Geographical indications and trade: Firm-level evidence from the French cheese industry

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Geographical indications and trade: Firm-level evidence from the French cheese industry

Sabine Duvaleix*, Charlotte Emlinger†, Carl Gaigné‡, Karine Latouche §

Abstract

The protection of geographical indications is now an important feature of trade agreements. In this paper, we examine whether geographical indications are valued by foreign consumers and whether they have implications for trade at firm level. We use firm-product level data from French Customs and a unique dataset of firms and products concerned by Protected Designations of Origin (PDO) in the cheese and butter sector. Our estimations show that PDO varieties are perceived by consumers as varieties of higher quality than non-PDO varieties and that the prices of PDO varieties are 11.5% higher than those of non-PDO. Firms producing PDO varieties do not export higher volume, but benefit from a better access to European markets and to countries with a similar policy about geographical indications. varieties. The inclusion of some GI varieties in trade agreements may thus constitute an opportunity for PDO producers to increase their market access.

Keywords: Geographical indication; PDO cheeses; export performance; product quality; trade margins

JEL: F10, F14.

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1 Introduction

Geographical indications (GIs) are a contentious issue in trade negotiations. In the past, the European GI system has twice given rise to complaints to the WTO dispute settlement body, once by the United States in 1999 and once by Australia in 2003. Recently, the protection of GIs was very controversial in the negotiation of the Comprehensive Economic and Trade Agreement (CETA) between the European Union and Canada. These tensions arise from the significant differences in the approaches between the European Union and the US, Canada and Australia (Josling, 2006).The European Union favors a sui generis system for protecting products based on their geographical origin whereas the US supports trademark laws.

In the opinion of the EU, there is a clear link between the place of production and the quality of agricultural products, which is mainly explained by soil, weather and local know-how. In this respect, geographical indications defined by the EU policy have three goals. First it improves the information given to consumers about the intrinsic quality of products. Second, it helps promoting rural development and securing cultural heritage. Third, it protects food products from imported counterfeited ones, through intellectual property right law. The EU's efforts to promote GIs in multilateral and bilateral negotiations conflict with the view of Anglo-Saxon countries who historically prefer to rely on trademarks. The US, Canada, Australia and South Africa are reluctant to adopt GIs and consider them as unfair trade impediments. More specifically, they consider some GI products as generic types of products and thus according to them, the GI system grants too much protection (Matthews, 2016). However, Canada made concessions to the European Union. In the CETA, Canada has agreed to recognize 145 GIs. While this agreement is still too recent to measure the impact of this recognition on trade in products with GIs from the European Union, it is worth investigating the impact of GIs on trade at firm level to shed light on the potential impact of such recognition outside the European Union. It is also worth examining how countries that develop a similar type of product protection system recognize the European GI products.

Relatively few papers analyze the impact of geographical indications on trade. Agostino and Trivieri (2014) focus on wine from France, Spain and Italy and demonstrate that quality wines produced in specified regions have higher export values. Sorgho and Larue (2014) quantify the effect of GIs on intra-community trade using a gravity model with data at country and product (defined with 2 digit codes - HS2) level. They identify the effects of GIs on trade within the EU varies, according to whether or not the importing country has GI protected products. They also

find a higher border effect for GI products, due to their greater appreciation by domestic consumers. The same authors continue their work in Sorgho and Larue (2018) and show that the effect of GIs on European trade is ambiguous, due to heterogeneity in consumer preferences. Raimondi et al. (2019) use a dataset with trade flows at country and product (defined with 6 digit codes - HS6) level to estimate the effect of GIs on intra- and extra-EU trade margins. They show that GIs positively affect trade and prices, in both European and non-European countries. The main challenge in studying GIs and trade is to identify the trade flows concerned by GIs, as this information is not recorded in trade databases. The works cited above analyze the effect of GIs at the aggregated level (country imports of HS2 or HS6 products) and use the number of existing GI per product category (HS2 or HS6) to identify flows containing potential GI varieties. To identify GI flows more precisely, one needs a more disaggregated product level (8 digit for instance) and information on the exporting firms. Indeed, for a given GI, only authorized firms are allowed to operate. In other words, the GI flows can only be properly identified in trade datasets once firm-product (8 digit) pairs are accounted for.

In this paper, we identify firm-product flows concerned with GIs and examine whether GIs impact prices and trade margins at firm level. We also test whether foreign consumers perceive GI varieties as higher quality varieties. We focus on the Protected Designations of Origin (PDO) scheme in the French cheese and butter industry, which is an important component of the French international reputation and one of the most contentious sectors in the international GI debate (see Frankel, 2017). We take advantage of a unique exhaustive list of firms-product (defined with 8 digit codes - NC8 in the European 8-digit level product classification) pairs concerned by PDO in France to compare exports of PDO varieties with exports of non-PDO varieties to a given destination. From our theoretical model, it appears that the effect of PDO on export performance is ambiguous. French cheese producers have been involved in PDO production for many years, mainly for the domestic market. Trade flows of PDO products have recently grown. [1] The choice of PDO label was made only for domestic considerations. In addition, the main characteristics of PDO products cannot be adjusted to the destination country. The reasons are that the principal steps for production are done following a well-established technique within the same geographical area, regardless of destination markets. The specifications for PDO cheese mandate requirements

[1] The sales value of traded agri-food PDO products within the EU member states were 854 million euros in 2005 and reached approximately 2 billion euros in 2017. Outside the EU, traded agri-food PDO products reached 796 million euros in 2017. The domestic market remains the largest market; however, GI cheese products represent half of the sales growth between 2010 and 2017 in the intra-EU trade and 40% of the growth outside the EU (ANDInternational et al., 2019).

that are deemed essential to achieve the desired cheese quality. As a consequence, the fact that firms supply PDO varieties reveals that the price premium exceeds the cost difference in the *domestic* market. However, we do not know whether there exists a price premium in foreign markets. Export performance of PDO varieties would depend on (i) how foreign consumers' preferences value quality and PDO varieties and (ii) the level of fixed export costs associated with marketing, promotion, and advertising that are necessary for a credible PDO. Hence, if a PDO label is profitable in the domestic market, the profitability of PDO varieties relatively to non-PDO varieties in foreign markets is still an open question.

In a first stage, we investigate whether PDO labels allow producers facing the same rules for a given product to charge higher prices in foreign markets. We also investigate whether PDO labels are perceived by foreign consumers as a quality signal. To this end, we follow the methodology developed by Amiti and Khandelwal (2013) to infer relative quality from the estimate of demand functions based on observed trade data at firm-product (NC8) level. Our approach thus differs from that used in other articles on consumer valuation of GIs that measure willingness to pay for geographical labels (Menapace et al., 2011; Bonnet and Simioni, 2001), price elasticities (Hassan et al., 2011) or price premiums (see for example a meta-analysis by Deselnicu et al., 2013). In a second stage, we estimate the impact of PDO labels on the margins of trade at firm-product level: the probability of exporting and the quantity exported. European destinations are distinguished from other destinations.

Our research builds on papers that investigate the relationship between quality and trade. A first strand of this empirical literature assesses the impact of different trade costs on trade according to the quality of the products, using either country level data (Schott, 2004, 2008; Hummels and Klenow, 2005; Baldwin and Harrigan, 2011) or firm level data (Bastos and Silva, 2010; Martin, 2012). A second strand of this literature focuses on the heterogeneity of firm-level quality. Johnson (2012) shows that highly productive firms export better quality goods and charge higher prices than other firms. Manova and Zhang (2012) show that Chinese firms producing higher quality goods have a better export performance. Crozet et al. (2012) tested the Melitz (2003) model using firm heterogeneity and show that quality increases both the probability of market entry and exported values. Curzi and Olper (2012) also confirm the relationship between productivity, product quality and export performance in the food sector. Except for Crozet et al. (2012), who use quality ranking by experts, and Curzi and Olper (2012), who used R&D and innovation as a proxy for quality, the majority of these studies have used trade unit values as a proxy for the quality of the product.

In this paper, we investigate the impact of another measure of quality, the label PDO. In the theoretical model, the PDO label is considered as a quality shifter for some consumers (increasing the demand for PDO varieties) but also, due to production constraints, as a marginal cost shifter for producers (increasing price and thus reducing demand). Thus the PDO label has an ambiguous effect on trade. In the empirical analysis, we show that this label has a positive impact on firm trade flows.

Our estimations reveal that PDO varieties allow firms to charge higher prices (their prices are 11.5% higher than those of non-PDO varieties). We also find that, for a given product-destination pair, PDO varieties are perceived by consumers as products of higher quality than non-PDO varieties. This confirms the link between PDO label and quality perception by consumers. As expected, this link is higher for EU consumers. We also show that PDO varieties benefit from a better access to EU markets and to markets where consumers are aware of geographical indication schemes. Based on this result, we propose a back of the envelope computation that shows that if the role of PDO on non-EU countries were the same as on european countries, firm's exported expected value of PDO varieties would increase by an average of 67.5%.

The paper is organized as follows. In the first section, we present the European approach to protecting GIs, highlighting how it differs from the trademark system. In the second section, we develop a theoretical framework showing the different mechanisms at work that we use as a guide for our identification strategy. In the third section, we describe our dataset and provide first evidence for differences in trade patterns between PDO and non-PDO varieties. In the fourth section, we present our empirical strategy. In the fifth section, we show our empirical results and present our conclusions in the last section.

2 The European Geographical Indications Policy

2.1 The GI component of the European quality package

In the European Union, GI protection is included in the European quality package, which was launched in 2010 and is defined in details in European regulation 1151/2012. This European quality policy aims to provide consumers with information both on the origin of the products and on traditional know-how. GIs include two quality schemes: Protected Designations of Origin (PDO)

and Protected Geographical Indications (PGI).[2]

In March 2021, the European Union listed 1542 food products that are registered with a GI (661 PDO, 881 PGI and 210 products are in the process of registration, among which 31 originate from countries outside the European Union. While wines are still the main GI products, the cheese sector also accounts for a large share of European GIs. Furthermore, the majority of the GI products are located in the south of the EU (France, Greece, Italy, Portugal and Spain as highlighted by Huysmans and Swinnen (2019) (see Table 1).

For a product to be registered as a PDO, applicants have to be a group of producers and/or processing firms and can apply for the name of an existing product. The application form includes the product description and the geographical area associated with the products. Details on the link between the region of origin and its causal influence on product quality or characteristics have to be provided. PDO requirements are stricter than those required for Protected Geographical Indications (PGI).

In France, GIs are managed by the INAO (*Institut National de l'Origine et de la Qualité*), which is a mixed public-private body. However, only public authorities (the Ministry of Agriculture) are authorized to examine GI specifications and to interact with the EU commission. INAO was created in 1935, but French law has recognized and associated the location with a product name since 1905. At that time, the aim of the law was to protect wine producers through the definition of AOC labels (*Appellation d'Origine Contrôlée*). The first cheese AOC, the AOC *Roquefort*, appeared in 1925. Another emblematic French cheese AOC, the AOC *Comté*, was recognized in 1958. Among the 51 French dairy PDOs, 36 existed before 1995 and 25 existed before 1980. The most recent French PDO applies to *Beurre et crème de Bresse* which was recognized in 2014 and to the cheese *Brousse du Rove* registered in May 2020.

2.2 Related literature on the impacts of GIs on producers and consumers

GIs are included in the European quality policy as a welfare-improving tool because they reduce market failures associated with information asymmetry and help producers to better market their products. GIs help promote regional and rural development by securing prices at farm gate level and by protecting producers of regional food products from unfair competition from trademarked products using the same denominations. Lence et al. (2007) demonstrate that when producer

[2]The label Traditional Specialties Guaranteed (TSG) only relies on traditional know-how without any reference to a specific location.

Table 1: Number of registered GIs in the cheese sector

	Total	PDO	PGI
European Union	243	189	47
France	55	46	9
Italy	55	53	2
Spain	29	26	3
Greece	23	22	1
Portugal	12	11	1

Notes: Authors' computation using the eAmbrosia database.

organizations obtain stronger property rights to collectively manage the geographically protected products, their welfare is enhanced. Their conclusion is in agreement with that of Moschini et al. (2008) who show that GIs lead to welfare gains in a competitive market structure of quality supply. Moreover, the GI scheme reduces the cost of establishing a reputation and GIs reveal more information than do trademarks (Menapace and Moschini, 2012). The positive effects of PDO labeling have also been empirically demonstrated by the exit rate of firms. Looking at the impact of PDO on the survival of French cheese firms, Bontemps et al. (2013) find that PDO labeling mitigates the exit rate for dairy firms. Bouamra-Mechemache and Chaaban (2010b) also demonstrate that PDO are efficient from the producer's perspective. However, PDO labeling restricts quantity and increases variable costs compared to private collective certification that relies on fixed costs such as investment in R&D and joint advertising. On average, PDO producers face 40% higher costs (more labor intensive, higher prices paid for raw material) than non-PDO producers (Bouamra-Mechemache and Chaaban, 2010a). Desquilbet and Monier-Dilhan (2015) examine the heterogeneity of PDO labeling by investigating two extreme cases: (i) a denomination label, *i.e.*, the PDO only protects the product name or brand and (ii) a minimum quality standard label, where the PDO label not only protects the product name but it also includes a set of binding requirements. They show that theoretically, producers are better off in the first PDO labeling scheme.

Consumers are not always aware of the differences between PDO and non-PDO varieties. Bonnet and Simioni (2001) found that only a small number of consumers prefer purchasing a PDO *camembert* to a non-PDO *camembert*. This author mentions that a trademark appears to provide more relevant information about the valuation of this specific product. Hassan et al. (2011) confirm this result by estimating price elasticities across various cheese products, but the finding is not widely supported in the literature. In their meta-analysis, Deselnicu et al., 2013 point out that the

biggest premiums from GIs are found in the cheese, fruit and vegetable and grain sectors. They also report that PDOs with the most stringent requirements get the highest premium.

2.3 GIs versus trademarks at international level

At the multilateral level, GIs were officially introduced and defined in article 22 of the Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreement of the World Trade Organization (WTO) in 1994. The TRIPS agreement is weakly prescriptive and leaves the means of GI protection to be defined by each country to account for the heterogeneity of national approaches. Whereas the US, and other countries including Australia and New Zealand, largely incorporate GI protection in trademark laws, *sui generis* systems were developed in countries with Roman law, (France,Italy and Spain) and are currently in force in the EU.

GIs and trademarks are thus the two main alternative means used by WTO members to protect products with GI provisions. They both protect products through intellectual property and grant exclusive rights to the users. They address a market failure and ensure that information is revealed to consumers to mitigate information asymmetry. However, based on stronger state intervention and involving both definition of the methods of production and facilitation of the supply chain coordination, the GI *sui generis* system differs considerably from the trademark system (Gangjee, 2017; Kireeva and O'Connor, 2010). In the *sui generis* system, when entry conditions (geographic area and adoption of GI code of rules) are met, all producers (farmers and processors) can use the associated GI. GI can be thus regarded as a collective brand shared between agricultural producers and processing firms that are authorized to use it. In that sense, in contrast to trademarks, they are not exclusionary.

The coexistence of GIs and trademarks on the same market due to international trade raises several concerns. For instance, in countries that use the trademark system, GI producers from other countries cannot prevent the misuse of their denomination unless the GI is registered as a trademark. As a consequence, GIs may not have the same impact on firms' exports depending on the destination market. We explore this issue in our empirical analysis.

3 Theoretical framework

The specification of our empirical model is driven by the firm-based trade theory. We built a model as a guide for our identification strategy. As we study the impact of PDO label on export

performances at firm level, we do not analyze the decision to produce a PDO variety. We consider that *exporters* are *ex ante* and exogenously identified as either authorized or non-authorized firms. For the reasons mentioned in the introduction, the choice of PDO label is assumed to be made by considering only the domestic market. In France, certified cheese producers have been involved in PDO production for many years. Hence, we can consider the PDO adoption was not driven by foreign markets as the exports of PDO varieties was very low in the past. Furthermore, the main characteristics of PDO products cannot be adjusted to the destination country as the principal steps for production are made following a well-established technique within the same geographical area, regardless of destination markets. As a consequence, the fact that firms supply PDO varieties reveals the existence of a price premium in the *domestic* market. Nevertheless, the profitability of PDO varieties in foreign markets relatively to non-PDO varieties depends on two main parameters: (i) how foreign consumer preferences value quality and PDO varieties and (ii) fixed export costs associated with marketing, promotion, and advertising that are necessary for a credible PDO.

Let U_{jk} be the utility associated to consumption of product k in country j:

$$U_{jk} = \left[\sum_i \int_{\Omega_{ijk}} \left[\lambda_{ijk}(v) q(v) \right]^{\frac{\varepsilon_{jk}-1}{\varepsilon_{jk}}} \mathrm{d}v \right]^{\frac{\varepsilon_{jk}}{\varepsilon_{jk}-1}}, \tag{1}$$

where $q(v)$ is the quantity purchased for each variety of product k, Ω_{ijk} is the set of varieties of product k available in country j and produced in country i, and $\varepsilon_{jk} > 1$ is the substitution elasticity between varieties. As in Kugler and Verhoogen (2012), Hallak and Sivadasan (2013), Gaigné and Larue (2016), $\lambda_{ijk}(v)$ represents the quality perceived by consumers living in country j for variety v of product k imported from country i. It captures all attributes of a product other than price, which consumers value. Standard calculations show that the equilibrium demand for variety v of product k in country j is such that:

$$q_{ijk}(v) = \left[\lambda_{ijk}(v) \right]^{\varepsilon_{jk}-1} E_{jk} P_{jk}^{\varepsilon_{jk}-1} \left[p_{ijk}(v) \right]^{-\varepsilon_{jk}}, \tag{2}$$

where E_{jk} is the amount of income allocated to the differentiated product k in country j and P_{jk} is the price index in country j associated with product k, defined as:

$$P_{jk} = \left[\sum_\ell \int_{\Omega_{\ell jk}} \left[p_{\ell jk}(v) / \lambda_{\ell jk}(v) \right]^{1-\varepsilon_{jk}} \mathrm{d}v \right]^{\frac{-1}{\varepsilon_{jk}-1}}, \tag{3}$$

where the price index responds negatively to an increase in product quality. We assume that foreign

consumers value varieties as follows

$$\lambda_{ijk}(v) = [\theta_{ik} e^{\xi_i \times \text{PDO(v)}}]^{\eta_j} \tag{4}$$

where $PDO(v)$ is equal to one if variety v of product k has a PDO label. If a variety belonging to product k from country i is not a PDO variety then the quality is given by θ_{ik}. Parameter ξ_i is a quality shifter associated with PDO labeling and η_j represents the consumer quality valuation of product k in country j. In this model, we do not quantify the quality shift induced by the PDO label. We introduce a shifter specific to consumers in country j. The more consumers value PDO (quality shift), the higher the imported quantity. Note that $\zeta_{ij} \equiv \xi_i \times \eta_j$ is the elasticity of perceived quality by consumers living in country j to PDO labeling from country i. As in Curzi and Olper (2012) and Crinò and Epifani (2012), the demand addressed to firm f from country i by consumers from country j for product k is higher for high quality varieties. In our model, as PDO is a potential component of quality, the demand will be higher if consumers in country j value PDO varieties.

We now describe production technology and market structure. Firms produce under monopolistic competition and can be multi-product. In the empirical section, we consistently used the firm-product pair (*variety*) as the basic unit of our analysis. However, each variety is supplied by a single producer. Technology is such that the marginal cost of firm f located in country i associated with its variety of product k and exported to country j is given by

$$c_{fijk} = \omega_f i (\theta_{ik})^{\alpha_i} e^{\beta_i \text{PDO}_{fik}} \tau_{ijk} / \varphi_{fik} \tag{5}$$

where $\omega_f i$ is a price index of inputs used by firm f and τ_{ijk} represents trade costs for product k shipped from country i to country j. Following Crinò and Epifani (2012), we assume that the marginal cost of producing its variety of product k to be exported to country j, is decreasing in firm f's efficiency for product k and increasing in product quality. In our case, we add a supplementary cost shifter to account for the fact that PDO production is costly, as in Moschini et al. (2008). The variable $(\theta_{ik})^{\alpha_i}$ with $\alpha_i \geq 0$ can be interpreted as a cost shifter due to product quality with no PDO label while $e^{\beta_i \text{PDO}_{fik}}$ is an additional cost shifter due to the PDO label. The parameter β_i can be interpreted as the cost elasticity of producing a PDO variety.[3] Higher marginal costs can

[3]In this model, we deal with the production of a PDO variety, once the firm obtained the authorization. We do not address the process to get authorized (surely involving sunk costs) as most PDO authorizations were obtained more than 20 years ago.

be caused by a more thorough selection of ingredients and/or additional production tasks. Note that $\text{PDO}_{fik} = 1$ if firm f has a PDO certification for a variety of product k and $\text{PDO}_{fik} = 0$ otherwise. Hence, $\text{PDO}_{fik} = \text{PDO}_v$ since each variety of product k is supplied by a single firm. In other words, the variety labeled v is defined as a product labeled k supplied by a firm labeled f.

The variable φ_{fik} is the productivity of firm f located in country i producing product k. We also consider that the multi-product firm has a core competence product it produces at the lowest cost. Adding more products incurs additional costs as it pulls a firm away from its core competency (Eckel and Neary, 2010; Mayer et al., 2014). An additional product entails a decrease in productivity as follows: $\varphi_{fik} = \varphi_{fi} \times \text{Rank}_{fik}^{-\gamma}$ with $\gamma > 0$ and φ_{fi} the productivity in producing the core product and Rank_{fik} the rank of product k within the product line of firm f. Thus the marginal production cost increases with the number of varieties supplied by the manufacturer. Note that we fall back on the "standard" firm-based theory when $\beta = 0$, $\alpha = 0$ and $\gamma = 0$.

As the marginal cost is assumed to be independent of output size, the profit of the firm producing variety v located in country i can be written as follows:

$$\pi_{fi} = \sum_j \sum_k \pi_{fijk} \quad \text{with } \pi_{fijk} = p_{fijk}q_{fijk} - c_{fijk}q_{fijk} - \phi_{fijk}\phi_{fijk}e^{\kappa_j \text{PDO}_{fik}} \tag{6}$$

where ϕ_{fijk} is a fixed cost associated with exporting product k from country i to country j incurred by firm f. Following Moschini et al. (2008), we also consider a fixed cost shifter $e^{\kappa_j \text{PDO}_{fik}}$. Firms selling PDO products must undertake additionnal investments in quality signaling (certified firms disclose information about the quality of their product to uninformed consumers). This quality-signaling activities undertaken by the certified firms imply a higher fixed export cost which may vary across destination markets. The profit-maximizing prices are

$$p_{fijk} = \frac{\varepsilon_{jk}}{\varepsilon_{jk} - 1} \frac{\omega_{fi}(\theta_{ik})^{\alpha_i} e^{\beta_i \text{PDO}_{fik}} \tau_{ijk}}{\varphi_{fi} \text{Rank}_{fik}^{-\gamma}} \tag{7}$$

Hence, as expected, firms charge a markup ($\varepsilon_{jk}/(\varepsilon_{jk} - 1)$) over the marginal cost (c_{fijk}). Note that the shift in marginal costs will induce a higher profit-maximizing price.

Our model makes explicit the ambiguous role of PDO labels in the probability of exporting (the extensive margin of trade) and the level of export quantity (the intensive margin of trade). On the one hand, foreign consumers could be more willing to pay for a food product with a PDO label because they perceive the product to be of higher quality. The demand addressed to PDO producers

will increase when consumers in a destination market value PDO varieties as quality goods (demand effect - noted ζ_{ij}in our model). On the other hand, the binding quality requirements associated with PDO labels could generate higher production costs at firm level and thus result in higher prices. PDO label increases marginal costs and doing so increases the profit maximizing prices (cost effect - noted β_i). In turn, higher prices decrease the demand addressed by consumers. According to the relative importance of these two components, the global effect of PDO labels on export will be different according to destination country. We expect it to be positive, especially on foreign markets where PDO are perceived as quality varieties: the positive demand effect will be higher than the negative cost effect.

4 Data and descriptive statistics

4.1 Data

The objective of the paper is to investigate the effect of PDO label on trade patterns. Based on our theoretical model described in section 3, our empirical analysis relies on an exhaustive list of product-plants concerned by PDO labels published in 2012, provided by the INAO. This list gives for each PDO label, the list of plants authorized to operate. We have 1083 distinct plants (including farms, small cheese factories and agri-food plants) involved in the production 48 PDO cheese labels. This bilateral link between plant and PDO name is the key point to identify PDO trade flows.

This dataset is merged with data on French firm-level trade and characteristics for 2012. Trade data from French Customs provide the value and quantity of exports, for each firm, according to the European 8-digit level product classification (NC8) and destination. Data on firm's characteristics come from the French national institute of public statistics (INSEE) and provide information on the main activity, total sales and the value added per worker of each firm. The activity code enables us to select the firms specialized in the production of butter and cheese.

The first issue we encounter when merging PDOs information and firm's characteristics is to match plant and firm identifiers. A plant is a production location and a firm may have multiple production locations. We aggregate plants into firms using the first nine numbers of the national identification code of plants (SIRET) which is the firm's identification code (SIREN).

The second challenge is to match the names of PDO (for instance *Camembert de Normandie*) from the INAO dataset with the NC8 classification of products used by French Customs (in our example 0406.90.82, which corresponds to *Camembert*). We build a correspondence table (Table

7) to make the transformation, using NC8 and PDO descriptions. Although the correspondence is straightforward for several products as in the case of *Camembert*, two types of problems may arise. First, a PDO label may not have an exclusive NC8 code, as in the case of *Comté* that can be registered under the code 0406.90.15 or 0406.90.99 depending on its fat content, which is linked with the period of the year. Second, an NC8 code can stand for both PDO and non-PDO varieties, as in the case of the NC8 code 0406.90.15. This code corresponds to *Comté* but also to products with the same characteristics in terms of fat or water content but that do not benefit from the PDO label, as *Gruyère*. At the end, we obtain a list of 14 NC8 categories that are concerned by PDO labels.

Among firms that belong to the same activity code (i.e. production of cheese and butter), we limit our analysis to firms that export products that belong to the NC8 categories for which at least one PDO label is defined.[4],[5] We only consider producing firms and exclude wholesalers from our sample to fit with our theoretical model, but also because it is impossible to follow PDO varieties produced by authorized firms and exported by wholesalers or other trade intermediaries in our data.

We end up with a sample of 29 authorized and 191 non-authorized exporting firms, both kinds of firms being multi-products, exporting to 151 destinations. It is worth noting that a PDO authorization is specific to a given PDO, so authorized firms may export both PDO varieties in some NC8 codes, but also non-PDO varieties for some other NC8 codes, as we can see in the figure 1. In this example, firms f_1, f_2 and f_3 all produce and export two products, the NC8 0406.90.82 (*Camembert*) and the NC8 0406.90.15 (hard cheese as *Gruyere* or *Comté*). The firm f_1 is authorized for *Camembert* (which corresponds to the PDO *Camembert de Normandie*) but not for the hard cheese category. As a consequence, only its exports of product NC8 0406.90.82 benefits from the PDO label and is identified as a PDO *variety* in our data. Note that the firm f_1 may also export *Camembert* without the PDO label. However, as the customs services do not register the PDO characteristic of the product, we can not distinguish between PDO and non-PDO variety for a given authorized firm-NC8 product pair. We thus consider that all the exports of authorized firms for the NC8 product benefits from the label.[6] The firm f_2 is authorized for the

[4]This concerns 14 NC8 codes among 40 different codes in the HS4 categories 0405 or 0406 for butter and cheese products

[5]We focus on the NC8 exported by firms as we do not know what products are produced by non-exporting firms.

[6]This hypothesis sounds realistic at the plant level as a plant is located in a specific geographical area; the hypothesis is stronger at the firm level (as a firm can have several plants located in different areas). This hypothesis may lead our empirical analysis to underestimate the effects of labels.

hard cheese category 0406.90.15 (which correspond to the PDO *Comté*) but not for *Camembert*, so only its exports of NC8 0406.90.15. are recorded as a PDO *variety* in our dataset. Firm f_3 is neither authorized for the *Camembert* nor for the hard cheese category.

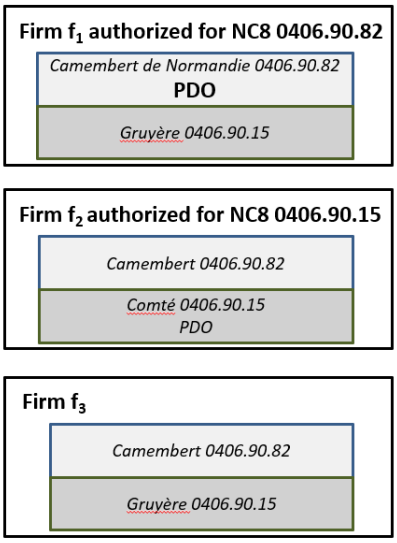


Figure 1: Firm-NC8 pairs and identification of PDO flows

4.2 Descriptive statistics

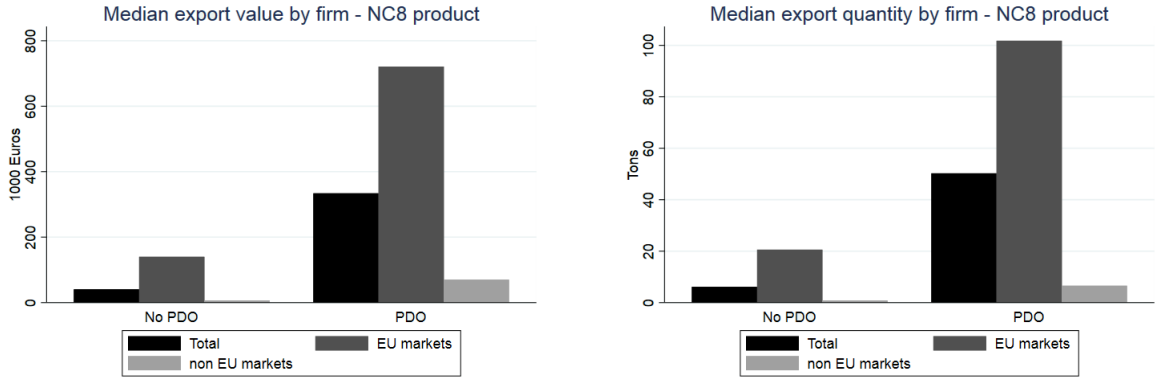
Table 2 provides descriptive statistics for authorized and unauthorized firms. Authorized firms appear to be slightly more productive (computed at firm level) and, based on the number of employees, to be larger. This is consistent with the fact that complying with PDO constraints may generate higher costs that can only be covered by more productive firms. Their higher average productivity and larger size may also partly explain why authorized firms export more products (without distinguishing between PDO and non-PDO varieties), to a larger number of destinations, and have a higher total export value. At the aggregated level, authorized firms represent more than 22% of the total export value of cheese and butter, whereas they only represent 13% of exporters.

PDO varieties represent 23.5% of the export value of authorized firms. As a consequence, PDO varieties represent a relatively small share (5%) of French total exports of butter and cheese. As explained in section 4.1, non-labeled varieties are exported by both unauthorized firms (representing 78% of total trade) and authorized firms (representing 17%). Figure 2 presents median French cheese exports per firm-product and shows that PDO-varieties export values and quantities are higher than for non-PDO varieties. Figure 3, which shows the kernel density of the export values

Table 2: Descriptive statistics on authorized and unauthorized firms

	Type of firm	Nb of firms	Mean	Sd	Median	Min.	Max
Productivity	*Authorized*	28	1,522.21	5,358	355.5	145.9	28,759.1
	Unauthorized	145	630.70	2,232	293.4	0	26,131.4
Number of Employees	*Authorized*	28	190.21	321.65	86.5	10	1512
	Unauthorized	145	148.12	313.2	35.5	1	2392
Number of products	*Authorized*	28	4.29	2.26	4	1	10
	Unauthorized	145	2.09	1.77	1	1	11
Number of destinations	*Authorized*	28	13.39	14.21	8.5	1	63
	Unauthorized	145	5.88	12.45	2	1	89
Total export value	*Authorized*	28	11,255	26,622	1,882	0.43	121,883
	Unauthorized	145	3,995	18,180	59	0.11	172,232

Notes: Authors' computation using INSEE and INAO datasets.



(a) Value (b) Quantity

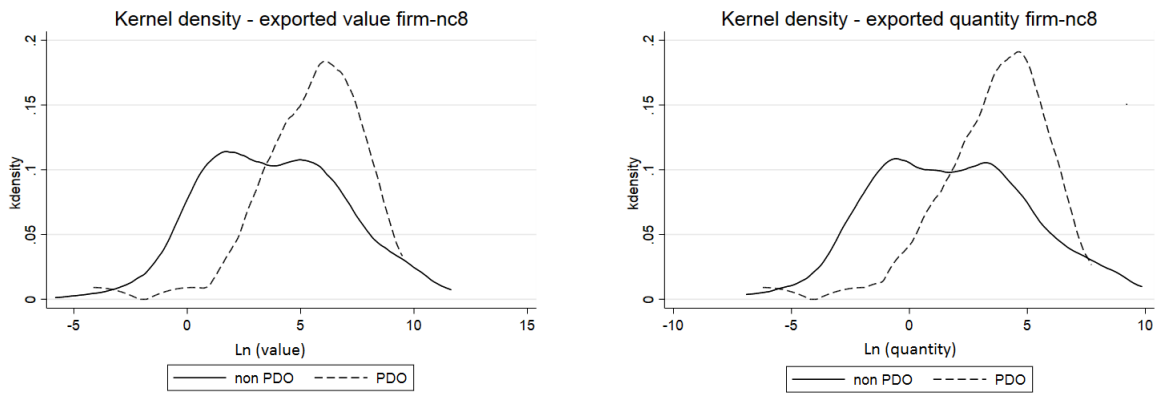
Notes: Authors' computation using French Customs and INAO datasets.

Figure 2: Export per firm and product (NC8)

and quantities per firm-product pair, confirms this observation. PDO varieties generate more flows with higher value or in larger quantities than other varieties.

Figure 4 shows the median of trade unit value of cheese and cream products computed for PDO and non-PDO varieties. In contrast to the export values, the unit value does not differ much according to the type of variety.

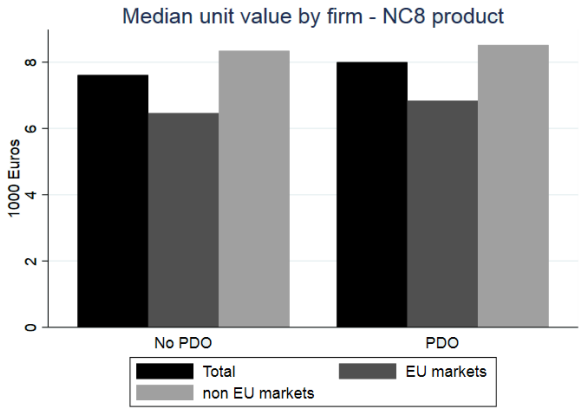
So far, the descriptive statistics suggest a positive role for PDO labels in firms' export performance in the cheese and cream industry.



(a) Value (b) Quantity

Notes: Authors' computation using French Customs and INAO datasets.

Figure 3: Kernel density of export



Notes: Authors' computation using French Customs and INAO datasets.

Figure 4: Exported unit value per firm and product (NC8)

5 Empirical strategy

5.1 Identification

Ideally, we would have liked to quantify the causal effect of PDO labeling on a firm's export patterns by comparing the mean change in a firm's export performance before and after the acquisition of the PDO label relative to a control group. This is unfortunately not possible because our database does not contain information on when a firm first obtained the PDO label. Moreover, in the French cheese sector, most of the firms authorized to handle PDO are the firms that introduced the PDO label, and have consequently been involved in PDO production for many years. As already mentioned in section 2.1, most PDO cheeses and creams, especially those exported as *Comté*, *Camembert de*

Normandie or *Roquefort*, were created before 1995. To be able to identify the first authorization to handle PDO would thus require a very long panel dataset for which firm level trade data are not available.

Our identification of the effect of PDO label on trade patterns exploits variation across firm-product varieties, for a given destination and product NC8. To come back to the example presented in section 4.1 and as we can see in figure 5.1, we are comparing exports of firms f_1, f_2 and f_3 of product NC8 0406.90.82 in a specific destination j, *Japan* in our example. More precisely, we compare the variety [f_1-NC8 0406.90.82], which benefits from the PDO label and is thus *Camembert de Normandie* to the other varieties [f_2-NC8 0406.90.82] and [f_3-NC8 0406.90.82] that do not have the PDO label and correspond to *Camembert* on the Japanese market. This strategy allows us to control for all the characteristics of the destination-product pair (as the taste of Japanese consumers for this specific kind of cheese, transportation cost, and other Japanese market characteristics) in order to focus on the difference between PDO and non-PDO varieties.

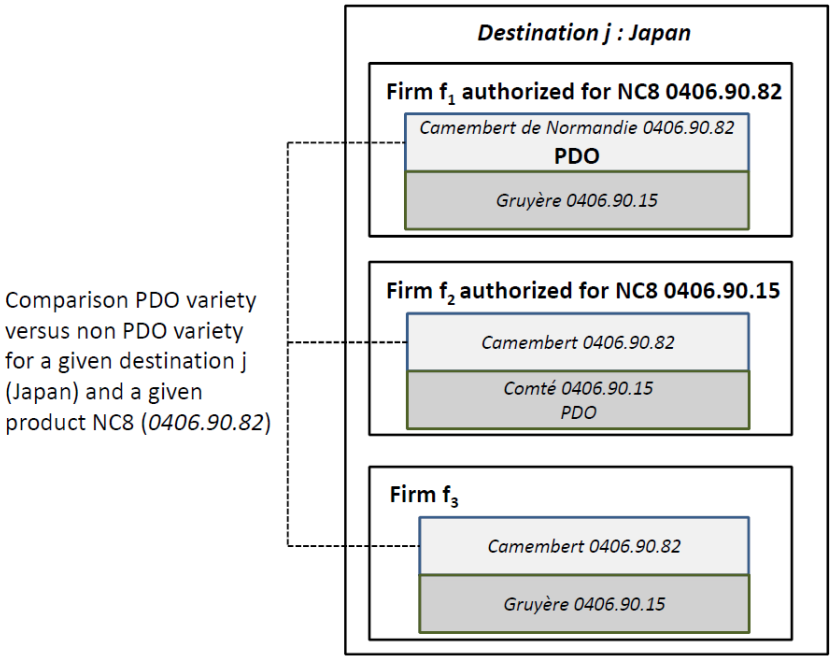


Figure 5: Firm-NC8 pairs and identification strategy

5.2 PDO labeling, price and perceived quality

Our first objective is to check whether exporters of PDO varieties can charge a price premium, compared to non-PDO varieties for a given product and a given destination market. As we have

information on unit value, which is a proxy for price, for each firm-destination-product triplet, we can identify the cost elasticity of PDO labeling (β) defined in section 3. Because data concern exports by firms located in France, we drop index i to ease notation in the following equations. By using equation (7), we obtain the following equation to estimate

$$\log p_{fjk} = \text{constant} + \beta \text{PDO}_{fk} + \gamma \text{logRank}_{fk} + \mathbf{FE}_f + \mathbf{FE}_{jk} + \nu_{fjk} \tag{8}$$

The term $\mathbf{FE}_f$ is a firm fixed effect controlling for firm heterogeneity (productivity φ_{fi}, production factor prices ω_{fi}). The inclusion of destination-product fixed effect $\mathbf{FE}_{jk}$ allows us to compare PDO varieties and non-PDO varieties for a given destination-product pair. This fixed effect captures heterogeneity in destination-product pair (consumer preferences, trade costs τ_{ijk}, markup, and foreign market structure). As our sample includes only one country of origin (France), an origin country-product fixed effect is not needed. Hence, the quality cost of non-PDO varieties $(\theta_{ik})^{\alpha_i}$ is captured in the constant term. The variable Rank_{fk} is computed using all the products exported by the firm f (not only cream and cheese products, as some firms also export other products than cream or cheese)[7].

Our interest variable is PDO_{fk}, a dummy variable equal to 1 if firm f benefits from PDO labeling for product k (defined at the NC8 level) and zero otherwise. We recall that a given firm-product pair fk corresponds to a variety: either a PDO variety ($\text{PDO}_{fk} = 1$) or a non-PDO variety ($\text{PDO}_{fk} = 0$). It is worth noting that, when $\text{PDO}_{fk} = 0$, the control group is heterogeneous as it groups two types of firms: the set of firms authorized to handle some PDO varieties and the others. Indeed, authorized firms can supply both PDO varieties and non-PDO varieties, while unauthorized firms only produce non-PDO varieties (as shown on figure 5.1). Including firm fixed effects FE_f avoids the biased estimates associated with price equations.

Our second objective is to check whether foreign consumers value PDO labels as quality signals for cheese products. Indeed, the purpose of the PDO label is to facilitate identification of food products with certified quality. To quantify the effect of PDO on product quality perceived by foreign consumers (ζ_j), we need to compute an index of quality at the firm-destination-product level. To estimate product quality from the demand side, we use the methodology developed in Amiti and Khandelwal (2013). This methodology does not account for label or quality signal.

[7] As the data of sales are not available by product, Rank_{fik} is computed using export data. We follow Eckel and Neary, (2010) and Mayer et al. (2014) where products are ranked in descending order of their total exported value at firm level

Indeed, the quality for each firm-destination-product observation is inferred from observed data.[8] For a given price in a firm-destination-product triplet, a variety with a higher quantity is attributed higher quality. The variable λ_{fjk} is estimated for each firm-destination-product observation as the residual of the following OLS regression:

$$\log q_{fjk} + \varepsilon_{jk} \log p_{fjk} = \mathbf{FE}_{jk} + \xi_{fkj} \tag{9}$$

with $\mathbf{FE}_{jk} = \log \left[E_j^k (P_j^k)^{\varepsilon_{jk}-1} \right]$. We consider $\varepsilon_{jk} = 5$, which corresponds to the elasticity estimates associated with cheese products reported in Ossa (2015). Hence, estimated quality perceived by foreign consumers is $\log \hat{\lambda}_{fkj} = \hat{\xi}_{fkj}/(\varepsilon_{jk} - 1)$. Therefore, to identify whether PDO label has an effect on the quality perceived by foreign consumers as supposed in (4) and to quantify this effect, we estimate the following equation:

$$\log \hat{\lambda}_{fkj} = \text{constant} + \mathbf{FE}_f + \zeta_j PDO_{fk} + \nu_{fjk} \tag{10}$$

Note that we do not include the variables $Rank_{fk}$ and the destination-product fixed effect $\mathbf{FE}_{jk}$ in the regression (10) as λ_{fkj} is estimated for a given price (p_{fjk}) which includes the variable $Rank_{fk}$ and for a given destination-product pair. We introduce a firm fixed effect $\mathbf{FE}_f$ in order to control for the perceived quality of all the products produced by one firm (the firm-specific component of quality). We expect the elasticity of perceived quality by consumers living in country j to PDO labeling $\hat{\zeta}_j$ to be positive and to be higher for EU countries than for others.

5.3 PDO labeling and trade margins

Our objective is now to estimate the trade margins at firm level. According to our theoretical framework, the effect of PDO label on export margins is ambiguous. We first test the effect of PDO labels on the probability of exporting product k to country j. A French firm exports if its operating profits $\Pi_{fkj} \equiv (p_{fjk} - c_{fjk}) q_{fjk} = \frac{p_{fkj} q_{fkj}}{\varepsilon}$ are greater than its fixed export costs $\phi_{fjk} e^{-\kappa_j \text{PDO}_{fk}}$ (see section 3). We assume that these fixed costs are stochastic due to firm-specific unmeasured trade frictions ν_{fjk} with $\phi_{fjk} = \phi_{jk} e^{-\nu_{fjk}}$. Hence, the conditional probability that

[8] Papers following the methodology of Amiti and Khandelwal (2013) usually use data at the origin-destination-product level to compare perceived quality of varieties from different origins on a given destination-product market (see Curzi et al. (2014) for an application on agricultural products). Here, we follow Emlinger and Lamani (2020) and rely on data at the firm-destination-product level to assess the perceived quality of varieties produced by different firms from a single origin, France. In other words, we substitute in the estimation the origin dimension for firm dimension.

firm f producing product k exports to country j is

$$\Pr[q_{fjk} > 0] = \Pr[\log(\Pi_{fkj} e^{-\kappa_j \text{PDO}_{fk}} / \phi_{jk}) > -\nu_{fjk}] \tag{11}$$

Using (7), (4) and (2), we obtain the following equation to estimate :

$$\log \Pi_{fkj}/\phi_{jk} = \rho_1 \text{PDO}_{fk} + \rho_2 \log\text{Rank}_{fk} + \mathbf{FE}_f + \mathbf{FE}_{jk} \tag{12}$$

with $\rho_1 \equiv (\varepsilon_{jk} - 1)(\zeta_j - \beta)$ and $\rho_2 \equiv -(\varepsilon_{jk} - 1)\gamma$. The term FE_{jk} is a destination-product fixed effect capturing E_{jk}, P_{jk}, ϕ_{jk} while FE_f is a firm fixed effect capturing φ_f and ω_f. As highlighted in the theoretical section, the impact of PDO labeling on the probability of serving a foreign country j depends on the foreign consumers' attitudes towards the EU label (ζ_j), relative to the cost elasticities of PDO labeling (β and κ_j). Indeed, on the one hand, PDO labeling can increase product quality as perceived by consumers and, in turn, the demand for the PDO variety (demand effect). On the other hand, PDO labeling implies higher marginal costs and prices, thereby reducing the demand for the PDO variety (cost effect). This leads to an ambiguous role of PDO labeling in foreign markets. We expect a positive impact of PDO labeling on the export decision at least when exporting to EU countries, where consumers are more aware of the difference in quality of PDO labeled products than anywhere else. Under standard assumptions, the unknown parameters could be estimated up to scale using a probit model. However, as the inclusion of fixed effects in a probit model would give rise to the incidental parameter problem, we use the conditional (fixed effects) logit model to account for the binary nature of the dependent variable.

Second, we test the effect of PDO on intensive margins. Using (2), (4), and (7), the logarithm of quantity exported of product k for firm f located in France to country j to be estimated is given by

$$\log q_{fjk} = \mu_1 \text{PDO}_{fk} + \mu_2 \log\text{Rank}_{fk} + \mathbf{FE}_f + \mathbf{FE}_{jk} + \epsilon_{fjk} \tag{13}$$

with $\mu_1 \equiv (\varepsilon_{jk} - 1)\zeta_j - \varepsilon_{jk}\beta$ and $\mu_2 \equiv -\varepsilon\gamma$. As above, the destination-product fixed effects FE_{jk} capture the role of all types of market size, price index, taste for NC8 products and trade barriers, while the firm fixed effect (FE_f) captures all firm-specific determinants, such as productivity, size, and whether the firm is authorized to handle certain PDO varieties. Our coefficient of interest is μ_1. Like for the extensive margin, two opposing effects (demand effect *versus* cost effect) are at work. However the relative weight of the cost effect is higher in the intensive margin than in the

extensive margin.

6 Results

6.1 Is there a PDO premium on foreign markets?

Table 3 columns (1) and (2) lists estimations of equation 8 on unit values. As our estimations include product-country fixed effects, we compare the export unit values of PDO authorized firms with those of unauthorized firms for a given destination-(8-digit)product pair. The dummy PDO_{fk} attracts a significant and positive coefficient (the estimated parameter β from equation 8) in column (1). A PDO label allows firms to increase their price by an average of 11.5%. Column (2) disentangles the effect of PDO per destination. The positive coefficients obtained both on European and non-European markets shows that PDO varieties benefit from a price premium, compared to non-PDO varieties. The effect is slightly higher on non-European destinations but the two interacted coefficients are not significantly different [9] which suggests that the price premium occurs whatever the destination country. These results are in line with those of Deselnicu et al. (2013) who identify the existence of price premiums induced by PDO, but that these depend on the characteristics of the sector concerned.

Columns (3) and (4) in Table 3 list the results of the estimation of equation 10 on the perceived quality, estimated according to Khandelwal's methodology presented in section 5.2. The estimated parameter ζ_j which is the coefficient of the variable PDO_{fk} is positive in column (1), suggesting that PDO varieties are, on average, considered by consumers to be of higher quality than non-PDO varieties. This results holds on both European and non-European markets, as ζ_j^{EU} and ζ_j^{non-EU} are positive and significant in column (2). Again, our results do not show differences in perception of PDO between European and non-European consumers as the two interacted coefficients in column (2) are not significantly different [10] . We conducted some sensitivity analyses using different values of ε_{jk} (see Table 4). Our results remain valid that is to say that consumers perceive PDO varieties, on average, to be of higher quality than non-PDO varieties. We only find that ζ_j^{non-EU} is positive but non significant for $\varepsilon^k = 2$. For all other values of ε^k, ζ_j^{EU} and ζ_j^{non-EU} are positive and significant.

[9] In Column (2) in Table 3, we test for the significant difference between 0.104 for EU markets, and 0.133 for non EU markets. The difference in unit values is not significant with a P value of 0.70

[10] In Column (4) in Table 3, we test for the significant difference between 0.233 for EU markets, and 0.218 for non EU markets. The difference in perceived quality is not significant with a P value of 0.91

Table 3: Effect of PDO on trade unit values and quality

Dependent variable	ln uv_{fkj}		ln $Qual_{fkj}$	
	(1)	(2)	(3)	(4)
PDO_{fk}	0.115**		0.227***	
	(0.052)		(0.085)	
ln $Rank_{fk}$	-0.012	-0.012		
	(0.022)	(0.022)		
$PDO_{fk} \times EU_j$		0.104*		0.233**
		(0.059)		(0.104)
$PDO_{fk} \times$ non-EU_j		0.133*		0.218**
		(0.07)		(0.104)
Fixed effects	f, kj	f, kj	f, kj	f, kj
N	2,365	2,365	2,365	2,365
R2	0.71	0.71	0.31	0.31

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Standard errors are clustered at the destination-8-digit-product level

$Rank_{fk}$ are computed using all the products exported by the firm f (not only butter and cheese products).

Table 4: Effect of PDO on quality - robustness checks for $\varepsilon^k = 2, 3, 4$

	(1)	(2)	(3)	(4)	(5)	(6)
	$\varepsilon^k = 2$		$\varepsilon^k = 3$		$\varepsilon^k = 4$	
PDO_{fk}	0.561**		0.339**		0.265***	
	(0.262)		(0.14)		(0.102)	
$\text{PDO}_{fk} \times \text{EU}_j$		0.614*		0.360**		0.275**
		(0.331)		(0.176)		(0.127)
$\text{PDO}_{fk} \times \text{non-EU}_j$		0.470		0.302*		0.246*
		(0.348)		(0.179)		(0.127)
N	2,365	2,365	2,365	2,365	2,365	2,365
R2	0.31	0.31	0.31	0.3	0.3	0.3

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Standard errors are clustered at the destination-8-digit-product level

$Rank_{fk}$ are computed using all the products exported by the firm f (not only butter and cheese products).

6.2 Do PDO labels improve export performance?

Our results reveal that PDO labeling plays an ambiguous role because of two opposing effects; consumers perceive an increase in quality for PDO varieties but PDO labels also results in higher prices and, in turn, reduce demand. We therefore expect a positive impact of PDO varieties on the export decision at least when exporting to EU countries, where consumers are more aware of this quality signal.

Table 5 reports our estimates of equation 12. The dependent variable is the decision to export (i.e. a dummy indicating whether the firm exports a given product to a given destination). It should be noted that our estimations compare the export decision of firms selling labeled varieties with that of firms selling non-labeled varieties for a given destination-product pair. For the extensive margin, the demand effect is higher than the cost effect. The dummy PDO_{fk} exhibits a positive coefficient in column (1). This result means that, for a given product-destination pair, benefiting from a PDO label entails a higher probability of being exported, in agreement with the results found by Agostino and Trivieri (2014). In column (2), we distinguish the impact of labeling according to the destination, assuming that the impact of PDO may differ within the European Union, as this label is defined at the community level and benefits from legal protection in the EU. Only the interacted variable $\text{PDO}_{fk} \times \text{EU}_j$ has a positive and significant coefficient, meaning that PDO labels increase the probability of varieties being exported only towards European markets. We confirm the results found by Raimondi et al. (2019).

In column (3), we go further and explore the heterogeneity of non-European countries by differentiating between countries that recognize PDO labels and countries that do not. We assume that destination country who registered a GI in the European system or has a similar system of geographical indications[11] may import more PDO products. The coefficient associated with PDO_{fk} turns significant and positive when it interacts with the dummy GI_j while the coefficient relating to other non-European countries remains non-significant in contrast to the results of Raimondi et al. (2019). PDO labeling favors the entry of French cheese producers on the European market and into countries with a similar policy of denomination of origin of food products, but not into other countries.

In all columns in table 5, the variable $\ln \text{Rank}_{fk}$ controls for the rank of product k in the exports of the firm f. As expected, it has a negative coefficient: the export performance of a firm is lower

[11] Countries with similar system and/or for which a GI was registered under the EU system (DOOR, before 2012) are Swizerland, Japan, Vietnam, China, Turkey, Brazil, Colombia, India, and Morocco.

for products that do not correspond to its core business. Column (4) estimates the impact PDO labeling PDO_{fjk} according to the rank of product k. It shows that the positive effect of PDO labels on the probability of export occurs only when the rank of the exported product within the firm is under 4 whether on the European market or on GI destinations. PDO labeling helps firms reach new markets only when the product is among the main products exported by the firm concerned.

Table 6 follows the same specification as Table 5 but with the logarithm of the quantity exported as explained variable (the intensive margin of trade). This table lists the estimated parameters $\hat{\mu}_1$ and $\hat{\mu}_2$ from equation 13. The estimated parameter $\hat{\mu}_1$ (the coefficient of the PDO dummy) is not significant in any specification whereas the estimated parameter $\hat{\mu}_2$ (the coefficient of the variable ln Rank_{fk}) is negative and significant in all columns. The two effects of PDO labeling (demand and cost effects) offset each other at the intensive margin. Our result suggests that PDO varieties lead to better export performance in the cheese industry but only at the extensive margin. PDO labeling may favor entry on new markets in European countries and in countries with a similar system of labeling, but has no impact on the volume of trade.[12]

We assess the impact of PDO labeling on exports at the extensive margin by evaluating the expected change in export performance if consumers in non-EU countries value PDO label as highly as EU consumers and/or benefit from the same additional fixed costs associated with marketing, promotion, and advertising. For exporters of PDO varieties, the difference in the probability of serving EU countries and non-Eu countries are given by, all things being equal,

$$\Delta\rho_1 = (\varepsilon - 1)(\zeta_j^{\text{EU}} - \zeta_j^{\text{non-EU}}) - (\kappa_j^{\text{EU}} - \kappa_j^{\text{non-EU}}), \tag{14}$$

where we have used equation (12) and we assume the elasticity of substitution does not vary across destinations. According to the results reported in Table 5, we know that the role of PDO on the probability to export to non-EU markets (*e.g.* $\rho_1^{\text{non-EU}}$) is 0.167 whereas it is 0.855 on EU markets.This difference is due to the difference in consumer appreciation of quality and to the difference in quality-signaling activities as $\rho_1^{\text{non-EU}} \equiv (\varepsilon_j - 1)(\zeta_j^{\text{non-EU}} - \beta) - \kappa_j^{\text{non-EU}}$ in equation (12). If the role of PDO on non-EU countries were the same as on European countries, then the probability to export to non-EU markets for PDO producers would increase by $\Delta\rho_1 = 0.855 - 0.167 = 0.688$.

It follows that the probability to export to non-EU markets will increase by 0.03 in mean (*e.g.*, $\Delta\rho_1 \times \Pr[\hat{q_{fjk}} > 0]$). This change in the probability to export leads to a change in the exported

[12] We confirm our results at the extensive margin using the traded value (see Table 8 in the Appendix).

expected value for PDO exporters to non-EU markets. The increase in the exported expected value is computed by crossing the change in the estimated probability ($\Delta\rho_1 \Pr[\hat{q_{fjk}} > 0]$) with the estimated value of exports per destination (unchanged as PDO has no significant impact on the exported value) for each firm-product pair. Based on our calculation, the expected value would increase by 67.5%. Note that this computation focuses on a partial effect of PDO labels. Indeed, we disregard its effect through the price index (see equation 3) as our estimations consider a destination-product fixed effect (for a given price index). However, the mass of products with a PDO label is very low in each foreign country so that general equilibrium effects can be disregarded.

Table 5: Effect of PDO on trade patterns - extensive margin - probability to export

Dependent variable	X_{fkj}			
	(1)	(2)	(3)	(4)
PDO_{fk}	0.539***			
	(0.113)			
ln $Rank_{fk}$	-0.950***	-0.947***	-0.950***	-0.913***
	(0.06)	(0.061)	(0.061)	(0.062)
$PDO_{fk} \times EU_j$		0.855***	0.863***	
		(0.143)	(0.144)	
$PDO_{fk} \times$ non-EU_j		0.167		
		(0.159)		
$PDO_{fk} \times GI_j$			1.122***	
			(0.297)	
$PDO_{fk} \times$ other EU_j			-0.058	
			(0.171)	
$PDO_{fk} \times EU_j \times Rank_{fk}^{1-3}$				1.307***
				(0.179)
$PDO_{fk} \times EU_j \times Rank_{fk}^{4-15}$				0.26
				(0.216)
$PDO_{fk} \times GI_j \times Rank_{fk}^{1-3}$				1.289***
				(0.355)
$PDO_{fk} \times GI_j \times Rank_{fk}^{4-15}$				0.976
				(0.534)
$PDO_{fk} \times$ other non-$EU_j \times Rank_{fk}^{1-3}$				-0.046
				(0.21)
$PDO_{fk} \times$ other non-$EU_j \times Rank_{fk}^{4-15}$				0.098
				(0.267)
N	26,317	26,317	26,317	26,317

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Standard errors are clustered at the destination-8-digit-product level

$Rank_{fk}$ are computed using all the products exported by the firm f (not only butter and cheese products).

Table 6: Effect of PDO on the intensive margin - quantity

Dependent variable	ln Q_{fkj}			
	(1)	(2)	(3)	(4)
PDO_{fk}	0.141			
	(0.247)			
ln $Rank_{fk}$	-1.387***	-1.387***	-1.391***	-1.383***
	(0.12)	(0.12)	(0.121)	(0.118)
$PDO_{fk} \times EU_j$		0.227	0.232	
		(0.3)	(0.299)	
$PDO_{fk} \times$ non-EU_j		-0.008		
		(0.366)		
$PDO_{fk} \times GI_j$			0.531	
			(0.773)	
$PDO_{fk} \times$ other EU_j			-0.197	
			(0.399)	
$PDO_{fk} \times EU_j \times Rank_{fk}^{1-3}$				0.375
				(0.34)
$PDO_{fk} \times EU_j \times Rank_{fk}^{4-15}$				-0.24
				(0.66)
$PDO_{fk} \times GI_j \times Rank_{fk}^{1-3}$				0.497
				(0.906)
$PDO_{fk} \times GI_j \times Rank_{fk}^{4-15}$				0.74
				(0.954)
$PDO_{fk} \times$ other non-$EU_j \times Rank_{fk}^{1-3}$				-0.456
				(0.513)
$PDO_{fk} \times$ other non-$EU_j \times Rank_{fk}^{4-15}$				0.459
				(0.619)
Fixed effects	f, kj	f, kj	f, kj	f, kj
N	2,365	2,365	2,365	2,365
r2	0.67	0.67	0.67	0.67

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Standard errors are clustered at the destination-8-digit-product level

$Rank_{fk}$ are computed using all the products exported by the firm f (not only cream and cheese products).

7 Conclusion and policy implications

This paper investigates the effect of GI on perceived quality, prices and trade margins, using firm-level data to identify trade flows concerned by PDO in the French cheese and cream industry. The identification of GI as quality products is a long historical debate as stated by Meloni and Swinnen (2018):

"While the quantity (supply) problem seems obvious from the historical documents, it is more difficult to establish whether the quality and consumer perception problems were real or mostly political arguments. However, in the debate and lobbying to influence the governments they were used very prominently."

In our theoretical model, we highlight the ambiguous effect of PDO labels on the probability to access new markets and on the intensity of exporting to those markets. When foreign consumers recognize the PDO label as a quality signal, it increases demand. However this label also implies higher production costs because of high quality ingredients or additional production tasks. Our empirical results show that the demand effect is higher than the cost effect and that PDO labels has a role in firm export competitiveness in the French cheese Industry. PDO varieties benefit from a price premium and consumers value PDO label as a quality signal, whatever the markets. Our results show no difference between PDO varieties and non-PDO varieties on the intensive margin of trade. This result confirms the role of the demand effect for PDO varieties as there is no impact on the quantity exported despite higher unit values. As for the extensive margin, the positive effect of GI is limited to European markets and to countries with a similar policy about geographical indications. These results show that the issue of legal protection of GIs in destination markets is essential, since PDO, although recognized as quality by consumers in all destinations, do not allow a better access to all markets.

The inclusion of some GI varieties in trade agreements may thus constitute an opportunity for PDO producers to increase their market access. The CETA between Canada and the EU, which allow the legal protection of 145 GIs, among which 20 are PDO varieties of French cheese, or the EU-Japan FTA which includes 200 GIs, with 5 PDO varieties of French cheese, will probably allow some French PDO producers to reach those markets to which they did not have access before. *Ex post* analyses of the effect of these agreements will allow to confirm these results in the future. At firm level, such analyses require to control for potential structural changes implied by these agreements in the strategies of firms (firm merging or new entrants).

To a wider policy extent, the recognition of GI varieties in EU bilateral agreements gives the possibility for countries outside the European Union to get their cultural heritage recognized as highlighted by Huysmans (2020). This may allow policy makers from different countries to support exports on a wider set of product variety rather than solely homogeneous products that represent large sales revenue. Such strategies could reshape some trade flows, food supply chains and protect small-scale producers from imported counterfeited products to create added value on rural territories worldwide.

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Appendix

Table 7: Correspondence table

NC8 code	PDO name
0405.10.11, .19, .90	Beurre de Charentes-Poitou, d'Isigny, de Bresse des Charentes, des Deux-Sèvres
0406.10.20	Brocciu
0406.40.10	Roquefort
0406.40.90	Bleu d'Auvergne, Bleu de Gex, Bleu des Causses, Fourme d'Ambert, Fourme de Montbrison
0406.90.82	Camembert de Normandie
0406.90.84	Brie de Meaux, Brie de Melun
0406.90.88	Goat cheese (Chabichou du Poitou, Chevrotin, Ste Maure de Touraine); Livarot, Maroilles, Pont-l'évêque
0406.90.79	Reblochon ou Reblochon de Savoie, St Nectaire
0406.90.81	Cantal, Salers
0406.90.87	Beaufort,Ossau-Iraty
0406.90.15	Beaufort, Comté
0406.90.18	Mont d'Or / Vacherin
0406.90.69	Morbier
0406.90.86	Munster
0406.90.99	Maroilles, Munster, Comté, Reblochon/ Reblochon de Savoie

Table 8: Effect of PDO on the intensive margin in value

Dependent variable	ln Value$_{fkj}$			
	(1)	(2)	(3)	(4)
PDO$_{fk}$	0.256			
	(0.241)			
ln Rank$_{fk}$	-1.398***	-1.399***	-1.403***	-1.394***
	(0.117)	(0.117)	(0.119)	(0.115)
PDO$_{fk}$ × EU$_j$		0.331	0.337	
		(0.295)	(0.293)	
PDO$_{fk}$ × non-EU$_j$		0.125		
		(0.352)		
PDO$_{fk}$ × GI$_j$			0.694	
			(0.784)	
PDO$_{fk}$ × other EU$_j$			-0.074	
			(0.371)	
PDO$_{fk}$ × EU$_j$ × Rank$_{fk}^{1-3}$				0.484
				(0.337)
PDO$_{fk}$ × EU$_j$ × Rank$_{fk}^{4-15}$				-0.143
				(0.637)
PDO$_{fk}$ × GI$_j$ × Rank$_{fk}^{1-3}$				0.667
				(0.917)
PDO$_{fk}$ × GI$_j$ × Rank$_{fk}^{4-15}$				0.888
				(0.988)
PDO$_{fk}$ × other non-EU$_j$ × Rank$_{fk}^{1-3}$				-0.312
				(0.464)
PDO$_{fk}$ × other non-EU$_j$ × Rank$_{fk}^{4-15}$				0.536
				(0.625)
Fixed effects	f, kj	f, kj	f, kj	f, kj
N	2,365	2,365	2,365	2,365
r2	0.66	0.66	0.66	0.66

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Standard errors are clustered at the destination-8-digit-product level

Rank$_{fk}$ are computed using all the products exported by the firm f (not only butter and cheese products).