Quality upgrading and position in global value chain

Kossi Messanh Agbekponou, Angela Cheptea, Karine Latouche

Quality upgrading and position in global value chain.

Firm-level evidence from the French agri-food industry

Kossi Messanh Agbekponou*, Angela Cheptea, Karine Latouche
INRAE-SMART, France.

May 2, 2024

Abstract

This paper analyses how the quality of produced goods affects firms' position in global value chains (GVCs). Extending the theoretical framework of Chor et al. (2021), we find that quality upgrading increases the span of production stages performed by the firm: it imports more upstream (less transformed) intermediate products and exports more downstream (more highly processed) products. Expansion along GVCs through quality upgrading is accompanied by an increase in input purchases, assets, value added, and profits. These theoretical predictions are tested using 2004-2017 firm-level data on French agri-food industries (from French customs and the AMADEUS database). In line with recent work, we identify firms that participate in GVCs with those that jointly import and export, and measure firms' position in value chains through the level of transformation (upstreamness) of goods they use and produce. We use several ways to measure product quality at firm level, all inspired by the commonly accepted assumption that, at equal prices, higher quality products are sold in larger quantities. Our findings confirm the prediction that higher-quality firms use more upstream inputs produced by other firms to produce more transformed outputs, and perform a larger span of intermediate production stages in-house. We find limited empirical evidence in support of other predictions.

Keywords: global value chains, production line position, quality upgrading, upstreamness, agri-food industry.

JEL Codes: F10, F13, F14, F23, L15, L23, L24, L25, Q17.

*Corresponding author: INRAE, SMART, Rue de la Geraudiere, 44316, Nantes-France. Email: kossi-messanh.agbekponou@inrae.fr, Phone: +33 (0)2 40 67 51 74.

1 Introduction

Product quality is the most important factor that drives firms to adapt their production processes and to align their products with consumer preferences in foreign markets. Lots of studies document the role of quality variation on trade performance across firms and countries (Crozet et al., 2012; Curzi and Olper, 2012; Aw-Roberts et al., 2020; Emlinger and Lamani, 2020). Conversely, the way quality allows firms to be successful in global value chains (GVCs) remains an unexplored issue even if GVCs have become an important part of international trade (Johnson and Noguera, 2012; Greenville et al., 2017; Beaujeu et al., 2018). For example, the Covid-19 pandemic unveiled the high fragility of the global supply chain due to the excessive reliance on offshore supplies that increases the degree of exposure of firms and countries to foreign shocks (Giroud and Ivarsson, 2020; Marvasi, 2023). This lack of interest is not surprising given the lack of direct measures of quality (Helpman, 2011) and the difficulty to measure participation in GVCs at firm level (Antràs, 2020).

In this paper, we theoretically and empirically : i) study the effect of the agri-food firms' product quality on their positioning in GVCs; ii) document the mechanisms that underlying this relationship; and iii) access how agri-food firms' global production line position affects their input costs and performances.

The positioning of firms in GVCs is a key driver in value creation (Mudambi, 2008; Rungi and Del Prete, 2018; Baldwin and Ito, 2021). Mahy et al. (2021) have shown that an upstream position in GVCs is significantly associated with more value creation for Belgian firms. As shown by Chor et al. (2021), productivity increases with *upstreamness* of imports. Overall, the rapid expansion in production stages conducted in China results in the increase of value added in this country. Furthermore, participation in GVCs through reshoring could increase the resilience of GVCs (Giroud and Ivarsson, 2020; Marvasi, 2023). In other words, these studies show that the position in GVCs must be at the forefront of the competitiveness strategies of firms and aggregate economies. With this respect, it is important to understand and analyze how to take into account the new sourcing strategies developed by firms and especially those operating in the agri-food sectors.

To achieve our aims, a first step is to position firms in GVCs by identifying the goods purchased and produced by them. The lack of firm's detailed data on the production at the product and/or production plant level leads us to rely on the product composition of their international trade flows. To do so, we determine the position at which a given product enters the production process of a final good. The idea is that firms that sell and/or buy products that are distant (respectively close) to final consumption are located further upstream (respectively downstream) in the GVCs. The implementation of these two steps requires the use of detailed trade flow data at the firm-product level. Our focus on a particular industry - the food industry - requires the use of an input-output table with a detailed level of disaggregation.

In this article, our contribution is threefold. First, we build on the partial-equilibrium model in Chor et al. (2021). We introduce heterogeneous quality across firms. In this setting, the production of the good is segmented and entails a large number of production stages, performed in several countries around the world. We focus on the firm's decision to operate along the production chain in order to maximize its profits. Upstream, each firm is thus confronted with the make-or-buy decision of producers in a context of international trade demonstrated by Antràs and Helpman (2004). Downstream, each firm tend to sell a final product with a higher quality, at a higher market price. These two sides of the production process, upstream and downstream, determine the firm's span of production stages. Therefore, we show that when the variable and fixed costs generated by integrating the neighborhood of the firm initial upstream cut-off stage are relatively small, quality upgrading would induce firm to purchase more upstream intermediate input and to produce more proximate to final demand, leading to the spanning more production stages. Not surprisingly, we show that the main predictions of Chor et al. (2021) continue to hold in an environment where firms are differentiated by quality rather than productivity, as productivity and quality enter equilibrium firm revenue in the same way when they are exogenous parameters. Further predictions suggest that quality upgrading and performing more stages of production are associated with more purchases and uses of inputs, more value added generated and higher profits.

Second, we exploit U.S. detailed input-output table on the detailed firm-level French customs trade data to identify firms position in GVCs. To measure the level of transformation of goods, the literature usually uses classification tables, such as the Broad Economic Classification (BEC). This approach generally produces rough results that poorly reflect the level of transformation of traded goods. Indeed, the same product may be an input for one industry, but a final product for another. Consider the example of tomato sauce, which can be used as a final consumption good by households, or as an intermediate good in the production of frozen pizza. An alternative solution adopted by recent works in the literature is to rely on input-output tables, exploring the links between all the sectors of an economy. This method is particularly attractive when industries are defined at a very narrow level. For France, we have highly disaggregated firm-level data, but a highly aggregated input-output table. To explore the richness of firm-level data, we use instead the U.S. input-output table characterized by a very detailed level of industry disaggregation. This permits us to build a highly detailed input-output table for French industry codes. We use this table to compute the *upstreamness* of each industry and firm. More interesting, we compute the difference between these two measures (*upstreamness* of imports and exports), which is informative of the span of production stages that the firm performs within France. The use of the U.S. input-output table for French firms is justified by the results of Antràs et al. (2012), which show a high degree of stability between the sectoral measures of the U.S. and some European countries economic production matrix.

Third, we empirically test the predictions of the theoretical model on firm-level data. We propose the analysis of French agri-food firms over the period 2004-2017. More precisely, we use French customs data at the firm-year-destination-product to infer index of food product quality at the firm-year level based on the methodology developed in Khandelwal et al. (2013). Then we matched this data with firm-level AMADEUS database that provide information about firms attributes.

In order to anticipate our main empirical results, our analysis uncovers that French agri-food firms reduce the number of production stages they perform in GVCs in France over the 2004-2017 period. Nevertheless, quality upgrading allows firms to import more upstream and export more downstream, resulting in the significant expansion in the production stages performed in GVCs within France, as predicted by the model. These findings are mainly corroborated by adopting an IV for quality measures that captures how exposed French agri-food firms are to plausibly exogenous shocks to foreign demand, and by performing several robustness tests. We also confirm empirically that quality upgrading would induce the firm to operate on a bigger scale by using more inputs, increasing its value added and earning higher profits. In contrast, the pattern for the relationships between increased production steps and increased input use, value added, and profits is not robust in the regression analysis (the *within* effect). Indeed, we find that the latter effects are driven mainly by the difference *between* firms, and that the within component is negligible.

The approach adopted in this paper is closely related to the burgeoning literature that examined the positioning of firms in GVCs, productivity-heterogeneity and performance (Chor et al., 2021; Baldwin and Ito, 2021; Mahy et al., 2021). By addressing the issue of the role of quality heterogeneity in global production line, this paper also relates to the trade in varying-quality products. The seminal productivity-heterogeneity framework (Melitz, 2003) has extended by incorporating heterogeneous quality across firms (Verhoogen, 2008; Fajgelbaum et al., 2011; Baldwin and Harrigan, 2011; Crozet et al., 2012; Curzi and Olper, 2012; Crinò and Epifani, 2012; Emlinger and Lamani, 2020). All these contributions has formed the basis of a new wave of theoretical and empirical contributions that show that vertical and horizontal quality differentiation of products enables firms to perform better in trade and use higher quality inputs. More broadly, our paper deals with a recent theoretical and empirical literature testing various aspects of the organization of Global Value Chains of firms via the direction of integration in the supply chain (Antràs and Helpman, 2004; Conconi et al., 2012; Antràs and Chor, 2013; Del Prete and Rungi, 2017; Gaigné et al., 2018; Alfaro et al., 2019), and with the growing empirical literature on GVCs, that seek to identify the different sources of value added embedded in trade flows (Hummels et al., 2001; Johnson and Noguera, 2012; Koopman et al., 2014; Borin and Mancini, 2019).

The remainder of the paper is organized as follows. In the next section, we present our theoretical framework, summarizing the key intuitions of firm behavior in GVCs, from which we build our key predictions. Section 3 introduces the data used, the methodologies to compute various variables and document some descriptives and stylized facts on aggregate trend in trade and position in GVCs at the industry and firm level. Section 4 introduces the econometric strategy to test the main theoretical predictions and presents the results. Discussion and main conclusions are formulated in Section 5.

2 The model

In this section, we rely on the Chor et al. (2021) framework to develop a partial-equilibrium heterogeneous firm model of GVCs, in which quality valuation by consumers allows firms to adjust their participation in GVCs.

2.1 Consumers preferences and demand

Consider a variety of differentiated goods that include both final consumption and semi-finished products. Consumers value goods through a constant elasticity of substitution (CES) utility function:

$$\Upsilon = \left[\int_{\Omega_\upsilon} \left[\lambda(\upsilon) q(\upsilon) \right]^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{1}$$

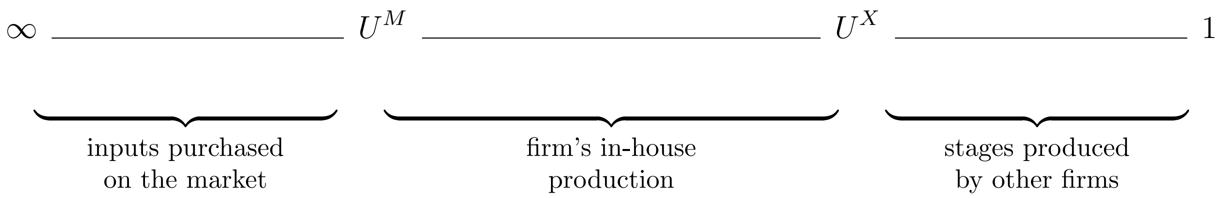
where Ω_υ is the set of available products varieties υ, and $\varepsilon > 1$ is the elasticity of substitution between different varieties that is common for all firms in a given industry. We assume that consumers value quality: they obtain a higher utility from consuming the same quantity $q(\upsilon)$ of a variety with a higher perceived quality $\lambda(\upsilon)$. Accordingly, they have a higher willingness to pay for high quality products, which leads firms to charge higher prices for these goods. Given the CES form of consumer preferences and consumers' utility-maximizing behavior, the firm producing variety υ faces the following equilibrium (domestic and foreign) aggregate demand:

$$q(\upsilon) = A \left[\lambda(\upsilon) \right]^{\varepsilon-1} \left[p(\upsilon) \right]^{-\varepsilon}, \tag{2}$$

where $p(\upsilon)$ and $A > 0$ indicate the price of variety υ and its market size, respectively. Demand is decreasing in price and increasing in quality λ. Parameter λ captures both the perceived and intrinsic quality of variety υ.

2.2 Technology and profits

We assume a continuum of firms that produce differentiated goods and operate in a free and competitive market. Each firm produces one variety and chooses to produce the quantity that maximizes its profits. For the simplicity of exposition, we omit hereafter firm and industry indices. Similarly to Chor et al. (2021), we assume that the production of a final good in a given industry requires the completion of a continuum of production stages $u \in [1, \infty[$ that are sequentially integrated from a technological point of view. A higher u denotes a more upstream production stage, and $u = 1$ indicates the production of a final consumption good. Parameter u reflects the level of processing, *i.e.* the *upstreamness*, of the product in the value chain (Fally, 2012; Antràs et al., 2012; Antràs and Chor, 2013). Firms purchase on the market less processed intermediate inputs (up to upstreamness level U^M), and produce internally intermediate inputs corresponding to more downstream stages (up to upstreamness level U^X). The obtained output is sold to final consumption (if U^X is close to 1) or used as an input by other firms to produce final consumption goods. The production process (value chain) of a final product can be synthesized by the following scheme:



A firm's participation to the value chain spells out as follows. Production stages $u \in [U^X, U^M]$ are produced by the firm. More upstream stages ($u > U^M$) and more downstream stages ($u < U^X$) are produced by other firms in the chain. The firm decides which inputs to purchase and which to produce internally by choosing the value of U^M and U^X. The output produced by the firm is a semi-finished good completed up to production stage U^X.

We assume the same production technology as Chor et al. (2021):

$$q = \theta \left(\int_{U^X}^{U^M} x(u)^{\frac{\sigma-1}{\sigma}} du + q_M^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\rho\sigma}{\sigma-1}}. \tag{3}$$

The firm uses a quantity q_M of intermediate products completed up to stage U^M purchased at price p_M, and quantities $x(u)$ of internally produced inputs $u \in [U^X, U^M]$ to produce a quantity q of an output completed up to stage U^X, which it sells (to other firms or final consumers) at price p. Inputs are characterized by a constant elasticity of substitution $\sigma > 1$. Parameter θ reflects the productivity of the firm. Parameter $\rho \in (0, 1)$ captures the degree of decreasing returns to scale of the firm's output. Similarly to Chor et al. (2021), we assume that $\rho > \frac{\sigma-1}{\sigma}$, so that firms find it profitable to increase production in order to match a higher demand.

We extend this framework by decomposing firm productivity into two components: $\theta = \varphi\lambda^{-\gamma}$, with $0 \leq \gamma < 1$, as in Hallak and Sivadasan (2013). Productivity increases with firm's efficiency φ, and decreases with the quality of produced goods λ. This expression permits to integrate the common assumption that high quality products are more difficult to produce and require more [expensive] inputs.[1] Previous research has shown that more productive

[1] Parameter γ is the elasticity of marginal cost with respect to quality. It reflects the industry-specific variable cost of quality.

firms produce and export higher quality goods (Johnson, 2012; Curzi and Olper, 2012; Curzi et al., 2015). The introduction of firm-specific efficiency (parameter φ) permits to reconcile this apparent contradiction. Then, firms' output rewrites as:

$$q = \varphi\lambda^{-\gamma}\left(\int_{U^X}^{U^M} x(u)^{\frac{\sigma-1}{\sigma}}du + q_M^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\rho\sigma}{\sigma-1}} \tag{4}$$

Firms take as given the price of purchased intermediate goods at different production stages. Each intermediate good completed up to stage u is traded in an open and competitive market at price $p(u)$. We assume that less transformed products, *i.e.* goods in more upstream production stages face a lower market price: $p'(u) < 0$. The cost of inputs produced in-house is specific to each firm. For each of these inputs $u \in [U^X, U^M]$, the firm incurs a variable cost $c(u)$ per unit of input $x(u)$, and a fixed cost $F(u)$ per time period if $x(u) > 0$. The former can be assimilated to labor costs; the latter refer to the acquisition and maintenance of fixed assets and equipment needed for the production process. Including quality in the model introduces a new type of fixed costs: costs related to quality, λ^α ($\alpha > 0$).[2] We assume that $c(u)$ and $F(u)$ are differentiable functions.

Firms sell their entire output on the market and maximize their profits:

$$\pi = pq - \left(p_M q_M + \int_{U^X}^{U^M} [c(u)x(u) + F(u)]\,du + \lambda^\alpha\right). \tag{5}$$

Overall profits are obtained by subtracting total production costs (the purchase of intermediate inputs, variable and fixed costs of inputs produced in-house, quality-specific fixed costs) from total revenues (total sales of the produced output at market price). Combining equations (2) and (4), one can express firm's total revenues as:

$$pq = A^{\frac{1}{\varepsilon}}\varphi^{\frac{\varepsilon-1}{\varepsilon}}\lambda^{\frac{(\varepsilon-1)(1-\gamma)}{\varepsilon}}\left(\int_{U^X}^{U^M} x(u)^{\frac{\sigma-1}{\sigma}}du + q_M^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\rho\sigma(\varepsilon-1)}{\varepsilon(\sigma-1)}}. \tag{6}$$

As in Chor et al. (2021), we disregard the origin and destination of products and focus on the global market. We assumed that at least a share of intermediate inputs and of firm's output is purchased, respectively sold, abroad. In section 3 we use data on French firms' imports and exports to proxy their purchases of intermediate inputs and sales of produced output.

The firm chooses the volume (q) and quality (λ) of its output, input quantities to purchase (q_M) and produce in-house ($x(u)$) and their corresponding level of processing (U^X and U^M) that maximize its profit π. We derive below the solution to this profit maximization problem. Note that U^X and U^M are processing cut-off levels that define the span of production stages performed by the firm. U^M is the processing threshold at which the firm is indifferent between producing the input in-house and purchasing it on the market. Inputs above this level ($u > U^M$) are more profitable to be purchased on the market; inputs bellow this level ($u < U^M$) are more profitable to be produced internally. In line with these definitions, producing purchased inputs in-house is not profitable for the firm. We translate this condition by imposing that $\frac{c(U^M)x(U^M)}{p_M q_M}$ and $\frac{F(U^M)}{p_M q_M}$ are sufficiently small. U^X is the processing threshold at which the firm makes no additional profits from integrating a more downstream stage.

[2]Similarly to Sutton (2007), we assume that marginal costs increase with quality. Indeed, firms need to invest in new equipment, train workers, and adapt their production process before producing a single unit of a higher-quality product.

2.3 Firms' optimal choices

Before solving the firm's profit maximization problem, it is important to identify how a shift in product quality affects profits. On the one hand, quality upgrading increases consumers' willingness-to-pay for a product, leading to a higher demand with a positive effect on firm's revenues (*demand effect*). In our model, this effect is reflected by exponent $\frac{(\varepsilon-1)(1-\gamma)}{\varepsilon} > 0$ of quality parameter λ in equation (6), and is driven by the positive effect on price. On the other hand, producing higher quality is binding. It requires more inputs ($-\gamma < 0$ in equation (4)), higher fixed costs (λ^{α}), and an expansion of production stages performed by the firm (*cost effect*), which result in a higher marginal cost. Therefore, quality upgrading has an ambiguous overall effect on profits. The negative *cost effect* and the positive *demand effect* are always at work and remain at the core of firm's decisions in the profit-maximizing process. In the agri-food sector, we expect the *demand effect* to outweigh the *cost effect* of quality because of the growing concern about the attributes of food products, and the strong link between diet and health.

To increase the quality of its output, a firm needs to use a higher volume of all intermediate inputs, both those purchased on the market ($\frac{dq_M}{d\lambda} > 0$) and those produced in-house ($\frac{dx(u)}{d\lambda} > 0$, $\forall\ u \in [U^X, U^M]$). A higher quantity q_M of purchased upstream inputs determines the firm to integrate more upstream production stages, *i.e.* increase the processing threshold U^M ($\frac{dU^M}{d\lambda} > 0$). An increase in U^M generates two opposite effects on firm's total expenditure on upstream inputs purchased on the market ($p_M q_M$): it leads to a lower p_M (since $p'(u) < 0$), which at its turn yields a higher demand q_M for purchased inputs. The latter effect outweighs the former, and the firm's overall expenditure on upstream inputs increases ($\frac{d(p_M q_M)}{d\lambda} > 0$). At the same time, a higher volume of in-house produced inputs $x(u)$ induced by quality upgrading generates an increase in total variable and fixed costs associated with these inputs ($\frac{d(c(u)x(u))}{d\lambda} > 0$; $\frac{d(F(u)+\lambda^{\alpha})}{d\lambda} > 0$).

Quality upgrading permits the firm to charge a higher output price (because of the higher willingness-to-pay of consumers). However, it has an adverse selection effect as it determines some consumers to switch to lower quality (and price) goods. To limit this effect, the firm needs also to integrate some more downstream production stages, *i.e.* shift its processing threshold U^X closer to final consumption ($\frac{dU^X}{d\lambda} < 0$). By doing so, the firm reinforces the positive *demand effect* of quality upgrading (by charging a price close to the market price) and limits its negative *cost effect.*

Combining the effects on U^M and U^X, we conclude that quality upgrading determines the firm to extend the range of production stages performed in-house ($\frac{d(U^M-U^X)}{d\lambda} > 0$), both upstream and downstream (See Theory AppendixB for computation details). This result matches the empirical findings of Del Prete and Rungi (2017), according to which firms producing intermediate goods prefer to integrate production stages close to the ones that they already perform and with similar technological characteristics. Finally, the opposite demand and cost effects yield an ambiguous overall effect of quality upgrading on firm's profits. A similar line of reasoning permits to derive that quality upgrading generates an increase in firm's value added (defined as the sum of its profits and internal production costs).

These results can be summarized in the following proposition.

Proposition 1 *Quality upgrading yields:*

(i) an extension, both upstream and downstream, of production stages performed by the firm, as it chooses to purchase more upstream inputs and produce output goods closer to final demand:

$$\frac{dU^M}{d\lambda} > 0 \ ; \quad \frac{dU^X}{d\lambda} < 0 \ ; \quad \frac{d(U^M-U^X)}{d\lambda} > 0$$

(ii) an increase in the volume of all inputs used by the firm:

$$\frac{dq_M}{d\lambda} > 0\ ;\ \frac{dx(u)}{d\lambda} > 0, \forall u \in [U^X, U^M]$$

(iii) an increase in firm's variable costs, fixed costs, expenditure on upstream inputs, value added, and an ambiguous effect on profits:

$$\frac{d(c(u)x(u))}{d\lambda} > 0;\ \frac{d(F(u)+\lambda^\alpha)}{d\lambda} > 0;\ \frac{d(p_M q_M)}{d\lambda} > 0;\ \frac{d(c(u)x(u)+F(u)+\lambda^\alpha+\pi)}{d\lambda} > 0;\ \frac{d\pi}{d\lambda} \lesseqgtr 0.$$

Note that the increase in the span of production stages performed by the firm $(U^M - U^X)$ generates an increase in total variable costs $\int_{U^X}^{U^M} c(u)x(u)du$ and total fixed costs $\int_{U^X}^{U^M} F(u)du + \lambda^\alpha$ due to an increase in the domain of the definite integral. This also leads to a positive effect on input purchases $p_M q_M$ because of a larger value of $(U^M - U^X)$ requires a higher U^M. Combining these effects with Proposition 1, indicates that a wider range of in-house production stages also increases the firm's value added and has an ambiguous effect on its profits. These results can be summarized as follows:

Proposition 2 *Under the product technology described above, an increase in the span of production stages performed by the firm generates an increase in firm's total variable costs, total fixed costs, expenditure on upstream inputs, total value added, and has an ambiguous effect on profits:*

$$\frac{d(c(u)x(u))}{d(U^M-U^X)} > 0;\ \frac{d(F(u)+\lambda^\alpha)}{d(U^M-U^X)} > 0;\ \frac{d(p_M q_M)}{d(U^M-U^X)} > 0;\ \frac{d(c(u)x(u)+F(u)+\lambda^\alpha+\pi)}{d(U^M-U^X)} > 0;\ \frac{d\pi}{d(U^M-U^X)} \lesseqgtr 0.$$

3 Data and variables construction

3.1 French food industry firms and international trade statistics

We use data from the AMADEUS database to identify French agri-food firms. More precisely, only food processing firms (chapters 10 and 11 of the 2-digit NACE Rev. 2 nomenclature, i.e. food and beverage manufacturers) are taken into account. AMADEUS dataset records firms' main economic activity (NACE Rev.2 4-digit), and annual data on the number of employees, turnover, total assets, wage bill, value added, total purchases of raw materials and profits at firm level over the 2004-2017 period. Focusing the analysis on a single industry makes it possible to limit the effects of unobserved factors. However, the agri-food industry is far from being a homogeneous industry. It includes 32 NACE activity codes, all of which are present in the panel.

Our second source of data is French customs, which provide us annual data on the value in Euro and the quantity of firm's imports and exports by product (8-digit Combined Nomenclature (CN8) and 6-digit CPF classification) and partner, over 2004-2017. In line with previous work (Baldwin and Yan, 2014; Antràs, 2020), we assume that participation to a GVC is reflected in the data by firms joint involvement in import and export activities. In the paper we focus only on firms that participate in GVCs, *i.e.* on firms that both import and export in a given year. As our aim is to capture firms' actual processing activities in GVCs, we exclude re-exports from our sample.[3] Its worth nothing that re-exports account for a large share of transactions in our data (about 53% and 71% of the total value of imports and exports,

[3] We identify as a re-export when a firm imports and exports the same product, defined at the most disaggregated level possible (CN8), in the same year. Then we just remove the product from the flow of goods imported and exported by the firm in that year.

respectively) and are related in most cases to the main activity of exporters (about 46%). However, taking them into account does not affect our empirical results.

We match the two datasets using the unique identification (Siren) number of each firm, and aggregate trade data at the Harmonised System 6-digit (HS6) level using CN8 codes, and at the 4-digit NACE Rev.2 level using correspondences with CPF codes.

The position of industries and goods in global value chains We compute the upstreamness index U_r of each industry r as a weighted average of the number of production stages distant from final demand for which it provides inputs. This approach developed by Fally (2012), Antràs et al. (2012) and Antràs and Chor (2013) is fully explained in Appendix A.1. To do so, we construct a highly disaggregated input-output table to identify the level of transformation of each industry. Since the French input-output table comes at a very high level of industry aggregation (only 2 industries identify the agri-food sector in most available tables for France except the GTAP table which identifies about 20), we use the U.S. input-output table that uses a much more narrow definition of industries (405, of which 42 agri-food), and correspondences between U.S. and French industry codes to build a highly disaggregated table (604 4-digit NACE Rev.2 industries, of which 88 agri-food) using the exact industry codes that identify French firms' main economic activity in our data. However, this brings an important challenge because of multiple correspondences in both directions between U.S. and French industry codes. We solve this problem by allocating equal weights to all correspondences within each pair industry codes (see Appendix A.2 fo more details).

Table 1 reports some examples from the 604 NACE Rev.2 industries identified. Not surprisingly, among the most downstream industries are retail and services industries that are close to final demand. The most upstream industries tend to be related to the agricultural and farming activities which provide raw products that mainly used in the agri-food sector.

Table 2 shows some summary statistics of the upstreamness index, comparing the agri-food industry to the other industries.

Firm's position in global value chains Following Chor et al. (2021), we consider that the level of transformation (processing) of goods used and produced by a firm indicates its position in the value chain.

Once the *upstreamness* indicators U_r are computed at industry level, we use the Chor et al. (2021) approach to compute this indicator at firm level. We assume that all products in a given industry share the same level of upstreamness. We compute the *upstreamness* of imports (U_{ft}^M) for each firm f as the weighted average *upstreamness* of industries to which belong the products imported by the firm. We use a similar approach to compute the *upstreamness* of exports (U_{ft}^X). The difference $U_{ft}^M - U_{ft}^X$ reflects the number of production stages in the global production line performed by the firm. We refer to it as the *GVC participation* of the firm. More specifically:

$$\begin{aligned} U_{ft}^M &= \sum_r^S \frac{M_{frt}}{M_{ft}} U_r \\ U_{ft}^X &= \sum_r^S \frac{X_{frt}}{X_{ft}} U_r \\ GVC_{ft} &= U_{ft}^M - U_{ft}^X = \sum_r^S \left(\frac{M_{frt}}{M_{ft}} - \frac{X_{frt}}{X_{ft}} \right) U_r \end{aligned} \tag{7}$$

where M_{frt} and X_{frt} are the value of imports, respectively exports, of firm f of products in industry r in period t. $M_{ft} = \sum_r^S M_{frt}$ and $X_{ft} = \sum_r^S X_{frt}$. Intuitively, the level of processing of sold

Table 1: Industry upstreamness (selection)

NACE industry	Upstreamness
Retail sale of fruit and vegetables in specialised stores	1.01
Retail sale of meat and meat products in specialised stores	1.01
Retail sale of fish, crustaceans and molluscs in specialised stores	1.01
Retail sale of bread, cakes, flour confectionery and sugar confectionery	1.01
Retail sale of beverages in specialised stores	1.01
Manufacture of rusks and biscuits; of preserved pastry goods and cakes	1.08
Manufacture of soft drinks; of mineral waters and other bottled waters	1.09
Manufacture of bread; manufacture of fresh pastry goods and cakes	1.10
Manufacture of macaroni, noodles, couscous and similar farinaceous products	1.15
Manufacture of beer	1.19
Manufacture of prepared meals and dishes	1.20
Manufacture of grain mill products	1.21
Restaurants and mobile food service activities	1.22
Manufacture of wine from grape	1.23
Growing of vegetables and melons, roots and tubers	1.28
Processing and preserving of poultry meat	1.31
Manufacture of condiments and seasonings	1.35
Production of meat and poultry meat products	1.37
Operation of dairies and cheese making	1.38
Manufacture of cocoa, chocolate and sugar confectionery	1.39
Manufacture of sugar	1.42
Processing and preserving of meat	1.44
Growing of perennial crops	1.46
Processing of tea and coffee	1.47
Manufacture of fruit and vegetable juice	1.47
Processing and preserving of fish, crustaceans and molluscs	1.60
Marine fishing	1.66
Freshwater fishing	1.69
Freshwater aquaculture	1.86
Sewerage	1.89
Growing of sugar cane	2.07
Marine aquaculture	2.10
Raising of swine/pigs	2.10
Raising of other animals	2.15
Raising of poultry	2.16
Manufacture of starches and starch products	2.16
Manufacture of oils and fats	2.72
Raising of dairy cattle	2.98
Manufacture of prepared feeds for farm animals	3.24
Raising of other cattle and buffaloes	3.30
Growing of rice	3.38
Growing of cereals (except rice), leguminous crops and oil seeds	3.45
Post-harvest crop activities	3.61
Seed processing for propagation	3.61

Notes: Computed by authors from the U.S. input-output table converted to NACE Rev.2 4-digit.

Table 2: Summary statistics of upstreamness index according to the type of industry

	Frequency	Min	Max	Mean	Std. dev.
Upstreamness - all industries	604	1.00	4.51	1.88	0.75
Upstreamness - agrifood	88	1.08	3.61	1.85	0.72

(exported) products is higher than the level of processing of purchased (imported) products ($U_{ft}^X < U_{ft}^M$), as the sold products are closer to final consumption.

Estimation of firm's quality Product quality is foremost a consumers' valuation of tangible (e.g. design, color, size) as well as intangible (e.g. reputation, brand name) characteristics of a good, while trade data only contains the classification in product categories. Thus, product quality is unobservable and difficult to estimate, and the quality for each firm-destination-product-period observation is usually inferred from observed data. In this article, we use the methodology developed in Khandelwal et al. (2013), according to which, for a given price, a higher quantity of sales indicates a higher quality variety:

$$\ln q_{fjkt} + \varepsilon \ln p_{fjkt} = FE_{jkt} + e_{fjkt} \tag{8}$$

where FE_{jkt} are country-product-year fixed effects, which capture heterogeneity in destination-product-year triplets (consumer preferences, trade costs, markup, and market structure); q_{fjkt} is the quantity of product k exported by firm f to country j in year t; p_{fjkt} is the price (unit value) of product k exported by firm f to country j in year t and ε are the estimated trade elasticities at product level (HS 6-digit) from Ossa (2015). The quality measure is computed from residual e_{fjkt} after estimating (8) with OLS:

$$\widehat{Qual}_{fjkt} \equiv \ln \widehat{\lambda}_{fjkt} = \frac{\widehat{e}_{fjkt}}{\varepsilon - 1} \tag{9}$$

This approach permits to estimate the quality of available varieties within a specific destination-product-year. Results for the same firm are not directly comparable across destination-product-year triplets.

To obtain a measure of quality at firm level, we adopt a cumulative method that compares the share of firms whose quality is lower than f's in a given product-market, and considers f's best position as its quality level. This approach is implemented by adopting the following two-step procedure after estimating $\widehat{Qual}_{fjkt}$. First, for a given jkt, we calculate a cumulative function $F_{fjkt}(\widehat{Qual}_{fjkt} > \widehat{Qual}_{gjkt}) \in (0;1)$ as follows

$$F_{fjkt}(\widehat{Qual}_{fjkt} > \widehat{Qual}_{gjkt}) = \frac{\text{Number of firms } g \text{ with } \widehat{Qual}_{fjkt} > \widehat{Qual}_{gjkt}}{\text{Number of firms on } jk \text{ in } t} \tag{10}$$

where $F_{fjkt}(\widehat{Qual}_{fjkt} > \widehat{Qual}_{gjkt})$ is the share of firms offering lower quality than f on the jk market in t. Second, for a given f and t over the set of jk, we retained

$$\widehat{Quality}_{ft} = Max_{jk}(F_{fjkt}) \tag{11}$$

as the maximum share of firms producing goods of lower quality than f as a measure of quality at the firm level. This is f's top-quality product.

For robustness, we compute two additional firm-level quality measures: the average standardized quality at firm-year level and the export-weighted firm-level averages quality (See Appendix A.3 for computation). Both measures exploit all the products exported by the firm to compute quality as a average, unlike the measure used in the core of the paper obtained from equation (11), which takes into account only the top-quality product. Nevertheless, both robustness measures are highly correlated with the core paper measure (0.66 to 0.5367), and produce similar results.

Table 3: Descriptive statistics: Firms in GVCs

	Frequency	Median	Mean	Standard deviation
# Firms	3,111			
ln Imports	22,208	6.4007	6.0505	2.5833
ln Exports	22,206	5.8322	5.5875	2.7648
Small firms (1 to 49 employees)	6,011	-	-	-
Middle-size firms (50 to 499 employees)	4,334	-	-	-
Large firms (500 employees or more)	875	-	-	-
ln Productivity	9,581	5.7038	5.7551	0.7763
ln Raw Inputs costs	14,538	9.0242	9.0808	1.8172
ln Wagebill	14,532	7.5670	7.7425	1.5378
ln Profits	11,837	5.9428	5.9452	2.1058
ln Value Added	13,866	8.0291	8.1897	1.5291
ln Sales	14,655	9.6417	9.7594	1.6942
Import *upstreamness* (U^M)	22,208	1.8301	1.9275	0.5096
Export *upstreamness* (U^X)	22,206	1.3818	1.5386	0.4971
GVC participation ($U^M - U^X$)	22,206	0.3307	0.3890	0.6148
Quality$_{ft}$	21,432	1	0.8498	0.2380
Average standardized quality	17,787	-0.4136	-0.3962	0.8515
Weighted average quality	21,197	0.5784	0.4792	0.7791

Notes: Re-exports are excluded at firm-year-CN8 level in trade flows before computing import and export *upstreamness* and estimate the quality. Quality measures are based on Khandelwal et al. (2013) methodology and are computed using price elasticities at the HS6 level from Ossa (2015).

Table 3 summarizes the statistics of variables used in the empirical analysis for French agri-food firms. Our sample include 3,111 firms that are both importers and exporters (firms in GVCs). These firms generated log import revenues on average (6.0505) larger than their mean log exports (5.8322).[4] Also, the average *upstreamness* of imports and exports, respectively 1.9275 and 1.5386, implies that French agri-food firms perform on average 0.3890 production stages in the global production line.[5] We observe the similar pattern if we consider all the importing and all the exporting agri-food-firms.

3.2 Some stylised facts

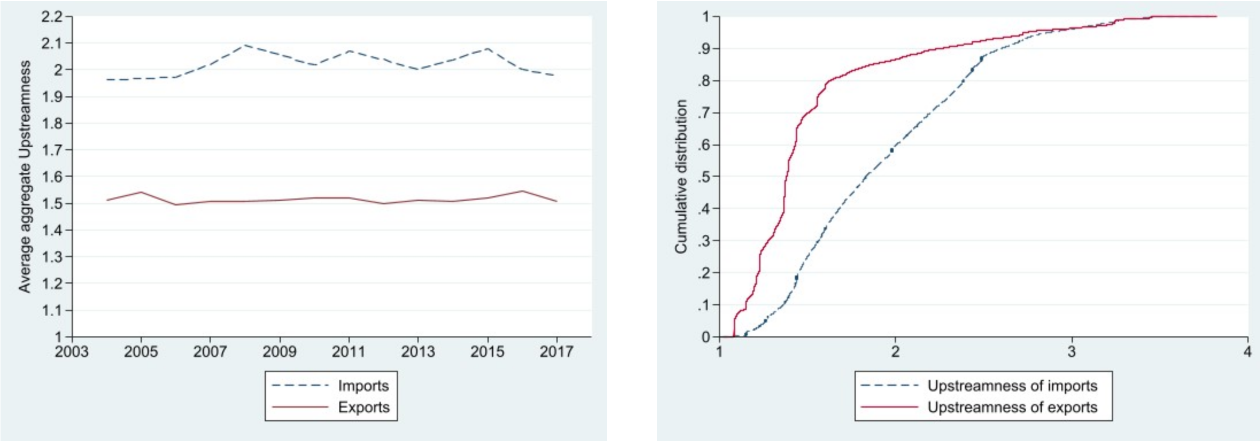
Figure 1a reports the aggregate trends of import- and export- *upstreamness* over the 2004-2017 period in the French agri-food sector. This figure illustrates the weighted average level of import- and export- *upstreamness* of all firms, computed at sector-level:

$$U_t^M = \sum_f \frac{M_{ft}}{M_t} U_{ft}^M, \text{ and } U_t^X = \sum_f \frac{X_{ft}}{X_t} U_{ft}^X. \tag{12}$$

We use firms' imports and exports as weights. $M_t = \sum_f M_{ft}$ and $X_t = \sum_f X_{ft}$ are total sector-level imports and exports in year t.

[4]This may reflect a pattern in which French agri-food firms rely partly on foreign supplies for processing and local consumption, before exporting the remainder. If we assume that foreign supplies account for foreign value added, French agri-food firms have less backward participation and therefore perform, on average, fewer processing activities in GVCs.

[5]Comparatively, Chor et al. (2021) found an average value of 0.42 for $U_{ft}^M - U_{ft}^X$ for the whole Chinese manufacturing sector.



(a) Average import and export upstreamness (b) Cumulative distribution of French firms

Figure 1: The *Upstreamness* of French agri-food firms

Two observations emerge from the analysis of Figure 1. First, the imports of French agri-food firms are persistently more upstream than their exports. This reflects the fact that firms tend to import intermediate goods, less processed, which they use to produce goods with a higher level of transformation (Figure 1a). A similar pattern was shown by Chor et al. (2021) in the case of China. Note that countries that mainly export primary goods and import final products may present different situations. Chor (2014) illustrates the examples of Brunei, Myanmar, Australia, and New Zealand, whose exports are more upstream (mainly concentrated in agriculture and primary products) than imports. The cumulative distribution of the *upstreamness* of French agri-food firms displays a similar pattern (Figure 1b). The gap between the import and export curves reflect an average span of production stages performed by these firms.

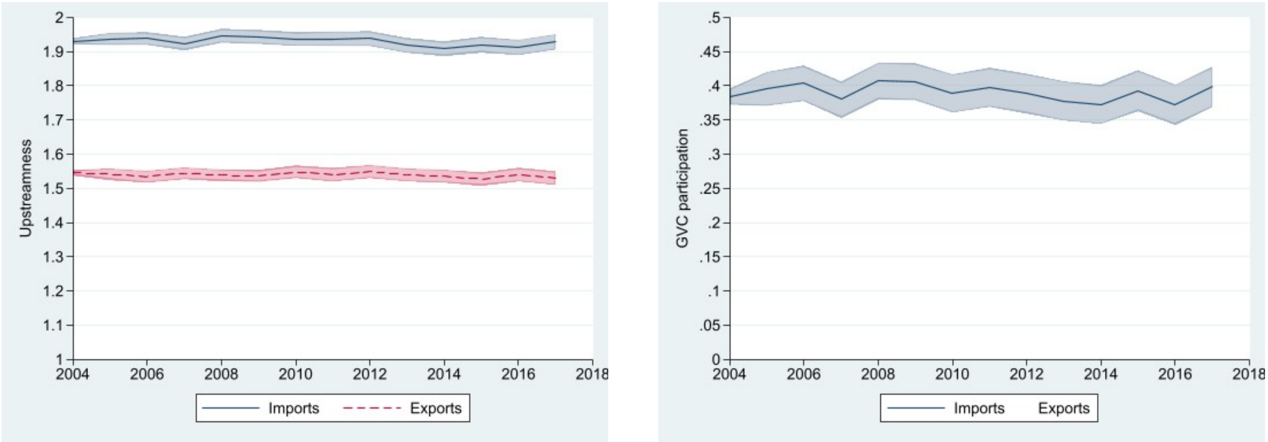
Second, we observe relative stability in the span of production stages performed by firms in figure 1a. This means that the French agri-food sector has not undergone any major transformation over the 2004-2017 period. Nevertheless, the gap between the import and export curves is quite significant, and close to that of the Chinese manufacturing sector, on average. Therefore, the French agri-food sector can be considered as an important contributor to the domestic value added of French exports.

For a more accurate computation of the evolution of upstreamness, we regress the firm-level import- and export- upstreamness, as well as their difference (i.e. the position of firms in GVCs) on the full set of year dummies β_t, and firm fixed effects, FE_f:

$$\begin{aligned} U_{ft}^{X/M} &= \beta_0 + \beta_{2004} + \beta_{2005} + \cdots + \beta_{2017} + FE_f + e_{ft}, \\ U_{ft}^{M} - U_{ft}^{X} &= \beta_0 + \beta_{2004} + \beta_{2005} + \cdots + \beta_{2017} + FE_f + e_{ft}. \end{aligned} \tag{13}$$

Figure 2 reports the average annual evolution of the upstreamness of French agri-food firms, i.e. terms $\beta_0+\beta_t$ of the above estimations. Figure 2a depicts a slight decrease in the average upstreamness of imports and a relatively steady average upstreamness of exports over the past two decades. The narrowing gap between the two indicators is more noticeable in Figure 2b. This indicates a likely off-shoring of the French agri-food supply chain.

The shift-share decomposition of the evolution of aggregate upstreamness in the French agri-food sector permits to identify the contribution of changes in firm composition (at the extensive margin)



(a) Import and export upstreamness (b) Participation in GVC

Figure 2: The evolution of French agri-food firms' *Upstreamness*

and within firms (at the intensive margin):

$$\Delta U_t^M = \sum_{f\in\Xi_t^M}\frac{M_{ft}}{M_t}\cdot U_{ft}^M - \sum_{f\in\Psi_t^M}\frac{M_{f,t-1}}{M_{t-1}}\cdot U_{f,t-1}^M + \sum_{f\in\Gamma_t^M}\frac{M_{f,t-1}}{M_{t-1}}\cdot \Delta U_{ft}^M + \sum_{f\in\Gamma_t^M}\Delta\frac{M_{ft}}{M_t}\cdot U_{ft}^M$$

$$\Delta U_t^X = \underbrace{\underbrace{\sum_{f\in\Xi_t^X}\frac{X_{ft}}{X_t}\cdot U_{ft}^X}_{\text{starting firms}} - \underbrace{\sum_{f\in\Psi_t^X}\frac{X_{f,t-1}}{X_{t-1}}\cdot U_{f,t-1}^X}_{\text{stopping firms}}}_{\text{extensive margin}} + \underbrace{\underbrace{\sum_{f\in\Gamma_t^X}\frac{X_{f,t-1}}{X_{t-1}}\cdot \Delta U_{ft}^X}_{\Delta\text{upstreamness}} + \underbrace{\sum_{f\in\Gamma_t^X}\Delta\frac{X_{ft}}{X_t}\cdot U_{ft}^X}_{\Delta\text{mkt share}}}_{\text{intensive margin}}$$

where Δ indicates annual change, Ξ_t is the set of firms that start exporting/importing, Ψ_t is the set of firms that stop to import/export, and Γ_t is the set of incumbent firms.

Table 4: Decomposition of aggregate *upstreamness* trend over time

	Extensive margin			Intensive margin (incumbent)			Overall
	Starting firms	Stopping firms	Net effect	change in firm's upstreamness	change in firm's mkt share	Net effect	
ΔU_t^M	0,2474	-0,0828	0.1646	0.1034	-0.3181	-0.2147	-0.0501
ΔU_t^X	0.2215	-0.1461	0.0754	0.2497	-0.3521	-0.1024	-0.0270
$\Delta U_t^M - \Delta U_t^X$	0.0259	0.0633	0.0892	-0.1463	0.0340	-0.1123	-0.0231

Notes: Columns "Starting" and "Stopping" display the contribution of firms that start exporting/importing and, respectively, of firms that stop exporting/importing. The "Net" extensive margin column sums these two effects. The "Net" intensive margin column sums the effect of a change in firms' upstreamness and market shares. "Overall" columns show the overall effect on the two "Net" effects.

Table 4 shows the results of this decomposition. First, we see that the firm-level trend observed for U_t^M is confirmed by the overall decrease during the period 2004-2017 (-0.0501). This decrease is driven mainly by the intensive margin induced by the decrease in share of individual firm's imports with higher upstreamness in French' total agri-food imports (-0.3181). This denotes an increasing share of firms that import more processed inputs, and is mainly counterbalance by the net extensive margin (+0.1646) which implies that new agri-food importers are sourcing more upstream products to France than exiting importers. A similar pattern is observed for exports, where we find an overall decrease in U_t^X (-0.0270). This fall is mainly accounted for by cross-firm changes among incumbents (-0.3521), and are almost offset by the within-firm intensive margins (+0.2497). This reflects the fact that over the 2004-2017 period, French agri-food imports moved much closer to downstream stages, while exports moved modestly closer to final demand. The within-firm intensive margin, both on the import (+0.1034) and export (+0.2497) sides are positive, but the change on the export side far outweighs that on the import side. This further reinforces the observation of off-shoring in the French agri-food supply chain, confirmed by the overall negative effect of $\Delta U_t^M - \Delta U_t^X$ (-0.0231). It is worth noting that a strong reliance on offshore increases the degree of exposure of firms to foreign shocks and the fragility of the supply chain. The key issue is how to reverse this trend. In this regard, we are particularly interested in the role of product quality.

4 Estimation Strategy and Results

According to prediction P1, firm's quality upgrading is associated with more upstream imports and more downstream exports, leading to the location of a wider segment of the supply chain within France. This is the central predictions of the model that we test empirically in this section. We also document the predictions about the increase in firms' input costs, value added and profits as firms upgrade their product mix and perform more production stages (P2).

4.1 Quality upgrading, firm's position in GVCs, costs, value added and profits

4.1.1 Quality upgrading and firm's position in GVCs

OLS correlation: In order to check more in details the variations within firms over time of quality upgrading and firm's position in GVCs (P1.i), we decide to run the following linear form

$$\{U_{ft}^M,\ U_{ft}^X,\ U_{ft}^M - U_{ft}^X\} = \beta + \delta\, Quality_{ft} + \Lambda\, \text{Controls}_{f,t-1} + FE_f + FE_{rt} + u_{ft}, \qquad (14)$$

In regression (14), the *upstreamness* of firm imports, U_{ft}^M, the *upstreamness* of firm exports, U_{ft}^X, and the difference between these two, $U_{ft}^M - U_{ft}^X$ (GVC_{ft}) are the outcome variables. Our main variable of interest is the measure of product quality, $Quality_{ft}$. It is worth noting that we control for time-varying firm characteristics, namely log productivity and size group (see section **??**). Because productivity and size may be subject to endogeneity issues (see Chor et al., 2021), we lagged them one year ($\text{Controls}_{f,t-1}$) to avoid or reduce these biases. The coefficient estimates of interest vary only marginally and all results are robust to the omission of these controls. We also control for permanent observed and unobserved firm-specific characteristics and sector-specific supply and demand shocks, by including firm fixed effects, FE_f, and industry-by-year dummies, FE_{rt}, where r denotes the NACE Rev.2 4-digit industry code which correspond to the firm f's primary activity. Doing so, we ensure that we compare changes within firms, by controlling for the potential omitted variable bias. Therefore, the coefficient of the variable $Quality_{ft}$ captures the variation within firms over time in supply chain position and firm's attributes relative to changes in quality. We estimate regressions (14) on a subpanel of GVCs' firms, using ordinary least squares (OLS) to measure correlations (and not causal relationships). All standard errors are clustered by firm.

Endogeneity of quality measures and instrument: The previous OLS estimations may be subject to an endogeneity bias when the firm's decision to upgrade quality is not exogenous from the GVCs' position. In other words, a common set of determinants affects both the GVCs' position patterns and the quality upgrading, despite the rich set of fixed effects.

The first possible source of endogeneity come from the fact that the types of inputs the firm used affect the firms' decision to control new stages in their production processes (see for example Alfaro et al., 2019). It can be for instance a way to ensure the quality of its inputs. This control will affect the product quality (Verhoogen, 2008), both at the firm and industry level, and hence will bias our results. The simultaneity of these decisions may also bias our results, since both decisions are made within the same firm. The inclusion of firm and industry-year fixed effects in our estimations control for these biases.

The second endogeneity bias problem arises if the firm's position in GVCs drives the quality upgrading. This reverse causality may occur given that participation in GVCs allows firms to access to high quality inputs through import activities (Gaigné and Le Mener, 2014; Gibson and Graciano, 2011), to improve the quality of exported products, either through the use these inputs (Verhoogen, 2008) and/or through the mechanism of learning-by-exporting (Park et al., 2010). Since international trade stimulates incentives to upgrade the quality of existing products (Helpman, 2011), the intensity of participation in CVGs can thus affect the level of quality of the firms' products. To account for endogeneity, we use an instrumental variable approach to test mainly for reverse causality between quality upgrading and GVCs' position patterns. Following Chor et al. (2021), we construct our instrumental variable using information on a plausibly exogenous positive shocks to foreign demand which can boost firm total factor productivity (TFP), by raising firms' exports and thereby total sales. Our strategy is based on the positive relationship between TFP and quality.[6] Similar to Chor et al. (2021), we obtain the $Inst_{ft}$ variable, as a shift-share projected growth rate in foreign demand for firm f's products from year $t-1$ to t. Based on the CEPII BACI dataset, we take weighted-average of the year-on-year growth in rest-of-the-world export flows, by excluding France in origin and destination countries of exports, as follow:

$$Inst_{ft} = \ln\left(X_{f,t-1}\left(1 + \sum_{j\neq \text{France},k} \frac{X_{fjk,0}}{X_{f,0}} \cdot \frac{X_{\text{RoW},jkt} - X_{\text{RoW},jk,t-1}}{X_{\text{RoW},jk,t-1}}\right)\right) \tag{15}$$

$X_{\text{ROW},jkt}$ (respectively $X_{\text{ROW},jk,t-1}$) is the total exports emanating from the rest of the world by destination country j and HS 6-digit product k in year t (respectively $t-1$), $\frac{X_{fjk,0}}{X_{f,0}}$ is the share of country j and product k in firm f's export profile in the first year (indexed by 0) where the firm f is observed in the French customs data on foreign trade over 2000-2018, and serves as a weight to capture the degree of exposure of each firm f to export demand shocks from the rest-of-the-world at country-by-product level. This degree of exposure represents the firm-year level predicted growth rate of exports, which, combined with the firm's one-year lagged level exports, predicts its export volume in each year. Therefore, we adopt a predicted (log) level of firm f's exports in year t provided by equation (15) as our instrument. A sufficient condition for identification is that foreign demand shocks affect individual French agri-food firms' production staging decisions, only through its effect on firms' product quality.

Table 5 shows the results about the role of quality in the GVCs' position patterns of the firms. The regressions with OLS are shown in columns (1) to (3) and document that, in line with the theoretical predictions, the coefficient of the variable $Quality_{ft}$ is significant and positive for imports *upstreamness*, negative for exports *upstreamness* and positive in the widening of the span of stages performed. These results show that within firms over time, quality upgrading allows firms to significantly expand its span of production stages within France. This means that an increase of 1% in the quality of the products of French agri-food firms may implied a change in the span of stages, $U^M_{ft} - U^X_{ft}$, of about 0.0012 [7].

It is worth noting that time-varying firm controls, namely lagged log productivity, is associated with no significant change in upstream imports and is significantly and negatively associated with

[6] A raise in TFP can increase quality either through the learning-by-exporting mechanisms (Park et al., 2010) or by increasing firms' exports revenue that lead to more investments in firm'ss production technology (Brandt et al., 2014).

[7] Given the level-log nature of the models, we obtain the change in units of production stages performed with respect to a one percent increase in quality measures by dividing the coefficient estimates of interest by 100

export *upstreamness*, leading to managing a wider span of stages within France, whereas lagged size have no significant change on GVC position patterns.[8] In other words, in line with Chor et al. (2021), our results tend to confirm that as firms become more productive, they import less processed inputs and export goods closer to final demand, and consequently extend the production stages performed in France.

Table 5: Test of model predictions – Quality and firms' position in GVCs

Sample	OLS			IV			
	(1)	(2)	(3)	1st Stage (4)	(5)	(6)	(7)
	(U^M_{ft})	(U^X_{ft})	$(U^M_{ft} - U^X_{ft})$	Quality_{ft}	(U^M_{ft})	(U^X_{ft})	$(U^M_{ft} - U^X_{ft})$
Instrument_{ft}				0.0147***			
				(0.0021)			
Quality_{ft}	0.0448*	-0.0722**	0.1170***		0.2784	-0.8690***	1.1474***
	(0.0233)	(0.0338)	(0.0420)		(0.1906)	(0.2661)	(0.3320)
$\ln \text{Productivity}_{f,t-1}$	0.0128	-0.0209*	0.0337*	0.0184**	0.0087	-0.0064	0.0150
	(0.0155)	(0.0114)	(0.0201)	(0.0079)	(0.0165)	(0.0149)	(0.0230)
Firm size:							
$\text{Small}_{f,t-1}$	reference	reference	reference	reference	reference	reference	reference
$\text{medium}_{f,t-1}$	0.0291	-0.0121	0.0412	0.0126	0.0223	-0.0087	0.0310
	(0.0324)	(0.0233)	(0.0401)	(0.0149)	(0.0337)	(0.0291)	(0.0455)
$\text{large}_{f,t-1}$	0.0657	-0.0024	0.0681	0.0264	0.0574	0.0197	0.0377
	(0.0488)	(0.0409)	(0.0564)	(0.0221)	(0.0511)	(0.0488)	(0.0648)
Fixed effects	firm, industry-year				firm, industry-year		
Observations	8,358	8,358	8,358	7,872	7,872	7,872	7,872
R^2	0.777	0.822	0.726	0.600	0.779	0.832	0.737
F-stat					50.1864	50.1864	50.1864
Endogeneity test					1.5431	10.4039***	11.1024***

Notes: The sample comprises French agri-food firms (10 and 11 of 2-digit NACE Rev.2) of the fully matched sample over 2004-2017, which both export and import. Re-exports are excluded at firm-year-CN8 level in trade flows before computing import and export *upstreamness* and estimate the quality. $Inst_{ft}$ stands for predicted exports (shift-share in foreign demand). The quality is estimated using price elasticities at the HS6 level from Ossa (2015). All regressions include firm and industry-year fixed effects. Standard errors clustered by firm in parentheses. $^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$.

Columns(4) to (7) reports the IV estimates. As expected, the first-stage in Column 4 indicates that a positive foreign demand shocks has a strong positive effect on firms' product quality. Moreover, the high explanatory power of first-stage estimation and higher F-statistics confirm the validity of our instrument as a good predictor of the quality measures. However, The results of the endogeneity tests suggest that the quality variable is endogeneous in almost all the regressions, except the import *upstreamness* regression (Column 5). This means that OLS estimates for *upstreamness* of imports do not suffer from any endogeneity bias and remain valid, unlike the other two OLS regressions (columns 2–3). Therefore, columns 6–7 show that controlling for endogeneity reinforces our previous findings that quality upgrading has a significantly negative effect on exports *upstreamness* and a positive effect on the span of production stages, and the effects are much larger than OLS estimates. Indeed, a 1% increase in product quality implies an effect on $U^M_{ft} - U^X_{ft}$ ten times greater than the

[8] We observe, however, the expected positive and negative effects on U^M_{ft} and U^X_{ft}, respectively, leading to positive $U^M_{ft} - U^X_{ft}$. When we introduce the time-varying firm controls at time t, both are significantly associated with more upstream imports and with no significant change in export *upstreamness*, leading to managing a wider span of stages within France. The quality effect is never affected, however, and remains robust to all specifications.

OLS estimator (0.0115).[9] Note that all the coefficients of the control variables (log productivity and size group) no longer seem to play a decisive role in the GVCs' participation of the firms (Columns 7), compared with the results of the OLS regressions (Columns 3), although most of the coefficients have the expected signs.[10]

The results discussed above mainly show the effect of intertemporal changes in the firm's product quality on its GVC position patterns (the *within* component of the product quality effect). We estimate equation (14) without firm fixed effects, to check whether these relationships are also present in cross-sectional variation (the *between* effect). Results are reported in Table C.3 of Appendix C, and have confirmed our empirical validation. Indeed, we find robust patterns that quality ugrading significantly allows firms to import inputs that are further upstream, and export products that are more proximate to the final demand, contributing to the widening of the span of production stages, $U_{ft}^{M} - U_{ft}^{X}$ (columns 1–7). This means that potential omitted variables at firm level do not affect our results. However, similar to Chor et al. (2021), we do not obtain such a consistent pattern of the effect of productivity and size on GVC position patterns, as higher firm productivity is positively correlated with both the *upstreamness* of imports and exports.[11] Overall, as mentioned early, we can safely conclude that quality is far more decisive factor in successful intensive GVC participation than productivity and firm size in the food industry.

4.1.2 Quality upgrading and firm's costs, value added and profits

We then assess the validity of predictions P1.ii and P1.iii, which summarize how the firm's decision to upgrade its product mix move in tandem with its input costs, value added and profit, motivating a widening of its span of stages. For this, we modify the dependent variable in the specifications (14) in order to uncover the effects of quality on firm attributes:

$$\Theta_{ft} = \beta + \delta\, Quality_{ft} + \Lambda\, \text{Controls}_{ft} + FE_f + FE_{rt} + u_{ft} \tag{16}$$

Θ_{ft} represents the logarithm of raw material purchases, wage bill, value added and profit, respectively. In both (14) and (16), we use the same control for time-varying firm characteristics at time t, Controls_{ft}, and the same set of fixed effects. Doing so, in regression (16) we examine the *within* component of how various aspects of a firm's attributes correlate with its product quality. Θ_{ft} could be the decision variable to upgrade the product mix of firm or outcomes of that decision that motivates the firm to extend its number of production stages, so that OLS estimates for (16) are partial correlations. As previously, regressions (16) are running on a subpanel of GVC firms and standard errors are clustered by firm.

Table 6 reports the results of estimating (16). Consistent with P1.ii and P1.iii, Columns 1–4 demonstrates that input costs (raw materials purchases and wage bill) significantly rise as the firm upgrade the quality of product mix, even when we control for productivity and firm size. This means that the relationship between quality and input costs is not an artefact of an expansion in the scale

[9] We tested whether our empirical validation is robust to control variable omission and to the structure effect. To do this, first, we run (14) without productivity and firm size. Second, as we lack data on productivity and size variables for many firms in our sample for some years, our sample is unbalanced. We account for all previously excluded observations, our sample size has more than doubled. The results are reported in panels A and B, respectively, in Table C.2 of appendix C The effects are very similar to the baseline results

[10] A surprising result is that the productivity has a non-significant role in the IV results. We try to elucidate these effects (of productivity on GVC participation), in order to verify to what extent quality is responsible for these results (due to colinearity between quality and productivity for instance). We run the same OLS and IV regressions without the quality variable, by instrumenting the productivity variable as in Chor et al. (2021). Table C.1 of Appendix C reports the results. The positive and significant role of the productivity in the widening of the span of stages is confirmed. This shows that higher quality production is more decisive than productivity for the intensity of agri-food firms' participation in GVCs.

[11] Similar results are obtained for firm productivity even if we run regression (14) without firm fixed effects and the quality variable.

of the firm's operations, confirming that high quality products require more upstream and stages inputs, which motivates an increase in $U^M_{ft} - U^X_{ft}$.

Consider the pattern of firms' performance, predictions P1.ii and P1.iii continue to hold. Indeed, we find that value added, defined as the sum of profits, total fixed costs and total variable costs, significantly increases with quality upgrading (Columns 5), but this effect occurs mainly through a scaling up of firm operations, as this partial correlation becomes non-significant once controlling for time-varying firm characteristics (productivity and firm size). Using the within specification, we cannot confirm that the "demand effect" outweighs the "cost effect" of quality, so that the two effects offset each other, leading to a non-significant relationship with profits (columns 7–8).

Table 6: Test of model predictions – Quality, input costs, value added and profits

Dep. variables:	Log Raw Inputs		Log Wagbill		Log Value added		Log Profits	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Quality_{ft}	0.1526***	0.0976***	0.0540***	0.0310*	0.0613**	0.0155	-0.0133	0.0368
	(0.0336)	(0.0363)	(0.0195)	(0.0178)	(0.0260)	(0.0277)	(0.0677)	(0.0868)
$\ln \text{Productivity}_{ft}$		0.6912***		0.0663		0.2926***		0.6832***
		(0.0732)		(0.0451)		(0.0488)		(0.0727)
Firm size:								
Small_{ft}		reference		reference		reference		reference
medium_{ft}		0.5923***		0.4289***		0.4268***		0.3581***
		(0.0533)		(0.0377)		(0.0445)		(0.0995)
large_{ft}		1.4593***		1.0908***		0.9594***		0.7308***
		(0.1624)		(0.1237)		(0.1188)		(0.2082)
Fixed effects	firm, industry-year							
Observations	13,423	8,722	13,431	8,778	12,835	8,402	10,789	6,900
R^2	0.959	0.971	0.970	0.980	0.959	0.965	0.851	0.861

Notes: The sample comprises French agri-food firms (10 and 11 of 2-digit NACE Rev.2) of the fully matched sample over 2004-2017, which both export and import. Re-exports are excluded at firm-year-CN8 level in trade flows before estimate the quality. The quality is estimated using price elasticities at the HS6 level from Ossa (2015). All regressions include firm and industry-year fixed effects. Standard errors clustered by firm in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Once again, we have further examined the presence of the *between* component in the relationship between the firm's decision to upgrade its product mix and its input costs, value added and profit, by estimating (16) without firm fixed effects. Results are rported in Table C.4 of Appendix C. We find that the *between* component of the effect of quality on firm's attributes is stronger than the *within* effect (higher coefficient of the quality variable with greater statistical significance) in all regressions (columns 1–8). Moreover these results are robust to productivity and firm size controls, even in the profit regression (Column 7–8), meaning that the *demand effect* clearly outweighs the *cost effect* of quality, across firms, as expected.

4.1.3 Robust tests

Using the sample excluding re-exports of GVC firms, we empirically validate that quality upgrading allows firms to perform more production stages in GVCs by importing further upstream, and exporting more proximate to final demand. Moreover, the decision to upgrade increase input costs, value added, and profits.[12] First, these results are robust to the omission of productivity and firm

[12] As we have observed in the data, re-exports account for a substantial share of the total value of imports (53%) and exports (71%) by French agri-food firms. Excluding re-exports may create a skewed sample which may affect the validity of our *upstreamness* and quality indicators, and bias our results upwards, particularly those related to the number of production stages performed by firms in GVCs. Indeed, re-exporting may

size controls, as mentioned earlier. Furthermore, all findings continue to hold when omitting firm fixed effects, and show that the patterns we have documented are also present in cross-sectional variation. Overall, this confirms that our empirical results are not affected by a structure effect.

Second, recall that the quality measure is estimated using trade elasticities taken from Ossa (2015), and based on the methodology developed in Khandelwal et al. (2013). However, as shown in section **??**, obtaining quality measures intrinsically linked to the firm component, from the Khandelwal et al. (2013) approach, is a major challenge insofar as most of the firms in our sample are multi-product and quality is not directly comparable within such firms and between products. In this respect, the measure used in the core of the paper may have two (2) main limitations: (i) the quality level attributed to a firm does not necessarily correspond to its best quality, nor to the product linked to its core activity, and (ii) it should be remembered that this measure of quality is truncated, since it lies within the interval [0,1]. Thus, the use of linear estimators could lead to biased results. To check that these limitations do not affect the consistency of our results, we use two other aggregation alternatives to compute quality at firm level. These are standardized average quality and weighted average quality. Both these measures exploit all the products exported by the firm to compute quality as an average component at the firm level (see Appendix A.3 for computation). We estimate (14) and (16) using these measures as variable of interest. Results in Table C.5 of Appendix C show that quality upgrading allows firms to significantly expand its span of production stages within France, adopting a stable profile in upstream imports (no significant change in U^M_{ft}, columns 1 and 5), and significantly exporting further processed goods (a lower U^X_{ft}, columns 2 and 6). these results confirm firms' interest in limiting the adverse selection effect of quality upgrading on the market by integrating production stages further proximate to final demand. The results differ only slightly from our baseline results and are full in line with the theoretical prediction. Similarly, if we consider the relationship between quality and firms' costs, value added and profits, results in Table C.6 Appendix C show that our baseline results remain valid, since firms' input costs, value added and profits increase with quality upgrading, except when using standardized average quality (panel B). Therefore, the possible limitations identified in the measure of quality used in the core of the paper do not fundamentally affect our baseline results.

Third, notice that elasticity parameters from Ossa (2015) are estimated for 251 3-digit SITC-Rev3 industries, via a demand system, combining GTAP 7 and NBER-UN data. However, the 3-digit SITC-Rev3 level offers a high level of aggregation and could introduces biases, and as indicated by Ossa (2015), a low level of aggregation is always preferable. To test for the absence of this aggregation biases, we infer quality measure by exploiting the trade elasticity parameters in Fontagné et al. (2022), which use variations in tariffs over 5,000 different product at 6-digit HS. Using this new measure of quality in regressions (14) and (16), our baseline results continue to hold and the coefficients are quite close (tables C.7 and C.8 in Appendix C), confirming that our empirical validations are robust to elasticity parameters from different sources.

reflect a marginally modified product by the firm, after import, before being exported. This means that the level of processing applied to the re-exported product is very low, and can pull down, on average, our indicator of the number of stages performed by firms in GVCs. Moreover, in 46% of cases, re-exports are linked to the firm's core activity and should correspond to the best-selling products of the latter. Since our measures of quality reflect the fact that, for a given price, a higher quantity of sales indicates a higher quality variety, re-exports should push quality measure upwards, on average. Given these two effects, both in the upstream indicators and in the quality measures, our baseline results, mainly related to the effect of quality on the number of production stages performed in GVCs, could be biased upwards. We check for the absence of such bias by estimating equations (14) and (16) on the sample of GVC firms including all transactions. Results are very similar to the baseline results in Tables 5 and 6 and show that excluding re-exports does not alter our empirical validation.

4.2 Firm's global production line position, input costs, value added and profits

Our theoretical predictions show that quality upgrading evolves along with input costs, value added and profits, driving the firm to widen its span of stages. In general, higher input costs, value added and profits do not necessarily lead to an increase in the number of production stages performed in GVCs. However, mechanically, the expansion along the global production chain is associated with increases in input costs, value added and profits, as our theoretical framework shows (P2). We test these by running a linear form as follows:

$$\Theta_{ft} = \beta + \delta \{U_{ft}^M,\ U_{ft}^X,\ U_{ft}^M - U_{ft}^X\} + \Lambda\ \text{Controls}_{ft} + FE_f + FE_{rt} + u_{ft}. \qquad (17)$$

Relative to (16), we now use the *upstreamness* of firm imports, U_{ft}^M, the *upstreamness* of firm exports, U_{ft}^X, and the difference between these two, $U_{ft}^M - U_{ft}^X$ (GVC_{ft}) as our main variables of interest in these regressions. The outcome variables, Θ_{ft}, remain in turn one of the four measures of firms' attributes (the logarithm of raw material purchases, wage bill, value added and profits). We continue to use the same controls and fixed effects to examine the partial correlations of the relationship between these features of the firm and the number of stages performed in global production line.

Results are reported in Table 7. Columns 1-8 demonstrate that the relationship between firms' span of stages and input costs, performance in terms of profits and value added are positive (even if non significant) in line with the theoretical predictions. Table 8 deepens the analysis and performs the between component analysis, by running regression (17) without firm fixed effects. A clear pattern emerges particularly when we observe results of regressions without time-varying firm controls (columns 1, 3 and 5). The estimated coefficients on the variable $U_{ft}^M - U_{ft}^X$ is positive and significant, consistent with prediction P2, confirming that firms' input costs and value added are increasing in its span of stages in GVCs. Interestingly, by including productivity and firm size as controls in regression (17), we find that partial correlations between the span of stages and firms' input costs and value added are mainly due to an expansion in the scale of firms' operations, since they become non-significant. The correlation between the span of stages and profits is still non-significant, underlining once again the ambiguous role of quality and expansion in GVCs.

5 Discussion and conclusion

Based on theoretical developments tested empirically using data on French agri-food firms, this article highlights to what extend product quality matters for a firm's position in GVCs. Our findings echo recent work by Chor et al. (2021) and Alfaro et al. (2019) in modeling and establishing new facts on how firms involve in the different stages of a production line and establish the boundaries in their participation. It appears in our work that the role of product quality is comparable to that of productivity in firms' key decision on which stages to perform in-house and which to outsource, and on how close to final demand should be their output. We show that quality upgrading pushes firms to integrate additional upstream and downstream stages. This implies using more upstream inputs produced by other firms to produce a more transformed output, a larger span of intermediate production stages being performed in-house. This increases input costs and value added for agri-food firms, and could lead to higher profits.

Quality upgrade increases firm's revenues due to the higher willingness-to-pay of consumers, but generates higher variable and fixed costs for the firm. To obtain the combined outcome of these opposite *demand* and *cost* effects, one needs to account for shifts in the boundaries of the production segment performed by the firm. In the case of French agri-food firms, we find that the *demand* effect outweighs the *cost* effect, and this result is mainly induced by differences across firms (the *between* effect). However, we find that the *cost* effect fully counterbalances the *demand* effect within firm (the *within* effect). Accordingly, producing higher quality outputs do not generates significant positive

Table 7: Firms' position in GVCs, input costs, value added and profits – The *within* effect

Dep. variables:	Log Raw Inputs		Log Wagbill		Log Value added		Log Profits	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$(U_{ft}^{M} - U_{ft}^{X})$	0.0214	0.0108	0.0060	0.0027	0.0106	0.0014	0.0153	0.0068
	(0.0132)	(0.0124)	(0.0119)	(0.0092)	(0.0129)	(0.0124)	(0.0285)	(0.0345)
ln Productivity$_{ft}$		0.6915***		0.0690		0.2981***		0.6730***
		(0.0719)		(0.0442)		(0.0480)		(0.0714)
Firm size:								
Small$_{ft}$		reference		reference		reference		reference
medium$_{ft}$		0.5813***		0.4170***		0.4197***		0.3569***
		(0.0520)		(0.0370)		(0.0432)		(0.0967)
large$_{ft}$		1.4460***		1.0780***		0.9522***		0.7306***
		(0.1627)		(0.1236)		(0.1185)		(0.2069)
Fixed effects	firm, industry-year							
Observations	13,956	8,983	13,967	9,043	13,349	8,662	11,224	7,106
R^2	0.960	0.971	0.970	0.981	0.959	0.965	0.848	0.861

Notes: The sample comprises French agri-food firms (10 and 11 of 2-digit NACE Rev.2) of the fully matched sample over 2004-2017, which both export and import. Re-exports are excluded at firm-year-CN8 level in trade flows before computing import and export *upstreamness*. All regressions include firm and industry-year fixed effects. Standard errors clustered by firm in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Firms' position in GVCs, input costs, value added and profits – The *between* effect

Dep. variables:	Log Raw Inputs		Log Wagbill		Log Value added		Log Profits	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$(U_{ft}^{M} - U_{ft}^{X})$	0.1134**	0.0300	0.1333***	0.0112	0.1066**	-0.0021	-0.0215	-0.0821
	(0.0522)	(0.0264)	(0.0472)	(0.0247)	(0.0479)	(0.0266)	(0.0635)	(0.0530)
ln Productivity$_{ft}$		1.1638***		0.2086***		0.4318***		0.8867***
		(0.0269)		(0.0240)		(0.0321)		(0.0716)
Firm size:								
Small$_{ft}$		reference		reference		reference		reference
medium$_{ft}$		1.8215***		1.8109***		1.7127***		1.6280***
		(0.0370)		(0.0358)		(0.0394)		(0.0712)
large$_{ft}$		3.7431***		3.9699***		3.9044***		4.1718***
		(0.0599)		(0.0731)		(0.0831)		(0.1595)
Fixed effects	industry-year							
Observations	14,466	9,446	14,462	9,505	13,801	9,092	11,770	7,618
R^2	0.172	0.813	0.111	0.762	0.102	0.736	0.092	0.518

Notes: The sample comprises French agri-food firms (10 and 11 of 2-digit NACE Rev.2) of the fully matched sample over 2004-2017, which both export and import. Re-exports are excluded at firm-year-CN8 level in trade flows before computing import and export *upstreamness*. All regressions include firm and industry-year fixed effects. Standard errors clustered by firm in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

profits within firm, which permits it to make new investments and expand its production chain. In the long term, this may reduce the firm's incentive to diversify its activities, leading it to rely more on outsourcing and off-shoring, as shown by Cuervo-Cazurra and Pananond (2023).

Chor et al. (2021) show that when Chinese firms span more production stages at the domestic level, they increase total input costs, assets, profits and value added, and conclude that some of the additional production stages are performed in-house, and not only substituting foreign suppliers with domestic suppliers. It should be stressed that we only confirm these findings across firms (the *between* effect) in French agri-food industry, since the *within* component of these effects, while positive and consistent with our theoretical predictions, is negligible. Indeed, we find that the *within* component of the relationship between the number of stages performed by French agri-food firms in GVCs and input costs, performance in terms of value added and profits are not robust. These results (the *within* effect) could suggest that French agri-food firms fulfills all or most stages $u \in [U^X, U^M]$ via subcontracts or other arm's length contracts with other domestic suppliers. If this is the case, it will be difficult to explore these theoretical predictions in the data, even they remain valid, since we do not have information on firm transactions at the domestic level. At this stage our theoretical predictions cannot be questioned and further analysis is needed to draw definitive conclusions.

With this overall picture in mind, we revisit the importance of firm characteristics in explaining their position in GVCs. A core element of our work is that firms' abilities to frame the range of internally performed production stages are unevenly distributed. Our findings offer an original understanding of the observed heterogeneity of firms' position in GVCs: it can stem from quality heterogeneity. This is a substantial contribution, but much remains to be done, in particular to empirically evaluate the potential gains associated with the intensity of participation in GVCs at firm or industry level, which we did not robustly achieve in this paper.

References

Alfaro, L., P. Antràs, D. Chor, and P. Conconi (2019, April). Internalizing Global Value Chains: A Firm-Level Analysis. *Journal of Political Economy 127*(2), 508–559.

Antràs, P. (2020, October). Conceptual Aspects of Global Value Chains. *The World Bank Economic Review 34*(3), 551–574.

Antràs, P. and D. Chor (2013). Organizing the Global Value Chain. *Econometrica 81*(6), 2127–2204.

Antràs, P., D. Chor, T. Fally, and R. Hillberry (2012, May). Measuring the Upstreamness of Production and Trade Flows. *American Economic Review 102*(3), 412–416.

Antràs, P. and E. Helpman (2004, June). Global Sourcing. *Journal of Political Economy 112*(3), 552–580.

Aw-Roberts, B. Y., Y. Lee, H. Vandenbussche, et al. (2020). Consumer taste in trade. Technical report, CEPR Discussion Papers.

Baldwin, J. and B. Yan (2014). *Global Value Chains and the Productivity of Canadian Manufacturing Firms.* Economic Analysis (EA) Research Paper Series. Statistics Canada â€“ Catalogue no.11F0027M, no. 090.

Baldwin, R. and J. Harrigan (2011). Zeros, quality, and space: Trade theory and trade evidence. *American Economic Journal: Microeconomics 3*(2), 60–88.

Baldwin, R. and T. Ito (2021). The smile curve: Evolving sources of value added in manufacturing. *Canadian Journal of Economics/Revue canadienne d'économique 54*(4), 1842–1880.

Beaujeu, R., C. Emlinger, J. Greenville, and M.-A. Jouanjean (2018). Contribution des ÃžliÃ¨res internationalisÃ©es et du commerce Ã l'emploi dans les secteurs agricole et agro-alimentaire. pp. 40.

Borin, A. and M. Mancini (2019, April). *Measuring What Matters in Global Value Chains and Value-Added Trade.* Policy Research Working Papers. The World Bank.

Brandt, L., J. Van Biesebroeck, and Y. Zhang (2014). Challenges of working with the chinese nbs firm-level data. *China Economic Review 30*, 339–352.

Chor, D. (2014). Where are Countries Positioned along Global Production Lines? *Macroeconomic Review 13*(1), 94–99.

Chor, D., K. Manova, and Z. Yu (2021). Growing like china: Firm performance and global production line position. *Journal of International Economics 130*, 103445.

Conconi, P., P. Legros, and A. F. Newman (2012). Trade liberalization and organizational change. *Journal of international economics 86*(2), 197–208.

Crinò, R. and P. Epifani (2012). Productivity, quality and export behaviour. *The Economic Journal 122*(565), 1206–1243.

Crozet, M., K. Head, and T. Mayer (2012). Quality sorting and trade: Firm-level evidence for french wine. *The Review of Economic Studies 79*(2), 609–644.

Cuervo-Cazurra, A. and P. Pananond (2023). The rise of emerging market lead firms in global value chains. *Journal of Business Research 154*, 113327.

Curzi, D. and A. Olper (2012, October). Export behavior of Italian food firms: Does product quality matter? *Food Policy 37*(5), 493–503.

Curzi, D., V. Raimondi, and A. Olper (2015). Quality upgrading, competition and trade policy: evidence from the agri-food sector. *European Review of Agricultural Economics 42*(2), 239–267.

Del Prete, D. and A. Rungi (2017). Organizing the global value chain: A firm-level test. *Journal of International Economics 109*, 16–30.

Emlinger, C. and V. Lamani (2020). International trade, quality sorting and trade costs: the case of cognac. *Review of World Economics 156*(3), 579–609.

Fajgelbaum, P., G. M. Grossman, and E. Helpman (2011). Income distribution, product quality, and international trade. *Journal of political Economy 119*(4), 721–765.

Fally, T. (2012). Production staging: measurement and facts. *Boulder, Colorado, University of Colorado Boulder, May*, 155–168.

Fontagné, L., H. Guimbard, and G. Orefice (2022, July). Tariff-based product-level trade elasticities. *Journal of International Economics 137*, 103593.

Gaigné, C., K. Latouche, and S. Turolla (2018). Vertical ownership and export performance: Firm-level evidence from the food industry. *American Journal of Agricultural Economics 100*(1), 46–72.

Gaigné, C. and L. Le Mener (2014). Agricultural prices, selection, and the evolution of the food industry. *American Journal of Agricultural Economics 96*(3), 884–902.

Gibson, M. J. and T. A. Graciano (2011). The decision to import. *American Journal of Agricultural Economics 93*(2), 444–449.

Giroud, A. and I. Ivarsson (2020). World investment report 2020: International production beyond the pandemic: United nations conference on trade and development, geneva and new york, 2020, 247 pp. isbn: 978-9211129854. *Journal of International Business Policy 3*(4), 465.

Greenville, J., K. Kawasaki, and R. Beaujeu (2017, February). How policies shape global food and agriculture value chains.

Hallak, J. C. and J. Sivadasan (2013). Product and process productivity: Implications for quality choice and conditional exporter premia. *Journal of International Economics 91*(1), 53–67.

Helpman, E. (2011). *Understanding global trade*. Harvard University Press.

Hummels, D., J. Ishii, and K.-M. Yi (2001, June). The nature and growth of vertical specialization in world trade. *Journal of International Economics 54*(1), 75–96.

Johnson, R. C. (2012, January). Trade and prices with heterogeneous firms. *Journal of International Economics 86*(1), 43–56.

Johnson, R. C. and G. Noguera (2012, March). Accounting for intermediates: Production sharing and trade in value added. *Journal of International Economics 86*(2), 224–236.

Khandelwal, A. K., P. K. Schott, and S.-J. Wei (2013). Trade liberalization and embedded institutional reform: Evidence from chinese exporters. *American Economic Review 103*(6), 2169–95.

Koopman, R., Z. Wang, and S.-J. Wei (2014, February). Tracing Value-Added and Double Counting in Gross Exports. *American Economic Review 104*(2), 459–494.

Mahy, B., F. Rycx, G. Vermeylen, and M. Volral (2021). Productivity and Wage Effects of Firm-Level Upstreamness: Evidence from Belgian Linked Panel Data. *The World Economy Accepted Author Manuscript*. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/twec.13227.

Marvasi, E. (2023). Global value chain resilience and reshoring during covid-19: challenges in a post-covid world. In *Inequality, Geography and Global Value Chains*, pp. 231–262. Springer.

Melitz, M. J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica 71*(6), 1695–1725.

Mudambi, R. (2008). Location, control and innovation in knowledge-intensive industries. *Journal of economic Geography 8*(5), 699–725.

Ossa, R. (2015). Why trade matters after all. *Journal of International Economics 97*(2), 266–277.

Park, A., D. Yang, X. Shi, and Y. Jiang (2010). Exporting and firm performance: Chinese exporters and the asian financial crisis. *The Review of Economics and Statistics 92*(4), 822–842.

Rungi, A. and D. Del Prete (2018). The smile curve at the firm level: Where value is added along supply chains. *Economics Letters 164*, 38–42.

Sutton, J. (2007). Quality, trade and the moving window: The globalisation process. *The Economic Journal 117*(524), F469–F498.

Verhoogen, E. A. (2008, May). Trade, Quality Upgrading, and Wage Inequality in the Mexican Manufacturing Sector*. *The Quarterly Journal of Economics 123*(2), 489–530.

Appendices

A Variables' construction

A.1 Industry upstreamness

To measure the position of the different industries in the production line, we start by using the input-output table at 4-digit NACE Rev.2 level constructed in section A.2. Then we use methodology developed by Fally (2012), Antràs et al. (2012) and Antràs and Chor (2013) to compute the positioning of an industry in relation to final demand. This methodology starts from a basic gross output accounting identity. Assuming an economy with S ($S \geq 1$) industries, the total gross output of industry r is given by :

$$\begin{aligned} Y_r &= F_r + B_r = F_r + \sum_{s=1}^{S} d_{rs} Y_s \\ &= F_r + \sum_{s=1}^{S} d_{rs} F_s + \sum_{s=1}^{S}\sum_{k=1}^{S} d_{rk} d_{ks} F_s + \sum_{s=1}^{S}\sum_{k=1}^{S}\sum_{l=1}^{S} d_{rl} d_{lk} d_{ks} F_s + ... \end{aligned} \tag{A.1}$$

where F_r (respectively $B - r$) is the value of industry r used for final consumption (respectively as an intermediate input), $d_r s$ is the value of the output of industry r needed to produce one unit of the output of industry s, i.e. the *direct requirements* coefficient. From the second row of equation (A.1), the gross output vector Y is obtained in matrix form as:

$$\begin{aligned} Y &= F + B \cdot F + B^2 \cdot F + \dots \\ &= [I - B]^{-1} \cdot F \end{aligned} \tag{A.2}$$

where B is the matrix of direct requirements coefficients of dimension $\times$, I is the identity matrix, $B^m F (m{>}0)$ is the vector of the value of the total gross output used for final consumption, after $m + 1$ production stages. Equation (A.2) expresses the classical Leontief inverse matrix formula that generates the gross output Y needed to produce the vector of final uses F. Y is equal to the sum of an infinite number of terms, which can be approximated by the matrix $[I - B]^{-1} F$, and Y_r is the $r - th$ term of Y. Each term on the right-hand side of the second row of equation (A.1) indicates the number of production stages through which the output of industry r passes before it is absorbed as final consumption. Expression (A.1) can thus be interpreted as the sum of the value of industry r's output used directly (F_r) and indirectly $\left(\sum_{s=1}^{S} d_{rs} F_s + \sum_{s=1}^{S} \sum_{k=1}^{S} d_{rk} d_{ks} F_s + \sum_{s=1}^{S} \sum_{k=1}^{S} \sum_{l=1}^{S} d_{rl} d_{lk} d_{ks} F_s + \dots \right)$ to produce the country's final consumption. From this point of view, a production stage is counted each time a good is absorbed as final consumption or used as an intermediate input. In an economy where $S \geq 1$, industry s's *upstreamness* is computed as:

$$U_r = 1 \cdot \frac{F_r}{Y_r} + 2 \cdot \frac{\sum_{s=1}^{S} d_{rs} F_s}{Y_r} + 3 \cdot \frac{\sum_{s=1}^{S} \sum_{k=1}^{S} d_{rk} d_{ks} F_s}{Yr} + 4 \cdot \frac{\sum_{s=1}^{S} \sum_{k=1}^{S} \sum_{l=1}^{S} d_{rl} d_{lk} d_{ks} F_s}{Y_r} + \dots \tag{A.3}$$

U_r is the weighted average of the number of stages from final demand (consumption or investment) at which r enters as an input in production processes. The weights correspond to 1 for the part of r's output that goes to final consumption, 2 for the part of r's output used in another industry before being absorbed as final consumption and so on. Each ratio in the right hand side in expression (A.3) permit the definition of the importance of industry r's share in the total output of r used at each production stage. In matrix form, we obtain the following expression:

$$F + 2 \cdot B \cdot F + 3 \cdot B^2 \cdot F + 4 \cdot B^3 \cdot F + \cdots = [I - B]^{-2} \cdot F. \tag{A.4}$$

The right-hand side term of equation (A.4) is the final consumption vector F pre-multiplied by the square of the Leontief inverse matrix $\left([I - B]^{-2}\right)$. The numerator of each right-hand side term in equation (A.3) is the $r-th$ element of the right-hand side expression in equation (A.4). Antràs et al. (2012) and Antràs and Chor (2013) construct the *upstreamness* indicator of the industry r by taking the ratio of the $r-th$ element of the column vector $[I-B]^{-2}F$ to the $r-th$ element of the column vector $[I-B]^{-1}F$. Fally (2012) proposes an alternative measure of *upstreamness* by assuming that an industry r that sells a disproportionate share of its output to another industry s located further upstream is itself located relatively further upstream. He sets up the following recurrence equation:

$$U_r = 1 + \sum_{s=1}^{S} \frac{d_{rs} \cdot Y_s}{Y_r} U_s \tag{A.5}$$

where $\frac{d_{rs} \cdot Y_s}{Y_r}$ is the total share of industry r's output purchased by industry s. Industry r is thus considered as belonging to a higher "upstream stage" than the weighted sum of industries s that use the products of industry r as intermediate inputs. Fally (2012) and Antràs et al. (2012) show that the measure of *upstreamness* expressed by equation (A.3) is the unique solution of expression (A.5). Using matrix algebra, they establish the following equivalence between these different measures of *upstreamness*:

$$U_r = [I - \Delta]^{-1} \mathbf{1} \tag{A.6}$$

where Δ is a matrix whose term (r, s) is equal to $\frac{d_{rs} \cdot Y_s}{Y_r}$ and $\mathbf{1}$ is a unit column vector.

In general, $U_r \geq 1$. A higher value of the *upstreamness* indicates that the industry is at a higher upstream stage in the production line. An *upstreamness* equal to 1 means that the entire output of industry r is directly used as final consumption in the sense of Fally (2012) and Antràs et al. (2012)[13].

We compute the *upstreamness* of each 4-digit NACE Rev.2 industry r in the input-output table constructed in section A.2, obtaining first:

$$d_{rs} = \frac{b_{rs}}{Y_s} \implies d_{rs} \cdot Y_s = b_{rs} \implies \frac{d_{rs} \cdot Y_s}{Y_r} = \frac{b_{rs}}{Y_s}$$

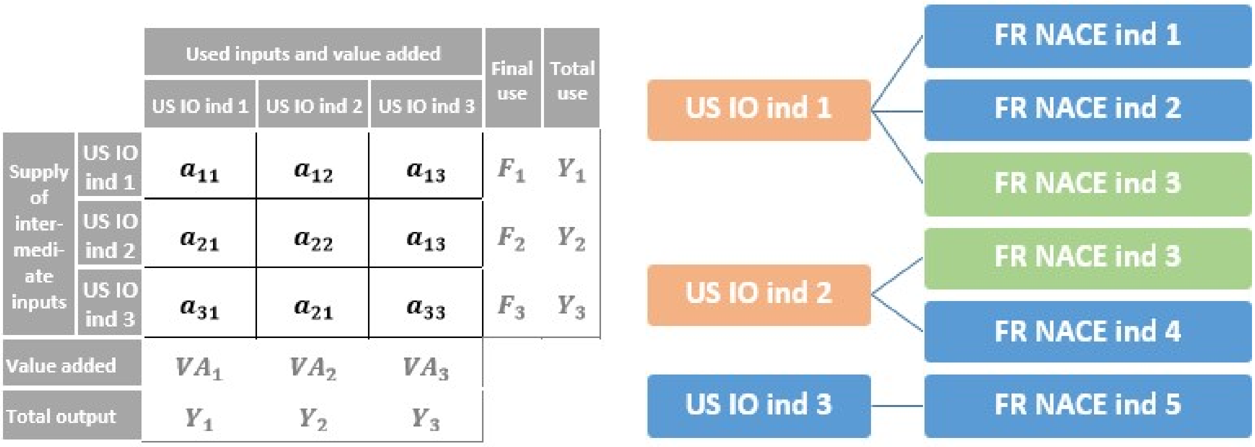
A.2 Input-output table

The measurement of the level of processing of products traded by firms relies on the information provided by the input-output table. The availability of these tables at detailed levels for each country remains an important challenge in carrying out this work. Moreover, our interest in the agri-food sector further complicates this task insofar as the European input-output tables are established at high levels of aggregation. In France, for example, the input-output tables provided by the OECD Structural Analysis database (OECD STAN) include only thirty industries, and only one concerns the agri-food industry. To overcome this issue, we use as a starting point the US input-output table, developed by the Bureau of Economic Analysis (BEA), which is available online, in open access[14]. More specifically, we rely on the most recent Use Table after redefinition at producer prices for 2012.

The US input-output table has the advantage to include information on production linkages between industries at a high level of disaggregation. It includes 405 industries (identified by individual 6-digit I-O codes) of which 42 are in the agri-food sector. It is important to take into account all the

[13] In the specific case of the *upstreamness* indicator developed by Alfaro et al. (2019), a value of 1 indicates that industry r is used entirely in the production of products of the same or other industries through a single production stage.

[14] `https://www.bea.gov/industry/input-output-accounts-data`



(a) US input-output table

(b) Multiple industry correspondences

Figure A.1: US input-output table structure and correspondences with NACE Rev.2

industries in the economy because the production of agri-food goods involves the use of inputs, raw materials and intermediate products from other sectors (for example, packaging). However, using the U.S. input-output table for an application on French data presents significant classification and matching challenges. We have developed a methodology to convert the U.S. input-output table to the 4-digit NACE Rev.2 codes level, reported for French firms.

The entries a_{ij} in Figure A.1.a report the value of intermediate goods of industry i used in the production of goods of industry j. In addition, there is a column (F_i) that reports the value of products i that goes into aggregate final uses, such as final consumption, investment, changes in inventories and net exports.

The main challenge in using the U.S. I-O table on French data is that there is not a one-to-one correspondence between the U.S. IO and the NACE Rev.2 industries. Note that the U.S. IO codes are specific to the 2012 North American Industry Classification System (NAICS) structure. An U.S. IO code can correspond to one or more NAICS codes. The NAICS codes in turn have different levels of aggregation, from 2 digits (most aggregated level) to 6 digits (least aggregated level). We have mapped the U.S. IO codes to NACE Rev.2 codes using the links between the U.S. IO codes and the NAICS 2012 codes and the correspondence table between NAICS 2012 and NACE Rev.2 provided by Eurostat [15]. However, there are several concerns with this mapping. As shown by Figure A.1.b, a 6-digit IO code may correspond to several 4-digit NACE Rev.2 codes. Similarly, a 4-digit NACE Rev.2 code may be associated with several 6-digit U.S. IO codes. Out of the the 1,547 U.S. IO-NACE Rev.2 code combinations, only 31 industries, (and 2 in the agri-food sector), had a one-to-one correspondence. In these circumstances, we chose to divide each a_{ij} entry in the U.S. I-O table equally among all (r, s) combinations of NACE Rev.2 codes to which the (i, j) entry corresponds (Figure A.2.a). We then simply take the sum of the (r, s) entries that are identical to obtain the entries b_{rs} of the new input-output table at NACE Rev.2 level. We end up with the table in Figure A.2.b.

For example, in Figure A.1.b the U.S. IO1, respectively IO2 codes correspond to 3, respectively 2 NACE codes and the NACE3 code corresponds to 2 I-O codes. Thus, in order to convert the structure of the U.S. I-O table from the level of U.S. IO codes (Figure A.1.a) to the level of NACE Rev.2 codes (Figure A.2.b), we formally have performed the following transformations:

$$b_{rs} = \sum_{i,j} \frac{a_{ij}}{n_i \times n_j}, \text{with } (i \supseteq r \text{ or } i \subseteq r) \text{ and } (j \supseteq s \text{ or } j \subseteq s)\,. \tag{A.7}$$

where n_i, respectively n_j represent the number of different NACE Rev.2 codes associated with input

[15] http://ec.europa.eu/eurostat/ramon/documents/NACE_REV2-US_NAICS_2012.zip.

		US IO ind 1			US IO ind 2		US IO ind 3
		FR NACE ind 1	FR NACE ind 2	FR NACE ind 3	FR NACE ind 3	FR NACE ind 4	FR NACE ind 5
US IO ind 1	FR NACE ind 1	$\frac{1}{9}a_{11}$	$\frac{1}{9}a_{11}$	$\frac{1}{9}a_{11}$	$\frac{1}{6}a_{12}$	$\frac{1}{6}a_{12}$	$\frac{1}{3}a_{13}$
	FR NACE ind 2	$\frac{1}{9}a_{11}$	$\frac{1}{9}a_{11}$	$\frac{1}{9}a_{11}$	$\frac{1}{6}a_{12}$	$\frac{1}{6}a_{12}$	$\frac{1}{3}a_{13}$
	FR NACE ind 3	$\frac{1}{9}a_{11}$	$\frac{1}{9}a_{11}$	$\frac{1}{9}a_{11}$	$\frac{1}{6}a_{12}$	$\frac{1}{6}a_{12}$	$\frac{1}{3}a_{13}$
US IO ind 2	FR NACE ind 3	$\frac{1}{6}a_{21}$	$\frac{1}{6}a_{21}$	$\frac{1}{6}a_{21}$	$\frac{1}{4}a_{22}$	$\frac{1}{4}a_{22}$	$\frac{1}{2}a_{13}$
	FR NACE ind 4	$\frac{1}{6}a_{21}$	$\frac{1}{6}a_{21}$	$\frac{1}{6}a_{21}$	$\frac{1}{4}a_{22}$	$\frac{1}{4}a_{22}$	$\frac{1}{2}a_{13}$
US IO ind 3	FR NACE ind 5	$\frac{1}{3}a_{31}$	$\frac{1}{3}a_{31}$	$\frac{1}{3}a_{31}$	$\frac{1}{2}a_{21}$	$\frac{1}{2}a_{21}$	a_{33}

(a) Equal weights for all correspondences within each pair of industry codes

	FR NACE ind 1	FR NACE ind 2	FR NACE ind 3	FR NACE ind 4	FR NACE ind 5
FR NACE ind 1	$b_{11}=\frac{1}{9}a_{11}$	$b_{12}=\frac{1}{9}a_{11}$	$b_{13}=\frac{1}{9}a_{11}+\frac{1}{6}a_{12}$	$b_{14}=\frac{1}{6}a_{12}$	$b_{15}=\frac{1}{3}a_{13}$
FR NACE ind 2	$b_{21}=\frac{1}{9}a_{11}$	$b_{22}=\frac{1}{9}a_{11}$	$b_{23}=\frac{1}{9}a_{11}+\frac{1}{6}a_{12}$	$b_{24}=\frac{1}{6}a_{12}$	$b_{25}=\frac{1}{3}a_{13}$
FR NACE ind 3	$b_{31}=\frac{1}{9}a_{11}+\frac{1}{6}a_{21}$	$b_{32}=\frac{1}{9}a_{11}+\frac{1}{6}a_{12}$	$b_{33}=\frac{1}{9}a_{11}+\frac{1}{6}a_{12}+\frac{1}{6}a_{21}+\frac{1}{4}a_{22}$	$b_{34}=\frac{1}{6}a_{12}+\frac{1}{4}a_{22}$	$b_{35}=\frac{1}{3}a_{13}+\frac{1}{2}a_{13}$
FR NACE ind 4	$b_{41}=\frac{1}{6}a_{21}$	$b_{42}=\frac{1}{6}a_{21}$	$b_{43}=\frac{1}{6}a_{21}+\frac{1}{4}a_{22}$	$b_{44}=\frac{1}{4}a_{22}$	$b_{45}=\frac{1}{2}a_{13}$
FR NACE ind 5	$b_{51}=\frac{1}{3}a_{31}$	$b_{52}=\frac{1}{3}a_{31}$	$b_{53}=\frac{1}{3}a_{31}+\frac{1}{2}a_{21}$	$b_{54}=\frac{1}{2}a_{21}$	$b_{55}=a_{33}$

(b) Group weights across NACE industries

Figure A.2: Convert the US I-O table to the NACE Rev.2 4-digit level

i (in rows in Figure A.1.a), respectively, output j (in columns in Figure A.1.a). This transformation makes it possible to remain as close as possible to the structure of the initial U.S. I-O table, i.e. at the level of U.S. IO codes. This permits us to build a highly detailed input-output table for 604 4-digit NACE Rev.2 industries, of which 88 agri-food. Once this transformation has been carried out, we only need to compute the *upstreamness* indicator for the 4-digit NACE Rev.2 industries.

We check the stability of the *upstreamness* measure of industries between U.S. and France in order to test the relevance of using the U.S. table on French data. To do so, we use French input-output data from several sources: the OECD STAN database and the INSEE input-output table. Note that the OECD STAN database include 34 industries and the INSEE input-output contain 15 industries. Given the high level of aggregation of these two tables, we aggregate the input-output table constructed above, so as to have respectively the 34 industries present in the OECD STAN database - Aggregate NACE (34 industries) - and the 15 industries present in the INSEE table - Aggregate NACE (15 industries) . After that, we check how *upstreamness* computed from the French table in the STAN database, respectively in the INSEE database, compares with the Aggregate NACE (34 industries), respectively Aggregate NACE (15 industries). To verify the consistency of industry *upstreamness* across industries in different input-output table, we conduct a Spearman rank correlation test.

Table 2 reports the Spearman rank correlation. We are particularly interested in the correlation between *upstreamness* from the pairs Aggregate NACE (34 industries) and OECD STAN database which are 0.65; Aggregate NACE (15 industries) and INSEE table which are 0.68. It useful to note that the rank correlation is always large and significantly different from zero at a p-value of 0.01.

Table A.1: Spearman (Pearson) correlation

	Aggregate NACE (34 industries)	Aggregate NACE (15 industries)	OECD STAN database (34 industries)	INSEE table (15 industries)
Aggregate NACE (34 industries)	1			
Aggregate NACE (15 industries)	-	1		
OECD STAN database (34 industries)	0.65 (0.66)	-	1	
INSEE table (15 industries)	-	0.68 (0.67)	-	1

Notes: Pearson correlation in brackets. Authors' own calculations based on U.S. input-output table converted to the 4-digit NACE Rev.2 level, French original input-output tables from OECD STAN database and INSEE.

The cross-industry variation of the *upstreamness* measure between French original input-output tables (OECD STAN database and INSEE table) and our constructed NACE level input-output table from U.S. table is largely consistent with the range of values reported by Fally (2012) for a subset of EU countries (Czech Republic, Luxembourg, Germany, Spain, *etc.*). In sum, this evidence gives us great confidence that the industry measures are stable across U.S. and France, at least at the higher level of aggregation, and confirm the relevance of using the U.S. table on French data.

A.3 Alternative measures of quality

For robustness, we compute two additional firm-level quality measures. We estimate equation (8) with firm-year fixed effects:

$$\ln q_{fjkt} + \varepsilon \ln p_{fjkt} = FE_{jkt} + FE_{ft} + e_{fjkt}. \tag{18}$$

Then, we transform terms $\widehat{FE}_{ft}$ by subtracting the mean and dividing by the standard error:

$$\widehat{Quality}_{ft} \equiv \frac{\widehat{FE}_{ft} - \bar{\widehat{FE}}_{ft}}{SE\left[\widehat{FE}_{ft}\right]}. \tag{19}$$

The obtained results correspond to the average standardized quality at firm-year level.

To compute the second one, we transform terms $\widehat{Qual}_{fjkt}$ obtained from equation (9) by subtracting the mean and dividing by the standard error $\left(\tilde{Qual}_{fjkt} \equiv \frac{\ln \hat{\lambda}_{fjkt} - \ln \bar{\hat{\lambda}}_{fjkt}}{SE\left[\ln \hat{\lambda}_{fjkt}\right]}\right)$. We compute export-weighted firm-level averages of transformed terms $\tilde{Qual}_{fjkt}$ as

$$\widehat{Quality}_{ft} = \sum \frac{X_{fjkt}}{X_{ft}} \tilde{Qual}_{fjkt} \tag{20}$$

where X_{fjkt} is the value of product k exported by firm f to country j in year t, X_{ft} is the total value of firm f's exports in year t. We use them as a second alternative measure of firm-level quality.

B Theory Appendix

Proof of Proposition 1: We start by determining the sales price for each type and variety of goods produced by the firm, $p(U^X)$, from the demand function (2), and then its total revenue $p(U^X)q$, by using the expression from (4).

$$q = A\lambda^{\varepsilon-1}\left[p(U^X)\right]^{-\varepsilon} \tag{B.1}$$

From (B.1), we have:

$$p(U^X) = A^{\frac{1}{\varepsilon}}\lambda^{\frac{\varepsilon-1}{\varepsilon}}q^{-\frac{1}{\varepsilon}} \tag{B.2}$$

By using q from the expression (4) in the main text, full expression of profit gives:

$$\begin{aligned}\pi = {} & A^{\frac{1}{\varepsilon}}\varphi^{\frac{\varepsilon-1}{\varepsilon}}\lambda^{\frac{(\varepsilon-1)(1-\gamma)}{\varepsilon}}\left(\int_{U^X}^{U^M} x(u)^{\frac{\sigma-1}{\sigma}}du + q_M^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\rho\sigma(\varepsilon-1}{\varepsilon(\sigma-1)}} \\ & -\left(p(U^M)q_M + \int_{U^X}^{U^M}\left[c(u)x(u)+F(u)\right]du + \lambda^{\alpha}\right)\end{aligned} \tag{B.3}$$

As the firm's choice variables are the level of quality (λ) of its output, input quantities to purchase (q_M) and produce in-house ($x(u)$) and their corresponding level of processing (U^X and U^M), the FOC for profit maximisation give:

$$\frac{(\varepsilon-1)(1-\gamma)}{\alpha\varepsilon}p(U^X)q = \lambda^{\alpha} \tag{B.4}$$

$$\frac{\rho(\varepsilon-1)}{\varepsilon}q_M^{-\frac{1}{\sigma}}p(U^X)q^{\frac{\rho\sigma-(\sigma-1)}{\rho\sigma}}\lambda^{-\gamma\frac{(\sigma-1)}{\rho\sigma}}\varphi^{\frac{(\sigma-1)}{\rho\sigma}} = P(U^M) \tag{B.5}$$

$$\frac{\rho(\varepsilon-1)}{\varepsilon}x(u)^{-\frac{1}{\sigma}}p(U^X)q^{\frac{\rho\sigma-(\sigma-1)}{\rho\sigma}}\lambda^{-\gamma\frac{(\sigma-1)}{\rho\sigma}}\varphi^{\frac{(\sigma-1)}{\rho\sigma}} = c(u) \tag{B.6}$$

$$-\frac{\rho\sigma(\varepsilon-1)}{\varepsilon(\sigma-1)}x(U^X)^{\frac{\sigma-1}{\sigma}}p(U^X)q^{\frac{\rho\sigma-(\sigma-1)}{\rho\sigma}}\lambda^{-\gamma\frac{(\sigma-1)}{\rho\sigma}}\varphi^{\frac{(\sigma-1)}{\rho\sigma}} + c(U^X)x(U^X)+F(U^X) = 0 \tag{B.7}$$

$$\frac{\rho\sigma(\varepsilon-1)}{\varepsilon(\sigma-1)}x(U^M)^{\frac{\sigma-1}{\sigma}}p(U^X)q^{\frac{\rho\sigma-(\sigma-1)}{\rho\sigma}}\lambda^{-\gamma\frac{(\sigma-1)}{\rho\sigma}}\varphi^{\frac{(\sigma-1)}{\rho\sigma}} - p'(U^M)q_M - c(U^M)x(U^M) - F(U^M) = 0 \tag{B.8}$$

We totally differentiate the system of equations (B.4) to (B.8) in order to understand how the firm's choice over the span of production stages is affected by λ. Equations (B.4) to (B.6) give:

$$\alpha\frac{d\lambda}{\lambda} = \frac{p\prime(U^X)}{p(U^X)}dU^X + \frac{dq}{q} \tag{B.9}$$

$$-\frac{1}{\sigma}\frac{dq_M}{q_M} + \frac{p\prime(U^X)}{p(U^X)}dU^X + \frac{\rho\sigma-(\sigma-1)}{\rho\sigma}\frac{dq}{q} - \gamma^{\frac{(\sigma-1)}{\rho\sigma}}\frac{d\lambda}{\lambda} + \frac{(\sigma-1)}{\rho\sigma}\frac{d\varphi}{\varphi} = \frac{p\prime(U^M)}{p(U^M)}dU^M \tag{B.10}$$

$$-\frac{1}{\sigma}\frac{dx(u)}{x(u)} + \frac{p\prime(U^X)}{p(U^X)}dU^X + \frac{\rho\sigma-(\sigma-1)}{\rho\sigma}\frac{dq}{q} - \gamma^{\frac{(\sigma-1)}{\rho\sigma}}\frac{d\lambda}{\lambda} + \frac{(\sigma-1)}{\rho\sigma}\frac{d\varphi}{\varphi} = 0 \tag{B.11}$$

From (B.10) and (B.11), we have:

$$\frac{dx(u)}{x(u)} = \frac{dq_M}{q_M} + \sigma\frac{p\prime(U^M)}{p(U^M)}dU^M \tag{B.12}$$

Then, we totally differentiate q from (4) in the main text:

$$\frac{dq}{q}=\frac{d\varphi}{\varphi}-\gamma\frac{d\lambda}{\lambda}+\frac{\rho\sigma}{\sigma-1}\frac{x(U^M)^{\frac{\sigma-1}{\sigma}}dU^M-x(U^X)^{\frac{\sigma-1}{\sigma}}dU^X+\int_{U^X}^{U^M}\frac{\sigma-1}{\sigma}x(u)^{\frac{\sigma-1}{\sigma}}\frac{dx(u)}{x(u)}du+\frac{\sigma-1}{\sigma}q_M^{\frac{\sigma-1}{\sigma}}\frac{dq_M}{q_M}}{(q\varphi^{-1}\lambda^{\gamma})^{\frac{\rho-1)}{\rho\sigma}}} \tag{B.13}$$

Note that from CPO (B.6), we have:

$$\frac{\rho\sigma(\varepsilon-1)}{\varepsilon(\sigma-1)}\frac{1}{(q\varphi^{-1}\lambda^{\gamma})^{\frac{\sigma-1}{\rho\sigma}}}x(u)^{\frac{\sigma-1}{\sigma}}=\frac{\sigma}{\sigma-1}\frac{c(u)x(u)}{p(U^X)q} \tag{B.14}$$

for all $u\in[U^X,U^M]$

It should be noted that, derivative $P(U^X)$ with respect to U^X, from (B.2) gives:

$$p\prime(U^X)=\frac{\rho\sigma}{\varepsilon(\sigma-1)}p(U^X)\left(q^{-1}\varphi\lambda^{-\gamma}\right)^{\frac{\rho-1}{\rho\sigma}}x(U^X)^{\frac{\sigma-1}{\sigma}} \tag{B.15}$$

By replacing (B.14) and (B.15) in the CPO (B.7) and (B.8), we have:

$$p\prime(U^X)q=\frac{1}{\varepsilon-1}\left[c(U^X)x(U^X)+F(U^X)\right] \tag{B.16}$$

$$F(U^X)=\frac{1}{\sigma-1}c(U^X)x(U^X) \tag{B.17}$$

$$p\prime(U^M)q_M=\frac{1}{\sigma-1}c(U^M)x(U^M)-F(U^M) \tag{B.18}$$

Using the (B.5), (B.12), (B.14) and (B.18), we can simplify $\frac{dq}{q}$ to obtain:

$$\frac{dq}{q}=\frac{d\varphi}{\varphi}-\gamma\frac{d\lambda}{\lambda}+\sigma\frac{dq_M}{q_M}-\frac{\varepsilon\sigma}{(\varepsilon-1)(\sigma-1)}\frac{c(U^X)x(U^X)}{p(U^X)q}dU^X+\sigma\left[\frac{\varepsilon}{\varepsilon-1}\frac{F(U^M)}{p(U^X)q}+\rho\frac{p\prime(U^M)}{p(U^M)}\right]dU^M \tag{B.19}$$

Now we totally differentiate the CPO (B.8):

$$\begin{aligned}&\frac{\sigma-1}{\sigma}\frac{dx(U^M)}{x(U^M)}+\frac{p'(U^X)}{p(U^X)}dU^X+\frac{\sigma-1}{\varepsilon\sigma}\frac{d\varphi}{\varphi}-\gamma\frac{\sigma-1}{\varepsilon\sigma}\frac{d\lambda}{\lambda}+\frac{\rho\sigma-(\sigma-1)}{\rho\sigma}\frac{dq}{q}\\ =&\frac{p'(U^M)q_M\frac{dq_M}{q_M}+c(U^M)x(U^M)\frac{dx(U^M)}{x(U^M)}+\left[p''(U^M)q_M+c'(U^M)x(U^M)+F'(U^M)\right]dU^M}{p'(U^M)q_M-c(U^M)x(U^M)-F(U^M)}\end{aligned} \tag{B.20}$$

Using (B.11), we can derive the left-hand side of (B.20), which exactly equal to $\frac{dx(U^M)}{x(U^M)}$. By replacing the expression of $\frac{dx(U^M)}{x(U^M)}$ from (B.12) on both sides of (B.20), we obtain:

$$\frac{dq_M}{q_M}=\frac{1}{F(U^M)}\left[\Phi^M-\frac{\sigma}{\sigma-1}c(U^M)x(U^M)\frac{p\prime(U^M)}{p(U^M)}\right]dU^M \tag{B.21}$$

where $\Phi^M=\left[p''(U^M)q_M+c\prime(U^M)x(U^M)+F\prime(U^M)\right]$.

Using the expression from (B.12) and (B.18) in (B.21), we obtain:

$$\frac{dx(U^M)}{x(U^M)}=\frac{1}{F(U^M)}\left[\Phi^M-\sigma\frac{(p\prime(U^M))^2q_M}{p(U^M)}\right]dU^M \tag{B.22}$$

By replacing the expression of $\frac{p\prime(U^X)}{p(U^X)}dU^X$ from (B.9) and the expression of $\frac{dq}{q}$ from (B.19) in (B.10) and simplify it, one can obtain:

$$\alpha\frac{d\lambda}{\lambda}=B\cdot dU^X+C\cdot dU^M, \tag{B.23}$$

where

$$B \equiv -\frac{\varepsilon}{\rho(\varepsilon-1)}\frac{c(U^X)x(U^X)}{p(U^X)q} \tag{B.24}$$

$$C \equiv \frac{1}{x(U^M)}\frac{dx(U^M)}{dU^M} + \frac{\varepsilon(\sigma-1)}{\rho(\varepsilon-1)}\frac{F(U^M)}{p(U^X)q} \tag{B.25}$$

Then, we totally differentiate the CPO (B.7):

$$\begin{aligned}\frac{\sigma-1}{\sigma}\frac{dx(U^X)}{x(U^X)} + \frac{p'(U^X)}{p(U^X)}dU^X + \frac{\sigma-1}{\varepsilon\sigma}\frac{d\varphi}{\varphi} - \gamma\frac{\sigma-1}{\varepsilon\sigma}\frac{d\lambda}{\lambda} + \frac{\rho\sigma-(\sigma-1)}{\rho\sigma}\frac{dq}{q} \\ = \frac{c(U^X)x(U^X)\frac{dx(U^X)}{x(U^X)} + [c'(U^X)x(U^X) + F'(U^X)]dU^X}{c(U^X)x(U^X) - F(U^X)}\end{aligned} \tag{B.26}$$

By replacing (B.8) and (B.13) in the left hand side of the expression (B.26) and simplifying it, one could obtain:

$$\alpha\frac{d\lambda}{\lambda} = D \cdot dU^X + E \cdot dU^M, \tag{B.27}$$

where

$$D \equiv -\frac{1}{(\varepsilon-1)}\left[\frac{\varepsilon}{\rho}\frac{c(U^X)x(U^X)}{p(U^X)q} - \frac{c\prime(U^X)x(U^X) + F\prime(U^X)}{p\prime(U^X)q}\right] \tag{B.28}$$

$$E \equiv \left[1 - \frac{1}{\varepsilon-1}\frac{F(U^X)}{p\prime(U^X)q}\right]\frac{1}{x(U^M)}\frac{dx(U^M)}{dU^M} + \frac{\varepsilon(\sigma-1)}{\rho(\varepsilon-1)}\frac{F(U^M)}{p(U^X)q} \tag{B.29}$$

Solving (B.23) and (B.27) simultaneously yields:

$$\frac{\lambda}{\alpha}\frac{dU^M}{d\lambda} = \frac{B-D}{B \cdot E - C \cdot D} \tag{B.30}$$

$$\frac{\lambda}{\alpha}\frac{dU^X}{d\lambda} = \frac{E-C}{B \cdot E - C \cdot D} \tag{B.31}$$

with:

$$B - D = -\frac{1}{(\varepsilon-1)}\frac{c\prime(U^X)x(U^X) + F\prime(U^X)}{p\prime(U^X)q} \tag{B.32}$$

$$E - C = -\frac{1}{(\varepsilon-1)}\frac{F(U^X)}{p\prime(U^X)q}\frac{1}{x(U^M)}\frac{dx(U^M)}{dU^M} \tag{B.33}$$

$$\begin{aligned}BE - CD = \left[\frac{\varepsilon}{\rho(\sigma-1)(\varepsilon-1)^2}\frac{c(U^X)x(U^X)}{p(U^X)q}\frac{c(U^X)x(U^X)}{p'(U^X)q} - \frac{1}{\varepsilon-1}\frac{c'(U^X)x(U^X) + F'(U^X)}{p'(U^X)q}\right]\frac{1}{x(U^M)}\frac{dx(U^M)}{dU^M} \\ - \left[\frac{\varepsilon(\sigma-1)}{\rho(\varepsilon-1)}\frac{F(U^M)}{p(U^X)q}\right]\left[\frac{1}{\varepsilon-1}\frac{c'(U^X)x(U^X) + F'(U^X)}{p'(U^X)q}\right]\end{aligned} \tag{B.34}$$

Since $\frac{\lambda}{\alpha}$ is positive, then the sign of $\frac{dU^M}{d\lambda}$ and $\frac{dU^X}{d\lambda}$ corresponds to the sign of $\frac{B-D}{B \cdot E - C \cdot D}$ and $\frac{E-C}{B \cdot E - C \cdot D}$, respectively. To determine the signs of $B - D$, $E - C$ and $B \cdot E - C \cdot D$, we refer to the second-order necessary conditions for U^X and U^M. The second-derivative of the profit function with respect to U^X and with respect to U^M both need to be negative when evaluated at the local turning point in order to ascertain that we have a local maximum. Differentiating the left-hand side of (B.7) with respect to U^X and the left-hand side of (B.8) with respect to U^M, and using (B.14), one can show that these second-order necessary conditions reduce to:

$$\frac{c\prime(U^X)x(U^X)+F\prime(U^X)}{p\prime(U^X)q} > \frac{\sigma}{\sigma-1}\frac{c(U^X)x(U^X)}{p(U^X)q} - \frac{\varepsilon\sigma(\rho\sigma-\sigma+1)}{\rho(\sigma-1)^2(\varepsilon-1)}\frac{c(U^X)x(U^X)}{p(U^X)q}\frac{c(U^X)x(U^X)}{p'(U^X)q}$$

and:

$$\Phi^M > \frac{\varepsilon\sigma(\rho\sigma-\sigma+1)}{\rho(\sigma-1)^2(\varepsilon-1)}\frac{c(U^M)^2x(U^M)^2}{p(U^X)q}.$$

Given that $p'(u)<0$, this implies: Φ^M, $\frac{c\prime(U^X)x(U^X)+F\prime(U^X)}{p\prime(U^X)q}>0$ if and only if $\rho>\frac{\sigma-1}{\sigma}$.

Examining (B.32), with the sufficient condition that $\rho>\frac{\sigma-1}{\sigma}$, we have $B-D<0$. Next, consider (B.33). Notice from (B.18) and (B.22) that:

$$\frac{1}{x(U^M)}\frac{dx(U^M)}{dU^M} = \frac{p(U^M)q_M}{F(U^M)}\left[\frac{\Phi^M}{p(U^M)q_M} - \sigma\left(\frac{\frac{1}{\sigma-1}c(U^M)x(U^M)-F(U^M)}{p(U^M)q_M}\right)^2\right] \tag{B.35}$$

If $\frac{c(U^M)x(U^M)}{p(U^M)q_M}$ and $\frac{F(U^M)}{p(U^M)q_M}$ are sufficiently small, at least relative to $\frac{\Phi^M}{p(U^M)q_M}$, then it would follow that $\frac{1}{x(U^M)}\frac{dx(U^M)}{dU^M}>0$. So, given that $p'(U^M)<0$ in the denominator of the right-hand side of (B.33), it follows that $E-C>0$.

Turning to (B.34), under the assumptions that $\frac{c(U^M)x(U^M)}{p(U^M)q_M}$ and $\frac{F(U^M)}{p(U^M)q_M}$ are sufficiently small, and that $p'(U^X)<0$, which imply that Φ^M, $\frac{c\prime(U^X)x(U^X)+F\prime(U^X)}{p\prime(U^X)q}>0$, it follows that the sign of the entire expression of equation (B.34) is negative ($B\cdot E-C\cdot D<0$).

With $B\cdot E-C\cdot D<0$, $B-D<0$ and $E-C>0$, (B.30) and (B.31) imply that $\frac{dU^M}{d\lambda}>0$, $\frac{dU^X}{d\lambda}<0$ and $\frac{(dU^M-U^X)}{d\lambda}>0$. Moreover, given that $\frac{1}{x(U^M)}\frac{dx(U^M)}{dU^M}>0$, we have $\frac{dx(u)}{d\lambda}>0$, and since $\Phi^M>0$, one can deduce from (B.21) that $\frac{dq_M}{d\lambda}>0$.

Dividing (B.12) by $d\lambda$ yields:

$$\frac{1}{x(u)}\frac{dx(u)}{d\lambda} = \frac{1}{q_M}\frac{dq_M}{d\lambda} + \sigma\frac{p\prime(U^M)}{p(U^M)}\frac{dU^M}{d\lambda} \tag{B.36}$$

which represent how the firm's payments for upstream intermediate inputs changes. Recall that $p'(U^M)<0$ and $\sigma>1$, and that $\frac{dx(u)}{d\lambda}>0$ implies $\frac{1}{x(u)}\frac{dx(u)}{d\lambda}>0$. Consequently, on can easily show that the demand effect, $\frac{1}{q_M}\frac{dq_M}{d\lambda}$, dominates the lower prices of the upstream intermediates inputs, $\sigma\frac{p\prime(U^M)}{p(U^M)}\frac{dU^M}{d\lambda}$, when U^M increases following the quality upgrading.

Relaxing the assumption that $\frac{c(U^M)x(U^M)}{p(U^M)q_M}$ and/or $\frac{F(U^M)}{p(U^M)q_M}$ are sufficiently small relative to $\frac{\Phi^M}{p(U^M)q_M}$ implies that $\frac{1}{x(U^M)}\frac{dx(U^M)}{dU^M}<0$. It is very unlikely that this situation arises, since it is technically difficult to imagine a decrease in the quantities $x(u)$ of stages inputs, while the cut-off stage U^M increases. Indeed, the increase in the cut-off stageU^M due to quality upgrading must result in a purchase of a higher quantity q_M of upstream intermediate inputs, and will require more quantities $x(u)$ of stage inputs.

Proof of Proposition 2: As discussed in the paper, the change in the profit following an upgrade in quality depends on the relative weight of two opposite effects, which can offset one another, but a positive change is expected even if it may be small. Obviously, when $\rho>\frac{\sigma-1}{\sigma}$, and $\frac{c(U^M)x(U^M)}{p(U^M)q_M}$ and $\frac{F(U^M)}{p(U^M)q_M}$ are sufficiently small, quality upgrading leads to an increase in U^M and a decrease in U^X, *i.e.* the firm expands its span of production stages, U^M-U^X. Under the condition that the firm performs all or most stages $u\in\left[U^X,U^M\right]$ in-house, the firm's total fixed costs $\left(\int_{U^X}^{U^M}F(u)du+\lambda^\alpha\right)$ would increase because λ increases and the same fixed costs are incurred for a wider span of production stages. Notice that we also have higher quantity $x(u)$ and consequently the firm's total variable costs $\left(\int_{U^X}^{U^M} c(u)x(u)du\right)$ would also increase. As mentioned earlier, since q_M increases and dominates the effect of the decrease in $p(U^M)$, the total expenditure on upstream inputs $\left(p(U^M)q_M\right)$ increases. Last, as the profit also increases because of an increase in λ, the firm produces a higher value added $(c(u)x(u) + F(u) + \lambda^\alpha + \pi)$.

C Additional results

Table C.1: Productivity and firms' position in GVCs

Sample	OLS			IV			
	(1)	(2)	(3)	1st Stage (4)	(5)	(6)	(7)
	(U^M_{ft})	(U^X_{ft})	$(U^M_{ft} - U^X_{ft})$	Quality_{ft}	(U^M_{ft})	(U^X_{ft})	$(U^M_{ft} - U^X_{ft})$
Instrument_{ft}				0.0092***			
				(0.0035)			
$\ln \text{Productivity}_{ft}$	0.0405**	-0.0142	0.0547***		0.6692*	-1.6613**	2.3304**
	(0.0170)	(0.0115)	(0.0208)		(0.3799)	(0.7672)	(0.9982)
Firm size:							
Small_{ft}	reference	reference	reference	reference	reference	reference	reference
medium_{ft}	0.0698**	-0.0028	0.0727**	-0.4329***	0.3250*	-0.7098**	1.0348**
	(0.0276)	(0.0208)	(0.0361)	(0.0615)	(0.1722)	(0.3565)	(0.4668)
large_{ft}	0.0933*	0.0231	0.0702	-0.6849***	0.5044*	-1.0992*	1.6037**
	(0.0488)	(0.0382)	(0.0605)	(0.1573)	(0.2826)	(0.6241)	(0.8153)
Fixed effects	firm, industry-year				firm, industry-year		
Observations	9,068	9,068	9,068	8,416	8,416	8,416	8,416
R^2	0.772	0.812	0.716	0.911	0.770	0.829	0.728
F-stat					6.9958	6.9958	6.9958
Endogeneity test					4.1260**	17.2461***	21.3290***

Notes: The sample comprises French agri-food firms (10 and 11 of 2-digit NACE Rev.2) of the fully matched sample over 2004-2017, which both export and import. Re-exports are excluded at firm-year-CN8 level in trade flows before computing import and export *upstreamness*. $Inst_{ft}$ stands for predicted exports (shift-share in foreign demand). All regressions include firm and industry-year fixed effects. Standard errors clustered by firm in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table C.2: Quality and firms' position in GVCs

Sample	OLS			IV			
	(1)	(2)	(3)	1st Stage (4)	(5)	(6)	(7)
	(U_{ft}^M)	(U_{ft}^X)	$(U_{ft}^M - U_{ft}^X)$	Quality_{ft}	(U_{ft}^M)	(U_{ft}^X)	$(U_{ft}^M - U_{ft}^X)$
Instrument_{ft}				0.0164***			
				(0.0021)			
Quality_{ft}	0.0546**	-0.0806**	0.1352***		0.3037*	-0.9146***	1.2182***
	(0.0236)	(0.0324)	(0.0408)		(0.1821)	(0.2419)	(0.2998)
Fixed effects	firm, industry-year				firm, industry-year		
Observations	8,803	8,803	8,803	8,183	8,183	8,183	8,183
R^2	0.773	0.813	0.714	0.612	0.771	0.828	0.726
F-stat					63.5697	63.5697	63.5697
Endogeneity test					2.0132	14.1762***	15.6961***

Notes: The sample comprises French agri-food firms (10 and 11 of 2-digit NACE Rev.2) of the fully matched sample over 2004-2017, which both export and import. Re-exports are excluded at firm-year-CN8 level in trade flows before computing import and export *upstreamness* and estimate the quality. $Inst_{ft}$ stands for predicted exports (shift-share in foreign demand). The quality is estimated using price elasticities at the HS6 level from Ossa (2015). All regressions include industry-year fixed effects. Standard errors clustered by firm in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table C.3: Quality and firms' position in GVCs – Cross-firm specification

Sample	OLS			IV			
	(1)	(2)	(3)	1st Stage (4)	(5)	(6)	(7)
	(U_{ft}^M)	(U_{ft}^X)	$(U_{ft}^M - U_{ft}^X)$	Quality_{ft}	(U_{ft}^M)	(U_{ft}^X)	$(U_{ft}^M - U_{ft}^X)$
Instrument_{ft}				0.0365***			
				(0.0015)			
Quality_{ft}	0.0661**	-0.0763**	0.1423***		0.3392***	-0.4512***	0.7903***
	(0.0313)	(0.0348)	(0.0457)		(0.1101)	(0.0974)	(0.1418)
$\ln \text{Productivity}_{ft}$	0.0330**	0.0507***	-0.0177	0.0070*	0.0271	0.0661***	-0.0389*
	(0.0162)	(0.0137)	(0.0186)	(0.0042)	(0.0170)	(0.0152)	(0.0199)
Firm size:							
Small_{ft}	reference	reference	reference	reference	reference	reference	reference
medium_{ft}	0.0271	0.0081	0.0190	0.0317***	0.0069	0.0416*	-0.0347
	(0.0212)	(0.0190)	(0.0260)	(0.0068)	(0.0234)	(0.0220)	(0.0305)
large_{ft}	0.0958***	0.0259	0.0699	0.0386***	0.0573	0.0822***	-0.0249
	(0.0354)	(0.0284)	(0.0429)	(0.0094)	(0.0382)	(0.0317)	(0.0488)
Fixed effects	industry-year				industry-year		
Observations	9,259	9,259	9,259	8,584	8,584	8,584	8,584
R^2	0.236	0.418	0.158	0.280	0.229	0.428	0.171
F-stat					617.0052	617.0052	617.0052
Endogeneity test					7.6935***	19.4803***	27.0423***

Notes: The sample comprises French agri-food firms (10 and 11 of 2-digit NACE Rev.2) of the fully matched sample over 2004-2017, which both export and import. Re-exports are excluded at firm-year-CN8 level in trade flows before computing import and export *upstreamness* and estimate the quality. $Inst_{ft}$ stands for predicted exports (shift-share in foreign demand). The quality is estimated using price elasticities at the HS6 level from Ossa (2015). All regressions include industry-year fixed effects. Standard errors clustered by firm in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table C.4: Quality, input costs, value added and profits – Cross-firm specification

Dep. variables:	Log Raw Inputs		Log Wagbill		Log Value added		Log Profits	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Quality_{ft}	1.8792***	0.2939***	1.6970***	0.3843***	1.7169***	0.3953***	2.1243***	0.6702***
	(0.1073)	(0.0601)	(0.0999)	(0.0635)	(0.1044)	(0.0741)	(0.1474)	(0.1415)
$\ln \text{Productivity}_{ft}$		1.1525***		0.1941***		0.4134***		0.8515***
		(0.0273)		(0.0238)		(0.0321)		(0.0722)
Firm size:								
Small_{ft}		reference		reference		reference		reference
medium_{ft}		1.7941***		1.7733***		1.6698***		1.5351***
		(0.0376)		(0.0354)		(0.0389)		(0.0702)
large_{ft}		3.6937***		3.9045***		3.8354***		4.0293***
		(0.0607)		(0.0763)		(0.0869)		(0.1638)
Fixed effects	industry-year							
Observations	13,934	9,179	13,929	9,234	13,290	8,831	11,327	7,411
R^2	0.232	0.815	0.172	0.767	0.170	0.740	0.155	0.523

Notes: The sample comprises French agri-food firms (10 and 11 of 2-digit NACE Rev.2) of the fully matched sample over 2004-2017, which both export and import. Re-exports are excluded at firm-year-CN8 level in trade flows before estimate the quality. The quality is estimated using price elasticities at the HS6 level from Ossa (2015). All regressions include industry-year fixed effects. Standard errors clustered by firm in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table C.5: Quality and firms' position in GVCs –Alternative measure of quality

Sample	OLS			IV			
	(1)	(2)	(3)	1st Stage (4)	(5)	(6)	(7)
	(U^M_{ft})	(U^X_{ft})	$(U^M_{ft} - U^X_{ft})$	Quality$_{ft}$	(U^M_{ft})	(U^X_{ft})	$(U^M_{ft} - U^X_{ft})$
Quality$_{ft}$	Panel A: Weighted quality						
Instrument$_{ft}$				0.0650***			
				(0.0070)			
Quality$_{ft}$	0.0042	-0.0388***	0.0430***		0.0684	-0.2200***	0.2884***
	(0.0067)	(0.0092)	(0.0118)		(0.0463)	(0.0558)	(0.0712)
Observations	8,733	8,733	8,733	8,136	8,136	8,136	8,136
R^2	0.772	0.819	0.717	0.620	0.771	0.830	0.726
F-stat					86.9724	86.9724	86.9724
Endogeneity test					2.2208	10.8234***	12.8878***
Quality	Panel B: Fixed effect quality						
Instrument$_{ft}$				0.0381***			
				(0.0079)			
Quality$_{ft}$	-0.0027	-0.0116	0.0089		0.1365	-0.3640***	0.5005***
	(0.0070)	(0.0081)	(0.0113)		(0.0910)	(0.1079)	(0.1505)
Observations	7,499	7,499	7,499	7,219	7,219	7,219	7,219
R^2	0.767	0.839	0.726	0.651	0.768	0.848	0.733
F-stat					23.1648	23.1648	23.1648
Endogeneity test					2.8277*	12.4367***	14.3082***
Fixed effects	firm, industry-year			firm, industry-year			
ln Productivity$_{ft}$	Y	Y	Y	Y	Y	Y	Y
Firm size	Y	Y	Y	Y	Y	Y	Y

Notes: The sample comprises French agri-food firms (10 and 11 of 2-digit NACE Rev.2) of the fully matched sample over 2004-2017, which both export and import. Re-exports are excluded at firm-year-CN8 level in trade flows before computing import and export *upstreamness* and estimate the quality. $Inst_{ft}$ stands for predicted exports (shift-share in foreign demand). The quality is estimated using price elasticities at the HS6 level from Ossa (2015). All regressions include firm and industry-year fixed effects. Standard errors clustered by firm in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table C.6: Quality, input costs, value added and profits – Alternative measures of quality

Dep. variables:	Log Raw Inputs		Log Wagbill		Log Value added		Log Profits	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Quality	Panel A: Weighted quality							
Quality_{ft}	0.0483***	0.0311***	0.0145*	0.0114*	0.0155**	0.0050	0.0327	0.0452*
	(0.0111)	(0.0108)	(0.0075)	(0.0058)	(0.0072)	(0.0087)	(0.0201)	(0.0250)
Observations	13,309	8,652	13,320	8,709	12,734	8,340	10,697	6,843
R^2	0.959	0.971	0.970	0.981	0.959	0.965	0.851	0.863
Quality	Panel B: Fixed effect quality							
Quality_{ft}	0.0139	0.0101	0.0017	0.0006	-0.0034	-0.0112	0.0470**	0.0341
	(0.0127)	(0.0095)	(0.0063)	(0.0059)	(0.0073)	(0.0088)	(0.0202)	(0.0250)
Observations	11,252	7,430	11,271	7,474	10,861	7,193	9,101	5,940
R^2	0.961	0.973	0.974	0.980	0.959	0.966	0.853	0.866
Fixed effects	firm, industry-year							
$\ln \text{Productivity}_{ft}$	N	Y	N	Y	N	Y	N	Y
Firm size	N	Y	N	Y	N	Y	N	Y

Notes: The sample comprises French agri-food firms (10 and 11 of 2-digit NACE Rev.2) of the fully matched sample over 2004-2017, which both export and import. Re-exports are excluded at firm-year-CN8 level in trade flows before estimate the quality. The quality is estimated using price elasticities at the HS6 level from Ossa (2015). All regressions include firm and industry-year fixed effects. Standard errors clustered by firm in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table C.7: Quality and firms' position in GVCs – Estimated quality using elasticities from Fontagné et al. (2022)

Sample	OLS			IV			
	(1)	(2)	(3)	1st Stage	(1)	(2)	(3)
	(U^M_{ft})	(U^X_{ft})	$(U^M_{ft} - U^X_{ft})$	Quality$_{ft}$	(U^M_{ft})	(U^X_{ft})	$(U^M_{ft} - U^X_{ft})$
Instrument$_{ft}$				0.0128***			
				(0.0020)			
Quality$_{ft}$	0.0150	-0.0757**	0.0906**		0.3629	-1.2101***	1.5730***
	(0.0240)	(0.0315)	(0.0414)		(0.2334)	(0.3242)	(0.4029)
ln Productivity$_{ft}$	0.0382**	-0.0116	0.0499**	0.0209***	0.0307	0.0192	0.0115
	(0.0172)	(0.0118)	(0.0211)	(0.0078)	(0.0189)	(0.0166)	(0.0256)
Firm size:							
Small$_{ft}$	reference	reference	reference	reference	reference	reference	reference
medium$_{ft}$	0.0605**	-0.0014	0.0619*	0.0103	0.0398	0.0215	0.0183
	(0.0286)	(0.0218)	(0.0376)	(0.0121)	(0.0301)	(0.0279)	(0.0434)
large$_{ft}$	0.0796	0.0263	0.0533	0.0358*	0.0473	0.0806*	-0.0332
	(0.0495)	(0.0386)	(0.0611)	(0.0194)	(0.0541)	(0.0422)	(0.0666)
Fixed effects	firm, industry-year			firm, industry-year			
Observations	8,720	8,720	8,720	8,118	8,118	8,118	8,118
R^2	0.774	0.812	0.714	0.617	0.772	0.829	0.727
F-stat					40.2548	40.2548	40.2548
Endogeneity test					2.5398	15.4047***	17.6130***

Notes: The sample comprises French agri-food firms (10 and 11 of 2-digit NACE Rev.2) of the fully matched sample over 2004-2017, which both export and import. Re-exports are excluded at firm-year-CN8 level in trade flows before computing import and export *upstreamness* and estimate the quality. $Inst_{ft}$ stands for predicted exports (shift-share in foreign demand). The quality is estimated using price elasticities at the HS6 level from Fontagné et al. (2022). All regressions include firm and industry-year fixed effects. Standard errors clustered by firm in parentheses. $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C.8: Quality, input costs, value added and profits – Estimated quality using elasticities from Fontagné et al. (2022)

Dep. variables:	Log Raw Inputs		Log Wagbill		Log Value added		Log Profits	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Quality$_{ft}$	0.1235***	0.0816**	0.0735***	0.0450***	0.0504**	0.0299	0.0081	0.0367
	(0.0334)	(0.0369)	(0.0216)	(0.0167)	(0.0242)	(0.0262)	(0.0641)	(0.0815)
ln Productivity$_{ft}$		0.6895***		0.0675		0.2938***		0.6684***
		(0.0732)		(0.0452)		(0.0487)		(0.0721)
Firm size:								
Small$_{ft}$		reference		reference		reference		reference
medium$_{ft}$		0.5961***		0.4268***		0.4239***		0.3568***
		(0.0540)		(0.0379)		(0.0446)		(0.1010)
large$_{ft}$		1.4526***		1.0861***		0.9553***		0.6979***
		(0.1601)		(0.1252)		(0.1204)		(0.2100)
Fixed effects				firm, industry-year				
Observations	13,247	8,637	13,257	8,695	12,683	8,327	10,653	6,836
R^2	0.959	0.971	0.972	0.981	0.959	0.965	0.851	0.862

Notes: The sample comprises French agri-food firms (10 and 11 of 2-digit NACE Rev.2) of the fully matched sample over 2004-2017, which both export and import. Re-exports are excluded at firm-year-CN8 level in trade flows before estimate the quality. The quality is estimated using price elasticities at the HS6 level from Fontagné et al. (2022). All regressions include firm and industry-year fixed effects. Standard errors clustered by firm in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.