Distance to destination and export price variation within agri-food firms

Dela-Dem Doe Fiankor*

Agroscope, Switzerland

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*Corresponding author: Tänikon 1. 8356 Ettenhausen. Switzerland.
dela-demdoe.fiankor@agroscope.admin.ch

Abstract

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Keywords Agricultural trade, trade costs, export unit values, product quality, distance

JEL code F14; Q17; Q18

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1 Introduction

It is now obvious that there is substantial within-firm variation in export prices for the same goods — even within narrowly defined product categories — destined for different countries. This is also the case in the agri-food sector. For instance, a Swiss firm exported the same HS8 digit product "hard cheese (HS 04069099)" to 18 different countries and charged free-on-board (FOB) prices ranging from a low of 10.70 CHF in Peru to a high of 16.00 CHF in South Korea (see Figure 3). This strong empirical regularity has been explained by factors including destination country characteristics such as size, income, and domestic price levels, but also trade costs. In this paper, I focus on the latter, specifically distance.

The role of distance in explaining spatial variation in export prices across destinations has received some attention in the manufacturing sector. Yet, the evidence from the agri-food sector is either thin or non-existent. Indeed, in some cases, existing contributions (e.g., Görg et al., 2017) exclude the agricultural and food sectors entirely from the analyses. However, the agricultural and manufacturing sectors are characterised by different market situations. Thus, it is imperative to assess whether and to what extent these findings hold in the agri-food sector. This paper does that.

The study is based on Swiss firm-level customs data covering all agri-food exporting firms over the period 2016 to 2020. The Swiss agri-food sector makes for an interesting case study for different reasons. Competing via quality differentiation rather than price may be especially feasible in a high-income and high-cost country such as Switzerland. It is a small market with a large demand for high-quality products and the necessary purchasing power to pay for them (Hillen and von Cramon-Taubadel, 2019). This positioning of Swiss products into a differentiated, high-quality segment also extend to their exports. Unlike raw agricultural products where quality differentiation is hard, Swiss agri-food exports are mainly processed products where quality sorting is dominant. The destinations of Swiss agri-food exports are also mostly rich countries where consumer demand for quality is high.

Empirically, I compute FOB export unit values as a proxy for export prices at the firm-HS8 digit product-destination level, and investigate the pricing strategies of exporting firms in response to bilateral distance. Consistent with other firm-level studies, I estimate a log-log linear specification that regresses FOB unit values on distance, firm-product-time fixed effects, and different controls for destination country characteristics. Previewing my results, I document a positive relationship between distance and HS8 digit FOB export prices within firms. If distance doubles, the average Swiss agri-food firm increases its FOB export price by 2.3%. In all cases, the estimates are statistically significant at the 1% level, and the coefficient of the distance variable is identified solely from the within-firm-product variation of unit values across destination countries. Thus, my findings imply that firms choose higher-quality and more expensive goods when they export to more distant markets. I explain my findings using existing trade models that allow for quality upgrading or higher markups at the firm-level.

My contribution to this literature is twofold. First, for manufacturing firms, a few studies examine export price variation across markets using firm-level data, including (Martin, 2012) for France, Bastos and Silva (2010) for Portugal, Görg et al. (2017) for Hungary, Manova and Zhang (2012) for China, and Harrigan et al. (2015) for the U.S. I show that Swiss agri-food exporting firms behave in a manner similar to manufacturing firms. As a result, from a policy perspective, I document that the patterns in the food sector are similar to those found in manufacturing. Why is this important? Whereas agricultural markets have long been the textbook case for perfect competition, my findings confirm the observation that as consumers have become less sensitive to price and more sensitive to quality, firms in the food industry have adopted vertical product differentiation strategies (Grunert, 2005).

Second, I validate empirically the Alchian and Allen effect for agri-food products using firm-level customs transaction data. Earlier attempts to study these effects — starting with the work of Curzi and Pacca (2015) and followed by Miljkovic and Gómez (2019), Miljkovic et al. (2019), and recently Emlinger and Guimbard (2021) — have all used aggregate country-product data. An inherent drawback in these studies is the implicit assumption of a representative firm per country. However, advances in the trade literature make it clear that firms behave differently. As a result, a question that remains unanswered in the agricultural trade literature is whether the Alchian and Allen effect is due to selection across or within firms (Emlinger and Lamani, 2020). My within-firm-product analysis provides insights into this firm behaviour within the agri-food sector. I show that firms choose higher-quality and more expensive exports when they are faced with a fixed per-unit trade cost. Furthermore, these country-level studies use product data at the aggregated HS6 digit level. At such aggregate levels, prices may not be good proxies for quality. My price measure — calculated at the firm-HS8 digit product-destination level — addresses this limitation.

The food policy implications of this contribution are evident. First, food products constitute a large and stable share of consumers' expenditures. Hence, understanding the pricing behaviour of firms in the agri-food sector has a substantial impact on consumers' welfare (Gullstrand et al., 2014). Furthermore, testing the validity of the law of one price (LOP) is popular question in agricultural economics (Gobillon and Wolff, 2016). Whenever pri differ between two separate markets, spatial arbitrage is supposed to remove this difference (Fackler and Goodwin, 2001). My findings show that specific trade costs may play a key role in generating deviations from the LOP.

The rest of this paper is organized as follows. Section 2 reviews the relevant theoretical literature that guides the interpretation of my findings. I present detailed data and stylised facts on Swiss agri-food exporting firms in Section 3. This is followed by the empirical analysis in Section 4. I present and discuss the results in section 5. In Section 6, I conduct further sensitivity analysis and extensions of my baseline findings. Section 7 concludes.

2 Theoretical background

How does an increase in bilateral distance affect a firm's incentive to vary its FOB product prices by destination? In this section, I discuss theoretical predictions based on extensions of the heterogeneous firms literature that will guide the interpretation of the findings.

A first mechanism is a selection effect. This occurs if firms find it profitable to export higher quality varieties to more distant markets only. This is a supply-side mechanism that will induce some form of quality sorting behaviour as firms can vary the quality of their outputs by choosing the quality of their inputs.[1] More productive firms will use more expensive, higher-quality inputs to produce high-quality goods. These firms may then choose to sell higher quality versions — for example those where they use more durable packaging — of their products in remote destinations and thus charge higher prices or markups (Martin, 2012). In the end, the exit of cheap and lower quality exports from more distant markets implies that, on average, export prices rise with distance.

Second, firms may price discriminate and charge higher markups and therefore higher prices when exporting to more distant countries. This arises naturally if the elasticity of demand for products is a decreasing function of distance. This is the case in constant elasticity of substitution (CES) models with additive transport costs (Martin, 2012). Unless there is perfect competition, prices contain a markup component reflecting the ability for a firm to set a price above marginal costs. Markups are an integrated component of export pricing in trade models, which typically adopt the assumption of monopolistic competition. However, in the Melitz (2003) model with CES preferences and iceberg trade costs, heterogeneous exporters charge a constant markup above marginal

[1] This mechanism is consistent with trade models where firms endogenously choose destination-specific quality for their products. The alternative is in efficiency sorting models or models of price competition wherein there is no quality sorting (Melitz, 2003). Here all firms use identical inputs to produce symmetric outputs to produce symmetric inputs but more productive firms have lower marginal costs.

cost across countries and price discrimination is absent (see, for instance, Arkolakis et al., 2012). Melitz and Ottaviano (2008) extend the Melitz (2003) setup and use linear demand to introduce endogenous variations in markups across destinations, which respond to the toughness of competition in a market. They show that larger markets exhibit tougher competition in the form of hosting more, and larger, competing firms, leading to lower markups and prices.

Both mechanisms are connected to a third mechanism: a demand-driven composition effect also known as the Alchian and Allen (1964) "shipping the good apples out" effect (Hummels and Skiba, 2004). It predicts that higher per-unit trade costs — in this case a per-unit transport cost — tend to reduce the relative price of high quality products vis-à-vis lower quality products subject to the same cost. As higher quality goods are more expensive, firm-level prices increase with distance. To understand the mechanism, consider a competitive sector in country i that exports two quality grades (q) of the same product k. Let $q = H, L$ for high and low quality grades of k respectively. For each grade, we hold income constant and consider the following Hicksian demand function at destination country j:

$$X_{jk} = f(p_{jH}, p_{jL}, U), \qquad \text{where} \quad k = H, L \tag{1}$$

where p_{jH}, p_{jL} are the prices of the high and low quality good, respectively, at destination country j, with $p_{jH} > p_{jL}$ and U is the level of utility. Prices at j depend on prices at i (p_{iH}, p_{iL}), and a per-unit charge, t_j, such that $p_{jk} = p_{ik} + t_j$. Supposing there is no loss in quality due to transport, and consumers in the destination perceive H and L as two grades of the same good, the Alchian and Allen theorem conjecture is that an increase in t_j will lower the relative price of, and raise the relative demand for, high-quality goods, i.e., $\delta(X_{jH}/X_{jL})/\delta t_j > 0$.[2] As a result, per-unit transport costs lead firms to ship high-quality goods abroad while holding lower-quality at home. Empirical support for the Alchian-Allen effect has been demonstrated in agri-food trade. For example, Curzi and Pacca (2015) report a positive relationship between specific tariffs and product quality in the food sector. Emlinger and Guimbard (2021) extend the analysis and confirm this finding for all agricultural products but show that the effects are more pronounced for developed country exporters. Miljkovic and Gómez (2019) and Miljkovic et al. (2019) examine the relative demand for quality-differentiated coffee varieties exported globally and confirm that a common per-unit charge increases the overall quality of coffee demanded.

[2]For a full derivation, see Emlinger and Lamani (2020).

3 Data — sources and patterns

3.1 Firm-level customs transaction level data

To test my hypothesis, I use firm-level export data on Swiss agricultural and food exporting firms between the period 2016 and 2020. The data comes from transaction-level declarations filed by exporting firms with the customs in Switzerland. It contains information on HS8-digit product codes, free on board (FOB) trade values in Swiss Francs (CHF), trade volumes in kilograms, export destinations, and year for every shipment within the HS01 to HS24 category. With these data at hand, I calculate firm-specific HS8 digit FOB unit values (UV) as:

$$\mathrm{UV}_{fjkt} = \frac{\text{Export value}_{fjkt}}{\text{Export volume}_{fjkt}} \tag{2}$$

where f denotes the exporting firm, j is the destination country, k is the HS8 digit product and t is the year. Export values and volumes are denominated in Swiss Francs (CHF) and kilograms, respectively.

I clean up the data in several steps.[3] To focus on the agri-food sector, I merge the HS codes with the Broad Economic Category (BEC) classifications and then limit the sample to food and beverage mainly for household consumption, i.e., BEC codes 112 and 122.[4] I also exclude firm-product combinations that occur only once.[5] Because unit values can be noisy, I exclude unit values $> 50\tilde{x_k}$ and $< 1/50\tilde{x_k}$, where $\tilde{x_k}$ is the sample median unit value for product k (Berthou and Emlinger, 2011) and trim extreme values in the 5th and 95th percentiles of the unit value distribution. With these data cleaning steps, we drop 34% of the original sample.

This data is particularly suited and has several advantages for the empirical analysis. First, Swiss customs have been careful about maintaining consistent units of measurement within product categories. The trade quantities are all reported in kilograms. Thus our unit values are denominated in CHF/kg. Second, the data are reported in CHF FOB across all destination countries, which enables a cross-country comparison of unit values net of the transportation cost — cost, insurance and freight — component. Third, working at the HS8 digit level allows us to observe enough scope for product-

[3] The total sample in the original trade data is 158,185 observations. Excluding the non-food sector drops 35,037 observations. Merging the dataset with the distance dataset from CEPII further reduces it by 734 observations. Countries omitted include American Samoa, Bonaire Sint Eustatius and Saba, Canary Islands, Saint Barthélemy, Curaçao, Guam, the British Indian Ocean Territory, Montenegro, Mayotte, South Georgia and the South Sandwich Islands, Serbia, South Sudan, Sint Maarten, Timor-Leste, the Holy See, Virgin Islands, Kosovo. This brings to a total sample of 122,41 before we drop outliers.

[4] This excludes agricultural products such as tobacco and live animals from the analysis.

[5] Their exclusion does not affect the results.

Table 1: HS8 digit classifications within the HS6 digit code 040690

HS8	HS8 digit description
04069011	Brie, Camembert, Crescenza, Italico, Pont-l'Évêque, Reblochon, Robiola, Stracchino
04069019	Soft cheese (excl. blue-veined cheese or containing veins, and Brie, Camembert ...)
04069021	Green cheese [herb cheese], hard or semi-hard
04069031	Caciocavallo, Canestrato, Aostataler Fontina, Parmigiano Reggiano, semi-hard cheese
04069039	Caciocavallo, Canestrato, Aostataler Fontina, Parmigiano Reggiano, hard cheese
04069051	Asiago, Bitto, Brà, Fontal, Montasio, Saint-Paulin, Saint Nectaire, semi-hard cheese
04069059	Asiago, Bitto, Brà, Fontal, Montasio, Saint-Paulin, Saint Nectaire, hard cheese
04069060	Cantal
04069091	Semi-hard cheese, n.e.s.
04069099	Hard cheese, n.e.s.

specific quality differentiation. At such a granular level, we reduce the incidence of comparing prices of products of different quality as will be the case at the HS6 digit level. For instance, within the HS6-digit cheese category, we observe even much more granular cheese products such as hard cheese, soft cheese, semi-soft cheese, among others (Table 1). Thus, at the HS8 digit, level the variations in FOB prices we observe within firms across destinations may well reflect differences in product quality (Flach, 2016). Finally, the Swiss agri-food sector is focused on exporting value-added. Swiss exports in terms of value are mainly roasted coffee and extracts thereof, non-alcoholic beverages, cheese, chocolates, and edible preparations (Table A1). These are agri-food products where quality differentiation is happening. For example, sustainability issues are rife in the cocoa and coffee sector with consumers willing to pay more for certified quality beans signalling high quality (e.g., 4C, Rainforest Alliance/UTZ). In Figure A2a, we also observe that Swiss exports are mainly destined for the European Union, the United States, Canada and parts of Asia — these are destinations with high-levels of quality requirements.

3.2 Swiss agri-food exporting firms — stylised facts

I begin by describing the structure of Swiss agri-food exporting firms. There are 6369 distinct firms and 183 destination countries over the course of the panel.[6] The number of firms exporting, the number of products they export and the number of destinations they serve increased between 2016 and 2019. Given the COVID-19 pandemic, the drop in 2020 is as expected. The mean and median export values also increased over time. The average firm exported about 10 HS8 digit products to four destinations.

The literature suggests that serving international markets requires setting features of a firm

[6]This is after I clean the dataset for outliers. See Table A2 in the appendix for the complete list of destination countries.

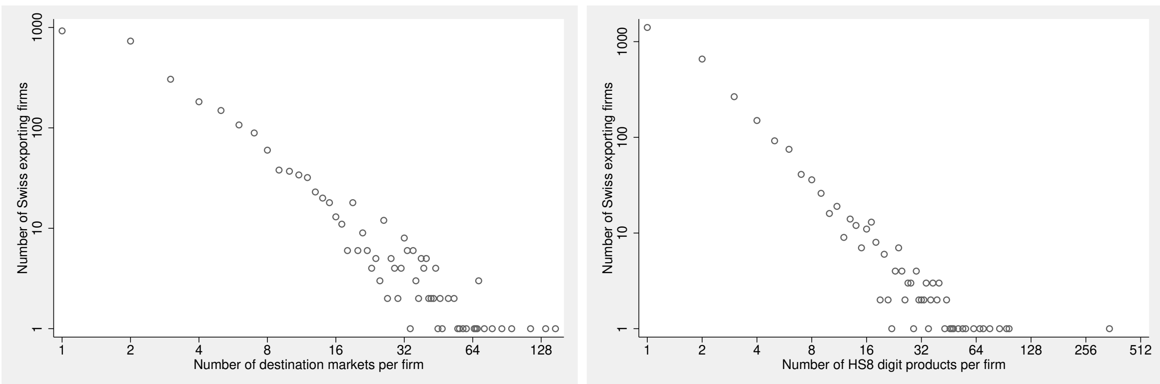
Table 2: Swiss exporters and their exporting characteristics by year

					Exports per firm			
Year	*N*	Firms	Products	Destinations	Mean	Median	Products	Destination
2016	20374	1724	593	172	332.88	5.15	9.62	4.30
2017	20217	1829	623	163	352.43	5.17	9.77	3.95
2018	19252	1914	608	157	383.33	5.16	10.12	3.79
2019	18593	1888	599	160	401.39	4.95	10.11	3.73
2020	16788	1695	577	162	430.90	5.23	9.27	3.77

Notes: The mean and median values are in 1000 CHF.

and explains the particular characteristics exhibited by exporters vís-a-vís firms who serve only the domestic market. Sunk costs are involved in entering new foreign markets. These include costs of establishing distribution systems, market research, product design and standards compliance. These entry costs can be substantial. As a result, only the more productive and efficient firms, who have the means to incur these costs, enter export markets. In Figure 1 we observe a similar pattern for Swiss exporting firms. The frequency with which more markets are served declines smoothly and monotonically to the point where at most a single firm serves a very large number of firms (Figure 1a). The qualitative pattern is very much the same when we consider the number of products exported (Figure 1b). Here again, the number of firms exporting multiple products also decreases monotonically. The modal exporting firm serves only one destination. This is in line with recent theories that emphasize the role of firm heterogeneity and selection in international trade. Firms that are more productive are more likely to engage in exporting and the most productive of the exporting firms ship more goods to more markets (Bernard et al., 2007). Graphically this depiction is in line with the evidence provided by Arkolakis and Muendler (2013) for manufacturing firms in

Figure 1: Swiss firms, destination markets and HS8 digit products



(a) Destination markets

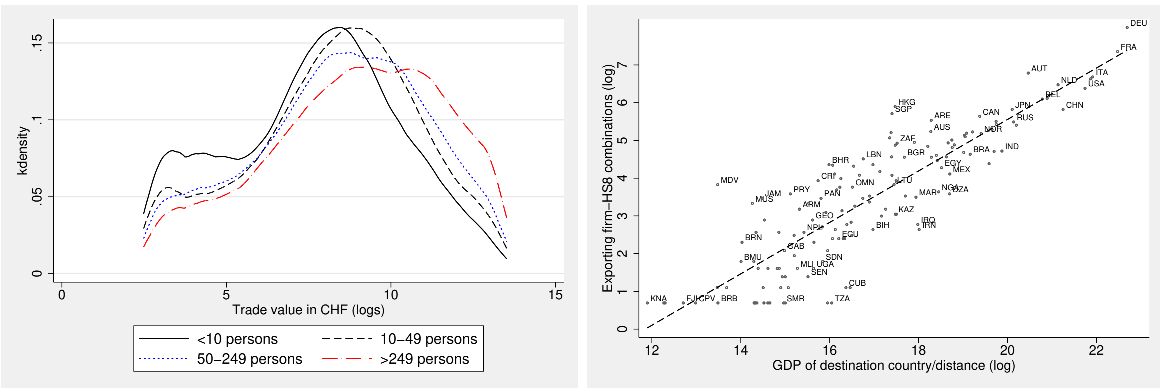
(b) HS8 digit products

Note: while the axis are reported as absolute values, for simplicity I follow Arkolakis and Muendler (2013) and impose a log-log specification on the distribution to ease the depiction of both relationships.

Brazil, Chile, Denmark and Norway.

A number of patterns are visible in Figure 2. In many countries, markets are made up of a few large firms and many small firms. The same is true for Swiss agri-food exporting firms. In my dataset, firms with > 240 employees account for 61% of all observed trade values. In Figure 2a, we see that firm structure, specifically, firm size — measured by number of employees — matters for exports. On average, bigger firms export more in value terms relative to smaller firms. Empirical evidence shows that, conditional on firm size, exporters sell higher quality products and charge higher prices, as well as pay higher input prices and higher wages (Curzi and Olper, 2012; Kugler and Verhoogen, 2012). In Figure 2b, we observe a gravity relationship: the number of products exported to a destination and the number of firms exporting to a particular destination increases with market size of the destination — here measured as gross domestic products — and decreases with bilateral distance. In other words, after controlling for distance, economic size of the destination country is associated with more HS8 digit product-country combinations.

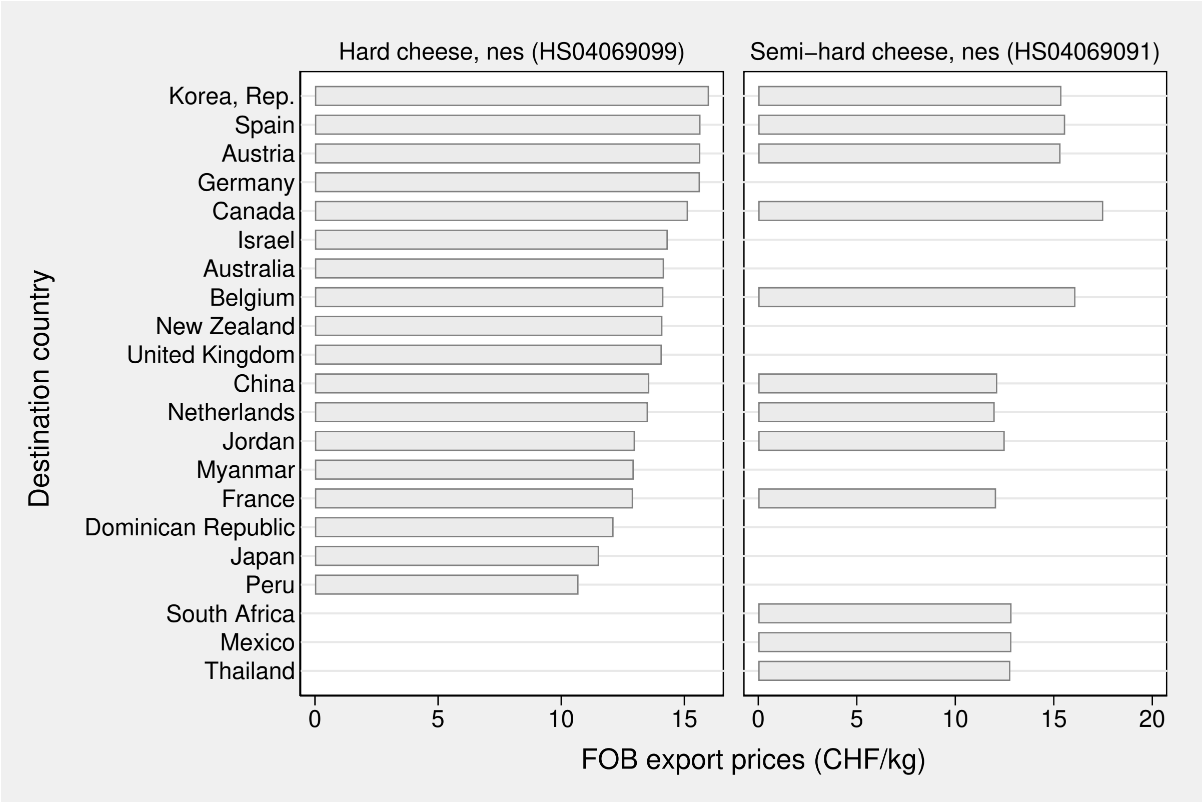
Figure 2: Exports by firm size and destination market attractiveness



(a) Exports by firm size (b) Export market attractiveness

Finally, is it really the case that within-firms, prices vary, even within narrowly defined product categories, for the same products shipped to different locations? To answer this question, I use the case of a particular firm exporting hard cheese and semi-hard cheese to multiple destinations in 2016. In Figure 3, firm-specific FOB prices for hard cheese range from a low of 10.70 CHF in Peru to a maximum of 16.00 CHF in the Republic of Korea. For semi-hard cheese, FOB export prices range from a low of 12 CHF/kg in France to a high of 18 CHF/kg in Canada. This is the sort of variation I exploit across multiple HS8 digit products to assess the role of bilateral distance.

Figure 3: Within firm variation in FOB unit values



3.3 Country-level data

I also combine the firm-product data with country data for the destination country-level. Country-level macroeconomic data on GDP and GDP per capita come from the World Bank World Development Indicators. We retrieve tariff data from the United Nations Commission on Trade and Development (UNCTAD) via the World Integrated Trading System (WITS). Data on bilateral distance comes from Centre d'Etudes Prospectives et d'Informations (CEPII). Finally, we calculate country-level average prices in the importing country using trade data from the Base pour l'Analyse du Commerce International (BACI) database. The BACI data offers the advantage that it corrects, with a rigorous procedure, the potential discrepancies between import values, expressed as Cost Insurance Freight (CIF), and export values, expressed as FOB. Summary statistics on all variables are reported in Table A3 of the appendix.

4 Empirical analysis

To test how within-firm variations in agri-food FOB prices are related to distance, I estimate the following equation using ordinary least squares (OLS):

$$\ln \mathrm{UV}_{fjkt} = \beta_0 + \beta_1 \ln \mathrm{Distance}_j + \mathbf{b}'\mathbf{w}_{jkt} + \phi_{fkt} + \varepsilon_{fjkt} \tag{3}$$

where UV_{fjkt} is the price (unit value) — expressed in Swiss Francs per kilogram — of product k (defined at the HS8 digit level) exported by Swiss firm f to destination country j in year t. $\mathrm{Distance}_j$ is the bilateral distance between Switzerland and country j. ε_{fjkt} are robust standard errors that are clustered at the destination-time level. ϕ_{fkt} are firm-product-time fixed effects. They control for all observable (e.g., firm size) and unobservable firm- and product-specific effects that may affect unit values. Their inclusion means we use only within-firm variation across markets to identify β_1. This allows a direct test of the hypothesis that firms vary their export prices systematically by export market characteristics. This means that for the empirical analysis, I only include firms that export to at least two destination countries. This way, I can assess whether and to what extent they vary their FOB export prices in different destination markets (see Figure 3).

Product variant and invariant destination country controls are captured in vector $\mathbf{w}_{jkt}$. It includes at the country-level, a measure of market size — i.e., Gross Domestic Product (GDP) — and a demand-related control — i.e, real GDP per capita. At the country-product level, we control for HS6 digit bilateral tariffs imposed on imports from Switzerland, remoteness — which I construct as the logarithm of GDP-weighted averages of bilateral distance (Baier and Bergstrand, 2009) — and average prices of HS6 digit product imports from all origins in the destination.[7]

5 Results

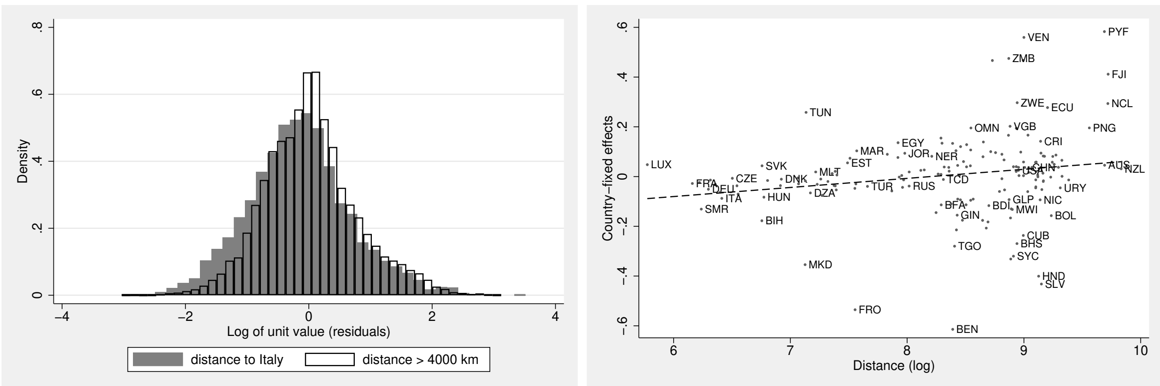
5.1 The distance and within-firm-product price effect

First, I provide some initial descriptive evidence on the distance to export destination and price effect. In Figure 4a, I show the relationship between (demeaned) firm-product-destination unit values and distance. To do this, I regress firm-specific HS8 digit unit values on a set of HS8 digit

[7] The multilateral average unit values of imported products in a destination country depend on the number of firms serving the market, and their FOB and CIF prices of exports. We will expect that in competitive markets where the multilateral unit value is low, the exporting firms charge lower prices to gain market share. For each HS6 digit product p in destination country j, I calculate quantity weighted unit values as $\mathrm{UV}_{jpt} = \sum q_{ijpt} UV_{ijpt}$. Where UV_{ijpt} and q_{ijpt} are the unit values of imports and quantity imported from country i in j of product p at the HS6 digit level.

product fixed-effects. I then plot the residuals from this distribution by distance in a histogram (see also Baldwin and Harrigan, 2011; Bastos and Silva, 2010). The grey bars depict products shipped from Switzerland to its neighbour Italy. The white bars depict the average unit values for product shipped over a distance >4000 km. We see that, on average, products that are exported to further destinations are more skewed to the right. In Figure 4b, I regress unit values on firm-product-time and destination country fixed effects. A large destination country fixed effect implies that average within-firm FOB export prices are higher to this country than to other destinations. I then plot the destination country fixed effects against bilateral distance. With a slope coefficient of 0.032 and an R^2 value of 0.35, distance is positively related with firm-specific FOB unit values and explains a third of the variation in within-firm pricing across destinations. In summary, Figure 4 provides preliminary descriptive evidence that firm-product-destination unit values increase with distance.

Figure 4: Unit values and distance



(a) Distributions of unit values by distance (b) Destination-specific prices and distance

Next, I discuss the empirical results from estimating equation 3. The results are presented in Table 3. In column (1), I control for only bilateral distance and find an elasticity of 0.031. Conditional on exporting, within-firm-product prices are increasing with bilateral distance. This is consistent with the descriptive evidence in Figure 4. In columns (2) and (3), I add further controls. My findings remain unchanged; only the magnitude reduces from 0.031 to 0.023. If bilateral distance doubles, the average exporting firm increases its FOB export price by 2.3% *ceteris paribus*. In all cases, the estimates are statistically significant at the 1% level, and the coefficient of the distance variable is identified solely from the within-firm-product variation of unit values across destination countries. Thus, my findings imply that firms choose higher-quality and more expensive goods when they decide to export to more distant markets. The differences in the estimates across the columns are not due to the differences in sample sizes. If I estimate the models in columns (1) and (2) on the sample used in column (3), the estimates are 0.028 and 0.022 respectively (see Table A4).

Table 3: The effect of distance on unit values

	(1)	(2)	(3)
Log Distance$_j$	0.031***	0.023***	0.022***
	(0.003)	(0.004)	(0.004)
Log GDP$_{jt}$		−0.027***	−0.025***
		(0.007)	(0.007)
Log GDP per capita$_{jt}$		0.009**	0.010***
		(0.004)	(0.004)
Log Remoteness$_{jt}$		0.012***	0.009**
		(0.005)	(0.005)
Log (1 + Tariff$_{jkt}$)		0.010***	0.010***
		(0.002)	(0.002)
Log Unit value$_{jkt}$			0.013
			(0.008)
Firm-product-time FE	Yes	Yes	Yes
Observations	78773	77522	59394
Adjusted R^2	0.761	0.761	0.770

Notes: The dependent variable is the log of free on board unit values of firm f, HS8 digit product k to destination j in year t. All models are estimated using ordinary least squares. p values are in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported. p is defined at the HS6 digit level and k is defined at the HS8 digit level.

How do my findings fit within the existing literature? Since this is the first paper to focus on the agri-food sector, the findings are not directly comparable to existing estimates. That notwithstanding, estimates from the manufacturing sector may still offer some guidance. For manufacturing firms, existing estimates on the within-firm–product elasticity of price to bilateral distance ranges between 2% and 5% for France (Martin, 2012), 5% for Portugal (Bastos and Silva, 2010), 5% for Hungary (Görg et al., 2017), 1% for Germany (Wagner, 2016) and 1% for China (Manova and Zhang, 2012). My 2% estimate falls within the range established in the existing literature. Thus, Swiss agri-food firms behave in a way consistent with manufacturing firms in other European countries.

5.2 Control variables

GDP has a negative effect on export prices. In larger countries — measured here in terms of their GDPs — competition is tougher (since they are more likely to host many more firms in terms of numbers and sizes) which means prices and mark ups are lower (Melitz and Ottaviano, 2008). On the other hand, per capita GDP has a positive effect on prices which may arise from the fact that in richer countries, consumers have a higher willingness to pay (Bastos and Silva, 2010). The estimates of the remoteness index is positive and statistically significant confirming that, all else equal, prices are higher in export destinations that are more remote. Bilateral tariffs have positive effects on prices. This effect is consistent with the agricultural trade literature (Fiankor et al., 2021), where almost half of the applied tariffs are not *ad valorem*. However, different mechanisms may be at play here. Firms may charge lower prices in countries with higher tariffs to increase their competitiveness (Martin, 2012; Chen and Juvenal, 2020). Exporting firms may also pass through the cost of custom tariffs to consumers in their destination countries as higher prices. The direction of the tariff–price effect may also depend on the type of tariff applied by the importing country. Specific tariffs are positively correlated with prices while *ad valorem* tariffs are negatively correlated with prices (Curzi and Pacca, 2015; Emlinger and Guimbard, 2021). In column (3), I include a control for the average prices of HS6 digit product p in the destination country. Here, I attempt to capture further competition effects in the destination market. Firms may vary their prices across destinations keeping in mind the level of prices or competition existing in a particular market. I identify a positive but statistically insignificant destination market price effect. Yet, our distance variable retains its positive and statistically significant effect. Thus, this form of price competition does not appear to be driving our results.

5.3 Discussion

What are the possible reasons for the positive relationship between variations in within-firm export prices and distance? For one, this finding is contrary to many workhorse trade models. Trade models where firms partly absorb transportation costs, e.g., Melitz and Ottaviano (2008), predict a negative relationship between distance and prices. In others such as Eaton and Kortum (2002) and Melitz (2003), exporting firms charge the same FOB price to all destinations. My findings, on the other hand, indicate either (i) variable mark-ups, (ii) quality differentiation by firms across destinations or (iii) a combination of both mechanisms. As I highlighted in Section 2, several mechanisms may explain this finding. One possibility is that firms ship the good apple out (Alchian and Allen, 1964; Hummels and Skiba, 2004). If transportation costs are a function of the physical quantity of products rather than their value, then firms will export higher quality products than sold in the domestic market. This requires that firms are able to differentiate their own goods even within quite narrow product categories. This finding is consistent with country-product level estimates from the agricultural literature (Curzi and Pacca, 2015; Miljkovic and Gómez, 2019; Miljkovic et al., 2019; Emlinger and Guimbard, 2021).

6 Sensitivity analysis

6.1 The case of Swiss cheese exports

The baseline model is estimated on a pooled sample of all Swiss firm-level exports. However, Switzerland is a country noted for its milk production. The alpine state is a net exporter of milk products with cheese being its most important dairy export product. There are two product groups in the Swiss milk market: (i) homogeneous bulk products, e.g., butter and milk powder, and (ii) highly differentiated cheese products (Hillen and von Cramon-Taubadel, 2019). Given the obvious quality differentiation happening in the Swiss cheese sector, I narrow down my analysis in this section to cheese. The goal of this exercise is to see if exporting firms in this narrowly defined product group act in accordance with my main findings. I focus specifically on hard and semi-hard cheese because about 50% of production is exported (Hillen and von Cramon-Taubadel, 2019). Over the study period, 120 firms exported hard cheese and 162 firms exported semi-hard cheese to multiple destinations. The results presented in Table 4 confirm my baseline findings. A doubling of distance increases the FOB export price of hard cheese by 6% and semi-hard cheese by around 4%.

Table 4: The effect of distance on unit values

	Hard cheese		Semi-hard cheese	
	(1)	(2)	(3)	(4)
Log Distance$_j$	0.059***	0.047***	0.045***	0.051***
	(0.010)	(0.010)	(0.013)	(0.014)
Log GDP$_{jt}$	0.013	0.011	−0.062*	−0.012
	(0.025)	(0.024)	(0.032)	(0.030)
Log GDP per capita$_{jt}$	−0.006	−0.006	−0.036***	−0.030**
	(0.013)	(0.013)	(0.013)	(0.014)
Log Remoteness$_{jt}$	−0.013	−0.010	0.024	−0.007
	(0.018)	(0.017)	(0.020)	(0.017)
Log (1 + Tariff$_{jkt}$)	−0.001	−0.008	0.001	0.001
	(0.009)	(0.006)	(0.008)	(0.009)
Log Unit value$_{jkt}$		−0.073**		−0.038
		(0.031)		(0.041)
Firm-time FE	Yes	Yes	Yes	Yes
Observations	1393	1041	1291	1004
Adjusted R^2	0.648	0.523	0.435	0.413

Notes: The dependent variable is the log of free on board unit values of firm f, HS8 digit product k to destination j in year t. All models are estimated using ordinary least squares. p values are in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported. p is defined at the HS6 digit level and k is defined at the HS8 digit level.

6.2 Does size matter?

In a recent contribution, Emlinger and Guimbard (2021) show that the Alchian-Allen effect depends on the size — measured as income level — of the exporting country. Taking this idea to the firm-level, I test if my findings depend on the firm structures presented in Figure (2a). The positive distance and price effect is confirmed for all the different firm sizes (Column 1 of Table 5) with magnitudes that are increasing with firm size. However, the estimated effects are not statistically significantly different from each other.[8] I then check if the positive distance effect is moderated by the development level of the destination country. I define two importing country groups based on their GDP per capita in year t. Across all destinations in the sample, those with GDP per capita above

Table 5: The effect of distance on unit values — sample split by firm size

	Firm size	Country size
	(1)	(2)
Log Distance$_j$	0.016***	0.020***
	(0.005)	(0.006)
Log Distance$_j$ × Firm size 2	0.006**	
	(0.003)	
Log Distance$_j$ × Firm size 3	0.004	
	(0.004)	
Log Distance$_j$ × Firm size 4	0.011**	
	(0.005)	
High income$_j$		−0.009
		(0.039)
Log Distance$_j$ × High income$_j$		−0.002
		(0.005)
Log GDP$_{jt}$	−0.025***	−0.031***
	(0.007)	(0.008)
Log GDP per capita$_{jt}$	0.011***	0.016***
	(0.004)	(0.005)
Log Remoteness$_{jt}$	0.009**	0.013***
	(0.005)	(0.005)
Log (1 + Tariff$_{jkt}$)	0.010***	0.010***
	(0.002)	(0.003)
Log Unit value$_{jkt}$	0.013	0.012
	(0.008)	(0.008)
Firm-product-time FE	Yes	Yes
Observations	59022	59394
Adjusted R^2	0.769	0.770

Notes: The dependent variable is the log of free on board unit values of firm f, HS8 digit product k to destination j in year t. All models are estimated using ordinary least squares. p values are in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported. p is defined at the HS6 digit level and k is defined at the HS8 digit level. Firm size 2 are firms with 10 – 49 employees, Firm size 3 refers to firms with 50 – 249 employees and Firm size 4 are employees with $>$ 249 persons. The reference group is thus firms with $<$ 10 employees.

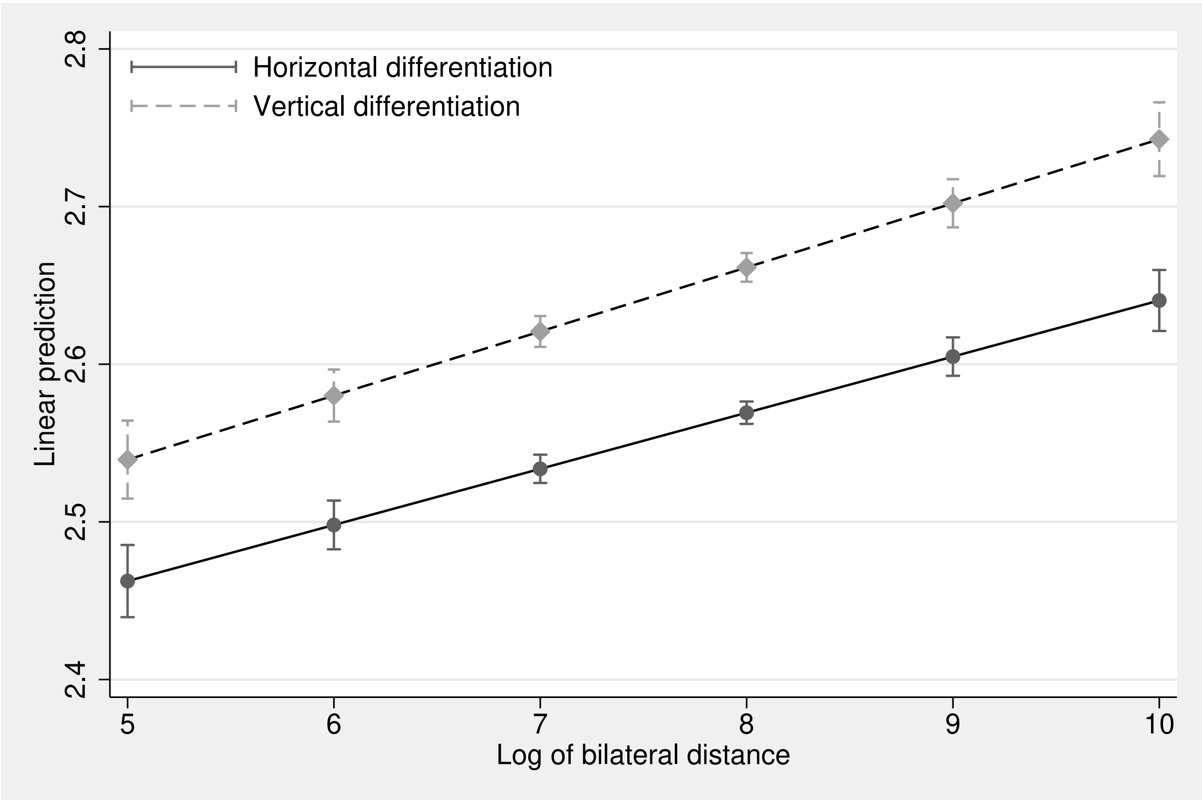
[8] Furthermore, these small firms usually export low values. As a result, I further drop trade values below 500 CHF to test if small firms are driving the main results. The findings remain qualitatively the same; if anything, the magnitudes are reinforced. The estimated distance effect in this restricted sample is 0.03 compared to 0.02 in the benchmark model (Table A5). Another measure of size is how many destinations a firm exports to. If we keep only firms who export to $>$ 20 destinations, the main findings are confirmed (Table A6).

the median GDP per capita value are classified as high income. Destinations with GDP per capita values below the median GDP are classified as low income. The results presented in column (2) of Table (5) show that the development level of the destination does not matter for the distance–price effect.

6.3 Heterogeneity across product types and industry

I have thus far argued that observed prices are correlated with product quality at such low-levels of trade data disaggregation.[9] Nevertheless, to ascertain if there is indeed some quality effect, we test the heterogeneity of the estimates in Column 2 of Table 3 across two product groups: when the scope for product differentiation is (i) high (i.e. vertical differentiation) and (ii) low (i.e. horizontal differentiation). Here I simply calculate price dispersion of unit values within each HS8 digit product using the data at hand. I adapt the quality ladder concept in (e.g., Khandelwal, 2010) to observed prices. I define product differentiation as the difference between the maximum and minimum prices

Figure 5: The effect of distance on unit values: quality differentiation



[9]Some papers in the agricultural trade literature have measured unobserved product quality using trade data (Curzi and Pacca, 2015; Fiankor et al., 2021). This papers mainly employ the assumption in the work of Khandelwal et al. (2013) that conditional on price, varieties imported in higher volumes are assigned higher quality. While such an approach is direct and straight-forward to implement, the empirical application requires time-varying importing country-specific elasticity of substitution. For multiple countries these are only publicly available as a cross-section at the 3-digit HS level from Broda et al. (2017). These are inadequate for our analysis which are at the very dis-aggregated HS8-digit level.

in a given product-destination market. I expect that the lower the variation, the more standardised the product and vice versa. Products with values above (below) the median of the quality ladder are vertically (horizontally) differentiated. If the effects from Table 3 are driven by quality, then — relative to horizontally differentiated products — we expect more pronounced marginal effects for vertically differentiated products. The results presented in Figure 5 confirm this hypothesis. Notably, prices within more differentiated industries are more responsive to changes in distance, which indicates that in these sectors, firms have more room to adjust their markups or their quality

Table 6: The effect of distance on unit values: HS2 digit sector estimates

Log Distance$_j$ × HS2	−0.026
	(0.017)
Log Distance$_j$ × HS3	0.075**
	(0.033)
Log Distance$_j$ × HS4	0.039***
	(0.007)
Log Distance$_j$ × HS7	0.020
	(0.046)
Log Distance$_j$ × HS8	−0.001
	(0.030)
Log Distance$_j$ × HS9	0.042***
	(0.011)
Log Distance$_j$ × HS10	0.026
	(0.068)
Log Distance$_j$ × HS11	0.012
	(0.035)
Log Distance$_j$ × HS15	0.049**
	(0.024)
Log Distance$_j$ × HS16	0.040
	(0.034)
Log Distance$_j$ × HS17	0.024***
	(0.008)
Log Distance$_j$ × HS18	0.011**
	(0.004)
Log Distance$_j$ × HS19	0.022***
	(0.006)
Log Distance$_j$ × HS20	0.004
	(0.007)
Log Distance$_j$ × HS21	0.019***
	(0.006)
Log Distance$_j$ × HS22	0.009
	(0.008)
Observations	76807
Adjusted R^2	0.761

Notes: The dependent variable is the log of free on board unit values of firm f, HS8 digit product k to destination j in year t. p values are in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported. Estimations include firm-product-time fixed effects. Controls for GDP, GDP per capita, Remoteness, Tariffs, and average unit values in the importing country have their expected signs and are statistically significant but are omitted from the table for brevity.

across destinations.

I conclude by obtaining industry-specific estimates of the distance–unit value elasticity. I assess how the effects differ by HS2 digit codes. For brevity and clarity of exposition, I only report the results that are of central interest to the study, i.e., the distance estimates. Overall, the estimates at the industry level from Table 6 largely reinforces my conclusions. Where the effects are statistically significant, they are always positive with magnitudes in line with the baseline model results.[10]

7 Conclusion

At the core of this paper is a simple question: how does distance affect spatial variation in product-specific export prices within agri-food exporting firms? This paper is the first to analyze how distance affects within-firm-product export price variations across countries in the agri-food sector. Existing works have been conducted at the country-product level and ignore the heterogeneity across firms within countries. My work contributes to filling this gap. Estimating linear models that regress firm-product-destination-time FOB unit values on distance, firm-product-time fixed effects, and destination country controls, I find that if distance doubles the average Swiss agri-food firm increases its FOB export price by 2.3%. This finding holds true when controlling for the wealth, size, tariffs and level of price competition in the destination country. In the end neither firm size nor the development level of the destination country matters for the distance–price elasticity.

My paper is not without limitations. My explanations of the distance–price effect embeds mechanisms closely related to prices — e.g., quality and mark ups — that are largely unobservable or hard to quantify. In future studies, it should be possible to focus on one product, isolate the objective quality component (e.g., wine or cheese quality ratings by experts) and isolate the markup element.

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[10] An alternate approach is to estimate equation for each HS2 digit sector. This approach generates results similar to those reported here. The results are available on request from the author.

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Figure A1: Export values by HS2 chapter

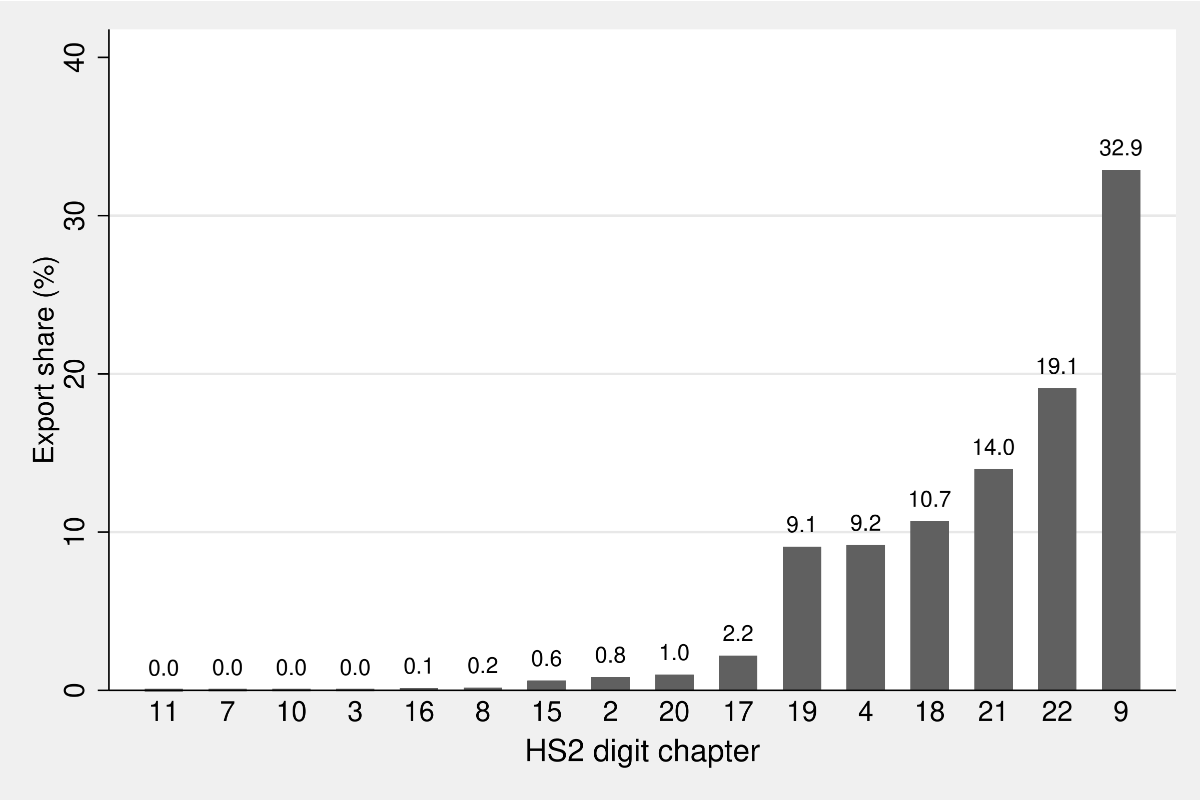

Figure A2: Export destinations of Swiss agri-food exports (2016 – 2020)

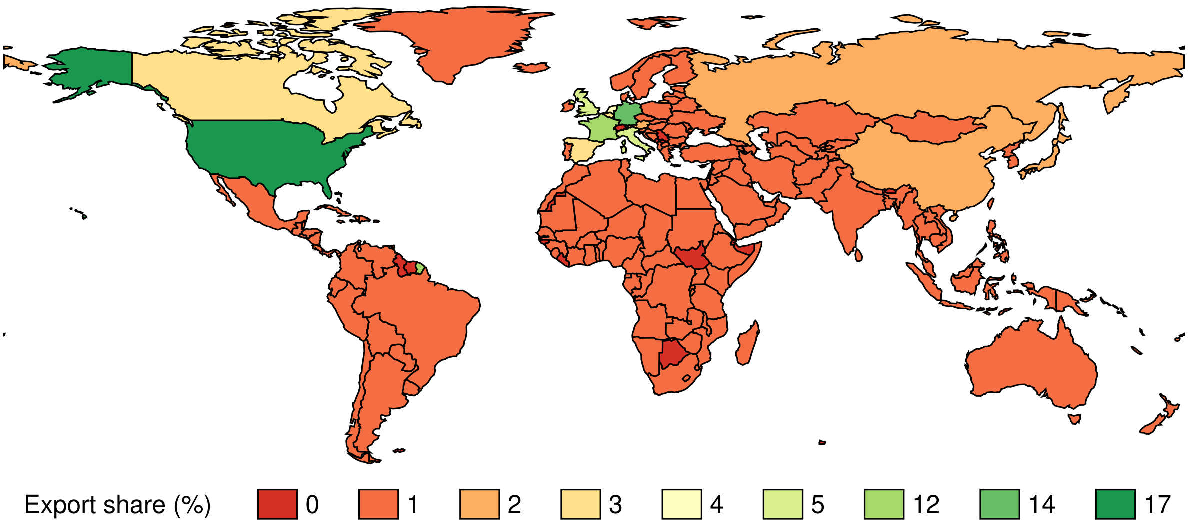

Table A1: Top 30 Swiss agri-food export values by HS8 chapter (2016 – 2020)

Product description	HS8	Export (m. CHF)	Export share (%)
Roasted coffee, not decaffeinated	9012100	10680	27
Non-alcoholic beverages (excl. water, fruit or	22029990	5251	13.27
Hard cheese, n.e.s.	4069099	1739	4.4
Vegetable juice, non-alcoholic, diluted with wa	22029090	1389	3.51
Food preparations for infant use, meet to the b	19011020	1286	3.25
Chewing-gum and sweets, tablets, pastilles and	21069040	1262	3.19
Semi-hard cheese, n.e.s.	4069091	1003	2.54
Roasted, decaffeinated coffee	9012200	978	2.47
Milk chocolate, in blocks, slabs or bars of =<	18063210	820	2.07
Chocolate and other food preparations containin	18063290	762	1.93
Extracts, essences and concentrates, of coffee	21011102	739	1.87
Preparations for sauces and prepared sauces; mi	21039000	507	1.28
Food preparations, n.e.s., not containing fat,	21069094	494	1.25
Food preparations, not containing fat, n.e.s.	21069100	407	1.03
Food preparations, n.e.s., containing > 1% but	21069074	354	.9
Moulded sugar confectionery, not containing coc	17049042	329	.83
White chocolate	17049010	290	.73
Soups and broths and preparations therefor	21041000	277	.7
Meat of bovine animals, salted, in brine, dried	2102090	241	.61
Edible mixtures or preparations of animal or ve	15179091	211	.54
Bread, pastry, cakes, biscuits and other bakers	19059084	204	.52
Mixes and doughs for the preparation of bakers'	19012096	194	.49
Food preparations, n.e.s., containing > 25% but	21069072	182	.46
Pasta, stuffed with meat or other substances, w	19022000	160	.41
Food preparations, n.e.s., containing milkfat,	21069064	154	.39
Fresh cheese [unripened or uncured], incl. whey	4061090	133	.34
Prepared foods obtained by the swelling or roas	19041090	120	.3
Chocolate and other preparations containing coc	18063112	118	.3
Jams, jellies, marmalades, purées or pastes of	20079930	114	.29
Waffles and wafers, whether or not containing c	19053220	100	.25

Table A2: List of destination countries

Afghanistan, Albania, Algeria, Andorra, Angola, Anguila, Antigua and Barbuda, Argentina, Armenia, Aruba, Australia, Austria, Azerbaijan, Bahamas, The, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bermuda, Bolivia, Bosnia and Herzegovina, Brazil, British Virgin Islands, Brunei, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Cayman Islands, Central African Republic, Chad, Chile, China, Colombia, Congo, Dem. Rep., Congo, Rep., Costa Rica, Cote d'Ivoire, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Djibouti, Dominican Republic, Ecuador, Egypt, Arab Rep., El Salvador, Equatorial Guinea, Eritrea, Estonia, Ethiopia (excludes Eritrea), Faeroe Islands, Fiji, Finland, France, French Guiana, French Polynesia, Gabon, Georgia, Germany, Ghana, Gibraltar, Greece, Greenland, Guadeloupe, Guatemala, Guinea, Haiti, Honduras, Hong Kong, China, Hungary, Iceland, India, Indonesia, Iran, Islamic Rep., Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea, Dem. Rep., Korea, Rep., Kuwait, Kyrgyz Republic, Lao PDR, Latvia, Lebanon, Libya, Lithuania, Luxembourg, Macao, Macedonia, FYR, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Martinique, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Palestine, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Reunion, Romania, Russian Federation, Rwanda, Samoa, San Marino, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Singapore, Slovak Republic, Slovenia, Somalia, South Africa, Spain, Sri Lanka, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Sudan, Swaziland, Sweden, Syrian Arab Republic, Taiwan, Tajikistan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Turks and Caicos Isl., Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Uzbekistan, Vanuatu, Venezuela, Vietnam, Yemen, Rep., Zambia, Zimbabwe

Table A3: Summary statistics

Variable	Mean	SD	Min	Max	N
Trade value (mo. CHF)	0.38	7.42	0	896.12	95224
Trade quantity (mo. kg)	0.05	1.99	0	296.41	95224
Unit value (CHF/kg)	22.02	26.71	1.97	176.23	95224
Distance (Km)	3358.87	3917.52	322.15	18635.84	95180
GDP (bo. USD)	2334.14	3897.77	0.79	21433.22	93930
GDP per capita ('000 USD)	35.76	19.58	0.27	117.10	93770
Tariff	8.02	25.5	0	277.00	95224

Table A4: The effect of distance on unit values (restricted sample)

	(1)	(2)	(3)
Log Distance$_j$	0.028***	0.022***	0.022***
	(0.003)	(0.004)	(0.004)
Log GDP$_{jt}$		−0.026***	−0.025***
		(0.007)	(0.007)
Log GDP per capita$_{jt}$		0.012***	0.010***
		(0.004)	(0.004)
Log Remoteness$_{jt}$		0.010**	0.009**
		(0.005)	(0.005)
Log (1 + Tariff$_{jpt}$)		0.010***	0.010***
		(0.002)	(0.002)
Log Unit value$_{jpt}$			0.013
			(0.008)
Observations	59394	59394	59394
Adjusted R^2	0.769	0.770	0.770

Notes: The dependent variable is the log of free on board unit values bf firm f, HS8 digit product k to destination j in year t. p values in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported.

Table A5: The effect of distance on unit values (trade values above 500 CHF)

	(1)	(2)	(3)
Log Distance$_j$	0.034***	0.024***	0.027***
	(0.003)	(0.004)	(0.005)
Log GDP$_{jt}$		−0.028***	−0.022***
		(0.007)	(0.008)
Log GDP per capita$_{jt}$		0.013***	0.015***
		(0.004)	(0.004)
Log Remoteness$_{jt}$		0.011**	0.006
		(0.005)	(0.005)
Log (1 + Tariff$_{jkt}$)		0.010***	0.010***
		(0.002)	(0.002)
Log Unit values$_{jpt}$			0.004
			(0.006)
N	59180	58025	41090
adj. R^2	0.833	0.833	0.836

Notes: p values in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported. All models include controls for importer-product-mode and exporter-product-mode fixed effects.

Table A6: The effect of distance on unit values: More than 20 destinations per firm

	(1)	(2)	(3)
Log Distance$_j$	0.030***	0.018***	0.022***
	(0.004)	(0.005)	(0.006)
Log GDP$_{jt}$		−0.030***	−0.017
		(0.009)	(0.011)
Log GDP per capita$_{jt}$		0.007	0.012**
		(0.004)	(0.005)
Log Remoteness$_{jt}$		0.015**	0.006
		(0.006)	(0.007)
Log (1 + Tariff$_{jkt}$)		0.011***	0.010***
		(0.003)	(0.003)
Log Unit value$_{jpt}$			−0.004
			(0.009)
N	35710	35069	24484
adj. R^2	0.754	0.755	0.765

Notes: The dependent variable is the log of free on board unit values bf firm f, HS8 digit product k to destination j in year t. p values in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported.