16 | 1.06 | 1.41 | 1.35 | 1.83 |
| Observations | 8,049 | 6,046 | 3,822 | 72,059 | 43,761 |

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 are observed at the group-*département*-time level, markups at the group-product-time level, and margins at the group-*département*-product-time level. Margins computed under an assumption of homogeneous milk sourcing across products for a given firm.

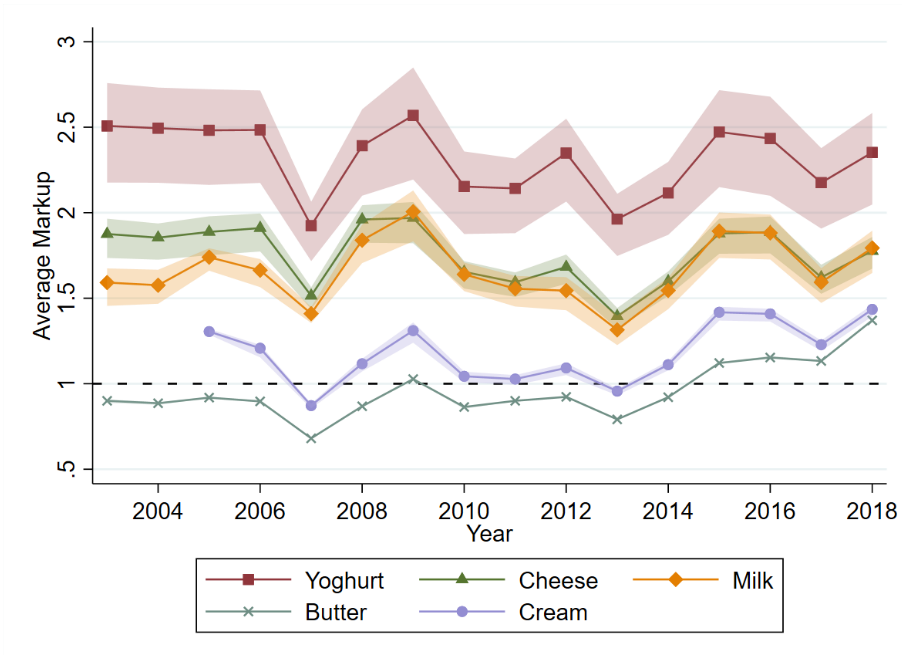
The industry's weighted average margin amounts to 1.56. It means that, on average, the unit price of a dairy product sold by a French dairy firm exceeds the accounting marginal cost by 56%. The difference with the weighted average markup shows the non-negligible contribution of buyer power. Moreover, this weighted average margin goes up to 81% 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 firm margins mainly come from the exploitation of seller power, especially for larger firms. However, these averages hide a substantial amount of heterogeneity along several dimensions we discuss below.

## 5.2 Heterogeneity Dimensions

### 5.2.1 Heterogeneity Across Products

**Figure 5: Markups on Final Consumption Goods - Product Category Averages**



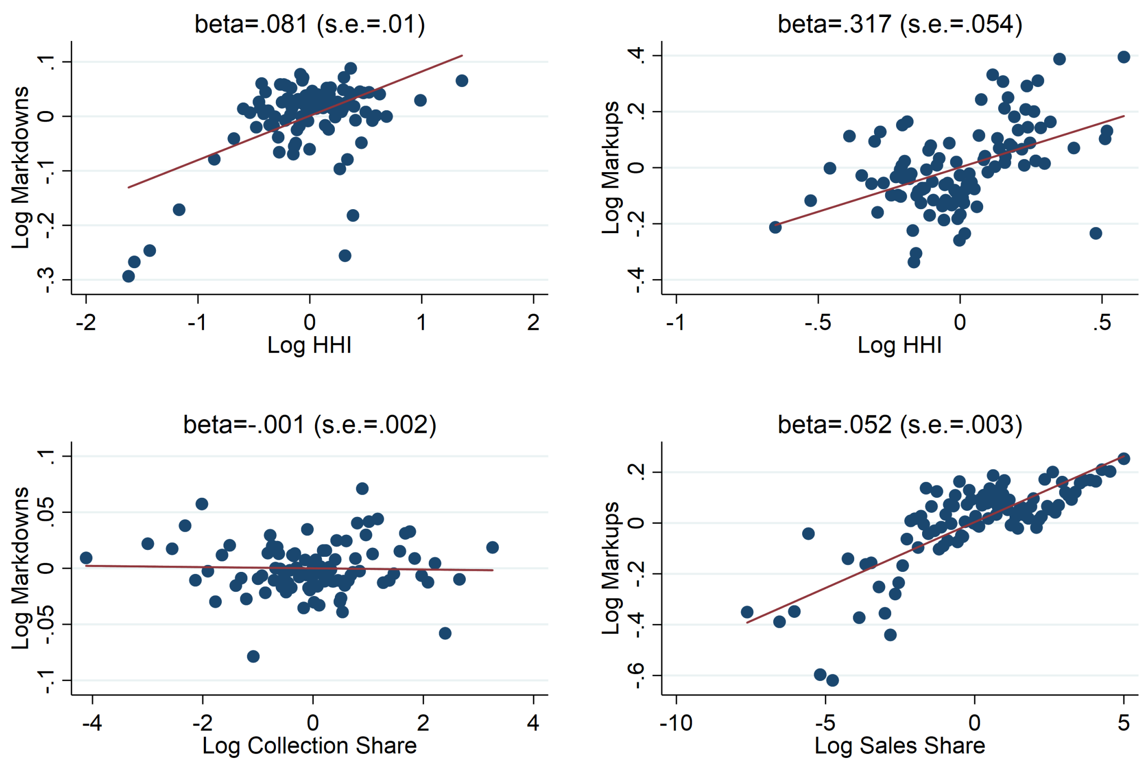

Notes: Weighted averages, using dry matter content quantity weights. Bootstrapped 95% confidence intervals (CI) displayed. CI emanate from errors in the estimation of the marginal processing cost and are thus proportional to its share in the total marginal cost of the considered product. Cream products average not displayed for 2003 and 2004 as products nomenclature does not allow to distinguish final from bulk cream before 2005.

Computing weighted averages by product category shows how markups vary across final consumption goods and the importance of taking this dimension into account. Figure 5 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.[53] As a result, the margin generated on low-markup products like cream merely comes from the markdown, showing the importance of taking both into account. These results show that product positioning can explain a large part of markup heterogeneity between firms, which is neglected when assuming a single-product production function.

[53]Figure 17 in the Appendix display average markups of bulk products.

### 5.2.2 Heterogeneity Across Firms and Markets

**Figure 6: Market Power, Market Concentration and Market Shares**




Notes: Observations at the market-time (up) and group-market-time (bottom) level, grouped into 100 equal-size bins in terms of the X-axis variable. All variables are demeaned by year on the up left-hand graph, by market and year on the up right-hand graph, and by market-year on the two bottom graphs.

Panel 6 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 in 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 firm sales shares within the market. These results are consistent with our interpretation that 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 firm milk collection shares. This result indicates that upstream prices are determined at the market level.

### 5.2.3 Heterogeneity in Market Power Exertion over Time

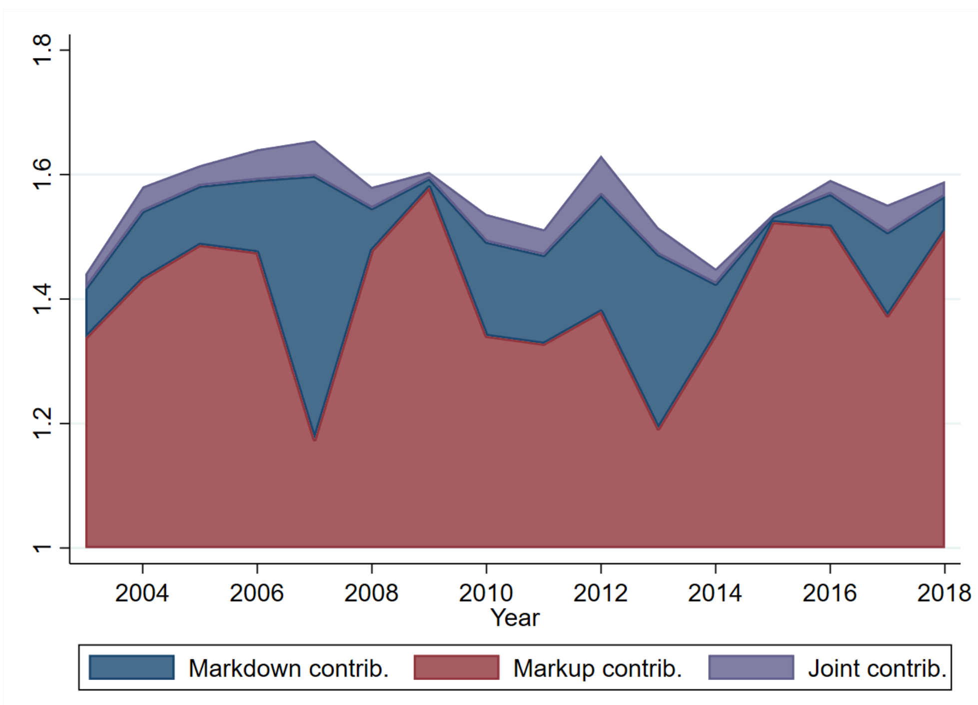
In this subsection, we first show that while dairy processor margins are relatively stable, markup and markdown contributions vary significantly over time.

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 (5) and get:

$$\tilde{M}_{fij} = \underbrace{\theta_{fij}\tilde{\nu}_{fi}}_{\text{Markdown contrib.}} + \underbrace{\tilde{\mu}_{fj}}_{\text{Markup contrib.}} + \underbrace{\theta_{fij}\tilde{\nu}_{fi}\tilde{\mu}_{fj}}_{\text{Joint contrib.}} \tag{12}$$

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

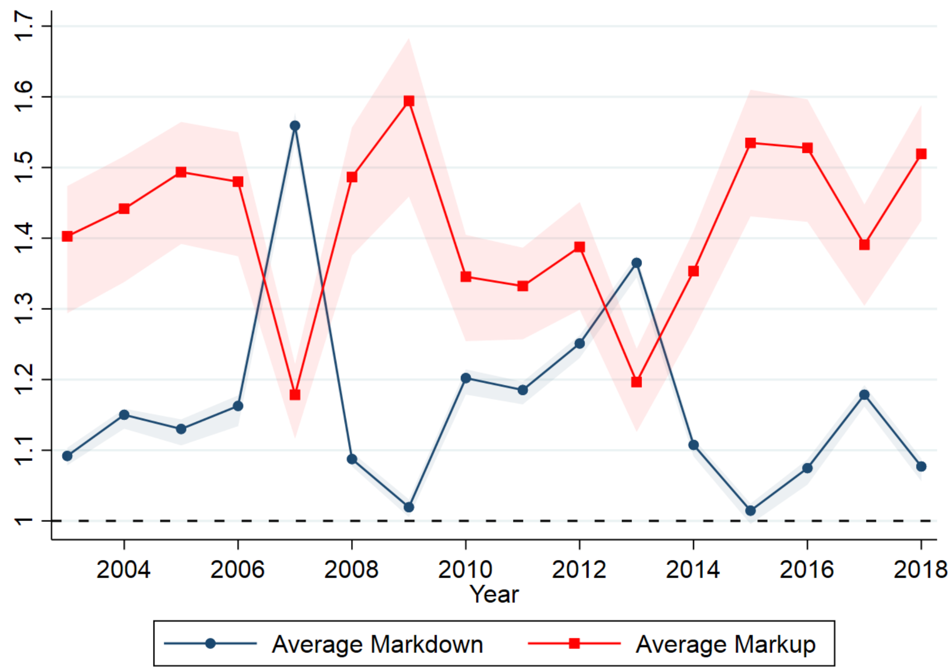
**Figure 7: Margin Decomposition**




Notes: Weighted averages, using dry matter content quantity weights. Weighted average margin computed under an assumption of homogeneous milk sourcing across products for a given firm. The confidence intervals associated with the different objects are not displayed here but can be found in Figures in 8 and 15.

Figure 7 plots the different terms of Equation 12 across time. While the average margin rate remains somewhat stable, around its 56% average 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 in Figure 8. Over the period, the average markdown rate fluctuates between 1% (2015) and 56% (2007), while the average markup rate lies between 18% (2007) and 59% (2009). Our estimates indicate that markdowns are higher than markups for two years of the period of analysis (2007 and 2013).

**Figure 8: Markdowns and Markups**




Notes: Weighted averages, using dry matter content quantity weights. Bootstrapped 95% confidence intervals (CI) displayed. CI emanate from errors in the estimation of the marginal processing cost (MPC), hence the narrower CI for the average markdown where MPC estimates only intervene for WMP sellers.

Overall, we do not find any particular trends in the evolution of total margins over the period of analysis, despite the concentration observed at the manufacturing level in the industry.[54] Multiple factors can explain this. Upstream, processors have incentives not to fully exploit their potentially increasing monopsony power in order to avoid too many exist

[54]See Appendix A.1.

of local suppliers. As shown by Mérel and Sexton (2017), concentration on local markets can - to that extent - even lead to better internalization of such effects by a relatively reduced number of relatively bigger firms. Downstream, the retailing stage of the value chain also is highly concentrated, letting room for countervailing retailer buyer power.[55] Several purchasing alliances also have been created during the period of analysis, possibly reinforcing this countervailing buyer power, and explaining the absence of trends in the aggregate processor markup. Finally, processor concentration is endogenous and may arise in order to preserve margins.

Markups and markdowns appear to be strongly negatively correlated. In the subsequent pass-through analysis, we document the drivers of this relationship.

## 5.3 Pass-Through Analysis

In this subsection, we show with a pass-through analysis that variations in processor MP across time reflect endogenous adjustments following exogenous shocks to (i) WMP price and (ii) farmer costs. Upstream, in response, processors adjust raw milk prices and markdowns when facing raw milk supply curves characterized by non-constant elasticities. Downstream, the pass-through of upstream cost shocks is governed (i) by its incidence on the bargaining between processors and retailers regarding final goods and (ii) by standard perfect competition mechanisms for bulk products sold on commodity markets. To investigate these mechanisms, we proceed in three steps. Based on the model, we first examine the role of MP in shaping pass-throughs. We then leverage our identifying assumption to make pass-through predictions, before analyzing reduced-form results in light of these predictions.

### 5.3.1 Theoretical Pass-Through Predictions

First, we use the model to describe how shocks affect the chain and make predictions on pass-through that would have prevailed under perfect competition.

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

[55] See Appendix A.2.2.

costs:

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

All equilibrium objects are endogenous, which we make explicit here by writing them as functions of any variable $x$.

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

$$\varepsilon_x^{p_{fj}} = \varepsilon_x^{M_{fij}} + \theta_{fij}\varepsilon_x^{w_{fi}} + (1 - \theta_{fij})\,\varepsilon_x^{\lambda_{fj}}, \tag{13}$$

where we, here and hereafter, note $\varepsilon_x^z \equiv \frac{\partial z}{\partial x}\frac{x}{z}$ for $z = \{M_{fij}, p_{fj}, \mu_{fj}, w_{fi}\}$, remembering that $\theta_{fij} = \frac{w_{fi}e_{ij}}{w_{fi}e_{ij}+\lambda_{fj}}$ is the share of milk purchased in market $i$ in the *accounting* marginal cost.[56] We thus see that a shock is passed through 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, starting from the definition of the markup (or equivalently from the first order condition of the variable profit maximization program), repeated here for convenience:

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

This yields:

$$\varepsilon_x^{p_{fj}} = \varepsilon_x^{\mu_{fj}} + \tilde{\theta}_{fij}\left(\varepsilon_x^{\nu_{fi}} + \varepsilon_x^{w_{fi}}\right) + \left(1 - \tilde{\theta}_{fij}\right)\varepsilon_x^{\lambda_{fj}}, \tag{14}$$

where $\tilde{\theta}_{fij} = \frac{\nu_{fi}w_{fi}e_{ij}}{\nu_{fi}w_{fi}e_{ij}+\lambda_{fj}}$ is the share of milk purchases from $i$ in the marginal cost of product

[56] At this stage, variations in $x$ can reflect any modification in market primitives (introduction or modification of a tax/subsidy, other firm-level or industry-wide cost shock, a firm entry, a merger...).

$j$. As expected, the margin adjustment $\varepsilon_x^{M_{fij}}$ appearing in (13) decomposes into a proportional markup adjustment $\varepsilon_x^{\mu_{fj}}$ and an adjustment $\varepsilon_x^{\nu_{fi}}$ of the markdown on raw milk that affects 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 $\varepsilon_x^{\mu_{fj}} = \varepsilon_x^{\nu_{fi}} = 0$), Equation (14) would collapse to:

$$\varepsilon_x^{p_{fj}} = \theta_{fij}\varepsilon_x^{w_{fi}} + \left(1 - \tilde{\theta}_{fij}\right)\varepsilon_x^{\lambda_{fj}}. \tag{15}$$

Comparing Equations (14) and (15) shows how the pass-throughs of economic shocks to upstream and downstream prices crucially depend on *adjustment* of processor markups and markdowns, *i.e* on the terms $\varepsilon_x^{\nu_{fi}}$ and $\varepsilon_x^{\mu_{fj}}$. It echoes a result shown by Weyl and Fabinger (2013): in the presence of seller power, pass-through rates crucially depend on the curvature of demand. Here, due to the presence of buyer power, pass-through rates also depend on the curvature of the supply curve. Note that through $\tilde{\theta}_{fij}$, pass-through also *directly* depends on the markdown *level*.

#### 5.3.2 Pass-Through Identification

**Pass-Throughs under the Identifying Assumption** One can dig further into the theoretical pass-through predictions by relying on our identifying assumption that French dairy processors do not have any price-setting power on the WMP commodity market, and can use WMP as an input or sell it as an output. Focusing on processors which do not sell WMP, thus assumed to be buyers, and starting from markup and markdown definitions for these firms we get:[57]

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

Proceeding as above yields two expressions for the pass-throughs of shocks to the up-

[57]We focus on firms assumed to be WMP buyers for the sake of simplicity. In Appendix E.5, we derive similar expressions for WMP sellers.

stream raw milk price paid by firm $f$ on market $i$:

$$\varepsilon_x^{w_{fi}} = \varepsilon_x^{w_c} - \varepsilon_x^{\nu_{fi}} \tag{16}$$

and to the downstream price of product $j$:

$$\varepsilon_x^{p_{fj}} = \varepsilon_x^{\mu_{fj}} + \theta_{fcj}\varepsilon_x^{w_c} + (1 - \theta_{fcj})\,\varepsilon_x^{\lambda_{fj}} \tag{17}$$

where $\theta_{fcj} = \frac{w_c e_{cj}}{w_c e_{cj} + \lambda_{fj}}$ is the share of WMP purchases in the marginal cost of product $j$.

**Pass-Through Predictions for the Reduced-Form Application** We then focus on the theoretical impact of two particular types of shocks, that we will be able to identify in the data. First, our model naturally delivers insights on the pass-through of shocks in the price of WMP, observes in the data. Rewriting (16) and (17) with $x = w_c$, assuming for simplicity $\varepsilon_x^{\lambda_{fj}} = 0$ we get:[58]

$$\varepsilon_{w_c}^{w_{fi}} = 1 - \varepsilon_{w_c}^{\nu_{fi}} \tag{18}$$

and

$$\varepsilon_{w_c}^{p_{fj}} = \varepsilon_{w_c}^{\mu_{fj}} + \theta_{fcj} \tag{19}$$

Equation (18) shows that markdown adjustments weaken or amplify the pass-through of WMP price shocks to the price of raw milk. In the absence of monopsony power ($\varepsilon_x^{\nu_{fi}} = 0,\ \forall x$), 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).[59]

Equation (19) similarly shows that markup reactions can attenuate or amplify the pass-through to downstream prices. In the absence of seller power ($\varepsilon_x^{\mu_{fj}} = 0,\ \forall x$), the pass-through

[58] Robustness checks (to be added in the Appendix) confirms that $\varepsilon_x^{\lambda_{fj}} = 0$ empirically.

[59] Under perfect competition with finitely elastic supply and demand, the literature has long shown that pass-through (of any shock to marginal cost) under perfect competition is incomplete and governed by the supply elasticity to demand elasticity ratio (see Jenkin (1872)). Here, given the perfect substitutability between raw milk and WMP (dry matter contents), the underlying processor demand is infinitely elastic. As a consequence, perfect competition pass-through equalizes the full pass-trough (= 1), living no role for demand nor supply elasticity.

would be *complete*, to the extent that it would be proportional to the share of the commodity in the accounting marginal cost of product $j$ ($\varepsilon_{w_c}^{p_{fj}} = \theta_{fcj}$).[60]

Second, we consider the pass-through of idiosyncratic shocks in the average French dairy farm costs, for which we will have a good measure, as further explained in the next subsection. Rewriting (16) and (17) with $x = I$, assuming that $\varepsilon_I^{w_c} = \varepsilon_I^{\lambda_{fj}} = 0$, we get:

$$\varepsilon_I^{w_{fi}} = -\varepsilon_I^{\nu_{fi}} \tag{20}$$

and

$$\varepsilon_I^{p_{fj}} = \varepsilon_I^{\mu_{fj}} \tag{21}$$

(20) highlights a stark prediction from our model. Due to adjustments in buyer power exertion, the price of raw milk can respond to variations in farm costs. Without buyer power ($\varepsilon_I^{\nu_{fi}} = 0$), it would be fully determined by the international price of the substitutable WMP input, leaving no role for French dairy farmer costs ($\varepsilon_I^{w_{fi}} = 0$). We further discuss the implication of such a mechanism when going to the empirical results. (21) similarly shows that the pass-through of shocks to French dairy farm costs will be fully determined by markup responses. In contrast, they would not react under perfect competition.[61]

#### 5.3.3 Reduced-Form Pass-Throughs

**Methodology** In order to assess the magnitude of the various adjustments, we estimate the elasticities $\varepsilon_x^z$ for $z = \{M_{fij}, p_{fj}, \mu_{fj}, \lambda_{fj}, w_{fi}\}$ in a reduced-form way, for two types of equilibrium perturbations. We consider variations (i) in the WMP price and (ii) in French dairy farmer costs. To proxy for the latter, we use a French dairy farm cost index computed by the French Ministry of Agriculture since 2005.[62] We consider both types of shocks as exogenous. French dairy farm costs for instance exogenously vary with the international

[60]Note that, by definition, $\nu_{fi} w_{fi} e_{ic} = w_c$ and thus $\tilde{\theta}_{fij} = \theta_{fcj}$, consistently linking (14), (16) and (17).

[61]We here impose for the sake of clarity that $\varepsilon_I^{\lambda_{fj}} = 0$. It is however possible that marginal processing costs $\lambda_{fj}$ co-move with French dairy farm costs, due to inflation for instance.

[62]Consequently, the period of analysis for the pass-through results presented here spans from 2005 to 2018. The French dairy farm cost index is available online here: https://idele.fr/ipampa.

prices of energy or of cow food (cereals, soy...).[63] We then regress the log of equilibrium objects (*i.e.* raw milk prices, markdowns, output prices, markups, and margins) on the log of these two variables. Note that regressions with raw milk and output prices as dependent variables are *purely* reduced-form in the sense that they do not rely on the model nor on estimates, whereas the other regressions involve estimated objects. The regression results are reported in Table 5. Incorporating relevant interacted fixed-effects, we rely on variations over time in both the WMP price and in French dairy farmer costs to identify the corresponding *average* responses (elasticities) of equilibrium objects.

In what follows, we sequentially analyze results provided in Table 5, which focuses on processors buying WMP. We provide results for firms observed to be WMP sellers and for the entire sample in Tables 15 and 16 in the Appendix. All results pertain across the different samples. Intuitions remain similar in essence but differ in that they rely on input substitution patterns for WMP buyers, while relying on output substitution for WMP sellers. For the sake of clarity, we thus restrict attention to WMP buyers here.

In such context, the implied pass-through measures are to be understood as equilibrium co-movements between various equilibrium objects (prices and MP measures) and aggregate cost shifters.[64] We here simultaneously consider two cost shifters, which *correspond to two distinct types of shocks*. Indeed, in light of the model and the identification for WMP buyers, shocks to the WMP price have to be considered as shocks to processor *marginal costs* (henceforth, MC). This stems from the fact that at the optimum, our identification condition implies that WMP buyers adjust markdowns to equalize the marginal cost of producing a given product $j$ using milk from $i$ with the marginal cost of producing $j$ using WMP from commodity market $c$:

[63] As the index incorporates measures of fixed and variable farm costs, we refer to farm costs, authorizing ourselves to confound average and marginal costs (for farmers only!).

[64] This interpretation is similar to Amiti et al. (2014) who consider exchange-rate shocks, but "is different than the pass-through concept sometimes considered in the literature, which is the change in price for a single firm/product given an exogenous shock", as pointed out by Hong and Li (2017) (who study a similar industry-wide shock).

$$MC_{fj} = \underbrace{w_c e_{cj} + \lambda_{fj}}_{\text{marginal cost } MC_{fcj}} = \underbrace{\left(1 + \varepsilon^{S\ -1}_{fi}\right) w_{fi} e_{ij} + \lambda_{fj}}_{\text{marginal cost } MC_{fij}}$$

In contrast, shocks to farmer costs negatively affect milk supply. These shocks pass through the supply chain via processors adjusting raw milk prices. They thus affect processor *accounting marginal costs* (henceforth, AMC), as defined by Equation (4), repeated here for convenience:

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

Figure 14 in the Appendix can further guide the interpretation of the results following below. By considering shocks on the WMP price, we consider shifts in processor equilibrium MC, represented by the horizontal green line. By considering shocks to farm costs, we consider shifts in milk supply curves and thus in processor AMC, represented by the increasing plain blue curve.[65] All other curves (demand, marginal revenue) are authorized to co-move in any way.

**Table 5: Pass-Through: Reduced-Form Estimates - WMP Buyers**

| | (1) Milk Price $w_{fi}$ | (2) Markdown $\nu_{fi}$ | (3) Output Price $p_{fj}$ | (4) Markup $\mu_{fj}$ | (5) Margin $M_{fij}$ | (6) Output Price $p_{fj}$ | (7) Markup $\mu_{fj}$ | (8) Margin $M_{fij}$ |
|---|---|---|---|---|---|---|---|---|
| WMP Price | 0.231*** | 0.784*** | -0.013 | -0.638*** | -0.073*** | 0.683*** | 0.047 | 0.582*** |
| | (0.015) | (0.014) | (0.023) | (0.036) | (0.009) | (0.065) | (0.069) | (0.022) |
| Farm Cost Index | 0.661*** | -0.697*** | 0.613*** | 0.378*** | -0.203*** | -0.088 | -0.284* | -1.070*** |
| | (0.014) | (0.015) | (0.060) | (0.094) | (0.030) | (0.136) | (0.167) | (0.051) |
| Obs | 5,570 | 5,570 | 2,676 | 2,676 | 22,466 | 1,522 | 1,522 | 15,577 |
| R2 | 0.695 | 0.789 | 0.972 | 0.846 | 0.847 | 0.927 | 0.797 | 0.806 |
| Sample | | | Final goods | Final goods | Final goods | Bulk products | Bulk products | Bulk products |
| FE | fi | fi | fj | fj | fij | fj | fj | fij |

Notes: Standard errors are in parenthesis. **** p<0.01, ** p<0.05, * p<0.1.* All variables are in log. Sample restricted to firms for which we manage to link raw milk collection and production, and WMP buyers only. The level of observation varies with the level at which the considered outcome is observed or estimated: (i) firm-*département*-year level for raw milk prices and markdowns (although prices used here are at the region-year level), (ii) firm-product-year level for output prices and markups, (iii) firm-*département*-product-year level for margins. Margins are computed under an assumption of homogeneous milk sourcing across products for a given firm.

[65] Through both the extensive (farm entry/exit) and intensive margins, shocks to farm costs can also alter the shape of milk supply and thus of processor AMC curves. It would be captured in our reduced-form estimates.

**Upstream Pass-through** Estimated elasticities from columns (1) and (2) confirm the mechanisms previously outlined. In order to simply interpret the reduced-form results, we consider in the following discussion a 1% increase in the price of WMP and a 1% increase in the average French dairy farm cost respectively, holding the other constant. On the upstream side, a 1% increase in the WMP price leads processors 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 0.23% on average. This purely reduced-form result indicates an incomplete pass-through from the price of WMP to the price of raw milk ($\varepsilon_{w_c}^{w_{fi}} < 1$), in line with the existence of monopsony power and the theoretical results derived above. Equation (16) 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 processors, which increase their monopsony power exertion by 0.78% on average. The strongly positive and significant coefficient on markdowns confirms the intuition mentioned above: processors face supply curves featuring decreasing 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 *directly* increases processor MC, but its impact on processor AMC is smoothed by markdown adjustments on raw milk markets.

Compared to increases in the WMP price, increases in the average French dairy farm cost also lead processors to adjust raw milk prices and markdowns, but in a very different way. A 1% increase in the average French dairy farm cost results in a 0.66% increase in the price processors (WMP buyers here) pay for raw milk. Again, after this shock, processors optimally adjust their sourcing strategy between purchasing raw milk and WMP. If processors had no buyer power, and as they trade off between raw milk and WMP, farmer cost shocks would not affect raw milk prices, which would be fully determined by the international WMP price. In contrast, due to buyer power, we observe a positive pass-through from French dairy farm costs to raw milk prices. The mechanism is the following. As farm costs increase, processors, which have incentives to preserve their local supply, consent to raw milk price increases. Processors however also adjust their sourcing mix here, this time substituting away from raw milk in favor of WMP (whose price is held constant here). While increases in farm costs primarily shift raw milk supply curves up, input substitution by processors also induces an endogenous decrease in raw milk demand, which graphically translates into a move (to the left) along the new supply curve. As a result, the markdown strongly decreases (-0.7%). Again, this is in line with decreasing elasticities along milk supply curves. A rationale is that, as raw milk demand decreases, French dairy farmers get closer to their cutoff exit level. At the local level, raw milk supply becomes very elastic through the extensive margin, leading processors - willing to preserve their local suppliers - to adjust buyer power exertion.

We now turn to shock pass-throughs on downstream markets.

**Downstream Pass-through** In order to investigate the pass-through of upstream cost shocks to downstream factory-gate prices, we separately consider two types of output markets. Columns (4), (5), and (6) focus on final consumption goods, essentially sold to retailers. As retailers are highly concentrated, factory-gate prices have to be considered as the result of a bargaining. Columns (4), (5), and (6) focus on intermediate goods, sold in bulk to other processors, merely through commodity markets. As we focus on firms not selling WMP here, such intermediate dairy products include butter, cream, and skimmed milk powder (SMP). As the WMP market, such markets are perfectly competitive. As a consequence, we expect very different pass-throughs of the considered cost shocks to output prices, depending on the competition in the considered market.

The first coefficient in Column (3) indicates that increases in the WMP price, and thus in processor MC, do not pass through final goods (factory-gate) prices. Again, this result is purely reduced-form, but the model helps interpretation. First, Equation (17) shows that we have a (totally) incomplete pass-through on final good prices, as $\varepsilon_{w_c}^{p_{fj}} < 0.75$, where 0.75 is the average value of the share $\tilde{\theta}_{fij}$ $(= \theta_{fcj})$ of raw milk purchases in MC. This confirms the existence of price-setting power on final goods. In contrast, the first coefficient in Column

[65] See Table 13 in the Appendix for more detail on the shares of milk purchases in MC.

(6) indicates that increases in the WMP price, and thus in processor MC, almost fully pass through bulk product prices (0.68 < 0.75). This result aligns with the model predictions for perfectly competitive output markets.

The second coefficient in Column (3) indicates that increases in farm costs, leading to increases in raw milk prices and thus in processor AMC, strongly pass through final good prices. A 1% increase in farmer costs translates into a 0.61% increase in final good prices. This result supports the idea that final good prices are set trough a bargaining between processors and retailers, as discussed below. The second coefficient in Column (6) nicely confirms a model prediction: variations in French dairy farm costs have no effect on the prices of products sold in competitive markets. This is the case of bulk products which are - as WMP, absent here - sold on *commodity* markets at exogenous prices.

Our model, together with the estimated markup adjustments from Columns (4), further rationalize purely reduced-form results from Columns (3). Pass-through of farmer and processor cost shocks to final good prices are governed by endogenous markup responses. A key insight here is that markup responses depend on the way the two types of cost shocks directly affect processors and thus the *bargaining between processors and retailers*. On one hand, shocks to processor MC through the lens of variations in the WMP price are largely mitigated by markdown increases. This leads strategic retailers to become more aggressive when negotiating with retailers on final good prices. As a result, processor markups severely decrease. A 1% increase in the WMP price results in final good markup decreases of -0.64%. On the other hand, shocks affecting farmer production costs are largely absorbed by processors, leading to an increase in their AMC. In turn, this surge in AMC is transmitted to retailers through increases in final product prices. On average, a 1% increase in farm costs results in final good markup increases of 0.38%.[66] This positive transmission of processor AMC (MC remaining constant) to final product prices reveals that retailers have (countervailing) buyer power. They thus internalize the variations in processor margins and their

[66]This coefficient differs from the farm cost coefficient regressed output prices (0.61%), in contrast with Equation (21). It merely stems from the fact that, for clarity, we imposed $\varepsilon_I^{\lambda_{fj}} = 0$ in this equation. Here we have evidence that marginal processing costs $\lambda_{fj}$ actually co-move with French dairy farm costs.

possible consequences in terms of their supplier exits.[67] In contrast, Column (7) shows that markups do not or barely respond to both types of shocks, showing the prevalence of perfect competition in commodity markets.[68]

Given the various markdown and markup adjustments, the two types of shocks have a heterogeneous impact on processor margins. Markdown and final good markup adjustments operate in opposite directions in reaction to a 1% surge in the WMP price affecting processor MC. As both adjustments almost compensate each other, processor margins are only weakly affected (-0.07%). Markdown and final good markup adjustments also operate in opposite directions in reaction to a 1% surge in farm costs, which transmits to processor AMC due to buyer power. As retailers only partly absorb the shock, processor margins are somewhat strongly affected (-0.20%). Conversely, when considering commodity output markets, markdown adjustments following both types of shocks cannot be compensated by markup adjustments. As a consequence, total margins vary with markdowns. A 1% increase in the WMP price leads to increases in processor margins on (other) bulk products of 0.58%. It stems from the fact that other commodity prices co-move with the WMP price. In contrast, a 1% increase in the French dairy farm cost leads to an equivalent decrease in processor margins on bulk products (-1,07%). As processors cannot transmit increases in their AMC to commodity prices, their margins fully absorb the negative shock.

Overall, due to processor buyer power, shocks to farmer and to processor costs spread along the supply chain. Markdowns absorb international shocks to the WMP price, smoothing farmer revenues. Processors partly absorb French dairy farm cost shocks. The two types of shocks then differently affect the supply chain depending on endogenous markup adjustments. While international shocks to the WMP price are fully absorbed by farmers and processors, local farm cost shocks disseminate along the chain, and farmers, processors, and

[67] In any standard model of competition between sellers freely fixing prices, the optimal price would only on the contrary only depend on their MC.

[68] The negative coefficient on farm costs significant at the 90% confidence level possibly results from marginal processing costs $\lambda_{fj}$ co-moving with farm costs, e.g. due to inflation. This result does not pertain when considering WMP sellers or all types of processors, as shown in Tables 15 and 16 in the Appendix.

retailers are all - yet differently - impacted.

**Pass-Through Implications** The pass-through patterns identified here allow us to draw two types of implications. The first set of implications is methodological. Our results first show the importance of authorizing flexibility in pass-throughs when doing structural analysis, as they vary both across markets and depending on the type of shock. Second, the results presented here reaffirm the importance of taking buyer power into account in structural analysis, as well as in reduced-form studies of pass-throughs. Markups and margins, which would have been confounded had we ignored buyer power, react in very different ways - and sometimes in opposite directions - to different types of cost shocks. In contexts where buyer power is suspected, distinguishing margins and markups, or similarly MC and AMC, both in structural and in reduced-form pass-through analyses, thus appears crucial for a full understanding of adjustments to shocks within a supply chain.

Second, our pass-through estimates allow us to draw policy implications. In particular, markdown and markup adjustments to shocks in farm costs will also govern the way subsidies currently paid to dairy farmers are captured by downstream players. We tackle policy implications in further detail in Section 6.2.

# 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.

### 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 attributing 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:

$$M \equiv \theta \frac{py}{wm} = \frac{1 + \varepsilon_S^{-1}}{1 + \varepsilon_D^{-1}} \tag{22}$$

where $\theta_m = \dfrac{\partial f(m)}{\partial m} \dfrac{m}{f(m)}$ is the output elasticity with respect to the input. (22) directly delivers the total *margin*. The margin can then be empirically recovered from the left-hand side thanks to an estimation of $\theta_m$, 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:

$$\mu \equiv \theta \frac{py}{wm} = \frac{1}{1 + \varepsilon_D^{-1}} \tag{23}$$

The so-called *markup* is then similarly empirically recovered from the left-hand side. Equations (22) and (23) 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 power, 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.[69] However, in our context, assuming buyer power would have similarly led to assuming 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 (23).[70] 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 56% (instead of 41%), falsely equal to the margin rate. This amounts to an average markup rate overestimation of 37%. Moreover, in a context as ours where costs pass-through to prices upstream and downstream adjust over time, the bias varies accordingly. Hence, while we would have correctly estimated the annual markup rate in 2015, we would have overestimated it by 162% in 2013. Finally, our results (see Table 7) 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 indicates 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.

Having this in mind, we compare our paper's estimates with markups estimated in the production function approach literature in Table 6. To the exception of Tortarolo and Zarate

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

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

**Table 6: 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 |
| De Loecker et al. (2020) | | 1.61 | Manufacture, Retail & Wholesale |
| De Loecker and Scott (2016) | | 1.59 | Beer |
| **This paper** | **1.56** | **1.41** | **Dairy** |
| 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 that can also partly emanate from buyer power on materials.

(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.[71] 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 (23) to pin down markups and dividing it by a labor version of (22) 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

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

unchanged. Margins 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. The remaining markdown (of WMP sellers) and markup 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) 25% 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 that are the closest to ours. Their estimates are however above our average markup estimate (1.41). Among other reasons, this can possibly be driven by the existence of some buyer power in the studied sectors. Although disregarded by the authors for practical concerns, processors 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.[72] 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 6 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.

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

Conversely, one can assume away markups and attribute the entire estimated margins to buyer power markdowns. In our context, this would have implied a 295% overestimation of markdown rates. Such an assumption would not have made sense in many contexts, but note that it could have been defended in our context, especially given the concentration levels observed at the retail 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* allow to recover, 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. In the pass-through analysis conducted in Section 5.3, we have shown that markups and margins, which would have been confounded had we ignored buyer power, react in very different ways - and sometimes in opposite directions - to different types of costs shocks. Confounding margins and markups can thus severely bias assessments and policy advice, which we view as an important concern.

### 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:

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

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[73]. 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 firm behavioral assumptions, which would not have been the case of an approach based on supply and demand elasticities estimation.*** In Appendix C.1.3, we show how we can accommodate a wide range of firm behaviors, such as (i) intra-brand competition internalization, (ii) collusion, (iii) vertical cooperation... Some dairy processors 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 product prices perceived by the firm. Similarly, our estimation procedure allows for any type of bargaining between processors and retailers. This is due to the fact that we could fully rely on cost minimization only, as shown in Appendix C.1.3. Given the importance of taking into account retailer strategic behavior highlighted by our pass-through analysis, we view this as a major advantage of the suggested methodology. Overall, markup and markdown estimates thus remain valid under a wide range of theoretical behaviors and competition models.

Related to this point and in the particular context of agricultural markets, Sexton (2013) points out the trade-off faced by processors between exploiting MP and preserving local supply.[74] This can alleviate MP and in particular generate a wedge between the true markdown

[73]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.

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

and the one predicted by approaches relying on supply elasticities.[75] 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.[76] Finally, the hypothesis of supply-preserving considerations reducing the markdown is consistent with low markdowns estimates found by 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).[77]

**Table 7: Markdowns 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** | **1.19** | **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)

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 competitor behaviors as fixed. This is akin to our approach, relying on a Nash-equilibrium concept. On the contrary, any reduced-form elasticity estimates would encompass other firm adjustments and more general

[75]See Appendix C.1.3 for a formal derivation.
[76]The specific context also strongly supports the existence of strong buyer power. We refer the interested reader to Rubens's paper (2021) for more details.
[77]These papers however assume constant MP exertion across time, and may have missed the type of underlying variations we document.

equilibrium effects.[78]

Finally, even omitting the caveats mentioned above 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 function approach) literature has come up with solutions to deal with.[79] 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.[80] Second, and more importantly, the variations in markups and markdowns from a year to the other we document respectively reflect (i) implied in changes processor-retailer bargaining and (ii) *non-constant elasticities along milk supply curves*.[81] Point (i) is the reason why demand estimation is generally performed when considering transactions between a firm and final consumers, assumed to be price-takers. From a theory viewpoint, point (ii) relates to the curvature of these raw milk *supply* functions here, *i.e* to their second derivatives, and remains a not-yet answered challenge for the *demand* approach, which directly aims at identifying such functions.[82]

We thus view our framework, which remains agnostic on exact supply and demand

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

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

[80]An exception is Döpper et al. (2021) who estimate processor 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, in doing so, they crucially rely on a constant marginal costs assumption, ruling out the possibility of buyer power.

[81]It can also reflect change in the competition context. We refer the interested reader to Appendix A.2 for more details on the first point.

[82]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." A similar challenge arises for estimating supply functions featuring non-constant elasticities.

functions and rather (partly) reveals their shapes, as circumventing the mentioned 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 cost shocks, as well as the implied pass-throughs to upstream and downstream prices. Furthermore, we think such an approach to buyer and seller power estimation can be applied 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 the firm total margins with a production function approach. As mentioned, it requires increasingly available data and is fairly standard, and we refer the reader to the corresponding literature for more details.[83] 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*.[84] However, in doing so, such papers rely 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 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.

[83] 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.

[84] A flexible input is defined as a 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 applications. M. Morlacco and E. Guigue are however currently working on a revision of Morlacco (2019), relying on a different estimation methodology.

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...)...[85] In many of these industries, notably food and beverages industries, buyer and seller power are a concern, for reasons akin to those outlined in the analysis of the French raw milk market. This concern is particularly important in emerging economies, where local or international intermediary price-setting power, can largely harm development (Sexton et al., 2007). In such contexts, our approach provides a useful tool to disentangle monopsony and monopoly power.

Moreover, the suggested tool is especially practical to quantify buyer power in a context of limited data. Based on firm arbitrage conditions, our theoretical model indeed micro-founds a markdown imposed by processors that, for most of them, simply is the ratio of the substitutable commodity (here WMP) price and of the price of the raw material (here milk), 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 price data. Commodity prices data are directly available online, while unit prices of the input 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 fairly homogeneous product is considered, as in most food industries mentioned above. For others, an adjustment similar to what we do with dry matter contents data can be implemented.

[85] 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 for broader applications of our methodology.

## 6.2 Economic Implications

In this subsection, we highlight the consequences of processor MP on farmer revenues and public policy efficiency.

### 6.2.1 Processor Market Power, Farmer Subsidies, and Farmer Revenues

We find what one could consider as "low" markdown levels, 19% on average. However, farmer profits ultimately depend on the prices set by processors for raw milk, and thus not only on the markdown level, but on both buyer and seller market power. Their joint exploitation by processors indeed generates a distortive 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 - 56% 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 processors to the detriment of farmers.

Second, fluctuations in the degree of buyer power exerted by processors have important consequences on farmer revenues. Overall, markdown adjustments by processors smooth raw milk prices. On one hand, during dairy market downturn phases (2009, 2015), dairy firms compress their markdowns, and the weighted average markdown is *almost* pushed down to the competitive level (1). It however remains above it. On the other hand, processors conversely increase markdowns to remarkably high levels (1.4 on average) when facing positive demand shocks (2007, 2013). Our pass-through results indicate that processors also largely absorb farm cost shocks. The presence of buyer power thus partly insures farmers against conjunctural shocks, smoothing their revenues. However, it constantly implies a price below its competitive value over time.

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 in the medium and long run and without cash flow. To cope with these structural imbalances, the Common Agricultural Policy (CAP) massively subsidizes dairy farmers. As a consequence, CAP subsidies to farmers represent around 80% of their revenues.

Our model provides a rationale through which processors eventually divert these subsidies, through their buyer power. Indeed, any exogenous revenue supplement granted to farmers shifts downward in raw milk supply curves. In turn, processors internalize that their supplier profitability increases, implying decreases in raw milk supply elasticities, and increase their markdowns in response. Such reasoning totally aligns with the results from our pass-through analysis. In Table 16, reduced-form estimates show how a 1% increase in French dairy farm costs on average results in a 0.65% increase in the price of raw milk.[86] This average equilibrium pass-through is informative about the ability of processors to capture subsidies paid to farmers. It implies that, for the marginal euro of subsidy given to farmers between 2005 and 2018, 65% of it is on average diverted from farmers due to processor buyer power. This statement comes from an interpretation of a marginal increase in farmer subsidy as a marginal decrease in their average or marginal costs.[87]

However, as processors interact with highly concentrated retailers for part of their dairy product sales, part of the subsidy diverted from farmers is captured by retailers. We here (still) consider an increase of 1% in the average subsidy. While it allows processors to increase markdowns by 0.61% on average, it also conducts to adjustments on some of their output markets. Indeed, on one side, final product prices decrease by 0.65%, and markups decrease by 0.40% on average. It results from downstream strategic retailers internalizing increases in farmer subsidies and endogenous increases in their supplier markdowns. Overall, total margins on final products only increase by 0.12%. A large part of farmer subsidies is

[86]Here and hereafter, we use reduced-form pass-through estimates conducted on the entire sample of French dairy processors, rather than pass-through estimates for WMP buyers presented in Table 5.

[87]A few remarks are worth mentioning here. First, as we find strong evidence of non-constant raw milk supply elasticities, it is important to emphasize that this subsidy incidence is to be interpreted as *marginal*. Second, as (i) our farm cost index measures average costs, and (ii) as French dairy farmer subsidies are for some part coupled with production and for some other part coupled with land, we do not take a stand on whether the subsidy considered here is a unit or lump-sum subsidy. In theory, both can affect raw milk supply elasticity through the extensive (farm entry/exit) and intensive margins, and thus markdowns.

thus transmitted even more down the chain.[88] On the other side, processors sell bulk products in competitive commodity markets. On such markets, products are sold at exogenous international prices and processors are able to keep the diverted subsidy amount. Indeed, as prices do not react, margins on such activity increase by 0.87% on average. Overall, the sharing of the part of the subsidy originally diverted due to processor buyer power depends on the structure of the processor output market. On average on all product sold, our results reported in Table 17 in the Appendix indicate that a 1% increase in the average subsidy inflate processor margins by 0.40%.[89]

While part of the subsidy diverted from farmers to processors may be ultimately passed to retailers, our analysis shows *the source of inefficiency undoubtedly is processor buyer power*. We thus view the processor buyer power documented here 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 as a possible alternative policy to replace inefficient subsidies to farmers.*** In the context described above, a price floor would correct the value-added distortion, redistributing revenues from processors to farmers. It could at least partly 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 to the conventional wisdom of regulating authorities. Indeed, such an idea is typically perceived as likely to harm consumer 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 merely results from the predominance of theoretical work relying on constant processor marginal costs.[90] This

[88]An open question is to know if part of it ends up being transmitted to final consumers.

[89]We plan to investigate more underlying heterogeneity here.

[90]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.

assumption is equivalent to assuming infinite elasticity of the raw milk supply, prohibiting the existence of markdown and the possibility to have a raw milk price set below its optimal level.

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 farmer and processor representatives, a recommendation in practice closely followed by processors. 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 suggest that processor buyer power has not been much affected by this decision.

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.[91] Our model shows this policy was ineffective in raising farmer revenues since partly captured by processors through markdown increases. Additionally, our results suggest it distorted raw milk allocation between products toward more production of commodities and fewer final products.

In contrast to the type of work that motivated the removal of the *recommended price*, our model and estimates show that a price floor on raw milk would correct value-added sharing and increase farmer profits without necessarily harming consumer welfare. A price floor would first mechanically increase raw milk prices and decrease processor markdowns. This would have first order effects on value-added sharing, rebalancing it in favor or farmers. By largely neutralizing processor buyer power, it would lead to increases in raw milk quantity produced in equilibrium, thus having first order effects on welfare through increases in farmer

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

profits.[92]

Overall, the total effects on consumer welfare depend on downstream adjustments. In reaction to a price-floor introduction, internalizing processor markdown decreases, and retailers could consent to (undergo) higher markups, as suggested by our pass-through analysis. As a consequence, and depending on retailer reactions, the effect on final prices is unclear, and depends on margin absorption by processors and retailers. Our pass-through results on the effect of farm cost increases suggest the overall effect on processor margins would be negative, in contrast with margin-inflating subsidies. To the least, and given the potential welfare-improving effects, such a policy shall be seriously considered, as a potential substitute to largely inefficient and distortive subsidies. In practice, such a price floor would have to be regularly adjusted, following farm cost indexes - already computed by institutes scrutinizing the industry - and commodity price fluctuations, in line with our model.

Another alternative policy remedy could be to promote farmer countervailing seller power, for instance by authorizing farmers to regroup into producer organizations to bargain with processors. 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 remains modest.[93]

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

[92]Intuitions for such first-order effects regarding a price floor introduction are gathered in Figures 20 and 21 of Appendix E.7, showing its effects for firms that initially buy and sell WMP respectively.

[93]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 suggest a new methodology to separately identify buyer and seller market power, and apply it to French dairy processors. We rely on a production function approach to estimate total margins. The existence of a commodity, (i) substitutable as an input or as an output, and (ii) exchanged on global markets where firms are price-takers, allows us to separately estimate firm-origin markdowns and firm-product markups. This approach could be applied to other contexts, such as global food supply chain sourcing in developing countries, in which both buyer and seller power exerted by trade intermediaries are an important issue.

The joint exertion of buyer and seller power by firms, as we show is the case for French dairy processors, has several broad implications. First, we show they have to be simultaneously considered. Our results indicate that we would have largely misidentified the inefficiency origin, had we ignored buyer power and attributed the entire margin to seller power, as the production function approach traditionally does. We show such *markups* estimated following such an approach should be viewed as *margins*, coming from price-setting power *on both sides*, if there is reason to suspect buyer power in the sector of study. As markups and margins differently react to costs shocks, distinguishing both is crucial to understand how shocks pass through supply chains.

Finally, buyer power can have important policy implications. In our context, through sole markdown adjustments, processors partially absorb shocks to commodity prices and to farm costs, smoothing variations in farmer profits but also impeding farmers from benefiting from positive demand shocks. Second, also due to buyer power alone, 65% of the subsidies currently paid to farmers are diverted. Our results thus call for alternative welfare-improving policies, aiming at promoting farmer countervailing seller power or for a price floor on raw milk.

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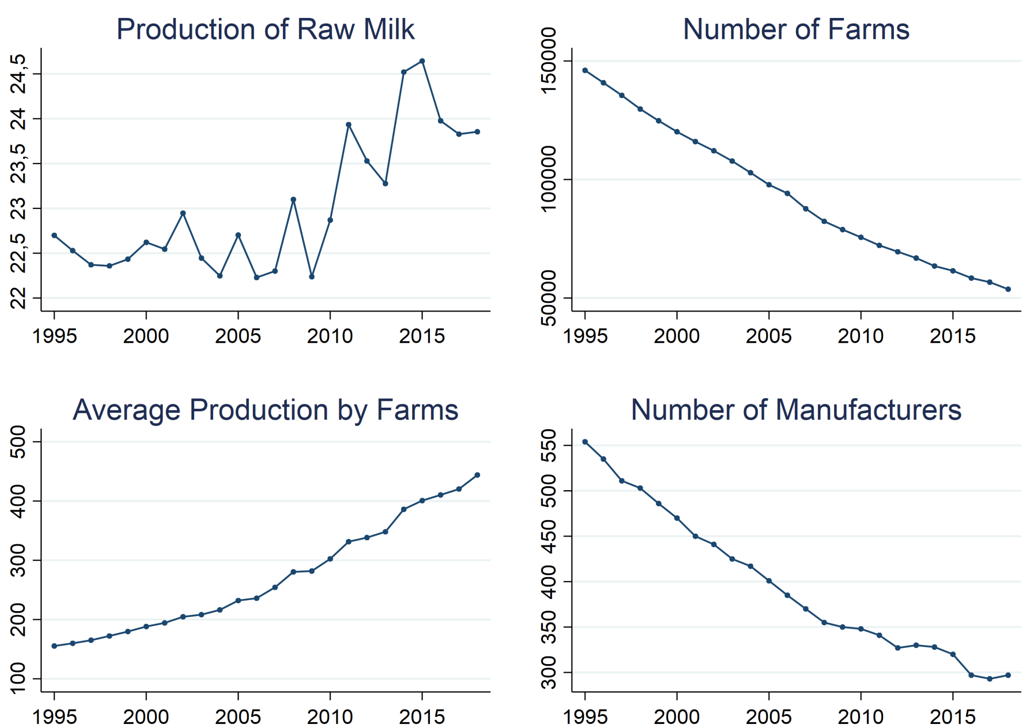
# Appendix

## 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

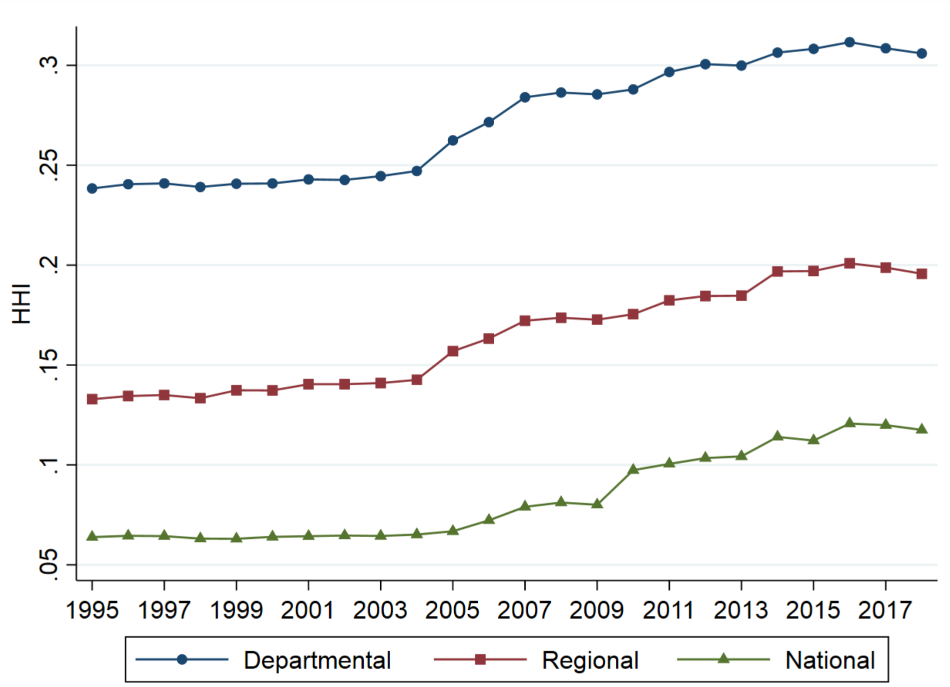
**Figure 9: Dairy Industry Trends**




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 in 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 21 shows the consequences of this 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 quota 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 (*département*) level.

**Figure 10: Raw Milk Collection HHI**




Notes: HHI based on group-level market shares. Dry matter content 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 processors and concentrating have 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 is the result of bilateral contracts linking processors and farmers. Moreover, raw milk prices have also been liberalized. Up to the spring 2008, the CNIEL (National Interprofessional Center for the Dairy Economy) was regularly publishing a recommended price resulting from negotiations between farmers and processor representatives, a recommendation in practice closely followed by processors. 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.[94]

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

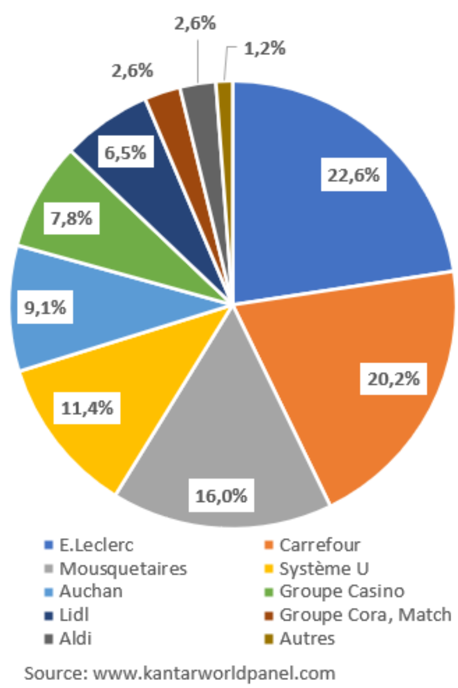
[94]See for instance this study summary: Study of Measures against Market Imbalance: What Perspectives after Milk Quotas in the European Dairy Sector?.

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 Processors 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 processors since the *Galland Act* (1996). The Galland Act was constraining processors to sell a given product to different retailers at a similar price, which in practice had effects akin to price floors (Biscourp et al., 2013). More recently, two waves of purchasing alliance 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 in Figure 11, 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 11: Food Retail Shares (2018)**




Overall, these changes soundly modified commercial relations and bargaining power along the entire dairy supply chain, *i.e* between farmers and processors on the upstream side, and between processors 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 bills 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 not 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 processor 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 *département*. Thanks to the EML, we are able to observe firm-*département* 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 (https://agridata.ec.europa.eu/extensions/DashboardPrice/DashboardMarketPrices.html).

## 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 with a substantial amount of research online to find out additional business relationships in the market. In doing so, we marginally adjusted groups as defined by LIFI, including business relationships that 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 11).

# 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 firm 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 firm marginal costs, 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 First Order Conditions

Processor $f$ maximizes its current variable profit by choosing for each pair $(i, j)$, which quantity $m_{fij}$ of input $i$ to dedicate to product $j$ and also the optimal quantity of labor $L_f$ to hire at unit cost $z_f$ to process these products. This yields the following program:

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

where $L_f$, $K_f$ and $\Omega_f$ respectively are vectors of $l_{fj}$, $k_{fj}$ and $\omega_{fj}$ , $\forall j \in \mathcal{J}_f$, other terms being simple scalars.

At the optimum, both terms of the Leontief production function are equal such that:

$$y_{fj} = \sum_i \frac{m_{fij}}{e_{ij}} = F_j(L_f, K_f, \Omega_f)$$

**Variable Processing Cost Minimization** The variable profit maximization implies that the variable processing cost is minimized, which results from the following program:

$$\begin{aligned} \min_{\{l_{fj}\}_{j\in\mathcal{J}_f}} \quad & \sum_j z_f l_{fj} \\ \text{s.t.} \quad & y_{fj} = F_j(L_f, K_f, \Omega_f),\ \forall j \end{aligned}$$

The associated Lagrangian for each product $j$ is:

$$\mathcal{L} = \sum_j z_f l_{fj} + \sum_j \lambda_{fj}(y_{fj} - F_j(L_f, K_f, \Omega_f))$$

First order conditions give:

$$\lambda_{fj} = \frac{z_{fj}}{\frac{\partial F_j(L_f, K_f, \Omega_f)}{\partial l_{fj}}}, \forall j \tag{24}$$

By definition, the Lagrange multiplier $\lambda_{fj}$ is equal to the marginal processing cost of producing an additional unit of $y_{fj}$. The solution of this problem gives the minimum processing cost $C_f(M_f)$ using the milk input vector $M_f = (m_{f11}, ..., m_{fij}, ..., m_{fIJ})$ to produce the output vector $Y_f = (y_{f1}, ..., y_{fj}, ..., y_{fJ})$.

**Simplified Variable Profit Maximization** The profit maximization problem of the processor is then simplified as follows:

$$\max_{\{m_{fij}\}_{(i,j)\in\mathcal{I}_f\times\mathcal{J}_f}} \quad \sum_j p_{fj}\left(\sum_i \frac{m_{fij}}{e_{ij}}\right)\sum_i \frac{m_{fij}}{e_{ij}} - \sum_i w_{fi}(m_{fi})m_{fi} - C_f(M_f)$$

The first order condition for every $m_{fij}$ yields Equation (2):

$$\begin{aligned}\left(\frac{\partial p_{fj}(.)}{\partial y_{fj}}\frac{y_{fj}}{p_{fj}} + 1\right)p_{fj} &= \left(\frac{\partial w_{fi}(.)}{\partial m_{fi}}\frac{m_{fi}}{w_{fi}} + 1\right)w_{fi}e_{ij} + \lambda_{fj} \\ \iff \left(1 + \varepsilon_{fj}^{D\ -1}\right)p_{fj} &= \left(1 + \varepsilon_{fi}^{S\ -1}\right)w_{fi}e_{ij} + \lambda_{fj}.\end{aligned}$$

### C.1.3 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 processors 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.[95]

We propose here a simple of modelization of this wide range of possible (vertically) cooperative behaviors. Denoting $\alpha_f$ the parameter characterizing firm $f$ interest in its supplier revenues, firm $f$ 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 $\alpha$, the more important the cooperation, $\alpha_f = 0$ bringing us back to the non-cooperative behavior. The corresponding first order condition yields:

$$\underbrace{\left(1+{\varepsilon^{D}_{fj}}^{-1}\right)p_{fj}}_{\text{marginal revenue } MR_{fj}} \quad = \quad \underbrace{(1-\alpha_f)\left(1+{\varepsilon^{S}_{fi}}^{-1}\right)w_{fi}e_{ij} + \lambda_{fj}}_{\text{marginal cost } MC_{fj}}. \tag{25}$$

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

$$\nu_{fi} \equiv \frac{\left(p_{fj}\left(1+{\varepsilon^{D}_{fj}}^{-1}\right) - \lambda_{fj}\right)}{w_{fi}e_{ij}} \tag{26}$$

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

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

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

Given that our empirical analysis hinges on (27) 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 $\alpha_f$).

**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 colluded 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 $\gamma_f$ the parameter characterizing firm's $f$ interest in some of its competitor profits (for instance belonging to a cartel $C$), the 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 $\gamma$, the more important the collusion, $\gamma_f = 0$ bringing us back to the non-collusive behavior. The corresponding first order condition yields:

$$\underbrace{\left(1 + {\varepsilon^{D}_{fj}}^{-1}\right) p_{fj} + \gamma_f \sum_{f' \in C} \sum_{j'} {\varepsilon^{D}_{f'j'j}}^{-1} p_{f'j'} \frac{y_{f'j'}}{y_{fj}}}_{\text{marginal revenue } MR_{fj}} = \underbrace{\left(1 + {\varepsilon^{S}_{fi}}^{-1}\right) w_{fi} e_{ij} + \lambda_{fj}}_{\text{marginal cost } MC_{fj}}. \tag{27}$$

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

$$\mu_{fj} \equiv \frac{p_{fj}}{\left(1+\varepsilon_{fi}^{S\;-1}\right) w_{fi} e_{ij} + \lambda_{fj}}. \tag{28}$$

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

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

Given that our empirical analysis hinges on (27) 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** Generalizing 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):

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

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

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

and we still have the supply price-elasticity as

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

The implied markup is:

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

This expression is quite similar to the classical single product markup expression. Again, the more inelastic the demand (higher $\varepsilon^{D}_{fjj}$) the higher the markup. However, the markup here also takes into account intra-brand competition (through $\varepsilon^{D}_{fjj'}$ 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 cost 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 processors 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:

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

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

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

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

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

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

As logical since totally abstracting from the demand side, we do not have anymore equality between marginal revenue and marginal costs. As a consequence, (i) the markup does not explicitly relate to the 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 Static and Dynamic Inputs

Correlations shown in Table 8 are reassuring evidence that labor, milk, and materials are all variable and statically chosen, while capital is more dynamic.

**Table 8: 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.2.1 Ignoring Materials other than Milk Inputs

We exclude non-milk intermediary inputs from marginal cost estimation. We argue that this restriction is unlikely to have a significant impact on our marginal cost 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-*département*-year level.

**Table 9: Milk to Materials Expenses Ratio**

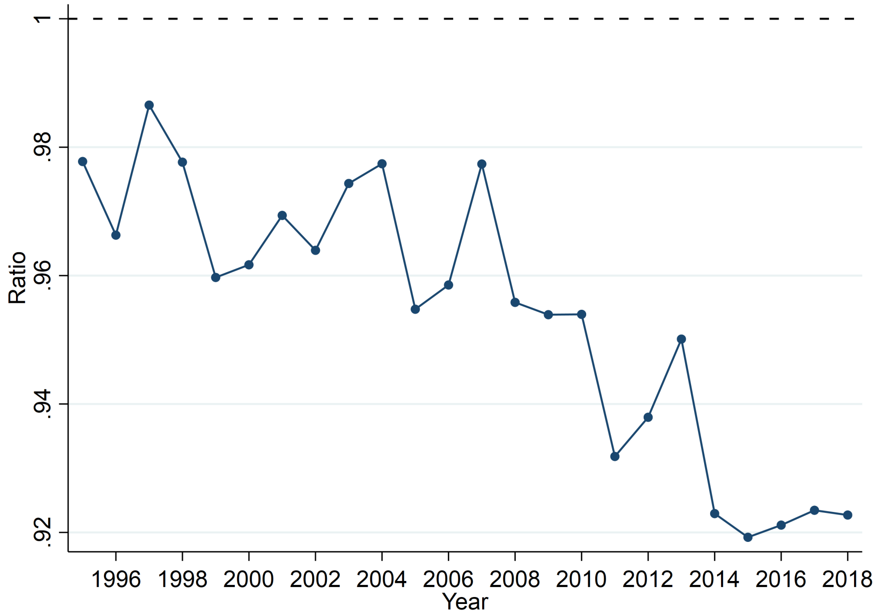
| Average | Median | P25 | P75 | Obs. |
|---|---|---|---|---|
| 0.78 | 0.88 | 0.65 | 0.95 | 980 |

# D Discussing Identification

## D.1 Dairy Input/Output Matrix

We plot here the ratio between the simulated processor 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 waste in the processing process which is assumed to be zero when dry matter content data are constructed.

**Figure 12: Estimated DMC needs vs. Real demand (Collection + Imports)**




Notes: Ratio between the estimated needs in dry matter contents (DMC) and the actual demand. The estimated needs in DMC is recovered from the production data and technical coefficients of DMC of milk and of dairy products. The actual milk demand is the sum of raw milk collection from our industry data and imports of WMP found in the BACI database from CEPII.

## 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.[96] 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 a multi-product production function as a sum of mono-product production functions, once having allocated

[96]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.

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 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 10 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 10 in Appendix D.2.1). Labor cost shares in firm 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) on average only represent 25% of firm accounting marginal costs, milk input purchases at the firm-origin-*product*-level constituting the remaining 75%.

Empirically, the labor shares displayed in Table 10 are supportive of firm-level production technology, as labor share distribution of specialized firms is remarkably constant across product categories. Moreover, the small number of mono-product firms in the dairy industry reflected by the number of observations in Table 10 also motivates our choice of not implementing a production function estimation relying on them *à la* De Loecker et al. (2016).

**Table 10: 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 is 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 (6), 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 $\epsilon_t$ is assumed to split into two parts: $\epsilon_t = \omega_t + \eta_t$ .

$\eta_t$ is an i.i.d. error that the firm does not influence (e.g., measurement/specification errors). $\omega_t$ 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**

$\omega_t$ 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 $\omega_t$ 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 $\omega_t$ given $\omega_{t-1}$ ($E[\omega_t|\omega_{t-1}]$) - 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 $\omega_t$, 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 $\omega_t$ - 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 $\omega_t$. 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:

$$\omega_t = g(k_t, h_t, z_t) = c(k_t, h_t, z_t)'\gamma, \tag{29}$$

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 (29) 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 $\beta$.

**(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[97] 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.[98]

**(iii) Endogenous Prices Upstream and Downstream**

We choose the firm's milk demand as our proxy for $\omega_t$, 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.[99] We thus incorporate these variables in the control function $z_{ft}$ for $\omega_t$ and define:[100]

$$z_{ft} = \left(s^m_{ft}, s^y_{ft}\right)$$

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

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

[98]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.

[99]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.

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

### D.2.3 Estimates

**Table 11: Processing Function Estimates - firm-level**

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

Notes: OLS sample 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 share controls. Standard errors are in parenthesis. *** $p<0.01$, ** $p<0.05$, * $p<0.1$ $p<0.1$

We present in Table 11 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 12. 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 12 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 12: 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 an alternative measure for the elasticity of output to labor required to retrieve marginal costs, using the firm-level elasticities implied by our Translog estimates. All results presented in the paper are robust to this alternative specification.

**Table 13: Share of Milk Purchases in Marginal Costs**

| | Ignoring buyer power | With buyer power |
|---|---|---|
| | $\theta_{fij}$ | $\tilde{\theta}_{fij}$ |
| Average | 0.68 | 0.70 |
| Weighted Average | 0.76 | 0.78 |
| Median | 0.72 | 0.74 |
| Observations | 72,059 | 72,059 |

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

Table 13 shows the average and median shares $\theta_{fij}$ 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 Intuition - Toy Examples

**WMP Sellers** A firm that is observed selling WMP trades off between producing dairy products and WMP. Figure 13 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 a simple example, combining both underlying firm's first order conditions amounts to equalizing the marginal revenues of each output with the marginal costs of milk input $i$, implying that:

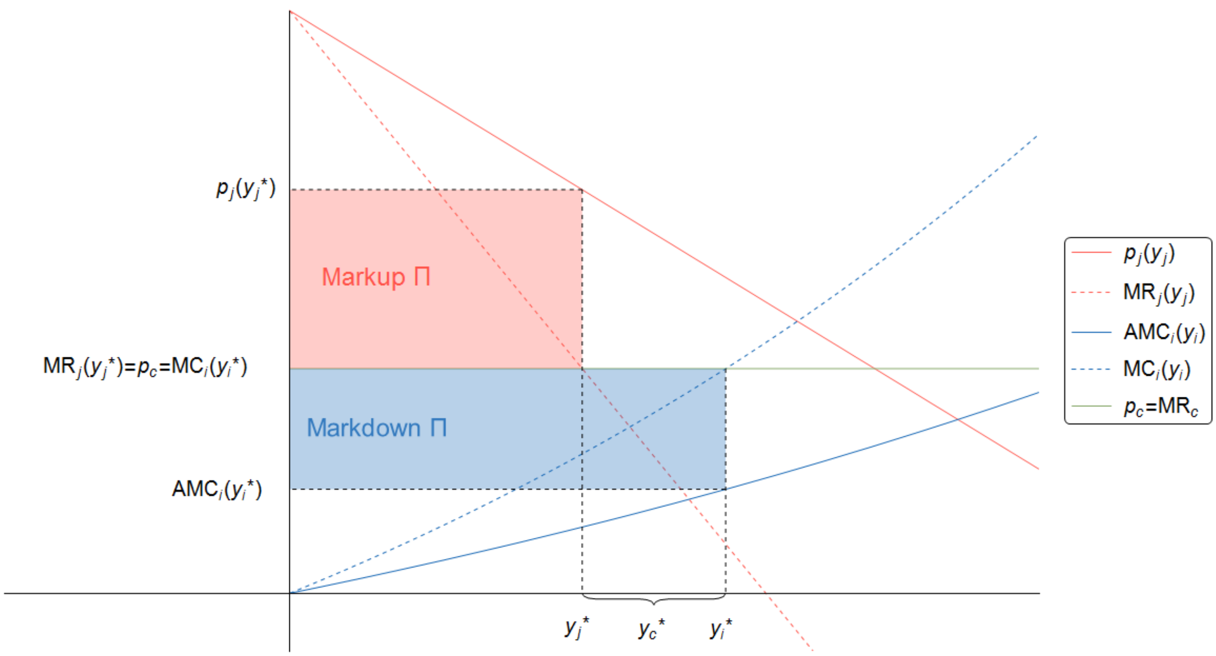
$$p_c = MR_j(y_j^*) = MC_i(y_i^*)$$

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.[101]

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 that firms selling commodities must be efficient enough ($\lambda_f$ low enough) to do so. Our data confirm this intuition, as we observe a small number of larger firms selling WMP.

**Figure 13: Equilibrium for Commodity Sellers**



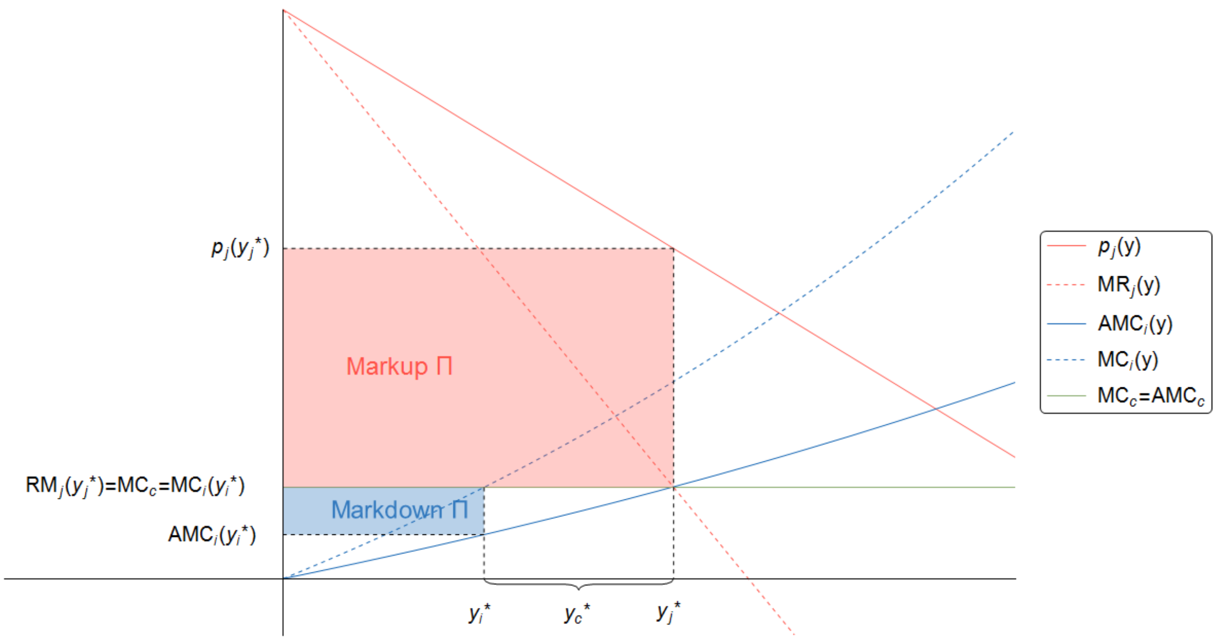

**WMP Buyers** Figure 14 displays general intuitions for a firm assumed to produce and sell one product $j$, processing milk $i$ and commodity $c$. It thus illustrates intuitions for identification of markups and markdowns of WMP buyers, evoked in subsection 4.2.2. Underlying

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

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 14: Equilibrium for Commodity Buyers**




### D.3.2 Firms Inactive on the WMP Market

In the main text, we assume that processors are active on the WMP market, either as buyers or sellers. In practice, we observe in the data whether or not a processor sells WMP, and assume non-sellers to be buyers. Our estimates of markdowns for non-buyers are possibly biased. We propose here a credible game in which the markdown empirical counterpart of a processor inactive on the WMP market is the same as for a buyer, *i.e.* $\nu_{fi} = \frac{w_c}{w_{fi}e_{ic}}$.

We assume the following game:

**Stage 1:** Processors sign a contract with their clients defining prices and quantities exchanged. Processors choose the network of farms constituting their supply for each *département* $i$.

**Stage 2:** In each *département*, processors and farmers engage in a Nash-in-Nash bargaining (Horn and Wolinsky, 1988).[102].

**Stage 3:** Each farmer decides which quantity to offer at the negotiated price. Processors can complete their milk input sourcing with commodity purchases.

**Resolution:** In Stage 3, farmers in each *département* decide which quantity of raw milk to supply observing $w_{fi}$. The aggregation of individual supplies yields the processor-*département* inverse supply $w_{fi}(m_{fi})$. In Stage 2, each processor $f$ enters in bargaining with farmers within its supply network in *département* $i$. The farmer bargaining weight is denoted $\alpha$. The farmer contracting profit is $w_{fi} \times m_{fi}(w_{fi})$, and their status-quo profit is 0 as the processor sourcing network is fixed in Stage 1. The processor gain from trade negotiating with farmers of *département* $i$ is the cost difference from sourcing its needs in milk inputs from *département* $i$ rather than sourcing it on the commodity market.

$$\max_{\{w_{fi}\}} \quad \alpha \ln \left[w_{fi} \times m_{fi}(w_{fi})\right] + (1-\alpha) \ln \left[m_{fi}(w_{fi}) \times \left(\frac{w_c}{e_{ic}} - w_{fi}\right)\right]$$

The first order condition of this problem gives:

$$\frac{w_c}{w_{fi} e_{ic}} = \frac{1 + \varepsilon_i^{S-1}}{1 + \dfrac{\alpha}{\varepsilon_i^{S-1}}}$$

This last expression shows that the markdown expression for a firm inactive on the WMP market is the same as for a WMP buyer. In the particular case where $\alpha = 0$, the processor has all the bargaining power and we find $\dfrac{w_c}{w_{fi} e_{ic}} = 1 + \varepsilon_i^{S-1}$.

[102]In this type of negotiation, firms engage in secret negotiations, they form passive beliefs and are "schizophrenic" (negotiation breakdown in a *département* does not affect negotiations in other *départements*).

### D.3.3 Estimates - WMP Buyers vs. WMP Sellers

**Table 14: Markdowns and Markups - WMP Buyers vs. WMP Sellers**

| | Markdowns | | Markups | |
|---|---|---|---|---|
| Sample | WMP Buyers | WMP Sellers | WMP Buyers | WMP Sellers |
| Average | 1,20 | 1,09 | 1,18 | 1,34 |
| Weighted Average | 1,22 | 1,11 | 1,46 | 1,36 |
| Median | 1,17 | 1,06 | 1,02 | 1,18 |
| Observations | 6,610 | 1,439 | 4,989 | 1,057 |

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-*département*-time level, markups at the group-product-time level, margins at the group-*département*-product-time level.

Table 14 shows summary statistics for markup and markdown 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:

$$w_c - \lambda_f < w_c$$

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 the 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 the labor market(s) than they are on milk markets, which implies 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 processors are confronted with regulation, especially when hiring low-skilled workers. An important part of such workers is 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 interest. The first order conditions would rewrite:

$$\underbrace{\left(1+\varepsilon_{fj}^{D\ -1}\right)p_{fj}}_{\text{marginal revenue } MR_{fj}} \quad = \quad \underbrace{\left(1+\varepsilon_{fi}^{S\ -1}\right)w_{fi}e_{ij}+\left(1+\varepsilon_{L}^{S-1}\right)\lambda_{fj}}_{\text{marginal cost } MC_{fj}}. \tag{30}$$

Due to the existence of monopsony power on the labor market, the marginal cost $MC_{fj}$ would additionally feature the supply elasticity of labor $\varepsilon_L^S$. This would imply redefining markups and markdowns in Definitions 1 and 2, replacing $\lambda_{fj}$ 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 (30), would be defined in the following way:

$$\nu_L \equiv \frac{\left(1+\varepsilon_{fj}^{D\,-1}\right)p_{fj}-\left(1+\varepsilon_{fi}^{S\,-1}\right)w_{fi}e_{ij}}{\lambda_{fj}} \tag{31}$$

The markdown on the 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 mentioned above, *the presence of such labor MP would not affect the margin estimates.* It would however impact our markup and markdown 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:

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

From these definitions and the discussion above, it is straightforward to see that *the presence of labor MP would leave unchanged our markdown estimates for WMP buyers*. It would however lead to an overestimation of their markups, which should have featured $\tilde{\lambda}_f$ instead of $\lambda_f$. In such a 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:

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

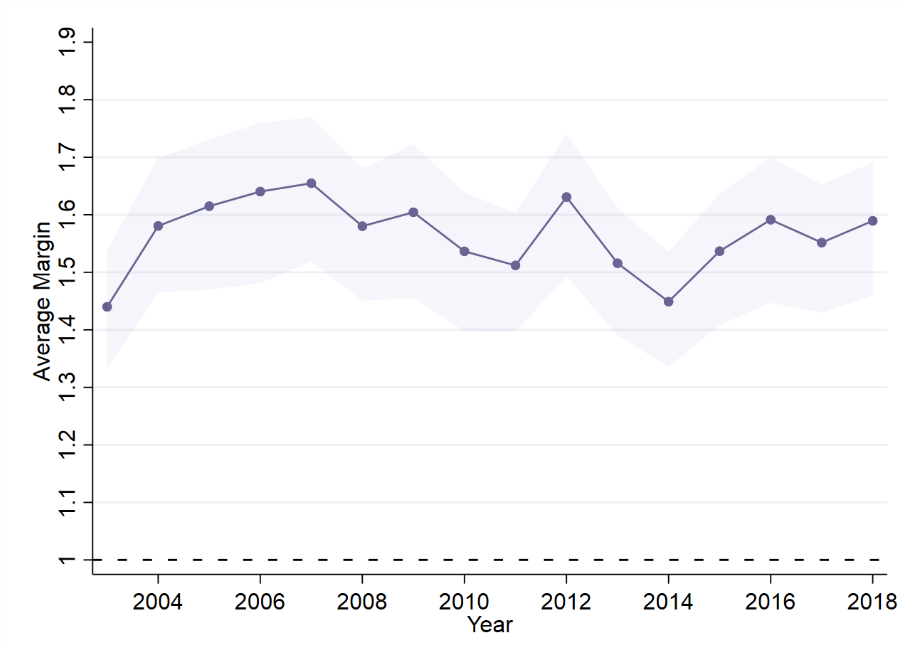
For reasons similar to the ones mentioned above, the markdown would be overestimated. The bias in the estimated markup on product $j$ depends on its dry matter content and the WMP one (the commodity $c$). The markup would be overestimated (resp. underestimated) if $e_j < e_c$ (if $e_j > e_c$), *i.e*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

Quantitatively, such biases would however remain limited, as the estimated MPC $\lambda_f$ (to be inflated by the potential wage markdown) only represents around 25% of the total marginal costs, the remaining part being constituted by raw milk or WMP purchases.

# E Additional Results

## E.1 Average Margin over Time

**Figure 15: Average Margin Over Time**

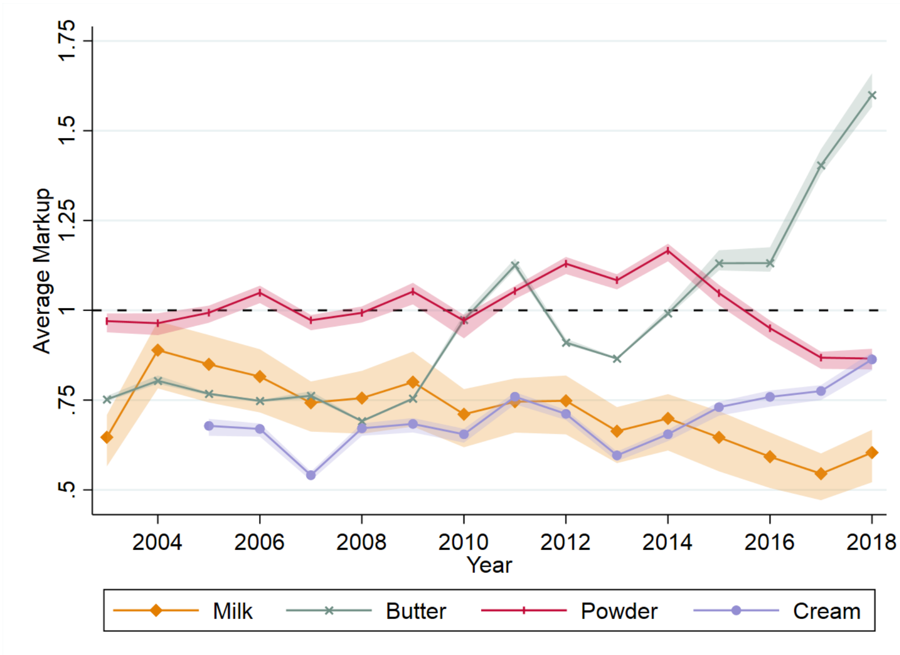



Notes: Weighted average, using dry matter content quantity weights. Bootstrapped 95% confidence interval displayed.

## E.2 Average Markups - Bulk Products

Among bulk products, and as shown in Figure 17, milk powder features an average markup of around one. The milk powder category encompasses WMP - on which our methodology imposes a markup equal to one for a subsample of firms - but also skimmed milk powder. Markup estimates on bulk products markets are noisier than on final consumption goods, as only a few French processors sell on such markets. Interestingly, markups are close to or below one on such products, either directly sold to other processors on sold on global commodity markets, on which our estimating procedure does not impose a constraint. We view this feature as supporting the idea that French manufacturing firms are price takers when selling bulk dairy products.

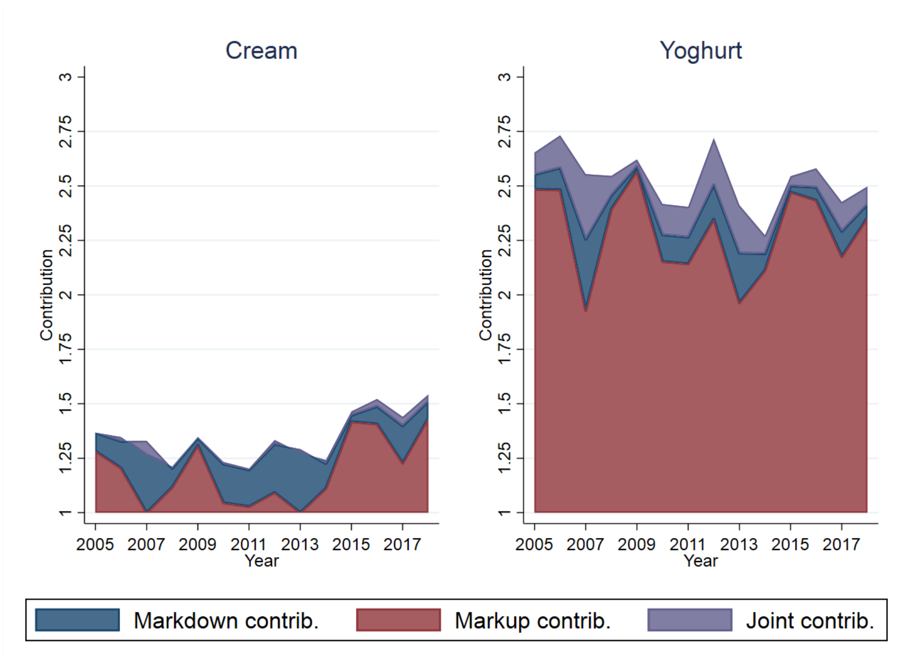
**Figure 16: Markups on Bulk Products - Product Category Averages**




Notes: Weighted averages, using dry matter content quantity weights. Bootstrapped 95% confidence intervals (CI) displayed. CI emanate from errors in the estimation of the marginal processing cost and are thus proportional to its share in the total marginal cost of the considered product. Cream product average not displayed for 2003 and 2004 as products nomenclature does not allow to distinguish final from bulk cream before 2005.

## E.3 Markup and Markdown Contributions by Product

**Figure 17: Markup and Markdown Contributions - Product Category Averages**




Notes: Weighted averages, using dry matter content quantity weights.

## E.4 Pass-Through Analysis - Graphical Representation

**Figure 18: Impact of an Increase of the Commodity Price for Commodity Buyers**

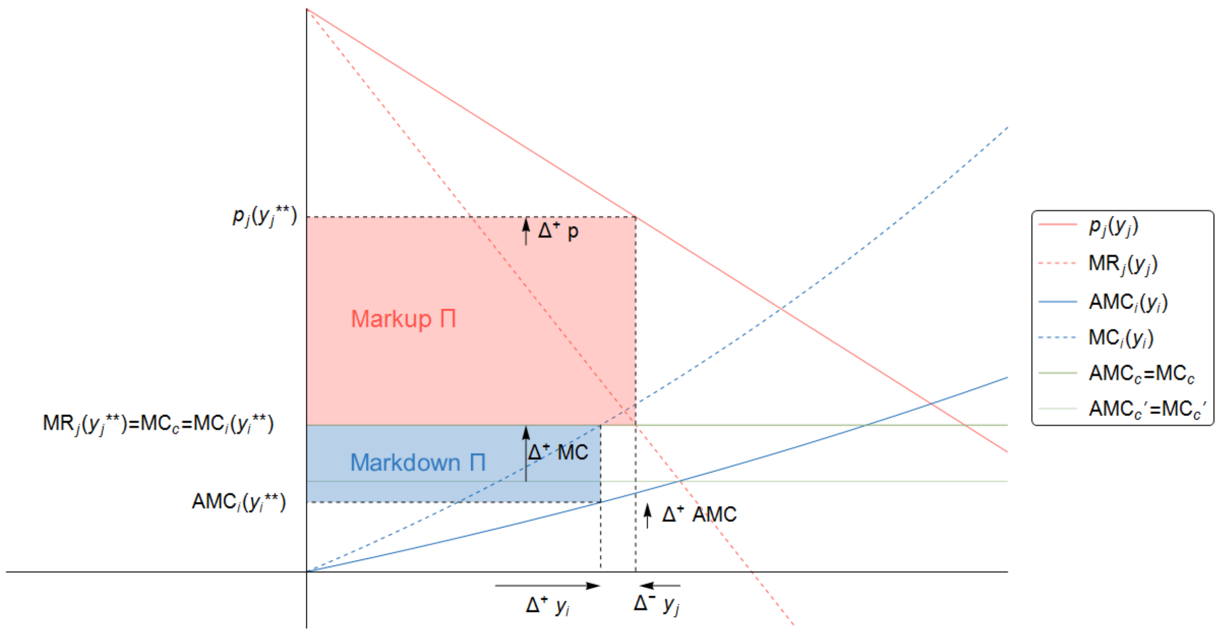
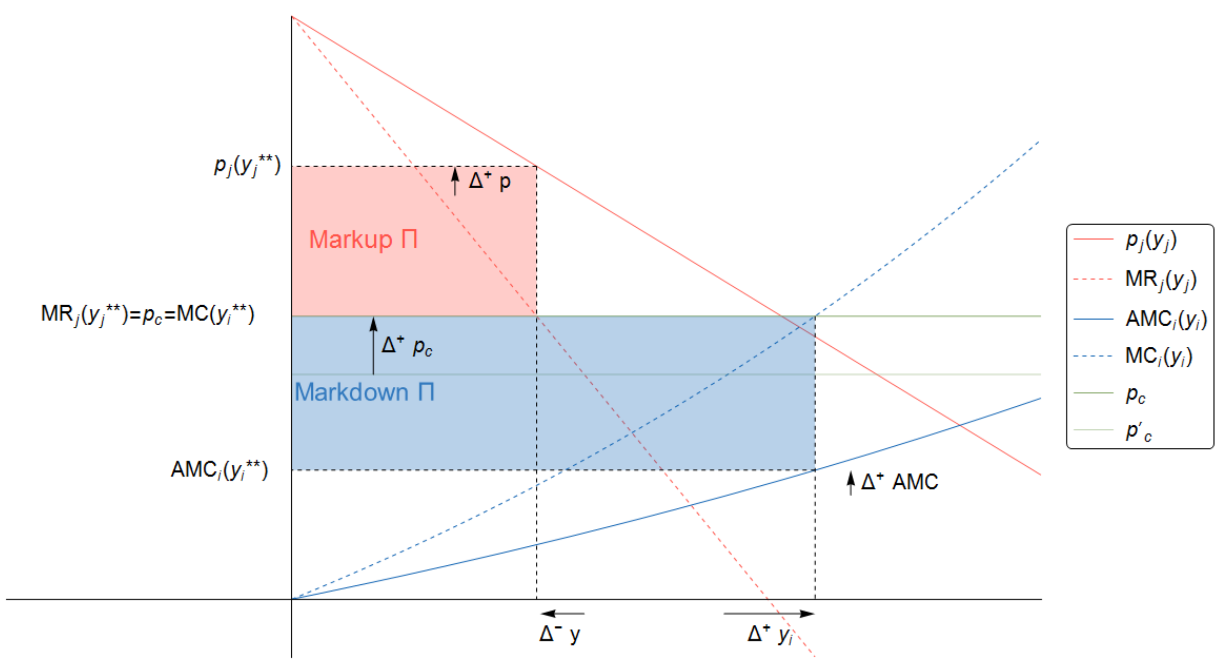



**Figure 19: Impact of an Increase of the Commodity Price for Commodity Sellers**



## E.5 Additional Theoretical Pass-Through Derivations

### E.5.1 Pass-Through for WMP Sellers

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

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

We consider here variations in the price $w_c$ at which they are able to sell WMP. Proceeding as in Section 5.3, both definitions yield the following pass-throughs on upstream prices:

$$\varepsilon_{w_c}^{w_{fi}}=\tilde{\theta}_{fic}^{-1}-\varepsilon_{w_c}^{\nu_{fi}}, \tag{32}$$

and downstream prices

$$\varepsilon_{w_c}^{p_{fj}}=\varepsilon_{w_c}^{\mu_{fj}}+e_{cj}\frac{w_c}{p_{fj}}\mu_{fj}. \tag{33}$$

### E.5.2 Pass-Through with Endogenous Marginal Processing Cost

We proceed in a similar way as in Section 5.3 but authorizing $\lambda_{fj}$ to adjust, *i.e* considering it as an endogenous object $\lambda_{fj}(w_c)$.

Starting from the margin definition, (13) rewrites:

$$\varepsilon_{w_c}^{p_{fj}}=\varepsilon_{w_c}^{M_{fij}}+\theta_{fij}\varepsilon_{w_c}^{w_{fi}}+(1-\theta_{fij})\,\varepsilon_{w_c}^{\lambda_{fj}}, \tag{34}$$

Starting from the markup definition, (14) 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 (15)):

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

Finally, (16) is unchanged:

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

while (17) rewrites:

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

## E.6 Additional Reduced-Form Pass-Through Estimates - WMP Sellers

**Table 15: Pass-Through: Reduced-Form Estimates - WMP Sellers**

| | (1) Milk Price $w_{fi}$ | (2) Markdown $\nu_{fi}$ | (3) Output Price $p_{fj}$ | (4) Markup $\mu_{fj}$ | (5) Margin $M_{fij}$ | (6) Output Price $p_{fj}$ | (7) Markup $\mu_{fj}$ | (8) Margin $M_{fij}$ |
|---|---|---|---|---|---|---|---|---|
| WMP Price | 0.239*** | 0.824*** | 0.067 | -0.667*** | -0.089*** | 0.748*** | -0.101 | 0.791*** |
| | (0.018) | (0.044) | (0.050) | (0.062) | (0.009) | (0.128) | (0.138) | (0.034) |
| Farm Cost Index | 0.595*** | -0.262** | 0.796*** | 0.555** | 0.015 | 0.181 | 0.281 | -0.465*** |
| | (0.041) | (0.077) | (0.183) | (0.255) | (0.034) | (0.298) | (0.362) | (0.069) |
| Obs | 1,259 | 1,259 | 489 | 489 | 15,337 | 408 | 408 | 9,620 |
| R2 | 0.649 | 0.762 | 0.972 | 0.775 | 0.761 | 0.916 | 0.596 | 0.568 |
| Sample | | | Final goods | Final goods | Final goods | Bulk products | Bulk products | Bulk products |
| FE | fi | fi | fj | fj | fij | fj | fj | fij |

Notes: Standard errors are in parenthesis. **** p<0.01, ** p<0.05, * p<0.1.* All variables are in log. Sample restricted to firms for which we manage to link raw milk collection and production, and WMP sellers only. The level of observation vary with the level at which the considered outcome is observed or estimated: (i) firm-*département*-year level for raw milk prices and markdowns (although prices used here are at the region-year level), (ii) firm-product-year level for output prices and markups, (iii) firm-*département*-product-year level for margins. Margins computed under an assumption of homogeneous milk sourcing across products for a given firm.

**Table 16: Pass-Through: Reduced-Form Estimates - All Firms**

| | (1) Milk Price $w_{fi}$ | (2) Markdown $\nu_{fi}$ | (3) Output Price $p_{fj}$ | (4) Markup $\mu_{fj}$ | (5) Margin $M_{fij}$ | (6) Output Price $p_{fj}$ | (7) Markup $\mu_{fj}$ | (8) Margin $M_{fij}$ |
|---|---|---|---|---|---|---|---|---|
| WMP Price | 0.229*** | 0.779*** | -0.007 | -0.646*** | -0.108*** | 0.697*** | 0.012 | 0.653*** |
| | (0.011) | (0.017) | (0.020) | (0.032) | (0.007) | (0.057) | (0.061) | (0.017) |
| Farm Cost Index | 0.647*** | -0.609*** | 0.638*** | 0.404*** | -0.126*** | -0.032 | -0.158 | -0.871*** |
| | (0.010) | (0.070) | (0.057) | (0.088) | (0.022) | (0.124) | (0.152) | (0.043) |
| Obs | 6,840 | 6,840 | 3,172 | 3,172 | 38,038 | 1,936 | 1,936 | 25,263 |
| R2 | 0.683 | 0.776 | 0.972 | 0.839 | 0.809 | 0.929 | 0.795 | 0.754 |
| Sample | | | Final goods | Final goods | Final goods | Bulk products | Bulk products | Bulk products |
| FE | fi | fi | fj | fj | fij | fj | fj | fij |

Notes: Standard errors are in parenthesis. **** p<0.01, ** p<0.05, * p<0.1.* All variables are in log. Sample restricted to firms for which we manage to link raw milk collection and production. The level of observation varies with the level at which the considered outcome is observed or estimated: (i) firm-*département*-year level for raw milk prices and markdowns (although prices used here are at the region-year level), (ii) firm-product-year level for output prices and markups, (iii) firm-*département*-product-year level for margins. Margins computed under an assumption of homogeneous milk sourcing across products for a given firm.

Table 17: Pass-Through: Reduced-Form Estimates - All Firms

| | (1) Output Price $p_{fj}$ | (2) Markup $\mu_{fj}$ | (3) Margin $M_{fij}$ |
|---|---|---|---|
| WMP Price | 0.210*** | 0.265*** | -0.392*** |
| | (0.010) | (0.031) | (0.035) |
| Farm Cost Index | -0.409*** | 0.386*** | 0.195** |
| | (0.022) | (0.061) | (0.080) |
| Obs | 63,557 | 5,119 | 5,119 |
| R2 | 0.856 | 0.964 | 0.878 |
| FE | fij | fj | fj |

Notes: Standard errors are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. All variables are in log. Sample restricted to firms for which we manage to link raw milk collection and production. The level of observation varies with the level at which the considered outcome is observed or estimated:(i) firm-product-year level for output prices and markups, (ii) firm-*département*-product-year level for margins. Margins computed under an assumption of homogeneous milk sourcing across products for a given firm.

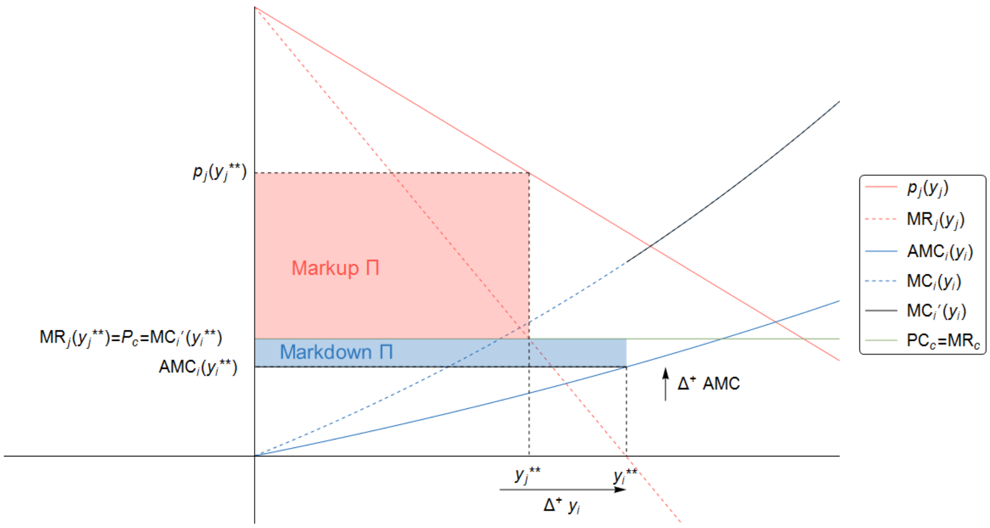
## E.7 Illustrating the Role of a Price Floor

The main intuitions regarding the impact of a price floor are gathered in Figures 20 and 21 of Appendix E.7, showing its effects for firms that initially buy and sell WMP respectively.

As mentioned, *absent strategic downstream retailers*, 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 processors. At the price floor level, milk supply becomes flat, and so does the marginal cost of processors. This implies that processors' 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 processors.

**Figure 20: 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.

**Figure 21: Price Floor - WMP Sellers**