Institut für Lebensmittel- und Ressourcenökonomik

International agri-food trade: country level stability and firms' labor market interactions

Dissertation
zur
Erlangung des Grades
Doktorin der Agrarwissenschaften
(Dr. agr.)

der
Agrar-, Ernährungs- und Ingenieurwissenschaftlichen Fakultät
der
Rheinischen Friedrich-Wilhelms-Universität Bonn

von

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aus

Volkmarsen

Bonn 2025

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Tag der mündlichen Prüfung: 28.05.2025

Angefertigt mit Genehmigung der Agrar-, Ernährungs- und Ingenieurwissenschaftlichen Fakultät der Universität Bonn.

Acknowledgements

First and foremost, I would like to sincerely thank my doctoral supervisors, PD Dr. Yaghoob Jafari and Prof. Dr. Thomas Heckelei, for their continuous support and guidance. Their valuable feedback, encouragement, and open-mindedness have been essential for the completion of this dissertation. I am grateful for the opportunity to work together on these interesting topics and for the motivating discussions in our meetings. Beyond their thematic and methodological expertise, I especially appreciate their empathy and sense of humor, which truly enriched my PhD journey. I am also thankful for the numerous conferences and project meetings that I was able to attend—I have fond memories of our joint trips.

I also thank Prof. Dr. Kathy Baylis and Prof. Dr. Monika Hartmann for being members of my examination committee and for their insightful comments and constructive suggestions throughout seminars and conferences.

During my doctoral studies, I had the opportunity to contribute to various projects, which have been both enriching and inspiring. I would particularly like to thank Dr. Andrea Zimmermann for the great collaboration, which has always been a true pleasure. I am also grateful to Dr. Karine Latouche for the valuable exchange and cooperation in the BATModel project and beyond.

I further want to thank my current and former colleagues at ILR for creating such a welcoming and stimulating work environment. I deeply appreciate the academic discussions as well as the countless coffee and lunch breaks with personal conversations that have made daily work more enjoyable. In particular, I would like to thank An, Anna, Bisrat, Catha, Elif, Elin, Kristin, Lenni, Monika, and Rienne for their friendship and support.

Finally, I would like to express my heartfelt gratitude to my family, especially my parents, as well as my friends, flatmates, and Anton, who have always supported me and provided the needed distractions along the way. I am incredibly grateful to have you by my side.

Kurzfassung

Der internationale Handel mit Agrarerzeugnissen und Lebensmitteln ist essenziell für die globale Ernährungssicherheit. Zuletzt wurde das Handelssystem jedoch mit zahlreichen Herausforderungen auf verschiedenen Ebenen —global, regional und auf Unternehmensebene— konfrontiert. Daher werden in dieser Dissertation, mit besonderem Fokus auf die Stabilität von Handelsbeziehungen, die Determinanten des internationalen Agrar- und Lebensmittelhandels anhand von vier Studien analysiert. Die Untersuchungen tragen zum Verständnis jener Dynamiken im internationalen Agrar- und Lebensmittelhandel bei, die mit der COVID-19-Pandemie, der Qualität von Institutionen, Lebensmittelsicherheitsstandards und der Macht von Unternehmen auf dem Arbeitsmarkt verbunden sind.

Die erste Studie zeigt, dass das Agrar- und Lebensmittelhandelssystem während der COVID-19-Pandemie kurzfristige Einbrüche erlebte, insbesondere als pandemiebedingte Einschränkungen ihren Höhepunkt erreichten. Durch Korrelationsanalysen wird deutlich, dass Veränderungen von Handelswerten und -diversifizierung mit der Strenge politischer Maßnahmen, der industriellen Produktionsleistung und den Bewegungsmustern der Bevölkerung zusammenhängen.

Die zweite und dritte Studie beleuchten den Einfluss der Qualität staatlicher Institutionen sowie der Stringenz von Standards auf die Handelsstabilität im Agrar- und Lebensmittelsektor. In der zweiten Studie werden Exporte aus Subsahara-Afrika (SSA) in die EU-28 analysiert. Hierbei zeigt sich, dass eine höhere institutionelle Qualität der Exportländer sowie geringere institutionelle Unterschiede zwischen Handelspartnern zu länger andauernden Handelsbeziehungen führen. Von den verschiedenen Dimensionen institutioneller Qualität hat die Regierungsauswahl, -überwachung und -absetzung in den SSA-Ländern den stärksten Einfluss. Hinsichtlich der bilateralen Unterschiede ist die Achtung von Institutionen durch Bürger und staatliche Organe am relevantesten. Die dritte Studie verdeutlicht zum einen, basierend auf Theorie und Literatur, dass die Stringenz und bilaterale Unterschiede bezüglich Lebensmittelsicherheitsstandards ambivalente Auswirkungen auf die Handelsstabilität haben können. Zusätzlich ergibt eine globale empirische Untersuchung, dass höhere Rückstandshöchstwerte für Substanzen auf Lebensmittel und Futter sowie ähnlichere Werte zwischen Handelspartners zu längeren und weniger volatilen Handelsbeziehungen führen.

Die vierte Studie analysiert den Zusammenhang zwischen Exportaktivitäten lebensmittelverarbeitender Unternehmen und deren Macht auf dem Arbeitsmarkt. Basierend auf französischen Unternehmensdaten ergibt die Studie, dass eine Exportteilnahme und höhere Exportintensität mit einer geringeren Marktmacht der Unternehmen auf dem Arbeitsmarkt verbunden sind. Umgekehrt verringert eine höhere Marktmacht von Unternehmen die Exportintensität, beeinflusst jedoch nicht die Exportteilnahme. Zudem verdeutlicht die Untersuchung, dass Lohn- und Produktivitätskomponenten von Marktmacht für diese wechselseitige Beziehung von Bedeutung sind.

Abstract

International trade of agri-food products is essential for global food security. However, the trade network has faced numerous challenges at different scales —global, regional, and firm-level. These include recent shocks that have tested the resilience of the trade system, as well as various policy interventions. With a particular focus on trade stability, this thesis comprises four studies that investigate determinants of trade patterns in the agri-food sector. They contribute to the understanding of challenges and benefits for agri-food trade associated with the COVID-19 pandemic, institutional quality, food safety standards, and firms' labor market power.

The first study reveals that during the COVID-19 pandemic, the agri-food trade system has experienced short-term disruptions when pandemic-related restrictions were at their peak. Correlation analyses show that changes in countries' trade values and diversification are associated with policy stringency, people's mobility, and industrial production output.

The second and third study shed light on the impact of countries' institutional quality and standard stringency on agri-food trade stability. Analyzing exports from Sub-Saharan Africa (SSA) to the EU-28 countries, the second study shows that higher levels of exporters' institutional quality and similarity of institutional quality between trading partners facilitate longer trade durations. When distinguishing between different dimensions of institutional quality, the strongest effect arises from exporters' government selection, monitoring, and replacement in SSA. Regarding bilateral similarity, respect for institutions by citizens and state is the most relevant dimension. In the third study, a theory- and literature-based framework shows that stringency and bilateral differences in food safety standards have ambiguous implications for trade stability. The global empirical analysis of agri-food trade reveals that higher importers' stringency in Maximum Residue Levels, an important agri-food standard, and bilateral similarities therein lead to longer and less volatile agri-food trade relations.

Focusing on the food processing sector, the last study analyses the relation of firms' export activities and their labor market power. Employing French firm-level data, the study finds that export participation and higher export intensity are associated with lower labor market power of firms. Reciprocally, higher labor market power of firms decreases export intensities but does not affect export participation. Investigating the relevance of markdown components demonstrates that wage and productivity components matter for both directions of the relationship between labor market power and export activities.

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List of Abbreviations

2SLS	Two Stage Least Squares
AoA	Agreement on Agriculture
ASEAN	Association of Southeast Asian Nations
CEPII	Centre d'Études Prospectives et d'Informations Internationales
CIF	Cost, Insurance, and Freight
COVID-19	Coronavirus SARS-CoV-2
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FOB	Free on Board
GVC	Global Value Chain
HS	Harmonized System
IQ	Institutional Quality
KM	Kaplan-Meier
MD	Markdown
MRL	Maximum Residue Level
NACE	Nomenclature statistique des activités économiques
NTM	Non-Tariff Measure
OLS	Ordinary Least Squares
PCA	Principal Component Analysis
PPML	Poisson-Pseudo Maximum Likelihood
RTA	Regional Trade Agreement
RQ	Research Question
SPS	Sanitary and Phytosanitary
SSA	Sub-Sahara Africa
TBT	Technical Barriers to Trade
TDM	Trade Data Monitor
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
WGI	World Governance Indicator
WHO	World Health Organization
WTO	World Trade Organization

Chapter 1

Overview

1.1 Background and motivation

International trade of agricultural products is crucial to reduce global food insecurity (Martin, 2017; OECD/FAO, 2023). Yet, it also poses significant challenges. Agricultural production is inherently constrained by geographical and climatic conditions, making it inefficient and unfeasible to cultivate all commodities in every region or season. As a result, relocation of agricultural commodities from surplus production areas to deficit regions is essential (FAO, 2022).[1] International trade makes this possible and contributes to a more stable and diverse food supply across importing countries; it thereby enhances access to healthy diets and reduces vulnerability to domestic shocks (FAO, 2024; FAO et al., 2022). For exporting countries, trade generates income and facilitates knowledge transfer, driving innovation, economic growth, and development (Grossman and Helpman, 1991; Makki and Somwaru, 2004). However, trade also brings challenges. Specialization in line with a country's comparative advantage may reduce domestic production diversity, increase dependency on imports, and lead to intensive agricultural practices that could harm the environment (FAO, 2022). Additionally, the interconnectedness of trade networks increases the risk of foreign shocks spilling over to domestic economies (Acemoglu et al., 2016), which is particularly critical when countries rely on a few specific trading partners.

Global agri-food trade has followed a positive trend with fluctuations around this path. The number of trade links between countries have expanded rapidly in the late 90s, followed by a substantial rise in trade values until the great financial crisis in 2008. Since then, the increasing global trend persists, but it has decelerated and become more prone to downward fluctuations. Agri-food trade has also become increasingly regionalized, meaning countries tend to enhance trade with neighboring countries to a higher level compared with countries outside their region (Jafari et al., 2023b).[2] However, these global developments are heterogeneous across different regions,

[1] During the time of her doctoral studies, Helena Engemann contributed to Part 1 of this FAO publication and to Part 3 of the FAO publication referred to as FAO (2024).

[2] In this background paper, the evolution of agri-food trade patterns from 1995 to 2019 is analyzed using network analysis. Helena Engemann co-authored this paper during her doctoral studies, however, it is not included as a main chapter in this thesis.

countries, firms, and products. Lower income countries significantly enhanced their participation in international markets contributing to a large share of trade value increases (Martin, 2018). Additionally, more productive firms have intensified their trade activities (Bernard et al., 2007; Melitz, 2003).

The global fluctuations and the heterogeneous contributions of different actors in the international trade call for investigating the determinants of trade to improve our understanding of how policies and measures at various scales interact and impact the different aspects of global trade patterns. Trade patterns encompass several dimensions, such as overall changes in trade values and the number of trade links, the share of exports in overall domestic production, trade diversification across products and markets, and the stability of trade links and values over time. This thesis aims to contribute to understanding this patterns in the agri-food sector and its relation with crucial determinants.

Numerous factors and policy measures may explain the evolution of international trade patterns in the agri-food sector. Rapid advancements in transport and telecommunication technologies in the 2000s have significantly contributed to the growth of trade values and connectivity between countries through trade cost reductions (Jafari et al., 2023b; Jungmittag and Welfens, 2009; Wilson et al., 2005). Although the agri-food sector remains the most protected sector in international trade (Beghin and O'Donnell, 2021), the establishment of the World Trade Organization (WTO) in 1995 and its Agreement on Agriculture (AoA) have been key drivers of the increasing trend by promoting trade liberalization through the reduction of tariffs, as well as export subsidies and domestic support measures that distort trade (Daugbjerg and Swinbank, 2008; Grant and Boys, 2012). Next to the multilateral negotiations that have stalled since the WTO's Doha Round in 2001, the proliferation of preferential and regional trade agreements (RTAs) has further reduced protectionism and enhanced integration, contributing to the increase of global trade values but also to the regionalization of agri-food trade (Beghin and O'Donnell, 2021; Jafari et al., 2023a, 2024).[3]

Amid the reductions of tariffs and other trade cost, the prevalence of non-tariff measures (NTMs), such as sanitary and phytosanitary requirements and technical regulations, has increased globally (Ghodsi et al., 2017). The significant rise in the number and strictness of NTMs resulting in more heterogeneity across countries has evoked debates about whether NTMs are trade-enhancing or -reducing (Santeramo and Lamonaca, 2019). Different stakeholders are questioning if some NTMs may be

[3]Both articles, Jafari et al. (2023a) and Jafari et al. (2024), were co-authored by Helena Engemann during her doctoral studies. They are not included as main chapters in this thesis.

used as disguised measures to prohibit trade (Schwarzenberg, 2024), or if they are really designed to protect, for instance, the public health and the environment. In line with this, recent RTAs have become deeper, shifting their focus from primarily covering tariff reductions to encompassing different provisions, for instance, on regulatory issues and competition policies (Hofmann et al., 2019).

While these developments have been observed, recent events —including climate change induced shocks, geopolitical conflicts and the COVID-19 pandemic, collectively also referred to as the 3C's— have impacted the agri-food sector and disrupted international trade relations (Benton et al., 2022; Hendriks et al., 2022; Khadka et al., 2025; Laborde et al., 2020). Climate shocks and armed conflicts might directly cause crop failures, disrupt seed and fertilizer supply chains, and prevent the transportation of produced commodities (Crofils et al., 2025; Pu and Zhong, 2020). The COVID-19 pandemic and political measures to curb the spread of the virus influenced international trade through multiple channels. The pandemic and induced policy measures resulted in shortages of (seasonal) workers in the agri-food sector and thus production losses, and changes in consumers' demand through income losses, price changes, and closures of restaurants (Fedoseeva and Van Droogenbroeck, 2023; Laborde et al., 2020; Montanari et al., 2021). Despite the risk of inducing higher global prices (Baylis et al., 2014; Martin and Anderson, 2012), several countries implemented export restrictions on agri-food products during COVID-19 and the Ukraine war (Laborde et al., 2020; OECD/FAO, 2023). Further, the number of economic sanctions implemented by countries against specific target countries has been increasing since 1950, especially recently, when numerous countries have started imposing extensive sanctions against Russia (Morgan et al., 2023). If these sanctions relate to trade, they can significantly reduce agri-food trade (Larch et al., 2024).

Other, generally less abrupt, country-specific policies and characteristics also play a crucial role for trade patterns. For instance, countries' institutional quality (IQ) reflects, among others, their control of corruption and political stability, has implications for trust, contracting, and investments, thereby affecting agri-food trade (Álvarez et al., 2018; Bojnec et al., 2014; Martínez-Zarzoso and Márquez-Ramos, 2019; Yu et al., 2015). Higher IQ enhances trade values, but also contributes to the observed regionalization trend, since more RTAs are concluded by countries with good institutions due to better information flows, lowering transaction costs (Baccini, 2014). Further, countries' regulatory standards affect international trade. Maximum Residue Levels (MRLs) constitute one important product safety standard in the agri-food sector, determining the tolerance levels on food and feed for substances like pesticides. Therefore, producers who want to export to the regulated market need to comply with such levels, affecting cost structures but also consumers' confidence in products (Fontagné et al., 2015; Xiong and Beghin, 2014).

Firms' characteristics contribute further to shaping trade patterns, since firms are mostly the actor realizing trade across countries. Firm-specific factors, such as their productivity, wages paid, market power, and investment strategies affect their competitiveness and therefore determine if they are successful exporters (Bustos, 2011; Eaton and Kortum, 2002; Lileeva and Trefler, 2010; Melitz, 2003; Melitz and Redding, 2014). In the context of global agri-food trade, whereas primary agricultural products are often traded through traders, firms in the processed food sector are directly involved in trading activities. In 2022, processed food accounted for around 63% of the agri-food export values (United Nations Conference on Trade and Development (UNCTAD), 2024). Processing offers significant market opportunities for farm products, creating jobs and value added through transforming primary agricultural commodities (GIZ, 2021; Townsend et al., 2017).

The discussed factors and related developments underscore the complexity and multi-layered nature of the agri-food trade system; and particularly, recent disruptions have raised questions about its resilience, mainly in the context of food security for import-dependent countries (FAO et al., 2022).

1.2 Research questions

The main objective of this dissertation is to contribute to the understanding of interactions of agri-food trade patterns with relevant policies and factors at different levels—global, country, and firm. Specifically, it addresses the following four main research questions each examined in a separate study:

(I) How have global agri-food trade patterns changed during the COVID-19 pandemic?

COVID-19 led to global disruptions and economic downturns, primarily in 2020 and continuing thereafter. The pandemic and associated containment measures have challenged the global agri-food system, raising critical questions about its resilience (Laborde et al., 2020). Key concerns include the ability of consumers to access sufficient quantities and varieties of food, and whether producers can sustain their (export) earnings (Khadka et al., 2025; Laborde et al., 2020). This situation fueled the interest in the first study of this dissertation, which examines changes in the global trade patterns of agricultural and food products and their association with COVID-19-related containment measures.

The analysis includes the evaluation of changes in the multiple aspects of trade patterns globally and across regions, countries, and different commodity groups. Specific questions are whether changes in trade values and diversification are significantly related to increased morbidity and mortality rates and to induced policy responses; and how trade changed during COVID-19 on average, and along the extensive (*i.e.* number of trade links) and the intensive (*i.e.,* trade values of existing trade links) margins of trade.

To date, an extensive body of literature has studied the agri-food trade changes during COVID-19, or the impact of COVID-19 on agri-food trade. Main findings of empirical studies (*e.g.,* Arita et al., 2022; Barichello, 2021; Hailu, 2021; Pawlak et al., 2024; Vickers et al., 2020) are that agri-food trade has declined during the COVID-19, however, less than trade in other sectors and recovered after a short time period, suggesting relatively high resilience of the sector. Arita et al. (2022) show that least developed and low-income countries were more vulnerable to the pandemic, with higher decreases in trade flows; Beckman and Countryman (2021) and Schmidhuber et al. (2020) find differences across agri-food groups.

This study contributes to the literature in three ways. First, it analyzes short-term changes in agri-food trade during the first wave of COVID-19, focusing on both the extensive and intensive margins of trade, as well as on the diversification of trade flows along these margins. Second, it investigates monthly variations within the agri-food trade network at various spatial levels and across different product groups. Third, it assesses the relation of pandemic-related factors with changes in trade values and their distribution across trade links. Consequently, this study provides a multi-faceted and timely analysis of the changes in agri-food trade relations and related impact channels triggered by a systemic shock, COVID-19.

(II) How does countries' institutional quality (IQ) and the bilateral similarity in IQ influence the duration of bilateral agri-food trade relations?

The quality of countries' institutions and differences in trading partners' institutional environment are crucial factors in the context of agri-food trade resilience. The second study of this thesis examines the impact of exporters' IQ and their bilateral differences with trading partners therein on the trade duration of agricultural and food products. In this context, the focus is on exports from SSA countries to individual EU-28 members that exhibit, on average, high differences in IQ, since most countries in SSA have comparatively low levels of IQ (AFDB, 2021). At the same time, maintaining stable export channels might be especially crucial for the economic development in many SSA countries, for which the EU constitutes a major export destination.

A study by Bojnec and Fertő (2012) examines the impact of exporters' IQ on the duration of EU agri-food exports, and finds a positive effect. Other empiricists (Álvarez et al., 2018; Martínez-Zarzoso and Márquez-Ramos, 2019; Nunn and Trefler, 2014) look at the impact of IQ on trade values, but not trade duration, They show that higher IQ reduces trade barriers through transparency and lower uncertainty between trade partners.

This second study contributes to the literature by analyzing the implications of IQ in SSA for their export durations. Further contributions are the analyses of bilateral dissimilarities between exporters' and importers' IQ on the duration of trade, and of the impact of the various IQ attributes (*i.e.,* 'government selection, monitoring, and replacement'; 'efficiency of policy formulation and implementation'; and 'respect of citizens and state for institutions') separately to be able to identify differences in their effects. Therefore, this work delivers insights about the role of IQ in the context of stability of agri-food trade relations, informing policy makers about the relevance of the different IQ dimensions, and exporters about implications of picking export destinations with different IQs to accomplish longer trade relations.

(III) How do importers' stringency of food safety standards and dissimilarity with exporters therein affect the stability of bilateral trade relations?

Food safety standards of countries are another determinant of agri-food trade. On the one hand, standards can reduce information asymmetries or improve product quality, which might be demand-enhancing and increase trade. On the other hand, standards might induce higher costs and prices, which could reduce trade. Previous studies analyze their impact on trade values (*e.g.,* Santeramo and Lamonaca, 2019), however, neglect possible implications for the stability of trade relations, which can be both positively and negatively influenced by multiple channels that induce ambiguous effects based on the stringency and the dissimilarity of trading partner's food safety standards.

This study adds to the literature in three ways. First, it provides a literature-based theoretical framework identifying through which channels importers' stringency in food safety standards might affect the stability of agri-food trade relations. Second, it identifies different channels through which bilateral dissimilarity in food safety standards affect bilateral trade stability depending on which trade partner has stricter standards. Third, econometric analyses are carried out, answering the question on how importers' food safety stringency and the dissimilarity with exporters therein affect the stability of bilateral trade relations. To quantify food safety stringency for the empirical analysis, the study focuses on the MRLs. With respect to import trade stability, two dimensions are considered, namely trade duration, that is also used in the second study, and trade volatility The stability across both dimensions inform about the ability to ensure food availability in variety and volume which is an important policy goal directly linked to achieving food security. Food safety standards, such as MRLs, play a crucial role in promoting food safety, another aspect of food security. Therefore, this study helps to understand a potential determinant of agri-food trade stability, and informs about counteracting or reinforcing implications of the strictness of MRLs for agri-food trade stability, contributing to the ongoing debate about the harmonization of standards as pursued by the WTO.

(IV) How do firms' export activities and power in the labor input market impact each other?

The aim of the final study of this thesis is to examine the interplay between firms' export activities and their labor market power. It focuses on French food processing firms, which is an interesting case for this analysis, since the food sector is labor-intensive and faces challenges, such as labor shortages and pressure on labor costs (Caroli et al., 2009; Cérou, 2024). At the same time, in France, the food industry is a main manufacturing sector and key exporter of the EU renowned for its high-quality outputs (Caroli et al., 2009; USDA, 2024).

If firms have the power to pay wages below, or contrarily, if they have to pay wages above competitive levels, this has implications for their profitability, and thus, ability to export. Once engaging in international trade, particularly by exporting to competitive global markets, firms may face additional pressure to balance labor costs with productivity (Munch and Skaksen, 2008), or can enhance profits that may enable firms to offer higher wages or improve working conditions (Bernard and Jensen, 1999; Bernard et al., 1995; Schank et al., 2007).

Previous works that have explored the impact of exporting on labor market power find a positive effect (Amodio et al., 2024; Felix, 2022; Mertens, 2019). Further, numerous papers have investigated the relationship between exporting or labor market power with various factors, like productivity and wages, that might channel these effects and suggest unclear effects (*e.g.,* Bernard et al., 2006; Eaton and Kortum, 2002; Melitz, 2003). This study adds to the literature by employing instrumental variables to estimate the simultaneous relationships between various dimensions of exporting and labor market power. It considers if a firm participates in export markets, which is then broken down to firms' entry to export markets, the continuation to export, and their export intensity. Further, the relevance of different components of labor market power for this relation is investigated.

1.3 Data and methods

Each of the main research questions requires different methodological approaches and data at various aggregation levels. Figure 1.1 summarizes the thematic focus, geographical scope, aggregation level, and broad methodological classification of the main chapters of this thesis that separately address the four research questions. Chapters 2 and 4 present country-level studies at a global scale, whereas Chapter 3 includes countries in specific regions, namely SSA and the EU-28. Chapter 5 consists of a firm-level analysis, examining French firm data. While Chapter 2 employs an exploratory data analysis of changes in the agri-food trade pattern, including correlation analyses, the other studies rely on econometric methods to draw causal inferences.

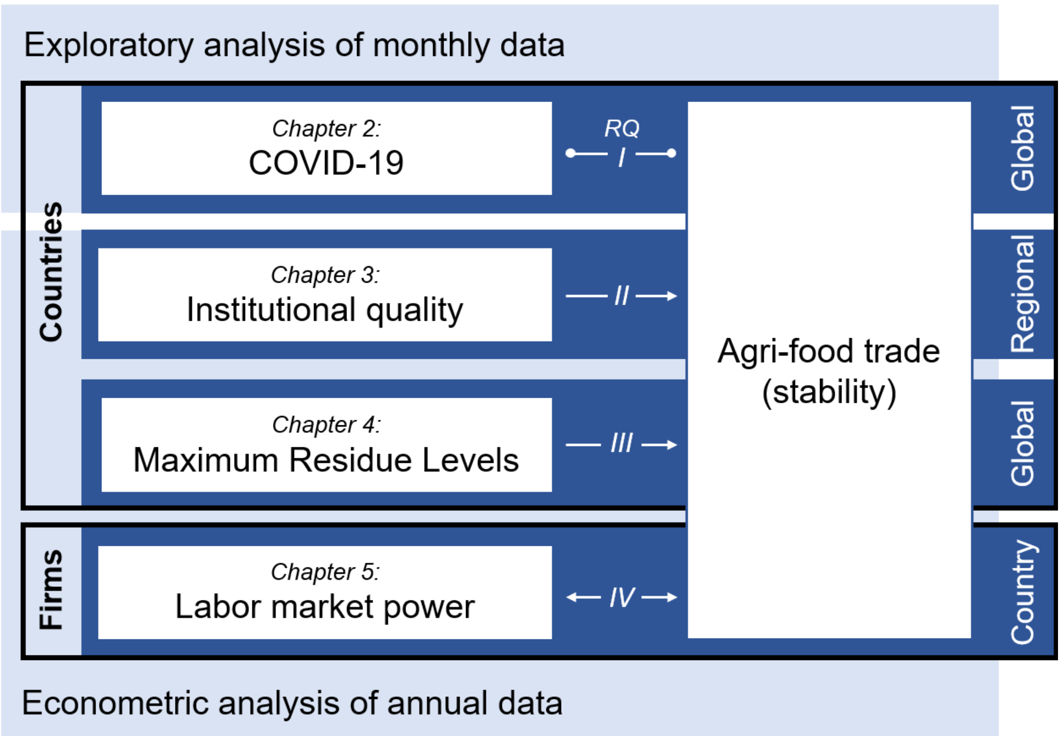

FIGURE 1.1: Perspectives of the empirical analyses

Note: This figure depicts the different perspectives of the empirical analyses included in this thesis that separately address the four main research questions. It illustrates the thematic focus of each main chapter, their geographical scope, aggregation level, and broad methodological classification, thereby summarizing the scope of this thesis.

Answering research question (I), requires data that enables to identify short-term changes during the event of COVID-19, thereby bilateral monthly trade values from Trade Data Monitor (TDM) are used. The data comprises agri-food commodities for 96 countries globally up to June 2020. Additional data on countries' incidence and mortality numbers (Dong et al., 2020; JHU, 2021), the policy stringency (Blavatnik School of Government, University of Oxford, 2021), the workplace and retail mobility (Google, 2021), and the industrial production (UNIDO, 2021) are used to identify further changes during the time of the pandemic.

Based on the mentioned data, a broad set of export and import trade indicators at the country and commodity level are constructed, and percentage changes in 2020 compared to their pre-pandemic monthly averages in 2018 and 2019 are calculated. The percentage change in monthly trade values and number of active trade links (*i.e.,* extensive margin of trade) in 2020 allow to infer changes in the average intensity of trade values per link (*i.e.,* intensive margin of trade). Based on absolute values, the state of regional net-trade positions (defined as export minus import value over the sum of export and import values) before and during COVID-19 are compared. Further, import and export diversification measures, such as Theil index and the Herfindahl index are computed. The Theil index measures the diversification of trade values across trade links, while the Herfindahl index allows to distinguish between the diversification along market and product dimensions, offering another layer to the analysis.

An exploratory data analysis is conducted using the constructed measures and their percentage changes. To identify changes during the first wave of COVID-19, changes across the months are visualized and descriptively analyzed. To examine the association of these changes in agri-food trade values and diversification with the pandemic related-factors, several correlation analyses are carried out.

In the third chapter, bilateral annual import values and quantities of agri-food products are used for the construction of the trade duration (UN Comtrade, 2022), which represents the persistence of uninterrupted trade flows of a given product between two trading partners over consecutive years. Following relevant literature (Besedeš et al., 2016; Hess and Persson, 2012), trade duration is constructed as a binary variable, indicating if a bilateral trade link survives or fails given that trade occurred in the previous year, and is used in a discrete-time hazard model. The dataset includes agri-food trade flows from the countries of SSA to the EU-28 member states from 1996 to 2017.

Further, the World Governance Indicators (WGIs) quantify six indicators in three dimensions of IQ assessing countries' (A) government selection, monitoring, and replacement; (B) governmental efficiency of policy formulation and implementation; and (C) respect of citizens and state for institutions (Kaufmann et al., 2010). To avoid the problem of multicollinearity, the six indicators are aggregated into a single index, which provides countries' overall IQ, and into the three dimensions (A–C), to identify the effects of the different aspects of IQ, following Asongu and Nwachukwu (2016); Bojnec and Fertő (2012); Globerman and Shapiro (2002); and Daude and Stein (2007). For the aggregations, Principle Component Analysis (PCA) is employed. This is done for the exporters' IQ and the dissimilarity index between trading partners.

Eight regressions constitute the core of the analysis. The binary trade duration is included as dependent variable in all econometric regressions and the different IQ indices (overall and subcategories) constitute the explanatory variables of interest in separate regressions. The discrete-time duration models are estimated using the probit model (Hess and Persson, 2012). Standardized marginal effects are calculated to compare the impact magnitude of the different IQ dimensions (Menard, 2004).

The study in the fourth chapter relies on the same source for the trade data, but extended the geographical scope to 164 countries globally and covers the years from 2005 to 2020. Based on this data, additional to trade duration, trade volatility is constructed as another dimension of trade stability, which reflects fluctuations in trade values/volumes across years. Trade volatility is quantified as the standard deviation of the actual bilateral trade values/volumes from the expected trade values/volumes (Guerra et al., 2019). Further, the third research question demands information on a countries' food safety standards, therefore, data on MRLs is used. MRL is a regulatory standard set by governments and supranational organizations, specifying the volume of substances —like pesticides, mycotoxins and veterinary drugs— that are legally tolerated on food and feed (European Commission, 2008; European Medicines Agency (EMA), 2024). The MRL data comes from the Lexagri International's Homologa (2021) database and has the advantage of wide geographical, time- and product-wise coverage along its relevance for agri-food products and quantification that allows for comparability. To specify the strictness of countries' MRLs, all MRLs are summarized into a standardized year-product-specific stringency measure per importer, and into a bilateral dissimilarity measure for each trading pair following Winchester et al. (2012) and Ferro et al. (2015). An additional index specifies the "direction" of countries' MRL dissimilarity,*i.e.,* whether the importer or the exporter is the more stringent partner country.

Based on econometric methods the impact of MRLs (stringency and dissimilarity) on trade duration and volatility is examined. Discrete-time duration models are applied to analyze the effects on trade duration. To capture the implications on trade volatility, the Poisson-Pseudo Maximum Likelihood (PPML) estimator is employed, following advancements in Gravity-model analysis, the workhorse of econometric assessments of the impact of policies and other factors on bilateral trade values (Santos Silva and Tenreyro, 2006; Yotov, 2024).

To address research question (IV), firm-level data is required. To this end, financial annual data from 2009 to 2020, along with additional data on time-invariant characteristics of French food and beverage processing firms, provided by Orbis, is utilized (Moody's, nd). Based on this data, firm-specific markdowns in the labor input market are calculated using the production function estimations (De Loecker and Warzynski, 2012; Jafari et al., 2023a), which allows for imperfections in input and output markets. The labor markdown shows if either a firm has the labor market power to pay wages below their marginal value of labor productivity, the workers have labor market power so that wages paid are above marginal value of labor productivity, or perfect competition exists in the labor input market. Further, the information on firms' export and total revenues is used to create different export variables that allow to examine a comprehensive picture on firms' export activities, namely firms' export participation, export entry, export continuation, and export intensity.

The estimated labor markdowns and the constructed export measures are used for the main analyses of Chapter 5, investigating their simultaneous relation. To reduce endogeneity issues, we estimate our specifications with the extended regression model and introduce instrumental variables (Wooldridge, 2016). Additionally, the relevance of the different components of labor markdowns for the relation is analyzed by regressing labor markdown on the firms' wages and productivity, separately and simultaneously, and plug the obtained residuals as "adjusted markdown" in the regression analyses instead of the markdown. This approach allows to determine whether wages and/or productivity are the main sources of the estimated effects, or whether the impacts arise from the residual component of the labor markdown (*e.g.,* output prices, remaining labor productivity).

1.4 Main findings

Relying on the discussed data and methods, the key findings associated with each research question are summarized in the following.

(I) Global agri-food trade experienced short-term disruptions during the first wave of COVID-19

Chapter 2 suggests an association between the COVID-19 pandemic and disruptions in agri-food trade values, links, and diversification, noting that most trade indicators have already recovered by June 2020.

Results show that countries' changes in agri-food trade values and diversification (*i.e.,* Theil index) are significantly correlated with their policy stringency, mobility rates, and changes in industrial production output; however, morbidity and mortality rates are not significantly related to the trade changes. Further, disruptions in agri-food trade values and the extensive margin of trade during the first wave of COVID-19 were limited to a short time period, primarily in April and May 2020, when global movement restrictions were at their peak. In June, global trade values rebounded or exceeded previous two-year averages. Non-food commodities, such as cotton and tobacco, experienced relatively more significant trade value reductions than foods, whereby some staple foods proved most resilient. Similar trends are observed for the Theil index. Comparing changes in the extensive and intensive margins of trade suggests that agri-food trade declined mainly along the extensive margin. Net trade positions generally did not change much across regions. Furthermore, differences across regions suggest that, given a higher level of development and regional integration, intra-regional trade proved more resilient than trade with other regions. The reverse holds for regions with a majority of countries at lower development stages. Lastly, the analysis shows that changes in trade diversification are mainly driven by a reduction in products, whereas declines in terms of trade partners are less pronounced.

(II) Institutional quality affects the duration of agri-food trade flows

The third chapter shows that, on average, agri-food export flows from SSA to EU-28 countries have a duration of 2.5 years. Results of the econometric analysis indicate that countries' institutional quality (IQ) is one determinant of the stability of agri-food trade relations. Higher IQ of exporters and similarity between the IQ of trading partners lead to a longer trade duration of bilateral trade links. This suggests that the low levels of IQ in SSA and high differences with EU-28 countries contribute to this short trade duration. It is further distinguished between the impacts of the three dimensions of IQ —"government selection, monitoring, and replacement"; "efficiency of policy formulation and implementation"; and "respect of citizens and state for institutions"—by comparing their standardized marginal effects. The regression results demonstrate that the quality of government selection, monitoring, and replacement in SSA, which is closely related to firms' stability of their business environment, has the largest effect on export duration. In terms of similarity, the institutional dimension evaluating the respect of citizens and state for institutions emerges as most significant. Thus, improving trade partners' compliance with common rules and standards, and institutional adjustments in exporting countries can contribute to an enhanced duration of trade relations. The variation in the impact across different institutional attributes suggests that targeting specific attributes of IQ may be meaningful.

(III) Food safety standards like MRLs affect the stability of agri-food trade flows

In the fourth chapter, various channels transmitting the impact of food safety stringency and dissimilarity across countries are identified based on literature and theory. According to this framework, the overall impact of countries' stringency and dissimilarity therein can be positive or negative depending the weight and interaction of the different channels. This established framework, but also the empirics discussed in the following, suggest that the stringency and bilateral dissimilarities in food safety standards such as MRLs have relevant implications for the stability of agri-food trade relations.

Empirical results show that stricter MRL standards of importing countries increase their trade stability, which means that they lead to longer trade duration and lower trade volatility of their bilateral import relations. The stability of trade relations also increases with lower differences in MRL standards between the countries, in which importers and exporters are located. These effects of bilateral MRL differences on both trade duration and volatility are similar regardless of the importing or exporting country being stricter. The simultaneous consideration of the results implies that, when importers have relatively low MRL stringency, setting their MRLs to a stricter level is implying higher food safety but also trade stability because of the importers' increase in stringency and the convergence with trading partners. When importers have already relatively stringent MRLs compared to other countries, further tightening these standards may come at the cost of negative impacts caused by the growing disparity between their standards with those of their trade partners. Consequently, importers who enforce standards exceeding the global average should recognize that these discrepancies could destabilize trade relationships.

(IV) French agri-food firms' export activities and labor market power influence each other

Most firms in the French food sector do not have labor market power, they pay wages above competitive levels, which suggests a strong position of the employees. The main results demonstrate that export participation and higher levels of export intensity are associated with lower labor markdowns, whereas firms' export entry does not have a significant effect. This suggests that the continuation to export drives this negative effect of participation on labor markdown. Reciprocally, higher labor markdowns of firms are shown to decrease their export intensities but do not significantly impact export participation, entry, or continuation. These simultaneous impacts between export intensity and labor markdowns indicate that an increase in export intensity reduces the firms' labor market power, thereby favoring the position of workers. In turn, higher labor market power of workers contributes to an increase in firms' export intensity.

Further investigating the relevance of different markdown components for explaining the mutual impacts indicates that the negative effect of participation on markdowns is primarily driven by changes in total factor productivity (TFP) and wage components of markdowns. Additionally, export entry might increase the remaining part of markdowns (other than TFP and wages) possibly related to labor productivity and/or output prices. The effect of labor markdowns on export participation, entry, and continuation remains insignificant when emphasizing the separate components of markdown. Regression analyses also reveal that the two-way relationship with export intensity is influenced by all markdown components.

To summarize, the objective of this thesis was to better understand and investigate the relations of different factors with agri-food trade activities, particularly trade stability. These factors include the COVID-19 pandemic, countries' institutional quality and food safety standard stringency (*e.g.,* MRLs), and firms' power in the labor market. For the latter, simultaneity requires to analyze not only the impact on trade measures but also the impact of export activities on labor market power. Our studies show that all analyzed factors are somehow relevant for the agri-food trade system, thereby determining food security: (I) COVID-19-related measures are associated with reductions in agri-food trade values, (II) higher IQ in exporting countries and similar IQ in trading partners' countries enhance bilateral trade duration, (III) higher MRL stringency in importing countries and similar stringency levels increase bilateral trade stability in terms of trade duration and volatility, and (IV) firms' export activities and labor market power mutually influence each other.

1.5 Policy implications

This thesis delivers several implications for policy makers and other stakeholders related to agri-food trade. First, despite the occurrence of a systematic shock like COVID-19, trade of necessities such as foods, particularly stable foods, continue to flow relatively smoothly and therefore proved resilient to the shock. Disruptions to the agri-food trade system were limited to a short time period at the beginning of COVID-19, in which uncertainty about the transmission of the virus and intervention measures were especially high. This implies that governments and other relevant stakeholders have already contributed to keeping agri-food trade flowing, highlighting the relevance of the trade stability of this product category.

Second, policy and stakeholder engagement for improving institutional quality, as well as exporters picking trade partners in countries with similar institutional environments can help to stabilize trade relations, since the second study underscores the importance of functioning institutions and of having trade partners that align with similar IQs for agri-food trade stability. Given the significantly lower IQs of many SSA countries compared to individual EU-28 members (and below the global average), there is substantial scope for institutional adjustments, which can also enhance trade stability by improving the common understanding of the business environment of trade partners. The positive impact of the similarity of the institutional environments of trading partners motivates exporters and importers to strategically select trade partners to foster long-term partnerships.

Third, with MRL adjustments, countries or supranational organizations can contribute to the stability of trade relations in the agri-food sector. In importing countries that have less strict MRLs than their trade partners, an increase in MRL stringency can improve trade stability through the importers strictness and by reducing bilateral MRL dissimilarities. However, when the country of the importer already has stricter MRLs, an increase in stringency might lead to a trade-off between destabilizing enhanced discrepancies in MRLs and a stabilizing increased stringency. Therefore, importers implementing/maintaining MRLs that exceed the global average should consider the potential adverse effects on their trade stability through higher discrepancies. They should verify the need and only impose stricter MRLs, when grounded in sound scientific evidence. Also along the lines of global MRL harmonization, such as aimed by the WTO, the potential trade-offs between trade stability and product safety needs consideration. Consequently, governments should strive for harmonized scientific MRLs to ensure food safety globally that can also improve agri-food trade stability and thus food availability.

Fourth, this dissertation delivers insights for policy makers responsible for labor market or export-related measurements. Changes in the labor law that favor the employees power on the labor market might induce higher export intensities of food processing firms in France. Export promoting policies (that increase export participation and intensity) would induce also reductions in labor market power of firms. Thus, the interplay between employees' labor market power and export activities is found to be of relevance and seems to enforce each other. However, the probability is high that, when relative wages increase over-proportionally, there may be a tipping point making firms unprofitable. Further, French food processing firms that aim to enhance their labor market power while simultaneously increasing their export intensity face conflicting objectives, all also determined by the French labor market and export conditions. Characteristics of exporters other than their exporting activities that might have further implications for labor market power (*e.g.,* firms size) should additionally be considered by political and firm-level decision makers.

In a nutshell, this thesis underscores the complexities of the trade system, which connects various exporters and importers, each surrounded by differing laws, political measures, geographical constraints, and other factors. By analyzing various determinants in four distinct studies, this work contributes to the understanding of these complexities, shows the resilience during the first wave of COVID-19, and offers insights that could inform decisions regarding the own and trading partners' IQ, food safety standards, and labor market power. Considering these insights can foster agri-food trade and contribute to food security.

1.6 Limitations and future research avenues

While the first study reveals that the simultaneity of the implementation of strict virus containment measures and changes in international agri-food trade suggests a clear association between COVID-19-related changes and short-term trade disruptions, the results should be interpreted with caution. Some factors that might have influenced the observed trade changes during the study period are not controlled for. Causal inference cannot be claimed, therefore, adopting more advanced quantitative methods could yield deeper insights into the impact of the pandemic-related factors on trade. Due to data limitations, the analysis does not decompose trade values into price and quantity components at the commodity level. Further analysis using trade quantities could complement our findings, given the significant price variations across time, commodities, and countries.

The second paper neglects the analysis on how different subcategories of IQ might substitute or complement each other in determining the overall impact of IQ on the stability of trade relations. Additionally, the impact of other factors, such as the implementation of (agri-food) trade-related policies, on trade relations may depend on a country's IQ. If these factors are not adequately controlled for, they could bias the estimated effects of IQ on trade duration. Analyzing the interactions between different IQ dimensions or with such policies, and assessing their impact on trade duration offers potential scope for further research. Furthermore, we cannot claim external validity, which makes exploring the IQ effects of country groups other than SSA and EU-28 countries an interesting pathway for future studies.

While the theoretical framework conceptualizes the impact of food safety standards on trade stability, the empirical analysis of the third study does not allow to draw implications for all these standards. MRLs are important but there exist numerous food safety standards that might play an important role for the stability of trade relationships either standalone or via interaction with MRLs or other standards. In this study, we rely on MRL data because of its relevance for agri-food products and the data accessibility for many countries and products. Further, only the overall effects of MRL policies for each product is considered and no distinction between different substances is made, even though Hejazi et al. (2022) find that insecticides are most trade-restrictive among chemicals, whereas strict herbicide policies have a potential demand-enhancing effect. While these findings relate to changes in trade values and not trade stability, it is important to note that different substances have their unique characteristics in terms of compliance costs and consumer perceptions of risk, which might also lead to different impacts on trade stability. Finally, countries' quality of institutions may also play a role for the enforcement of food safety standards (Swinnen, 2016). Thus, considering the impact of different types of substances and/or their interactions to identify possible contrary or mutually re-enforcing effects, and combining study two and four by looking at the effect of standards depending on countries' institutional quality on the stability of trade offer potential scope for future research.

There exists a trade-off between geographical coverages and aggregation levels. In the first three studies, trade data aggregated to country-level was used for the empirical analyses, since the lack of data availability often limits possibilities to conduct studies at less aggregated levels. The last study of this thesis is conducted at firm level, analyzing the case of French food processing sector. While findings of this study offer valuable insights into the French food and beverage industry, their external validity is limited due to the specific labor and export conditions of this sector in France. Further, the reliance on deflated values instead of physical quantities for estimating markdowns introduces potential biases, which could be mitigated when input and output quantities were available. Another limitation is that the data does not distinguish between the plants and destinations of each firm. Therefore, we cannot control for the location of the food processing sites, which could capture location-specific labor market characteristics, closeness to the border; and also not for the role of export market diversification and destination-specific characteristics. By linking firm-level data with customs data that specify destinations, future research could provide deeper insights into the implications of export destinations for labor market power and trade dynamics. Custom data would also allow to analyze the interplay of firms' imports and labor market power, which adds another crucial layer of the interactions of trade with domestic input market dynamics. Such a dataset may also enable addressing the research questions in Chapters 2 to 4 with firm-level analyses that would allow for the examination of the impacts of IQ and MRLs (and, if monthly data after 2020 is available, of COVID-19) at a more disaggregated level. For example, conducting the trade stability studies at the firm level would add to the existing trade stability literature, which —with very few exceptions— focuses on country-level analyses.

1.7 Structure and included papers

The subsequent Chapters 2 to 5 include the research papers based on four studies, each separately focusing on one of the main research questions of this thesis (please see Figure 1.1 for an overview). The full papers can be read independently and give more details on the backgrounds, methods, data, results, and implications of each study than delivered in this introductory chapter.[4]

Chapter 2 addresses research question (I) and is published as *"Engemann, H., & Jafari, Y. (2022). COVID-19 and changes in global agri-food trade. Q Open, 2(1), qoac013"*.

The Chapter 3 contains an article published as *"Engemann, H., Jafari, Y., & Heckelei, T. (2023). Institutional quality and the duration of agri-food trade flows. Journal of Agricultural Economics, 74(1), 135-154"*, answering research question (II).

[4]The present research has been funded by the European Union's Horizon 2020 research and innovation program under grant agreement no 861932 (BATModel), and partly received financial support from the FAO. The views expressed here are solely those of the authors of the papers and do not in any circumstances reflect the views or policies of the European Commission and the FAO.

The research article included as Chapter 4 is published in Applied Economic Perspectives and Policy as *"Engemann, H., Jafari, Y., & Heckelei, T. (2025). Stringency and dissimilarity of Maximum Residue Levels affect bilateral agri-food trade stability. Applied Economic Perspectives and Policy, 2025:1–29"*, and focuses on research question (III).

Lastly, Chapter 5 addresses research question (IV) and will be submitted for journal publication. The research paper is co-authored with Yaghoob Jafari, Thomas Heckelei, and Karine Latouche.

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Chapter 2

COVID-19 and changes in global agri-food trade[†]

Abstract: COVID-19 has raised questions about the resilience of agri-food trade to global shocks to the system. This paper analyses the changes in agri-food trade (values, extensive and intensive margin, and diversification) during the pandemic at global and regional levels. It also considers parallels in the changes in agri-food trade and changes of various COVID-19-related factors (infections, deaths, mobility, policy stringency, and industrial production output). The results show that changes in trade remained limited to short-term disruptions that mostly occurred at the extensive margin of trade and, primarily, at the height of policy stringency, mobility reductions, and the overall reduction of economic output. The trade of staples was most resilient, while that of other agri-food products declined considerably. Inter-regional trade of Asia, Africa, and Latin America and the Caribbean proved generally more resilient than these regions' intra-regional trade.

***Keywords**: COVID-19 pandemic, agri-food trade, extensive and intensive margin of trade, trade diversification*

[†] Chapter 2 is published as Engemann, H., & Jafari, Y. (2022). COVID-19 and changes in global agri-food trade. Q Open, 2(1), qoac013, https://doi.org/10.1093/qopen/qoac013.

2.1 Introduction

The rapid spread of the coronavirus disease 2019 (COVID-19) has increased morbidity and mortality rates worldwide. Countries implemented a multitude of policies to curb the spread of the virus and reduce the pressure on health systems. The pandemic's impact on public health, together with global mobility restrictions and macroeconomic impacts, has affected the supply, demand, and global trade of agri-food products. Trade policies were imposed to restrict imports and exports out of fear of contamination and to ensure the domestic availability of products, respectively. Meanwhile, trade-promoting policies, such as quota expansions and lowering non-tariff barriers, were implemented to counteract the negative impacts on food availability and access (FAO, 2021a).The unprecedented shocks caused by the pandemic and the policy interventions have created concerns over the resilience of the global food system. Will countries depending on agri-food imports still be able to meet their import demand? Will agri-food exporters still be able to generate sufficient export earnings? In this regard, what is the role of the structure of global agri-food trade?

This paper analyses the changes in agri-food exports and imports and their level of di- versification at global and regional levels during the first phase of the COVID-19 outbreak. In this respect, the association of several pandemic-related factors with changes in different dimensions of the agri-food trade network is considered. Pandemic-related factors include changes in the infection rate, death rate, retail and workplace mobility measures, policy stringency, and induced macroeconomic factors. The consideration of different dimensions includes changes in total trade values and the distinction between changes in the intensive (trade values of existing trade links) and extensive (number of trade links) margins of trade. Furthermore, this paper considers the changes in trade diversification along the extensive and intensive margins and in terms of market and product portfolios.

COVID-19 has affected trade through multiple channels. The primary impact of COVID-19 on trade occurred when mortality and morbidity hit workers, leading to lower labor productivity (see, *e.g.,* Keogh-Brown et al., 2020; McKibbin and Fernando, 2021) and thus, reduced trade values and volumes. These effects are similar to those found for outbreaks of HIV/AIDS (Arndt and Lewis, 2001), SARS (Lee and McKibbin, 2012), the 2009 H1N1 epidemic (Dixon et al., 2010), and Ebola (World Bank, 2014). The indirect effects of the COVID-19 pandemic included a range of containment and prevention measures. These measures resulted in policy-induced shocks on demand, such as the impact of restaurant closures (see *e.g.,* Baldwin, 2020; Brodeur et al., 2021; Lahcen et al., 2020; Roson and Van der Vorst, 2021), or supply, such as the impact of labor mobility restrictions (Lahcen et al., 2020; Roson and Costa, 2020) or both (Nechifor et al., 2020a,2,2). Trade is also affected when policies that restrict imports and exports are directly implemented at international borders (European Commission, 2020a,2; OECD, 2020). The range of direct and indirect policy-induced impacts affects almost all segments of domestic and global value chains (GVCs) in the agri-food system. Moreover, the health impact of the pandemic and policy-related measures directly affect output, demand, and trade and can spill over to the economy and result in deepening the initial impacts. In this respect, the economic downturn in several epicenters of the pandemic (China, then Europe, then the United States) led to a steep decline in global demand and affected global trade (FAO, 2021a; Laborde et al., 2021).

Countries participate in international trade to ensure or increase the availability and diversity of food products in their domestic markets and to generate income earnings from their exports. In food import-dependent countries, agri-food trade ensures people's access to food at reasonable prices and to provide a variety of different types of foods to enable healthy diets (FAO, 2015). In export-dependent countries, trade shocks significantly influence agri-food producers' earnings (FAO, 2015), particularly in developing countries, for which an important source of income is revenues from agri-food exports (FAO/UNCTAD, 2017). The literature suggests that trade increases and economic development and sustainable outcomes are promoted through participation in agricultural GVCs (FAO, 2020b). Nonetheless, the impact of shocks on agricultural and food exports and imports might differ depending on the role and degree of integration into global markets and GVCs (Koppenberg et al., 2021). Although strong integration in trade networks could potentially mitigate the impacts when only parts of the global system are affected, the effect on the entire network has been the concern of the emerging literature related to COVID-19.

Most attempts to shed light on the aforementioned concerns in the early literature were carried out using descriptive analysis to identify the short-term impacts or simulation analysis to project potential mid- and long-term impacts.[1] The main finding of this body of literature is that, despite uncertainties revolving around the continuation of the pandemic, the efforts of governments and agri-food sector stakeholders worldwide

[1] Arita et al. (2022) are the first who econometrically examine the factors affecting agricultural trade values and the extensive margin of trade of different products and regions.

have helped keep food and agricultural trade flowing (Barichello, 2021; Beckman and Countryman, 2021; FAO, 2021a; Hailu, 2021; Schmidhuber and Qiao, 2020a).

To analyze the relevance of COVID-19 for the agri-food trade system, this paper examines the changes in a set of trade indicators and diversification measures. The primary focus is on the first wave of COVID-19 (*i.e.,* first half of 2020 relative to the equivalent monthly averages of 2018 and 2019), during which the most significant changes in agricultural and food trade values are observed. The analysis is based on monthly trade data of 96 countries at the HS 6-digit commodity level. The trade indicators considered in this study are trade values, trade links and various trade diversification measures, such as the Theil, Gini, and Herfindahl indices showing the distribution of trade values across trade links. Moreover, the Theil index is decomposed to obtain information on changes in the distribution along the extensive and intensive margins of trade. The Herfindahl index is also modified to distinguish between product and market diversification. In addition, a correlation analysis is applied to test the association of pandemic-related factors (infection rate, death rate, retail and workplace mobility measures, policy stringency, and induced macroeconomic factors) with changes in trade values and diversification at the country level.

This paper contributes to the literature in three ways. First, this paper analyses changes in the trade system during the first wave of COVID-19 in terms of both the extensive and intensive margins of trade and the diversification of trade flows along both margins. Second, this paper investigates monthly changes in the agri-food trade network at both global and regional levels and across product groups. Third, this paper analyses the association of pandemic-related factors with changes in the trade system in terms of both values and the distribution of values across trade links.

This paper is organized as follows. The next section summarizes some key features of the COVID-19 outbreak and discusses different impact channels on agri-food trade. Specific research questions are derived using this background information. Next, the approach and data for calculating the trade indicators and diversification measures are presented. Then, the results are presented and the final section concludes.

2.2 Background and derived research questions

On 31 December 2019, the World Health Organization (WHO) was informed of pneumonia cases with an unknown cause in Wuhan City, China. On 7 January 2020, Chinese authorities recognized as the cause of the disease a novel coronavirus that previously had not been identified in humans. On 11 March 2020, following its rapid spread outside China, the WHO declared the outbreak of COVID-19 as a pandemic (WHO, 2020). The pandemic significantly affected health systems and resulted in the formulation of various containment measures that, in turn, reduced economic activities and resulted in reduced economic activity and affected the global trade system.

2.2.1 Morbidity and mortality rates

Changes in mortality and morbidity rates are factors that can interrupt the trade network. Mortality and morbidity rates directly affect labor availability. Since the outbreak of the pandemic, infection and mortality rates increased and picked up significantly from March (Panel A of Figure 2.1). The increased morbidity reduced labor productivity (Bochtis et al., 2020; Petrov et al., 2021) that, in turn, resulted in a supply decrease.[2]

2.2.2 Policy responses

In response to COVID-19's direct health impacts, virus containment measures were first imposed during the first half of the year, particularly, from March to June. As shown in Panel B of Figure 2.1, policy stringency as reflected by the Oxford Stringency Index increased, and workplace and retail mobility rates as measured by Google Mobility indices declined substantially from March to June.

The measures implemented to curb the circulation of the virus had disruptive effects on the value chains of many products, including on agri-food markets (Hale et al., 2020; Laborde et al., 2020). On the supply side, measures such as border closures and mobility restrictions led to shortages in labor, which, together with shutdowns and (partial) business closures, affected the availability of inputs, agricultural production, food industry, and the distribution of products in domestic and international markets (Bochtis et al., 2020; Larue, 2020; Schmidhuber and Qiao, 2020b). To counteract supply chain disruptions, countries provided logistics and marketing support, direct transfers, and loans to producers and traders (FAO, 2021a).On the demand side, reduced incomes, restrictions on the movement of people, fear of infection, and widespread closures of the hospitality sector induced

[2] See Melitz (2003) and subsequent literature on firm heterogeneity showing the negative impact of productivity reductions on trade. Lower productivity increases the cost of production and trade, thereby leading to less profitable firms, which can discourage them from operating in foreign markets.

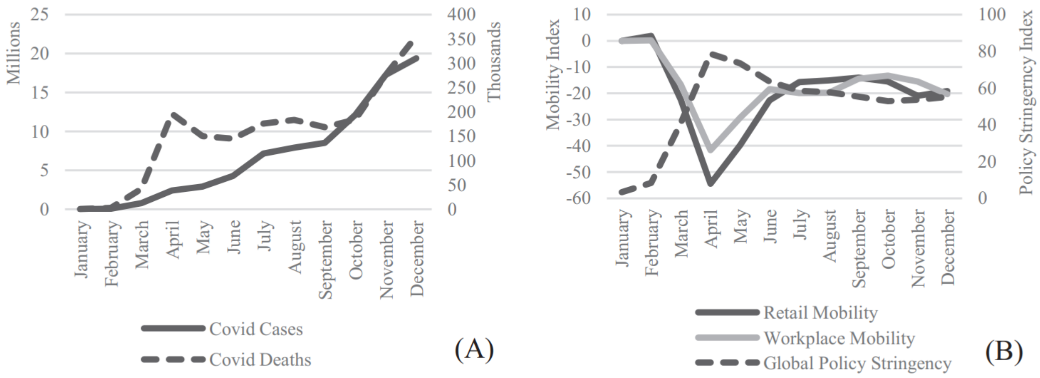


FIGURE 2.1: Evolution of global COVID-19 indicators and related factors

Source: Own calculations based on data from John Hopkins University (Dong et al., 2020; JHU, 2021), Oxford Stringency Index (Blavatnik School of Government, University of Oxford, 2021) and Google Mobility indices (Google, 2021). Remark: The mobility index is normalized with respect to its value in the base month of January 2020.

immediate changes in consumption patterns (Cranfield, 2020; FAO, 2020a; Goolsbee and Syverson, 2021; Hailu, 2021; Hobbs, 2020).

Countries imposed a range of trade policy measures to mitigate the impacts of the pandemic and the measures to contain it on food security and food safety (see FAO, 2021a). On the one hand, several countries restricted exports to ensure the domestic availability of food, particularly during the second quarter of 2020. Import restrictions, sanitary, and phytosanitary measures and additional certification requirements were applied to contain possible virus transmission through food imports. Both export and import restrictions implied direct trade disruptions. The measures also induced indirect impacts on GVCs for which traded commodities served as intermediate inputs in more downstream value chain segments. On the other hand, many countries committed to refrain from trade-restricting measures to alleviate supply chain disruptions and ensure global food security. Some exporters lowered export duties or implemented airfreight assistance programs to support their traders in overcoming transportation and logistics disruptions. Several countries lowered import tariffs and adopted trade facilitating practices, such as the digitalization of trade-related procedures, simplified import-licensing procedures, and the establishment of green corridors to accelerate the delivery of selected food products (FAO, 2021a).

Both domestic and trade measures affected trade values and the distribution of trade values noticeably across countries and products. Indeed, Arita et al. (2022) show strong impacts of policy restrictions and reduced human mobility rates on agri-food trade, whereas the effects of morbidity and mortality rates remained limited.

2.2.3 Macroeconomic factors and food prices

The direct health impacts and policy responses have resulted in a downturn in economic activity, which affected the trade network (Vickers et al., 2020). Global GDP in 2020 declined by 3.41% year-on-year (World Bank, 2021). Global industrial economic output started to decline in March (when it was 15% lower than its same month average in 2018 and 2019) and further reduced in April to approximately –25% of the same monthly average value (see Figure 2.2). In May, industrial output started to rebound but remained far below its 2018/2019 value (-20%). In June, industrial output rebounded to 5% less than its average monthly value. Thereafter, changes in industrial output remained within the range of -5% and +1% of the same monthly averages of previous years. These changes reflect the changes in mobility constraints and policy stringency, as given in Panel B of Figure 2.1. Global industrial output is negatively correlated with policy stringency ($r = -.61$, $p < .0001$, $n = 358$) and positively correlated with mobility measures; the lower the retail and workforce mobility, the lower the economic output (retail mobility: $r = .70$, $p < .0001$, $n = 337$; work mobility: $r = .66$, $p < .0001$, $n = 337$).

Along with the reduction in global industrial output, global food prices also decreased (Figure 2.2; Elleby et al. (2020)), albeit this reduction in prices was less than that of industrial commodity prices, mainly due to lower income elasticities (World Bank, 2020).Food prices reacted differently at the commodity level because of differences in demand and supply responses, which reflect differences in policies and expectations related to individual commodities, types of products (such as perishability and storability) , income elasticities, etc. For example, the prices of agricultural products that have stronger linkages with the demand for industrial goods, such as rubber, cotton, vegetable oils, and sugar cane dropped more significantly than the prices of products with weak linkages to industrial demand such as meat and dairy products (FAO, 2021a).These heterogeneous price responses at the commodity level led to differential price impacts across countries, because countries trade different bundles of commodities.[3]

The pandemic and related policy measures were also associated with changes in other macroeconomic factors including exchange rates (Gen-Fu et al., 2021). As countries export and import different bundles of products and changes in trade across products

[3] Data limitations mean that we do not consider heterogeneous price impacts across countries and commodities in our study.

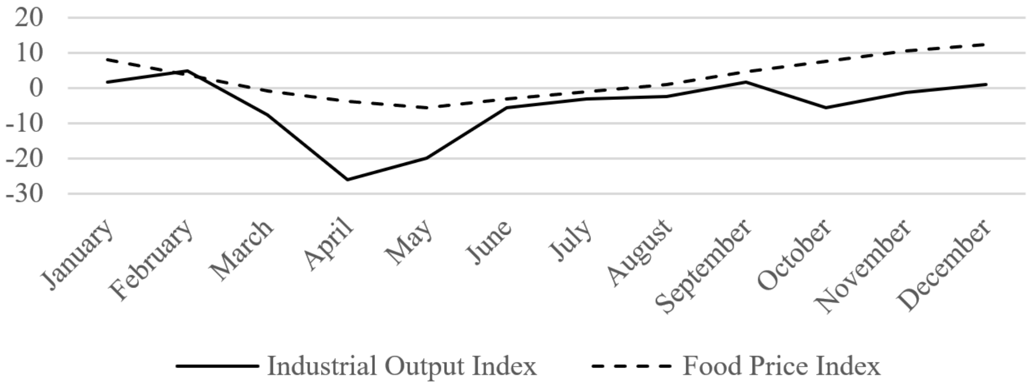


FIGURE 2.2: Percentage changes in global industrial output and food prices

Source: Own calculations based on the Monthly Index of Industrial Production (UNIDO, 2021) and the Food Price Index (FAO, 2021b).

were not uni- form, the ratio of export and import value changes resulted in shifts in the relative demand for and supply of currencies.

The changes in economic output, price and exchange rate, in turn, affected trade. The simultaneous changes of these macroeconomic variables and trade are the result of the interaction of a multitude of supply and demand side factors. Given the purpose of this analysis, that is, to describe changes in agri-food trade and draw parallels between trade and COVID-19 related measures, the quantification of the causal relationships is beyond the scope of this paper.

2.2.4 Empirics of COVID-19 and agri-food trade

Given the simultaneity and multitude of the impacts, the empirical literature generally does not distinguish between changes in these factors individually and their association with changes in agri-food trade but, rather, focuses on the assessment of the collective impact of COVID-19. An exception is a study by Arita et al. (2022), who econometrically show that an increase in COVID-19 incidence rates, governmental policy restrictions and declining human mobility led to reductions in agricultural trade in a range of 5 to 10%. Overall, few studies analyze the relevance of the pandemic for agri-food trade. Most of these studies rely on descriptive statistical methods and find only short-lived impacts, which are consistent with the peak of the policy measures and the short-term application of countries' trade restrictions.

The studies find that the decline in trade in non-agricultural sectors was generally more significant than the reduction in agri-food trade (Arita et al., 2022; WTO, 2020,2).

Arita et al. (2022) show that trade in both agricultural and non-agricultural products decreased in the second quarter of 2020 by approximately 2% and 18%, respectively.[4] The recovery of trade in subsequent quarters resulted in annual percentage changes of +3.5% for agricultural and -6% for non-agricultural products compared with the year before.[5] Thus, agri-food trade seems to have been more resilient compared with trade in non-agricultural sectors, whereas staple food product trade was more resilient than trade in non-staples against the shock.[6] In addition, the authors show that trade for least developed and low-income countries was most vulnerable to the shocks.

Beckman and Countryman (2021) find a total increase in global agricultural trade value of 2.3% in 2020 compared with 2019 but heterogeneous impacts across commodity groups. They show that the trade values of major food products (*e.g.,* coarse grains, sugar, and oilseeds) increased, whereas trade of other products, such as beverages, tobacco, and plant-fibers, experienced reductions of more than 10%.

Similarly, Schmidhuber and Qiao (2020a) show changes in biannual agri-food trade from 2019 to 2020 (0.8% increase in the first six months) and conclude that global food markets are resilient to COVID-19 shocks. In particular, the authors find a limited impact on staple foodstuffs (changes up to +11.2% for oilseeds and oleaginous fruits) and some food products important for a healthy diet, such as fruits and vegetables (2.5%).

Vickers et al. (2020) examine the impacts of COVID-19 on the food trade of Commonwealth countries and argue that national lockdowns affected domestic economic activities and trade logistics. These lockdowns also reduced the Commonwealth's exports between February and May 2020 relative to the same monthly averages for 2018 and 2019. How- ever, exports from African Commonwealth countries decreased only in May 2020 following a subsequent introduction of lockdown measures in these countries.

Barichello (2021) shows that the pandemic's impact on Canadian agricultural trade in 2020 (year-on-year increase of 11%) differed substantially from the expected impact at the beginning of the pandemic (decline of 12% to 20%). Consistent with this finding, Hailu (2021) also shows that the pandemic hit Canadian food exports

[4]All agricultural products are HS codes considered under the USDA's BICO definition of agricultural and agricultural-related goods, and non-agricultural products cover all other HS codes. They also show that reductions are mainly driven by reductions in the extensive margin of trade (8–10%).

[5]The authors associate the recovery with the less stringent restrictions in subsequent years and the learning effects from the preceding quarter that resulted in supply chain adjustments.

[6]These differences can be explained by the necessity of food and, accordingly, lower income-elasticity of food products (WTO, 2020).

in April and May 2020; however, thereafter, exports were higher than in the same months in 2019.

Based on combined CGE and household model simulations, Laborde et al. (2021) project a decline in global trade from both demand and supply-side effects. Elleby et al. (2020) employ a recursive dynamic partial equilibrium model (Aglink-Cosimo) and project that the rather inelastic nature of food consumption toward prices would prevent a sharp decline in agri-food trade.

2.2.5 Specific research question

Based on the discussion of individual impact channels and the evidence found in the literature, we derive several specific research questions (RQs) . The first question (RQ1) is whether increased morbidity and mortality rates induced policy responses, and macroeconomic impacts are significantly related to changes in trade values. Subsequent questions simultaneously consider the channels. The following questions are asked: (RQ2) What are the direction and the magnitude of the changes in global trade values during COVID-19? (RQ3) How does the impact on trade values differ across regions and commodities? (RQ4) What are the changes in the extensive and intensive margin of trade at global and regional levels during the pandemic? (RQ5) Are there changes in the net trade position of the different regions? (RQ6) Are there differences in the changes in the inter- and intra-regional trade values? Moreover, we consider several questions regarding the diversification of the agri- food trade and question (RQ7) the relationship between individual impact channels with trade diversification. (RQ8) What are the changes in the diversification of the trade system globally, regionally, and across commodities? (RQ9) Are there differences in the diversification along the extensive and intensive margins of trade? Finally, we ask (RQ10) whether changes in trade diversification occur more along market or product diversification.

2.3 Empirical approach and data

To answer the questions, we examine a set of export and import trade indicators and diversification measures at the global, regional, and commodity levels. We calculate the indicators and measures for the first half of 2020 on a monthly basis and compare them to the same monthly averages of 2018 and 2019.[7] Moreover, we run a correlation analysis to examine the relations of the individual indicators of

[7] An overview of global changes in agri-food trade through December 2020 is provided in Figure 2.3.

COVID-19 with the changes in agri-food import values and import diversification measures.

We consider three trade indicators, namely percentage change in trade values, percentage change in the number of active trade links and absolute values of the regional agri-food net trade positions. The percentage changes in monthly import and export trade values reflect the overall changes in trade during the pandemic compared to the pre-pandemic period. The percentage changes in the number of active trade links (*i.e.,* the number of exporting and importing country pairs per HS 6-digit product level for each month) denote the changes in the extensive margin of trade. We use information on the changes in total trade value and the extensive trade margin to deduce changes in the intensive margin of trade. The total trade value *Q* as the product of the number of trade links *N* (*i.e.*, the extensive margin of trade) times the average of the trade values per trade link *q* (*i.e.,* intensive margin of trade) results in $Q = Nq$. Therefore, we can infer the intensive margin of trade *q* from the changes in total trade values *Q* and the changes in the extensive margin of trade *N*.[8]

We also compare the net agri-food trade position at a regional level before and during the pandemic. This indicator is defined as the regional trade balance (export minus import value) over the trade value (sum of export and import values) and varies between -1 and 1. A positive number indicates net exporting regions, and a negative number indicates net importing regions. The higher the index, the stronger the position of the region towards having a positive trade balance.

We further use three diversification/concentration measures (hereafter called diversification measures) before and after the pandemic. These diversification measures include the Theil index, the Gini index, and the Herfindahl index and are applied to measure both import and export diversification. We present the calculation of the import diversification measures but skip the presentation of the export diversification measures because they are analogous to the import side diversification measures.

The Theil index measures the inequality of trade values across trade links based on the maximum possible entropy of the data (*i.e.,* complete equality in the distribution) and the observed entropy and ranges from zero to an infinite number. A higher Theil index shows greater inequality. We follow the reasoning of Cadot et al. (2011) and calculate the Theil entropy index to measure the diversification of trade values across trade links. We then attribute the total Theil index to the within-group components

[8]Taking the natural logarithm of both sides $\ln(Q) = \ln(N) + \ln(q)$ leads to $\frac{dQ}{Q} = \frac{dN}{N} + \frac{dq}{q}$ after total differentiation. Based on this formula, we infer the change in the intensive margin of trade.

that show diversification along the intensive margin of trade and the between-group components that show diversification along the extensive margin of trade. The change in the diversification along the extensive margin of trade refers to the change in the number of active trade links by each commodity and each source of imports. The change in diversification along the intensive margin of trade refers to the change in the equality of the import values across the existing trade links. The Theil index $T_{i,m,t}$ as an overall diversification measure for product i in importing country m in year t is calculated as[9]

$$T_{i,m,t} = \frac{1}{N_{i,m,t}} \sum_{x=1}^{N_{i,m,t}} \frac{V_{i,m,t,x}}{\mu_{i,m,t}} \ln\left(\frac{V_{i,m,t,x}}{\mu_{i,m,t}}\right), \quad (2.1)$$

where $\mu_{i,m,t} = \frac{1}{N_{i,m,t}} \sum_{x=1}^{N_{i,m,t}} V_{i,m,t,x}$. Considering that each trade link refers to the trade value of commodity i imported by country m from exporter x in year t, the trade value occurring at each trade link is defined as $V_{i,m,t,x}$. Additionally, $N_{i,m,t}$ refers to the number of trade links available for an importing country.

The decomposition of the total Theil index, $T_{i,m,t}$, into within-group ($T^W_{i,m,t}$) and between-group ($T^B_{i,m,t}$) components ensures that:

$$T_{i,m,t} = T^W_{i,m,t} + T^B_{i,m,t}. \quad (2.2)$$

The between-group Theil index is defined as:

$$T^B_{i,m,t} = \sum_{g=0}^{1} \frac{N^g_{i,m,t}}{N_{i,m,t}} \frac{\mu^g_{i,m,t}}{\mu_{i,m,t}} \ln\left(\frac{\mu^g_{i,m,t}}{\mu_{i,m,t}}\right). \quad (2.3)$$

The superscript g refers to each group of observations: zero and non-zero. $N^g_{i,m,t}$ is the number of import links in group g, and $\mu^g_{i,m,t}$ is the average trade value.

The within-group Theil index is defined as:

$$T^W_{i,m,t} = \sum_{g=0}^{1} \frac{N^g_{i,m,t}}{N_{i,m,t}} \frac{\mu^g_{i,m,t}}{\mu_{i,m,t}} \left[\frac{1}{N^g_{i,m,t}} \sum_{x \in g} \frac{V^g_{i,m,t,x}}{\mu^g_{i,m,t}} \ln\left(\frac{V^g_{i,m,t,x}}{\mu^g_{i,m,t}}\right)\right]. \quad (2.4)$$

The Gini index as an alternative measure to the Theil index shows the extent of inequality in trade values across different import links, that is, the diversification of import values across different trade links. It ranges between zero, which indicates

[9] The export diversification measures can be simply obtained by changing the notation *m* to exporter *x* and vice versa.

complete equality, and one, which indicates complete inequality in import shares across different import links. Following Jaimovich (2012), we calculate the Gini index using

$$\text{Gini}_{i,m,t} = 2\frac{\sum_{x=1}^{N_{i,t}} \chi V_{i,m,t,x}}{N_{i,t}\sum_{x=1}^{N_{i,t}} V_{i,m,t,x}} - \frac{1+N_{i,t}}{N_{i,t}}. \tag{2.5}$$

$\text{Gini}_{i,m,t}$ is the value of the Gini index for imports of commodity i by importer m for year t. Each exporter x is numerically ordered according to its value of exports of i to m during t, from smallest to highest, including zero trade flows. The variable χ refers to the numerical order.

Lastly, the Herfindahl index also shows the concentration of import shares across the spectrum of agricultural and food imports. It is defined as the sum of the squares of the import shares across import links and is normalized by subtracting $1/N$ and dividing by $(1 - 1/N)$, where N refers to the number of active import links. The normalization ensures that the index ranges from zero to one. A larger index value is associated with greater concentration. An index value of zero indicates high diversification across numerous trade links, and an index value of one indicates complete concentration in one import link. We follow Jaimovich (2012) and define the value of the normalized Herfindahl index of import shares of commodity i by importer m in year t as:

$$H_{i,m,t} = \frac{\sum_{x=1}^{N_{i,t}} \left(S_{i,m,t,x}\right)^2 - \frac{1}{N_{i,t}}}{1 - \frac{1}{N_{i,t}}}, \tag{2.6}$$

where $S_{i,m,t,x} = \frac{V_{i,m,t,x}}{\sum_{x=1}^{N_{i,t}} V_{i,m,t,x}}$. $N_{i,t}$ is the total number of active exporters of i during t. An active exporter of i during t is a country that has exported a strictly positive amount of goods *i* at least to one importer during year t. This index shows the overall concentration along both markets and products. A modification also allows for separately calculating the diversification for both dimensions. Removing subscript *m* from the previous formula results in a product diversification measure. Removing subscript *i* results in a market diversification measure. Market diversification refers to the diversification of import shares across trading partners regardless of the diversity of the product groups from each trading partner and to how a country's imports across all import sources differ from a uniform distribution; that is, it shows how import shares from different sources vary. In contrast, the product diversification measure refers to the diversification of import shares across the commodities regardless of the source country.

We calculate the aforementioned indicators and measures using monthly trade values from Trade Data Monitor (TDM) at the HS6 level for ninety-six countries up to June 2020. TDM gathers monthly export and import statistics from statistics institutes, customs agencies, and other sources. Trade values are given in USD. In our analysis, we include all HS6 level commodities belonging to agri-food commodity groups following Annex 1 of the World Trade Organization (WTO) Agreement on Agriculture (AoA) plus fishery products (see Table A2.1 in the Appendix for detailed information on the commodities considered). The analysis covers twenty-two countries in Asia, forty countries in Europe, seventeen countries in Latin America and the Caribbean, two countries in Northern Africa, two countries in Northern America, two countries in Oceania and, eleven countries in sub-Saharan Africa (see Table A2.2 in the Appendix for the country coverage).

At the global level, we analyze changes in both the imports and exports of the ninety-six sample countries to/from all countries. For the correlation analyses, we use country level data on incidence and mortality numbers provided by John Hopkins University, the Oxford Stringency Index, Google's Community Mobility Reports, and the UNIDO Index of Industrial Production (Blavatnik School of Government, University of Oxford, 2021; Google, 2021; JHU, 2021; UNIDO, 2021).

2.4 Results and discussion

2.4.1 Trade values

The changes in the trade values at the global level suggest a short-term effect of the pandemic. As shown in Figure 2.3, in January 2020, global import values declined by 2.0%, followed by an increase in February (4.5%).[10] In March, global import values increased by 2.2% compared with previous years. In general, no trade reduction was observed in the first quarter of 2020. Nonetheless, our analysis does not exclude the possibility that trade on a global level could have been higher in the absence of COVID-19. Widespread virus containment policies adopted by most countries mainly started during the second half of March 2020 when mortality and morbidity rates increased more strongly (FAO, 2021a, see also Figure 2.1). Global movement restrictions to contain the spread of the virus peaked in the following two months (Panel B of Figure 2.1), induced a downturn in economic activity (Figure

[10] One reason behind these figures is a change in the trade data reporting of China, which combined data for January and February in 2020 to account for volatility during the Chinese New Year period (Leng, 2020). As China is a major exporter and importer of agri-food products, this change in reporting affects not only Asian trade values but might also be reflected in global patterns in January and February 2020 compared with previous years.

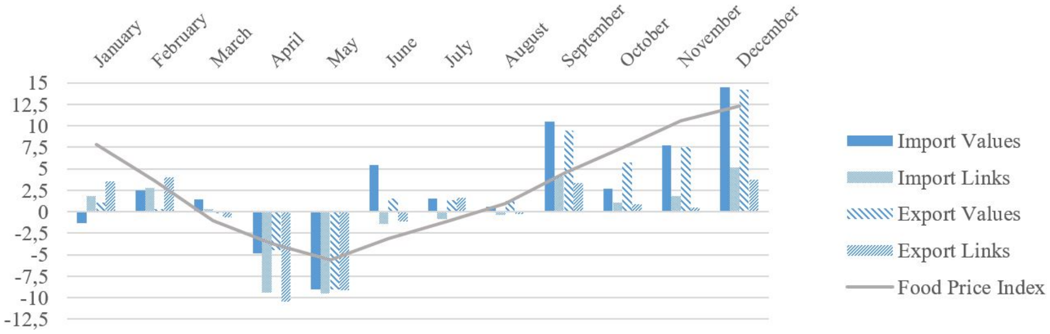


FIGURE 2.3: Global changes in trade indicators (percentage change compared with 2018/19)

Source: Own calculations based on data from TDM and the Food Price Index FAO (2021b).

2.2) and a decline in import values in April (-5.5%) and even more significantly in May (-10.0%). Thereafter, in June 2020 and in parallel with a relaxation of global movement restrictions and the recovery of the global economy, global import values rebounded and increased by 4.8% compared with the average import value of June 2018/2019. The changes in export values display a similar pattern as import values (Figure 2.3).[11]

Both containment measures and global economic activity are significantly correlated with import values. When policy stringency reaches its highest level, workplace as well as retail mobility are at their lowest levels, and industrial output and agri-food trade values decline. Figure 2.4 shows the correlations of the COVID-19 related factors with changes in import values. Policy stringency and changes in trade values are significantly, albeit weakly, negatively correlated (r = -.22). Both workplace and retail mobility are weakly positively correlated with changes in import values (with correlation coefficients of 0.24 and 0.23, respectively). A stronger association (r = .38) is found between the change in import value and the level of industrial production output. No significant correlation exists between changes in import value and the numbers of COVID-19 cases and related deaths. Similar correlations (not reported here) are found for the export value changes with the measures of global economic activity and policy restrictions. Thus, considering RQ1, we conclude that morbidity and mortality rates are not significantly related to changes in import value,

[11]The deviation of global exports from imports is caused by several reasons. First, we consider the imports and exports reported by ninety-six countries, whereby relatively more countries with higher imports than countries with higher exports are missing. Further, the time lag of the reporting of imports and exports can lead to differences in trade statistics, and imports are often more accurately reported at customs. Another important source of discrepancies is the fact that export values are reported on the basis of Free on Board (FOB) prices, whereas import values are based on Cost, Insurance, and Freight (CIF). Therefore, import values are generally expected to be higher than export values.

whereas induced policy responses to the pandemic and macroeconomic impacts show associations with changes in trade values.

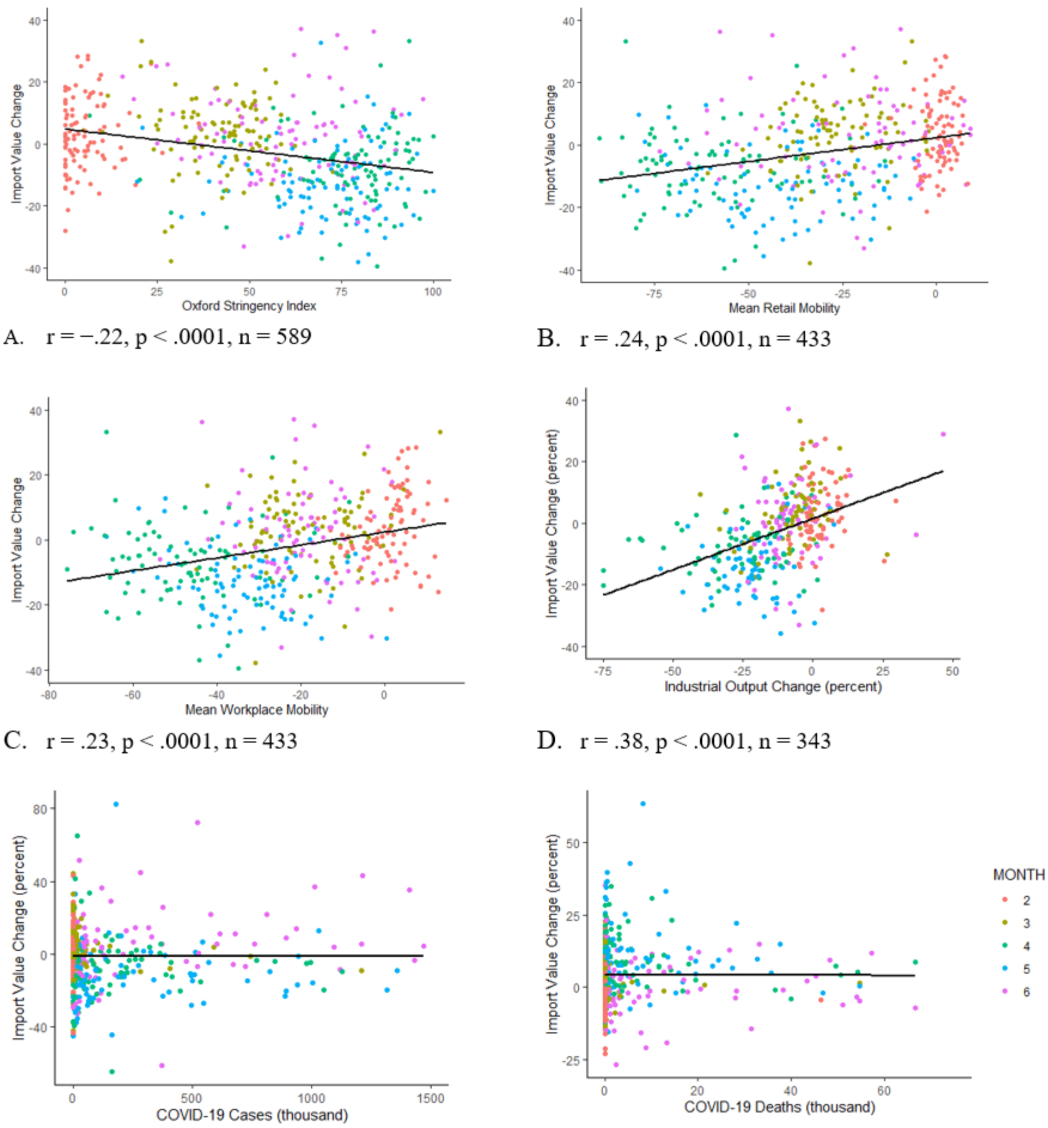
With respect to RQ2, we find that global trade values declined at the beginning of the COVID-19 pandemic relative to pre-pandemic levels, particularly in April and May 2020. Changes in trade values are associated with changes in both trade volume and price. A significant drop in food prices was observed between March and May 2020 (Figure 2.3), which suggests that part of the reduction in trade values may reflect declining prices. However, percentage decreases in prices are generally lower than that of import values in April and May, suggesting decreases in trade volumes.

Comparing changes by product groups, non-food commodities were relatively more affected than foods (Figure A2.2 in the Appendix). Import values of cotton declined by almost 30% and 50% in April and May, respectively. The main reason for this strong decline appears to have been reduced demand for downstream products that use cotton as an intermediate input (Muhammad et al., 2021; Voora et al., 2021). Significant declines are also evident on import values of products such as live animals (-18% in April, -14% in May), live plants and cut flowers (-28%, -14%) and tobacco (-12%, -21%), which were induced by logistical bottlenecks, reduced demand and, partly, policy restrictions (Morton, 2020; Saha and Bhattacharya, 2020).

Among food products, staple foods' trade values were least affected. They only decreased in May, with reductions ranging from -1% (fruits and nuts) to -4% (vegetables). In contrast, fish (-21%, -22%) and beverage (-16%, -25%) import values declined considerably from virus containment measures, such as restaurant closures and restrictions on social events (Eftimov et al., 2020; FAO, 2020a). Import values of most product groups recovered in June but still remained lower than the average level of 2018/19 for beverages (-11%), fish (-7%), live animals (-5%) and, noticeably, cotton (-39%).

At the regional level, mixed developments of import values are observed during the first quarter of 2020; however, similar to the global level, most regions show reduced imports in April and May (Figure 2.5). In June, import values generally rebounded.

Only the import values in sub-Saharan Africa and Latin America and the Caribbean remained lower than the monthly averages of previous years by 13% and 4%. One reason for the delayed impact in the sub-Saharan region could be that, given delayed soaring of COVID-19 infections, virus containment and trade-restricting measures in this region took place slightly after other regions (UN, 2021). In Latin America –a



A. $r = -.22, p < .0001, n = 589$

B. $r = .24, p < .0001, n = 433$

C. $r = .23, p < .0001, n = 433$

D. $r = .38, p < .0001, n = 343$

E. $r = -.09, p = .06, n = 571$

F. $r = .09, p = .06, n = 571$

FIGURE 2.4: Correlations of import value (percentage change) with containment measure indicators (indices) and industrial production output (percentage change)

Source: Own calculations based on data from TDM, John Hopkins University (Dong et al., 2020; JHU, 2021), Oxford Stringency Index (Blavatnik School of Government, University of Oxford, 2021), Google Mobility indices (Google, 2021) and the Monthly Index of Industrial Production (UNIDO, 2021).

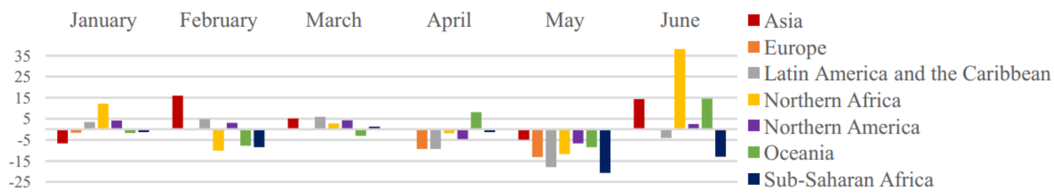


FIGURE 2.5: Import value changes at regional level (per cent)

Source: Own calculations based on data from TDM.

major net exporting region– the reduction in import values in absolute terms was relatively low.

On the export side, all regions except for Latin America and the Caribbean experienced a reduction in their exports between March and May 2020 (Figure A2.1 in the Appendix). Some of the major agricultural exporters are located in Latin America and the Caribbean and might have acted as a buffer to mitigate the negative impact on the imports of their partner countries. One driver of this development is China's increased import demand for oilseeds and grains from Brazil and Argentina (Schmidhuber and Qiao, 2020b). In June, mixed results are observed for export recovery.

Based on these findings and in accordance with RQ3, we state that non-food commodities experienced significant reductions compared with foods, whereby many staples were least affected. Changes in the trade values across regions were mixed, but most regions experienced a decrease in their imports and exports.

2.4.2 Extensive and intensive margins of trade

Percentage changes in the number of active trade links –denoting the extensive margin of trade– reveal sharp reductions in April and May 2020 (Figure 2.6). During these months, the decrease in the extensive import (export) margin at the global level was 9.3% and 9.4% (11.1% and 10.1%), respectively.

The change in the extensive margin of trade in April and May 2020 (Figure 2.6) is more pronounced than the change in the overall trade values (Figure 2.5). This finding indicates that changes in trade values are mainly derived by a reduction in trade links and less by changes in the intensive margin of trade. The data also suggest that the reduction in trade links was, in part, even counteracted by increasing intensity of trade in the remaining trade links. In June, the number of trade links still remains slightly lower than the 2018/19 average, whereas overall trade values rebounded, suggesting increases in the intensive margin of trade (*i.e.,* the average trade values per link).

Across regions, we notice similar patterns of change in the extensive margin of imports at the global level that reflect changes in the number of varieties available to consumers in terms of products and origins. In April and May in all regions, reductions range from -4.2% in Oceania (in April) to -15.7% in Latin America and the Caribbean (in May). In June, the extensive margin of imports increases again in Europe and Northern Africa, whereas the other regions continued to record subdued numbers of trade links. Additionally, at the regional level, the decline in the extensive margin of imports is more pronounced than the decline in import values, implying that the reduction in import values in April and May mainly stem from reduced numbers of trade links. In Asia, the percentage change in the total import value in April is negligible, whereas a reduction of 13.0% in the extensive margin of imports is observed (Figure 2.6). This finding implies that an increase in the intensive margin of trade outweighed the decline in the extensive margin of trade. A similar pattern is found in June when total import values of most regions increased, but the extensive margin of imports was still depressed.

Moreover, we observe a decline in the extensive margin of exports in all regions from March to June, with the exception of Latin America and the Caribbean, for which the number of export links increased (Figure A2.3 in the Appendix). In June, the number of export links is still lower than in 2018/19 but on an upwards trend compared with the previous months. Export values increased already in June, indicating that disruptions in the export links were compensated through higher trade intensity in the remaining links at the global level.

Linking these findings to RQ4, we summarize that agri-food trade declined mainly in the extensive margin at the global level and in most regions in April and May. Only in Latin America and the Caribbean did the number of export links increase throughout all months relative to previous years.

2.4.3 Net trade positions

The changes in import and export values led to changes in the net (agri-food) trade positions at the regional level, as shown in Figure A2.4 in the Appendix. Asia and Northern Africa are net importers of agri-food commodities throughout the period under investigation, and their overall trade position indicates that these regions deepened their position as net importers during the pandemic. Latin America and

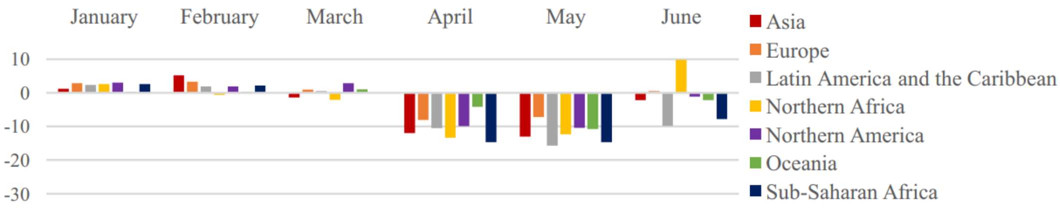


FIGURE 2.6: Changes in the number of active import links on a regional level (per cent)

Source: Own calculations based on data from TDM.

the Caribbean and Oceania remained net exporting regions during the pandemic. The former region had a more pronounced export position compared with the pre-pandemic period, suggesting this region's important role in alleviating severe reductions in the imports of some other regions, whereas net exports of the latter region weakened but remained positive. Considering the limited country coverage in sub-Saharan Africa in this study, this region also shows a positive and deepening net export position.[12] In May 2020, Europe changed its position from a net exporter to a net importer. Northern America shows a tendency to turn from a net exporting to a net importing region during the observed months in 2020 relative to 2018/19. However, when considering only the monthly net trade positions of 2019, Northern America is observed to already have been a net importer in April and May 2019.

In view of RQ5, changes in the net trade positions are generally small. The effects can also be mixed because regional net trade positions are often driven by a few major importers or exporters. Moreover, the limited country coverage of some regions must be considered when evaluating the regional net trade positions.

2.4.4 Intra- and inter-regional trade values

Next, we investigate the impacts of the pandemic and related policy measures on inter- and intra-regional trade. We focus on the import indicators to show the influence of the pandemic on the extensive margin of trade and overall trade values. Generally, intra-regional import links declined more intensely than inter-regional import links (see Figures 2.7 and 2.8), but the impact differs across regions. Sub-Saharan Africa, a region with many developing countries that mainly export a limited range of agricultural raw commodities to global markets and import foods from global markets, shows that its inter-regional trade flows have stronger trade resilience.

[12]Although many countries in sub-Saharan Africa are, in fact, net food importers, the sample includes mainly net exporters and also considers trade of a broader range of non-food agricultural commodities. Moreover, a large portion of intra-African trade is not formally reported which might lead to biased results (Malabo Montpellier Panel, 2020).

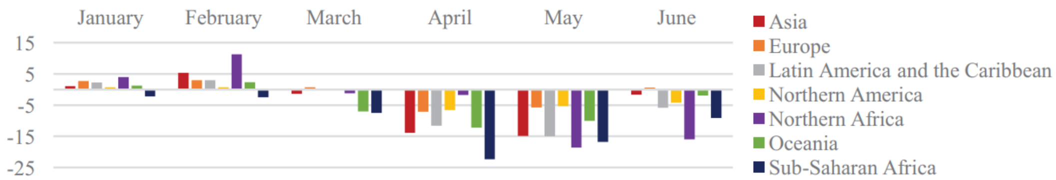


FIGURE 2.7: Changes in the number of active links of intra-regional imports (per cent)

Source: Own calculations based on data from TDM.

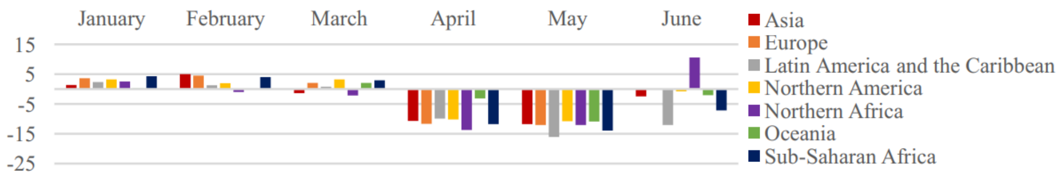


FIGURE 2.8: Changes in the number of active links of inter-regional imports (per cent)

Source: Own calculations based on data from TDM.

Europe and Northern America, with a majority of high-income countries and strong market integration, show higher resilience of intra-regional trade (FAO, 2020b,2). Intra-Asian trade also decreased more intensely than Asian countries' inter-regional trade. Figures A2.5 and A2.6 in the Appendix show the changes in intra- and inter-regional import values.

Given RQ6, the data suggest an association between the role of inter- and intra-regional trade of available food varieties in terms of the number of products and product origins and regions' stages of development and level of integration in global and regional markets. Given a higher level of development and regional integration, intra-regional trade proved more resilient than trade with other regions. The reverse holds for regions with a majority of countries at lower development stages.

2.4.5 Diversification of trade system

Import diversification as measured by the percentage changes in the Theil index is presented in Figure 2.9. Compared with the pre-pandemic period, the import diversification at a global level decreased (*i.e.*, the Theil index increased) by approximately 6% in April and May and by 3.3% in June.[13]

[13] Note that the results of the diversification measures remain the same regardless of whether these measures are applied to trade values or trade volumes.

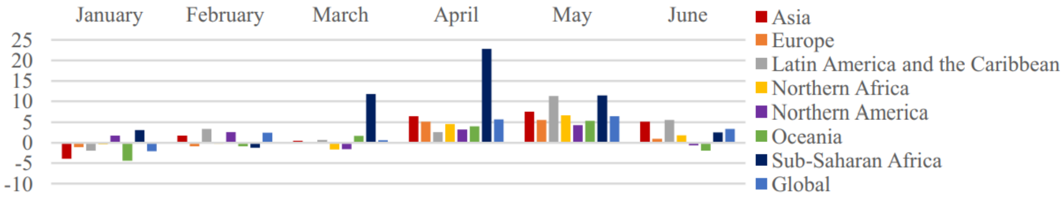


FIGURE 2.9: Changes in the Theil index of imports on global and regional levels (per cent)

Source: Own calculations based on data from TDM.

Policy stringency (r = 41), retail (r = -.46) and workplace mobility (r = -.41), and industrial output changes (r = -.49) are significantly correlated with the percentage changes in the level of import diversification (Figure 2.10). These correlations are somewhat stronger than the association of these variables with trade values.

With respect to RQ7, we conclude that stronger policy restrictions, lower industrial output, workplace and retail mobility are correlated with higher concentrations of countries' imports. However, we observe no significant correlations of case and death rates with import diversification.

We find significant decreases in import diversification (increases in the Theil index) for almost all commodity groups during April and May 2020, except for some staple foods, such as oilseeds (increase in April) and cereals (increase in all considered periods). Generally, the diversification of staple foods has shown weaker deterioration than for non-staple foods. The meat sector experienced the most noticeable concentration of import shares across trade links during the considered periods (range from 6% to 18%; see Table A2.1 in the Appendix for more detail at product level).

The results at the regional level (Figure 2.9) reveal similar patterns of change towards less diversification as at the global level. The most significant decline in import diversification is observed in sub-Saharan Africa, where trade diversification as measured by the Theil index diminished by 12%, 23%, and 12% in April, May, and June, respectively. Import diversification remained lower than in previous years from April to June also in Asia, Europe, Latin America and the Caribbean, and Northern Africa. Northern America and Oceania experienced declining diversification rates in April and May but not June 2020.

We apply the Theil index to exports and find that the diversification of export values across trade links also decreased significantly at both global and regional levels in

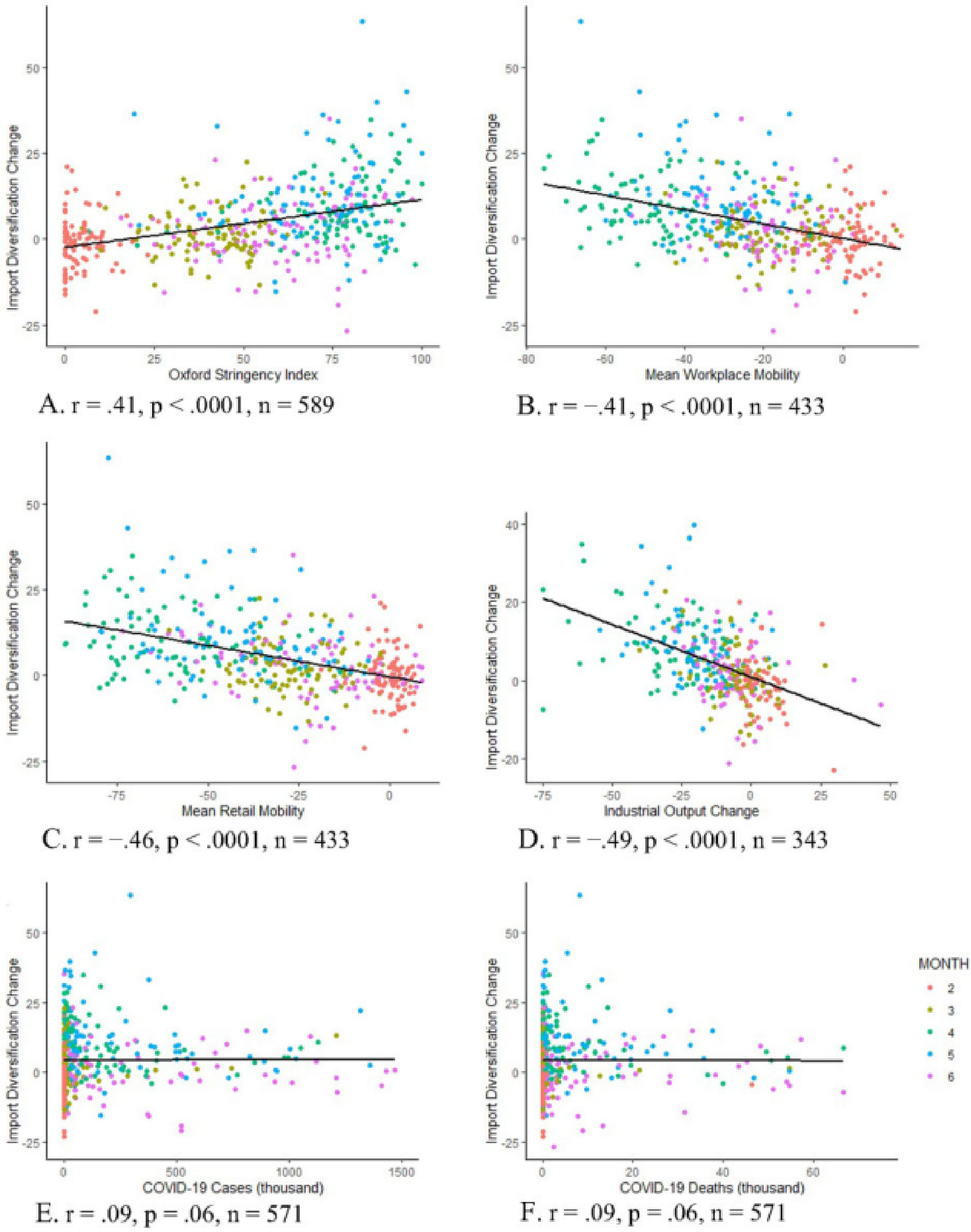


FIGURE 2.10: Correlations of import diversification (percentage change) with containment measures indicators (indices) and the global economic activity (percentage change)

Source: Own calculations based on data from TDM, John Hopkins University (Dong et al., 2020; JHU, 2021), Oxford Stringency Index (Blavatnik School of Government, University of Oxford, 2021), Google Mobility indices (Google, 2021) and Monthly Index of Industrial Production (UNIDO, 2021).

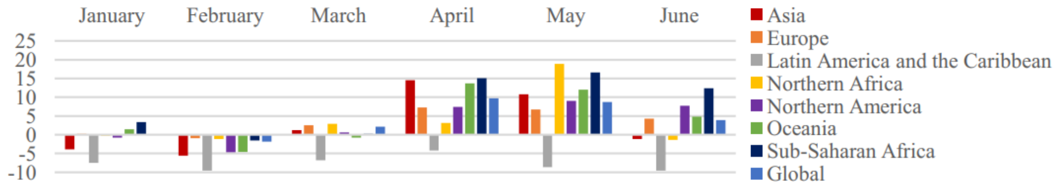


FIGURE 2.11: Changes in the Theil index of exports on global and regional levels (per cent)

Source: Own calculations based on data from TDM.

April and May (Figure 2.11). At the global level, diversification decreased by 9.7% and 8.7% during these months but less significantly in June (3.7%).

Similar patterns are observed at the regional level. In fact, exports were less diversified in all regions during April and May (in the range of 3.2% to 18.9% across regions and months). In line with increasing export values, Latin American and Caribbean exports were also more diversified throughout the considered period. While the concentration declined slightly again in June in Asia, Northern Africa and –quite significantly– in Latin America and the Caribbean, we observe further export concentration in all other regions.

We also provide information from two alternative measures –the Herfindahl and Gini indices– which reveal similar changes (see Figures A2.8 and A2.9 in the Appendix). Although the Theil and Gini indices are the two most popular for measuring diversification, the Herfindahl index is a widely employed trade concentration measure. The latter gives no weight (or very small weight) to zero (close to zero) values; thus, its results divert in some cases from the Theil and Gini indices.

With respect to RQ8, we conclude that the diversity of global agri-food trade decreased since February 2020 but mainly in April and May 2020. Non-staple foods and non-food commodities show the strongest tendency towards concentration. Considering each region separately, all regions, except for Latin America and the Caribbean's exports, show development towards more trade concentration –at least in April and May.

Next, we decompose the Theil index to identify changes in the diversification resulting from the extensive and intensive margins of trade. Changes in the between-group component of the Theil index indicate the diversification of trade flows along the extensive margin of imports (Figure A2.10 in the Appendix). At the global level, we observe a reduction in diversification along the extensive margin of trade in April and May by 16.2% and 15.6%, respectively. Therefore, imports occur in fewer trade links relative to the pre-pandemic period. These figures are in line with the changes in the number of active import links in Figure 2.6. Similarly, we observe a decrease in import diversification in all regions, noticeably in sub-Saharan countries (more than 40% increase in the between-group Theil index in April and May).

Moreover, Figure A2.11 in the Appendix shows changes in the within-group component of the Theil index – the diversification along the intensive margin of trade given the distribution of import shares in value terms across existing trade links. Diversification along the intensive margin of trade declines at the global level, but the results at the regional level are mixed. Overall, the changes in the diversification along the intensive margin are minor compared with the changes in the diversification along the extensive margin of imports. A comparison of the results of the overall Theil index (Figure 2.9) and its components (Figures A2.10 and A2.11 in the Appendix) suggests that import trade diversification declines mostly through changes in the diversification along the extensive margin of imports.

Similar to the changes in import diversification, the changes in export diversification, as reported by Figure 2.11, are mainly driven by changes in the diversification along the extensive margin of trade (Figure A2.12 in the Appendix). In this respect, the Latin America and Caribbean region again stands out with strongly increasing diversification along the extensive margin of trade. The within-group Theil index of exports shows that all regions except for Latin America and the Caribbean increased their diversification along the intensive margin in April and May (Figure A2.13 in the Appendix).

Concluding on RQ9, on both the import and the export side, changes in the extensive margin of trade towards more concentration dominate the changes in the intensive margin of trade.

2.4.6 Product and market diversification

Lastly, we use the modified Herfindahl index to show the results of import diversification in terms of trading partner and product differentiation. At the global level, market diversification –the range of countries from which imports are sourced– decreased throughout April, May, and June by 4.1%, 11.9%, and 18.3%, respectively (Figure A2.14 in the Appendix). Therefore, on average, countries imported from fewer trading partners than during the pre-pandemic period. At the regional level, the impact on market diversification is mixed.

Considering the diversification across product groups (Figure A2.15 in the Appendix), at the global level, import diversification increased significantly in February (40.8%), mostly driven by changes in the Asian region (33.3%),[14] followed by no significant changes in March. Subsequently, product diversification decreased from April to June. Interestingly, in May and June, the changes in the Herfindahl index of product diversification at the global level is greater than those at the regional levels, suggesting a greater increase in the concentration of imports across products between the different regions relative to the changes in concentration within each region.

A comparison of Figures A2.14 and A2.15 (in the Appendix) reveals that the overall decline in import diversification was mainly driven by a decline in the range of products imported, whereas changes in the number of trade partners played a smaller role. In some regions in which the trade of countries concentrated through market interruptions in March and April, the diversification across products increased, thus mitigating the overall reduction in the diversity of the trade values across trade links. Considering these changes along with RQ10, we state that reductions in trade diversification mainly occurred through a decline in the range of products traded.

2.5 Summary and conclusions

The pandemic and related containment measures have raised questions over the resilience of the global food system and its ability to ensure importers' access to sufficient import quantity and variety and whether exporters can realize their export earnings. To answer these questions, we provide a short-term analysis of the changes in agricultural and food trade in light of the COVID-19 pandemic and related containment measures. We use monthly data from the first half of 2020 to compare trade indicators, such as trade values, trade links, and various diversification indices, with their pre-pandemic averages. We explicitly consider changes in the intensive and extensive margins of trade and the differences across regions and product groups. At the country level, different pandemic-related factors, including direct health impacts (morbidity and mortality rates), induced policy restrictions (policy stringency and mobility changes), and macroeconomic impacts (industrial output), appear to be related to changes in the trade value and diversification of agri-food trade.

Our results indicate that the changes of agri-food trade values and the extensive margin of trade remained limited to short-term disruptions primarily in April and

[14]The significant increase in import diversification in Asia might reflect the change in trade data report- ing in China in January and February 2020, as previously mentioned.

May 2020. We find that morbidity and mortality rates are not significantly related to import values and trade diversification. However, policy responses implemented to combat the pandemic and the induced macroeconomic changes show parallels with the changes in trade value and diversification measures. Overall, in this regard, non-food commodities experienced relatively more changes than foods, whereby some staple foods were most resilient.

The extensive margin of trade decreased significantly at both the global and regional levels; however, trade intensity increased in some regions. The sharp reduction in the extensive margin of trade dominated the increase in the intensive margin, if any, during the period of heightened policy restrictions, thus leading to a decline in overall trade values in April and May. In June, increasing trade intensity compensated for the reduction in the extensive margin of trade and led to a rebound in trade values. Latin American and Caribbean exports were an exception as trade values and trade links increased during all months. Major exporters in this region increased their export values mostly in the extensive margin of trade, thus alleviating further global reductions in imports during the peak of the first wave of the pandemic.

Considering the changes in exports and imports, net trade position indicators reveal that most regions deepened their net import positions. Northern America and Europe changed their positions from net exporting to net importing regions of food and agricultural products in respective months. Mixed effects were found for changes in inter- and intra-regional trade across regions. For example, the intra-regional trade of sub-Saharan Africa, particularly in the extensive margin, was more prone to reductions than its inter-regional trade. However, the opposite held true for Europe and Northern America.

The diversity of global agri-food trade decreased primarily in April and May 2020. Over- all, the deterioration in export diversification was greater than that for imports. More pronounced policy restrictions, reduced workplace and retail mobility, and lower industrial output during COVID-19 are associated with a higher concentration of trade value across a lower number of products and countries.

Changes in the extensive margin were found to play a stronger role than changes in the intensive margin of trade in reducing overall trade diversification. Non-staple foods and non-food items showed stronger concentration tendencies than basic foods. In addition, our results indicate that reductions in the number of products traded were more pronounced than those in the number of trade partners.

The simultaneity of the implementation of strict virus containment measures and the sharp changes in international trade suggest a clear association between COVID-19-related effects and short-term trade disruptions. However, results should be interpreted cautiously as other factors besides the pandemic might have influenced the observed trade patterns during the study period. In addition, while the analysis considers the extensive and intensive margins of trade and provides insights into changes in aggregated agri-food trade quantities based on overall food prices and values, we do not decompose price and quantity components of trade values for each country and at commodity level because of data limitations. Given the observed variations in prices across commodities and countries, the results in this respect should be taken with caution. Lastly, the use of more advanced quantitative methods in future research could provide further insights with respect to quantifying the role that various factors (including macroeconomic variables such as exchange rate fluctuations) play in determining trade impacts.

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2.A Appendix

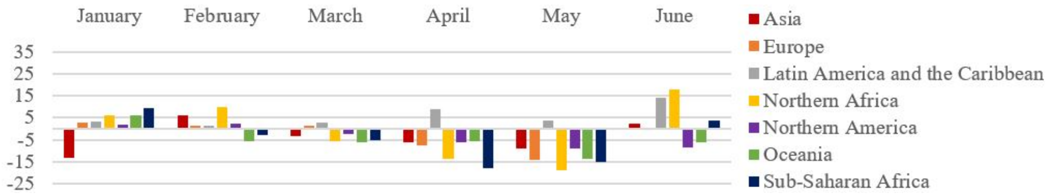

FIGURE A2.1: Export value changes at the regional level (per cent)

Source: Own calculations based on data from TDM.

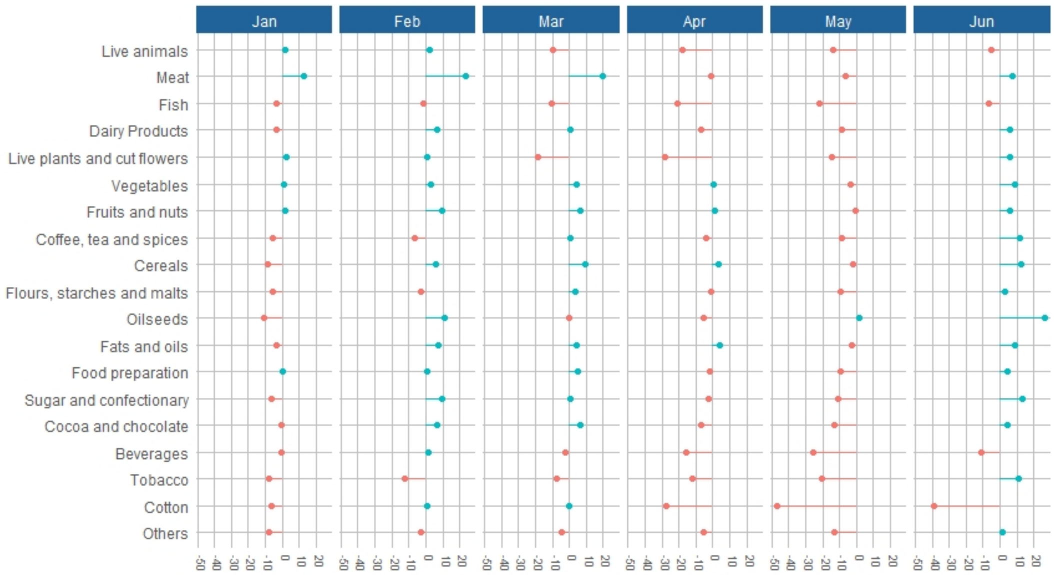

FIGURE A2.2: Global changes in import values at the commodity level (per cent)

Source: Own calculations based on data from TDM.
Note: Changes are calculated as percentage changes in the import values for each commodity group (aggregated as shown in Table A2.1) in a specific month in 2020 compared with the average values in the same month in 2018 and 2019.

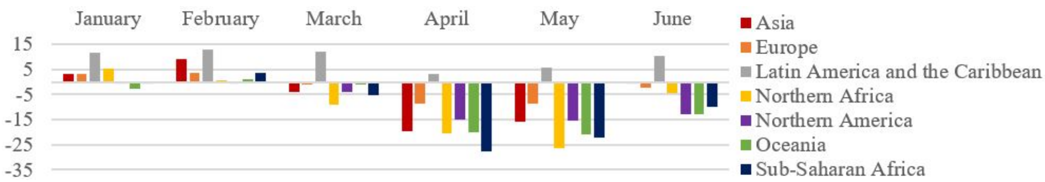

FIGURE A2.3: Changes in the number of active export links at the regional level (per cent)

Source: Own calculations based on data from TDM.

TABLE A2.1: Correspondence between commodity groups and HS2/4/6-digit levels

Commodity groups	HS 2-digits 01-24/HS 4/6-digits
Live animals	01
Meat	02
Fish	03
Dairy products	04
Others	05, 13, 14, 23, 290543, 290544, 3301, 3501–3505, 380910, 382360, 4101–4103, 4301, 5001–5003, 5101–5103, 5201–5203, 5301, 5302
Live plants and cut flowers	06
Vegetables	07
Fruits and nuts	08
Coffee, tea, and spices	09
Cereals	10
Flours, starches, and malts	11
Oilseeds	12
Fats and oils	15
Food preparations	16, 19, 20, 21
Sugar and confectionery	17
Cocoa and chocolate	18
Beverages	22
Tobacco	24
Cotton	5201–5203

Source: WTO (1995), AoA Annex 1 plus fishery products.

FIGURE A2.4: Net trade positions at the regional level

Source: Own calculations based on data from TDM.
Note: The net trade position (exports minus imports over exports plus imports) ranges between minus one and one.

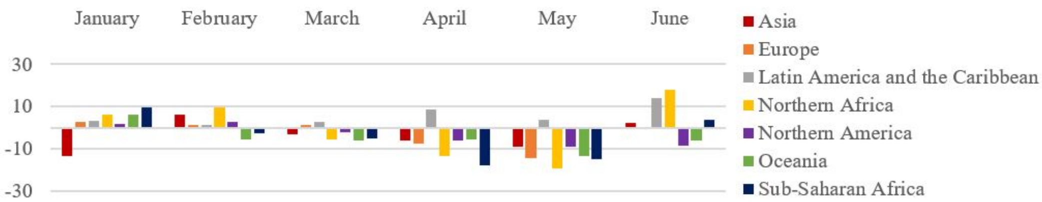

FIGURE A2.5: Import value changes in intra-regional trade (per cent)

Source: Own calculations based on data from TDM.

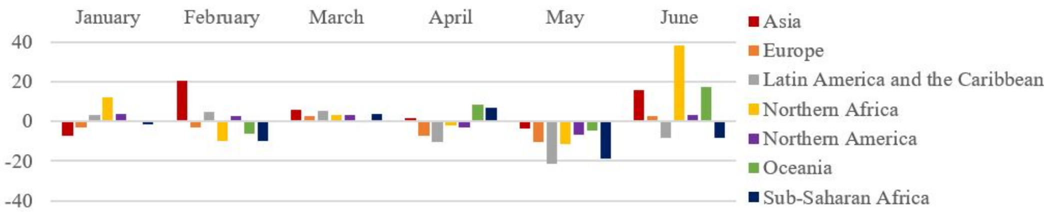

FIGURE A2.6: Import value changes in inter-regional trade (per cent)

Source: Own calculations based on data from TDM.

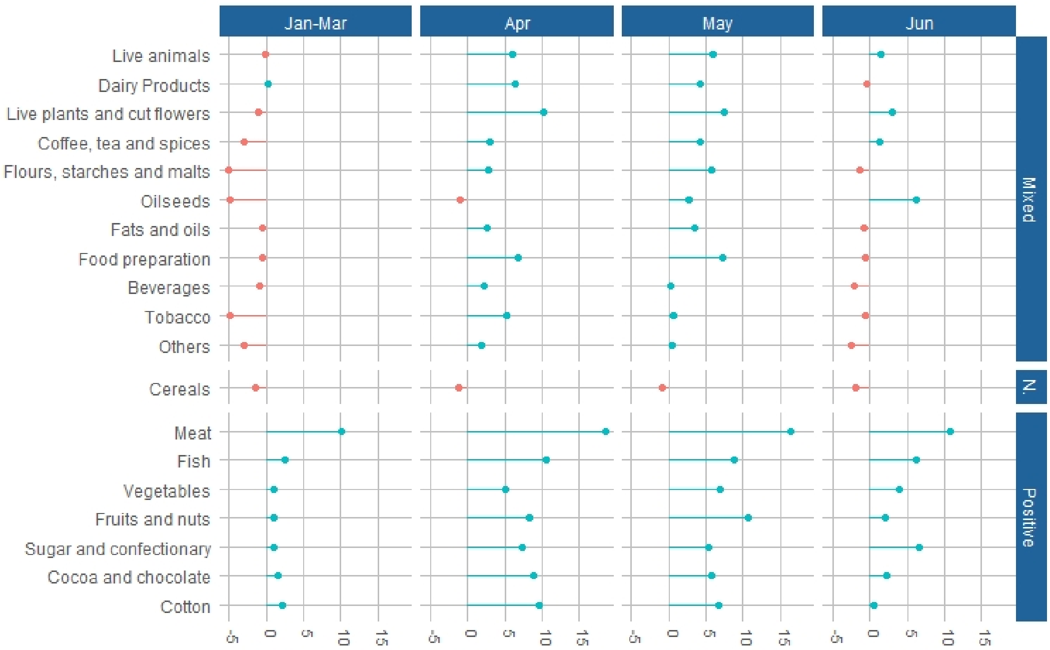

FIGURE A2.7: Global changes in the Theil index of imports at the commodity level (per cent)

Source: Own calculations based on data from TDM.

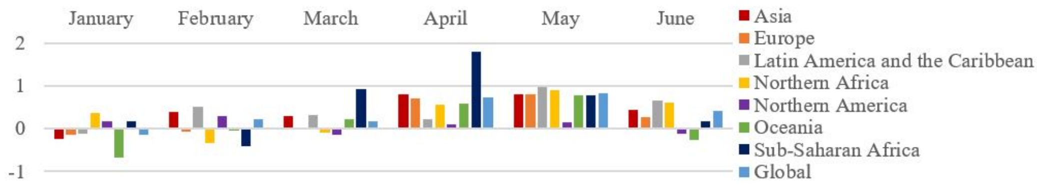

FIGURE A2.8: Changes in the Gini index of imports at the global and regional levels (per cent)

Source: Own calculations based on data from TDM.

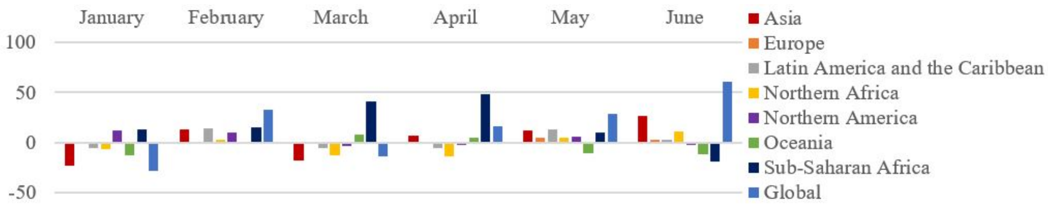

FIGURE A2.9: Changes in the Herfindahl index of imports at the global and regional levels (per cent)

Source: Own calculations based on data from TDM.

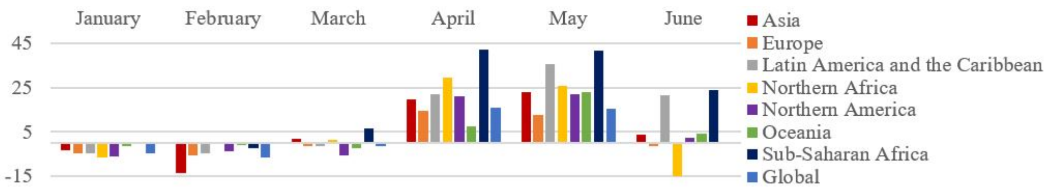

FIGURE A2.10: Changes in the between-group Theil index of imports at the global and regional levels (per cent)

Source: Own calculations based on data from TDM.

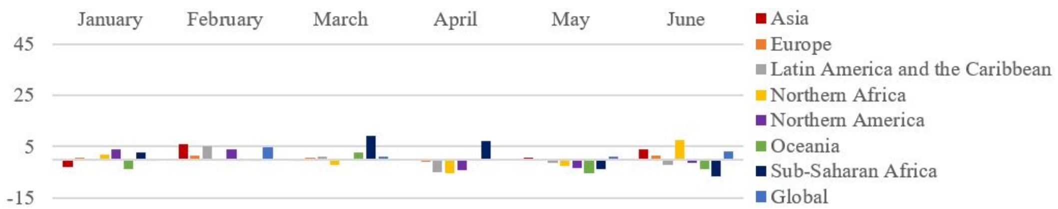

FIGURE A2.11: Changes in the within-group Theil index of imports at the global and regional levels (per cent)

Source: Own calculations based on data from TDM.

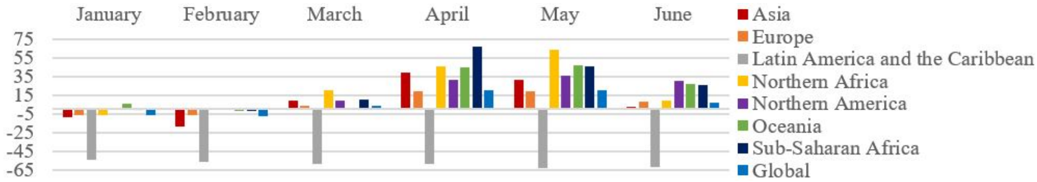

FIGURE A2.12: Changes in the between-group Theil index of exports at the global and regional levels (per cent)

Source: Own calculations based on data from TDM.

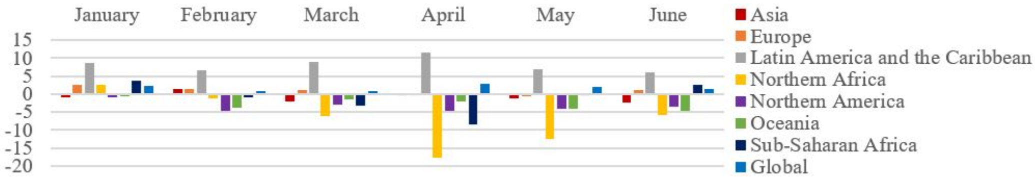

FIGURE A2.13: Changes in the within-group Theil index of exports at the global and regional levels (per cent)

Source: Own calculations based on data from TDM.

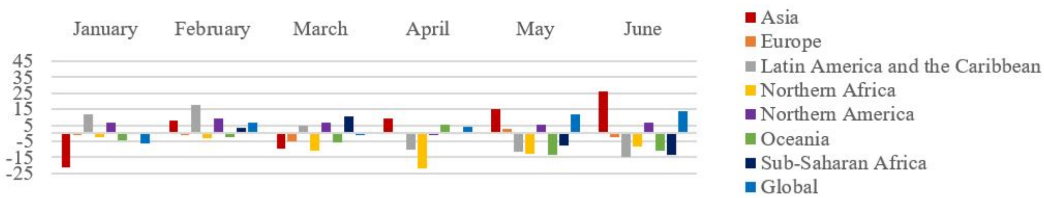

FIGURE A2.14: Changes in market diversification according to the Herfindahl index of imports at the regional level (per cent)

Source: Own calculations based on data from TDM.

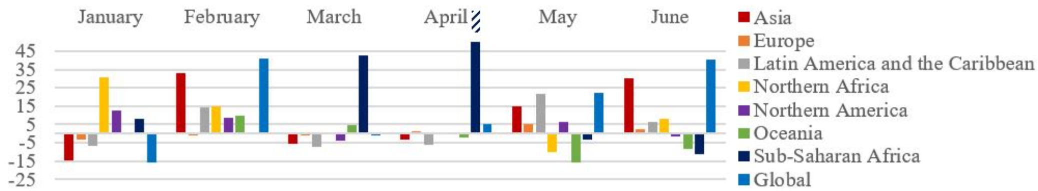

FIGURE A2.15: Changes in product diversification according to the Herfindahl index of imports at the regional level (per cent)

Source: Own calculations based on data from TDM. Note: In April, the change in the Herfindahl's product diversification index in sub-Saharan Africa is 123.38%.

TABLE A2.2: Correspondence between regions and countries

Regions	Countries
Asia	Armenia, Bahrain, Brunei Darussalam, China, Cyprus, India, Indonesia, Israel, Japan, Jordan, Kazakhstan, Malaysia, Myanmar, Pakistan, Philippines, Qatar, Republic of Korea, Saudi Arabia, Singapore, Sri Lanka, Thailand, Turkey
Europe	Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kosovo*, Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom
Latin America and the Caribbean	Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Panama, Paraguay, Peru, Uruguay
Northern Africa	Egypt, Morocco
Northern America	Canada, United States
Oceania	Australia, New Zealand
Sub-Saharan Africa	Botswana, Egypt, Ethiopia, Ivory Coast, Kenya, Madagascar, Mauritius, Mozambique, Namibia, Senegal, South Africa, Zambia

Note: Countries for which monthly agri-food trade data (from TDM) were available at the time of extraction. The regional aggregation follows the M49 standard of the United Nations Statistics Division (UNSD); *inclusion of Kosovo follows from our data availability.

Chapter 3

Institutional quality and the duration of agri-food trade flows†

Abstract: Recent trade disruptions and their consequences on supply chains show the importance of stable trade relations for exporters' economic planning and importers' supply security. Both instability in trading partners' economic and institutional environment and differences between them are likely to exacerbate these disruptions. We investigate the role of exporters' institutional quality (IQ) and its similarity with importers' IQ in the stability of trade links. We focus on the trade links of agri-food products exported from Sub-Sahara African (SSA) countries to the European Union (EU-28) and consider three dimensions of IQ: "government selection, monitoring, and replacement", "efficiency of policy formulation and implementation", and "respect of citizens and state for institutions". Using a discrete-time duration model, we show that the duration of SSA exports to the EU-28 increases with higher exporters' IQ and similarity of trading partners' IQ. The strongest impact of exporters' IQ is associated with "government selection, monitoring, and replacement". In terms of the similarity of trading partners, "respect of citizens and state for institutions" has the largest impact on trade durations. Our findings suggest that the improvement of countries' IQ may boost the stability of trade relationships. Moreover, the similarity of IQs between trading partners supports the stability of trade links and should be carefully considered when establishing new trade relations.

***Keywords**: Agri-food trade, discrete-time model, institutional quality, trade duration*

†This chapter is published as Engemann, H., Jafari, Y., & Heckelei, T. (2023). Institutional quality and the duration of agri-food trade flows. Journal of Agricultural Economics, 74(1), 135-154, https://doi.org/10.1111/1477-9552.12491.

3.1 Introduction

Given the substantial costs of establishing new trade relationships, the successful maintenance of existing trade relationships, *i.e.*, their long-term survival, is crucial for the success of exporters and importers. Stable trade relations contribute to the income of producers in exporting countries and the availability of product varieties in importing countries, which have welfare implications on both sides of the trade relationship. However, bilateral trade links across sectors can be short-lived, suggesting that specific factors hinder their continuity (Besedeš & Prusa, 2006a; Bojnec & Fertő, 2018; Hess & Persson, 2011; Nitsch, 2009). Recent advances in modeling the dynamics of heterogeneous firms' decisions to engage in costly export markets emphasize the role of variable trade costs (Melitz, 2003) and uncertainty in explaining the stability of bilateral trade relationships (Bernard, Jensen, & Schott, 2009; Rauch & Watson, 2003; Segura-Cayuela & Vilarrubia, 2008). The institutional environment of trading partners also has an impact on both uncertainties and variable costs (Martínez-Zarzoso & Márquez-Ramos, 2019; North, 1991), and can affect the stability of trade relations. Consequently, the role of institutional quality (IQ) factors can be important for firms' selection of trade partners to reduce uncertainties and for policy planners seeking to boost the stability of trade relations and/or to adjust their institutional environment.[1]

We investigate the impact of trading partners' IQ on the stability of trade relationships along the extensive margin of trade. We use the information on agri-food export flows from Sub-Sahara African (SSA) countries to the individual European Union (EU-28) countries, as an example. More specifically, we analyze the impact of exporters' IQ and the similarity of IQ between partner countries on the duration of trade (the time from the start of a trade relation to its end). We also examine the impact of different attributes of exporters' IQ and their similarity with that of importers on the duration of trade. These attributes we identify are: "government selection, monitoring, and replacement"; "efficiency of policy formulation and implementation"; "respect of citizens and state for institutions". Finally, we rank the importance of these attributes with regards to their impact on trade duration.

We focus on agri-food exports from SSA countries to the individual EU-28 members for several reasons. In many countries in SSA, the agri-food sector has the largest

[1] Countries worldwide have recently implemented institutional reforms as the drawbacks of institutional instabilities are evident (Boudreaux & Holcombe, 2018; Kanani & Larizza, 2021). Countries are also concerned about the stability of their trade relationships (Huang, Piñeiro, & Piñeiro, 2020; WTO, 2018).

share in GDP and trade indicating the importance of this sector. The EU-28 and even several individual EU-28 countries are major destinations for SSA agri-food exports (WITS, n.d.; World Bank, n.d.-a)[2] whereas the duration of these trade relationships are low with, on average, 2.5 years.[3] Moreover, the majority of countries located in SSA are least developed countries with low levels of IQ (see Tables A3.1 and A3.2 in the Appendix), but are trying to improve their IQ (AFDB, 2021). The EU-28 countries have, on average, higher IQs leading to substantial differences between IQs of the country-pairs involved in EU-SSA trade relationships. Consequently, the SSAs' export flows to the EU-28 countries are interesting for the analysis of the impact of IQ of exporters and its similarity with that of importers on trade duration.

Trade relations are initiated when both exporters and importers expect benefits from the exchange of goods over a sufficiently long period of time so that at least the costs of establishing a trade link are covered (Besedeš & Prusa, 2011). Upon successful entry, firms may revise their decisions at any time, depending on the changes in operating profits and the level of uncertainty they face. Reducing uncertainty is the major contribution of functioning institutions, which can help create stability for human interaction (North, 1991). In exporting countries, IQ is related to uncertainties associated with bilateral trade frictions, production and demand conditions, and the nonmarket factors that increase the firms' risk of exiting the export market (Besedeš & Prusa, 2011; Nguyen, 2010). Further, the similarity of IQ between trading partners is important. A greater similarity in the institutional environment leads to more confidence among economic agents due to partners' comparable formal procedures, behavioral norms, and levels of trust in conducting business (Groot, Linders, Rietveld, & Subramanian, 2004). This might reduce uncertainties regarding trading partners' mutual expectations. IQ environment also affects fixed and variable costs relevant for trade through several channels such as contracting, investment, productivity, comparability, trust, and transparency (Martínez-Zarzoso & Márquez-Ramos, 2019). (Unexpected) changes of these costs carry further implications for export participation and continuation (see Chaney, 2008; Helpman, Melitz, & Rubinstein, 2008).

Empirical evidence on the role of IQ of trading partners and institutional similarity in trade duration is limited. A study by Bojnec and Fertő (2012) is to our knowledge the only research that examines the impact of exporters' IQ on the duration of exports. They find that IQ increases the duration of the EU agri-food exports. However, further empirical studies investigate the impact of IQ on the quantity of trade (Álvarez,

[2]The Netherlands, the UK, and France are the top-3 destinations of food products from SSA (WITS, n.d.).

[3]See also Rudi, Grant, and Peterson (2012), who find low survival rates of exports from Africa.

Barbero, Rodríguez-Pose, & Zofío, 2018; Martínez-Zarzoso & Márquez-Ramos, 2019; Nunn & Trefler, 2014). These show that higher IQ reduces trade barriers, for example, due to greater transparency and reduced uncertainty between trading partners.

We contribute to the literature in two ways. First, we show the impact of different IQ indicators on the duration of trade. Compared to Bojnec and Fertő (2012), who analyze the impacts of the EU enlargement on its agri-food exports, we explore the relative importance of different dimensions of IQ with a focus on the exports of SSA countries to the EU-28. Second, we examine the effect of institutional dissimilarity between exporters and importers on the duration of bilateral trade for different dimensions. We use the trade flow information from 1996 to 2017 for each SSA country to the individual EU-28 countries at the HS 6-digit level to perform a duration analysis using the Kaplan-Meier survivor function that shows the probability of exports surviving a certain number of years. To analyze the impact of trading partners' IQs on trade durations, we use discrete-time analysis (Hess & Persson, 2012) as trade relationships are reported in discrete units of yearly length.

The remainder of this paper is structured as follows. Section 2 reviews relevant theoretical and empirical literature on IQ and the duration of trade relationships. Section 3 presents the methods used for analyzing the impact of institutional factors on trade duration. Sections 4 and 5 present the data description and results, respectively, and section 6 concludes.

3.2 Background and derived hypotheses

Duration of trade is defined as the number of consecutive years with uninterrupted trade flows of a specific product between two trade partners. Recent studies reveal short trade durations across sectors, with means between 2.7 and 5.7 years and medians of 1 and 2 years (*e.g.,* Besedeš & Prusa, 2006a; Hess & Persson, 2011; Peterson, Grant, & Rudi-Polloshka, 2017).[4] Although no specific theory explains the duration of trade, different trade theories, including those on firms' export behavior and buyers' behavior in the export destination markets, suggest reasons for (non-)continued trading on an already established trade link.

[4]For example, Besedeš and Prusa (2006a) find an average duration of 2.7 years and a median of one year for the US imports from 160 countries; and an especially low survival rate of exports from Africa (48% survive after one year of trade). Later, Besedeš and Prusa (2011) study the export survival of 46 countries and find that more than 50% of the relations fail in the first two years. Hess and Persson (2011) and Nitsch (2009) find an average import duration of 3.3 years and medians of one and two years, respectively. In addition, Rudi et al. (2012) find a mean export duration of 5.7 years for fresh fruits and vegetables trade.

An exporting firm's decision on initiating, continuing, or terminating a trading activity is inherently a decision under uncertainty. Assuming risk-neutral firms, a firm exports if the associated expected profit over the planned period is at least as large as the fixed costs of establishing an export link (see *e.g.,* Melitz, 2003). Since expected profits are not always earned, firms revise their expectations once they enter the export market or during their ongoing trade relation (Besedeš & Prusa, 2011; Nguyen, 2010). One reason for unexpected changes in profits is the uncertainty of market and nonmarket conditions in exporter countries, importer countries, or both (Bodt & van Wassenhove, 1983; Fera, Fruggiero, Lambiase, Macchiaroli, & Miranda, 2017), which can lead to changes in production costs and domestic demand conditions (see Esteves & Rua, 2015, for a review), in the export market's competition level (see Bernard et al., 2009), or in trading costs due to changing tariff and nontariff measures (see Chaney, 2008; Helpman et al., 2008). The revision of exporters' expectations is based on changes in uncertainty and actual market conditions.

Trade links are also established and (dis-)continued at the discretion of buyers, *i.e.*, importers, taking uncertainty into account. Buyers search for the supplier with the lowest price among all possible sellers of the desired product with a certain quality (Rauch & Watson, 2003). Once a suitable supplier, *i.e.*, exporter, is found, they bear the costs of establishing a trade relationship and revise the trade decision every time unexpected changes occur.[5] Importers establish new trade relations if these costs are lower than their expected operating profits. Their decision to continue trading with an exporter or to shift to another supplier depends on the ability of sellers to meet their expectations (Peterson et al., 2017).

IQ plays a crucial role in the entry and continuation decisions through its impact on uncertainty and costs for importers and exporters. IQ relates to how authority in a country is exercised. IQ has been more specifically defined by Kaufmann, Kraay, and Mastruzzi (2010) as: "the process by which governments are selected, monitored, and replaced"; "the capacity of the government to effectively formulate and implement sound policies"; and "the respect of citizens and the state for the institutions that govern economic and social interactions among them" (Kaufmann et al., 2010, p. 4; see Table 3.1). These dimensions of IQ affect trade duration through different pathways and cost elements (see Álvarez et al., 2018; Bojnec et al., 2014;

[5] Since agri-food products are subject to numerous product standards, buyers might face relatively high costs for finding the trading partners meeting such standards or training them to comply with those standards (Bojnec, Fertő, & Fogarasi, 2014; Peterson et al., 2017). We note that these training and time costs vary between products depending on product differentiation, which affects the ease of switching to another trade partner, and therefore, the trade duration (Besedeš, Moreno-Cruz, & Nitsch, 2016).

Lin, Flachsbarth, & Cramon-Taubadel, 2019; Martínez-Zarzoso & Márquez-Ramos, 2019).[6] Better IQ (1) facilitates contracting between companies; (2) leads indirectly to investment and firms' productivity improvements; (3) facilitates custom procedures; and (4) increases transparency and comparability. The IQ dimensions further differ in their impact on uncertainty, *i.e.*, how they (5) enhance trust between trading partners[7] and (6) stabilize factors that affect firms' business environment.[8] While IQ dimensions are interlinked, dimension (A) may relate most to channels 2 and 6, dimension (B) to channel 1, and dimension (C) to channels 3, 4, and 5. The impact direction of IQ dimensions on trade duration could also differ. For example, higher voice and accountability (dimension A) may be associated with bargaining power of workers and through channel 2 reduce trade duration, but better control of corruption (dimension C) increases domestic investment through channel 2 and may increase trade duration (Berden et al., 2014).[9]

TABLE 3.1: Institutional quality indicators

IQ dimension	WGI (World Bank)	Explanation
(A) Government selection, monitoring & replacement	Voice & Accountability	Citizens' ability to participate in government selection, freedom of expression, freedom of association, and freedom of media
	Political Stability & Absence of Violence	Likelihood of government destabilization by politically motivated violence and terrorism
(B) Efficiency of policy formulation & implementation	Government Effectiveness	Quality of public services, quality of civil service, and its degree of independence from political pressures, quality of policy formulation and implementation, and credibility of the government's commitment to such policies
	Regulatory Quality	Government's ability to formulate and implement sound policies and regulations that permit and promote private sector development
(C) Respect of citizens & state for institutions	Rule of Law	Agents' confidence in abiding by the rules of society (quality of contract enforcement, property rights, the police, and courts) and likelihood of crime and violence
	Control of Corruption	The extent of exercising public power for private gain (petty and grand forms of corruption) and capture of the state by elites and private interests

Source: Own illustration based on Kaufmann et al. (2010).
Remark: The annual indicators are created by Kaufmann and Kraay using an unobserved component model (UCM). They are based on 31 data sources and are available from 1996.

Bojnec and Fertő (2012) create one IQ indicator applying the Principal Component Analysis to different dimensions of IQ, *i.e.*, all six World Bank Worldwide Governance Indicators (WGI), and integrate this composite into an extended Cox proportional hazard model (Cox, 1972) to estimate the impact of IQ on the survival rate of trade

[6] See also Anderson and Marcouiller (2002); Berden, Bergstrand, and van Etten (2014); Bojnec et al. (2014); Levchenko (2007); Márquez-Ramos (2011); and Nguyen (2010).

[7] For example, Bojnec et al. (2014)indicate the role of IQ for meeting standards, which are particularly high for food consumed in the EU(European Commission, n.d.), as better IQ increases transparency and reduce uncertainty.

[8] See also Horsewood and Voicu (2012) and Ali and Mdhillat (2015).

[9] We note that the mentioned studies empirically analyzed IQ impacts on trade values but not on the trade duration. Anderson and Marcouiller (2002) and Jansen and Nordås (2004) identify market competition, legal security, and corruption as the most important impact factors on trade values. Álvarez et al. (2018) find stronger effects of countries' regulatory quality, governmental effectiveness, and rule of law compared to the voice and accountability, political stability, and control for corruption. Lin et al. (2019) conclude that voice and accountability is relevant for the degree of cooperation in the production process and workers' bargaining, government effectiveness mainly affects the ability of contract enforcement, and monitoring is generally important for both the production process and trade relations.

links. Their findings show that an overall measure of IQ increases the duration of EU agri-food exports. Nonetheless, there is a lack of an empirical analysis of the impact of individual dimensions of the institutional environment on trade duration. Literature that focuses on other determinants affecting trade duration find that in general, factors that reduce trade costs lead to lower failure rates and, consequently, to longer bilateral trade duration (*e.g.,* Bacchetta et al., 2012; Besedeš & Prusa, 2006b; Hess & Persson, 2011; Nitsch, 2009). Since higher IQ can reduce trade costs (Álvarez et al., 2018; Anderson & Marcouiller, 2002), this might lead to an increase in trade duration. Against this background, we hypothesize (H1a) that a higher IQ of SSA exporters leads to longer bilateral trade duration. Additionally, because of the different impact pathways of IQ dimensions, we hypothesize (H1b) that the various dimensions of IQ have different effects on the trade duration.

Trade relationships are affected by both countries' IQ and the similarity of importers' and exporters' IQ (Álvarez et al., 2018; Fiankor, Martínez-Zarzoso, & Brümmer, 2019; Yu, 2010). Similarity of IQs can affect transaction costs and the uncertainty related to trade links. It may reduce the transaction cost but its impact on uncertainty may depend on the absolute level of IQs of both partners involved. With respect to the transaction costs, Álvarez et al. (2018) argue that similarity among trading partners reduces trade costs due to familiarity regarding their institutional environment. For example, Horsewood and Voicu (2012) analyze the impact of importers' and exporters' corruption levels on trade flows between Romania and Bulgaria. They show that countries with similar business ethics and mutually acceptable practices for cross-border transactions tend to trade more. With regard to the uncertainty component of IQ similarity, trading with low IQ partners may increase the risk of deviations from expectations (Martínez-Zarzoso & Márquez-Ramos, 2019). Further, Ali and Mdhillat (2015) suggest that countries with high ethical standards would risk reputation when trading with a corrupt country. Consequently, countries with high IQ might prefer partner countries with same IQ standards, and, for example, increasing corruption in one partner country could lead to the termination of the trade link to avoid reputational damage. The overall impact of IQ similarity and its different dimensions on trade duration depends on the combined effect through transaction cost and uncertainty channels. Considering that EU-28 countries have generally high IQs, they would trade more with SSA countries of high IQs to reduce both the associated uncertainty and transactions costs. In this context, we hypothesize (H2a) that the greater the similarity of IQs between SSA countries and their EU-28 trading partners, the greater the probability of a longer bilateral trade duration. Finally, we hypothesize (H2b) that the various dimensions of similarity in IQ differ with respect to their effects on the trade duration.

3.3 Methodology

We apply the Kaplan-Meier survivor function to perform a descriptive duration analysis of the SSA-EU agri-food trade and use different discrete-time regression models to identify the effects of IQ and its various dimensions on the duration of trade.

Survival analysis estimates the expected time until one or more events happen, which we apply in the context of trade duration. We define an event as the failure of a trade relation after one or several successive years of trade (*e.g.,* Besedeš & Prusa, 2006a, 2006b; Hess & Persson, 2011; Nitsch, 2009; Peterson et al., 2017; Rudi et al., 2012). We follow Besedeš et al. (2016) and define the term "trade relation" as the trade of a specific product between two countries. For each trade relation, the time from the first trade flow in any given year until the year, in which the trade stops, is called a "spell" (Hess & Persson, 2011, p. 666). When two countries re-start trading a specific product, the trade relation has "multiple spells" (Hess & Persson, 2011, p. 667). The number of consecutive trade years of a spell is the "length of spell" representing the trade duration of that spell (Hess & Persson, 2011, p. 666).[10]

To calculate the probability of a spell of length *k*, we estimate the survival function $S(t)$ using the nonparametric Kaplan–Meier (KM) survival estimator of the hazard function. Thus, we calculate the probability of spells' survival in period t, given that the length of spell lasted until k using (Kaplan & Meier, 1958; Nicita, Shirotori, & Klok, 2013).

$$\hat{S}(t) = \prod_{t(k)<t} \frac{n_k - d_k}{n_k}. \tag{3.1}$$

The KM estimator is a standard measure in survival analysis and robust to censoring; however, it does not capture any functional relationship between trade survival and its covariates (Besedeš & Prusa, 2006a). We complement the analysis with a model that allows us to investigate the effects of IQ indicators and other factors on the duration of SSA–EU trade relations. Studies on trade duration widely use the Cox (1972)

[10] For example, Ghana exported eggplants to the UK in 1994 and 1995. Thus, the length of the first spell is two years. As Ghana exported eggplants again to the UK from 2003 to 2011, this trade relation reveals an example for multiple spells. In our analysis, we consider multiple spells.

proportional hazard model (Besedeš & Prusa, 2006b; Rudi et al., 2012). However, Hess and Persson (2011) argue that the application of the Cox hazard model is unsuitable for analyzing the determinants that affect trade duration because, first, the data are grouped into discrete units, while the Cox hazard model relies on a continuous-time specification leading to biased estimations. Second, it is difficult to properly control for unobserved heterogeneity using the Cox approach, which can create spurious negative duration dependence of the estimated survivor functions and biased parameters. Third, the Cox hazard model restricts the independent variables from having a constant effect on the hazard rate across a spell, but this is not expected for many explanatory variables (see for further discussion Hess & Persson, 2012). Following Hess and Persson (2012), we use the discrete-time model for our impact analysis on trade duration.

In the discrete-time hazard model, export duration is estimated as a conditional probability that the export of one specific product will terminate in a particular time interval $[t_k, t_{k+1}]$, whereas $k = 1, 2, \dots, k_{\text{max}}$, and $t_1 = 0$, given that the export of this specific product already lasted until this time interval. In this model, the estimated conditional probability is explained by independent variables x_{ik}. Consequently, the discrete-time hazard rate h_{ik}, that is, the probability of termination of a specific spell i at time interval k, can be defined as (Hess & Persson, 2012).

$$h_{ik} = P(T_i < t_{k+1} \,|\, T_i \geq t_k, x_{ik}) = F(x'_{ik}\beta + \gamma_k), \tag{3.2}$$

where T_i is a nonnegative continuous random variable denoting the length of the spell. x_{ik} denotes a vector of time-varying explanatory variables, and β refers to their corresponding coefficients. An appropriate distribution function $F(\cdot)$ ensures that the hazard rate h_{ik} lies in the range from zero to one for all i and k. γ_k refers to a function of time allowing the hazard rate h_{ik} to vary over time (Hess & Persson, 2012), captured in our discrete-time model by year-specific dummies.

The discrete-time hazard model can be estimated using the log-likelihood function,

$$\ln L = \sum_{i=1}^{n} \sum_{k=1}^{k_i} \left[y_{ik} \ln(h_{ik}) + (1 - y_{ik}) \ln(1 - h_{ik}) \right], \tag{3.3}$$

where y_{ik} is a binary variable equal to one if the spell i ends in the time interval k_i, that is, if the trade relation fails, and zero if trade occurs.

We follow Hess and Persson (2012) and assume that the hazard rate has a normal distribution and estimate Eq. 3.3 using the probit model. To test the sensitivity regarding this assumption, we re-estimate Eq. 3.3 with a logit model, which underlies the assumption of a logistic distribution (Hess & Persson, 2011). With regards to the hazard assumption, the probit model imposes nonproportionality, while the logit model only slightly deviates from the proportional hazards assumption of the Cox (1972) model (Hess & Persson, 2012).

Specifically, we estimate the hazard rates of exports using

$$y_{odpk} = \delta_0 + \delta_1 \mathrm{IQ}_{o(k-1)} + \delta_2 \mathrm{prod}_p + \tau_{od}\delta_3 + X_{odp(k-1)}\delta_4 + \lambda_o\delta_5 + \lambda_d\delta_6 + \lambda_k\delta_7 + \varepsilon_{odpk}, \tag{3.4}$$

where the dependent variable y_{odpk} equals one if the spell (of a specific product p between origin o and destination d) fails in k given that trade continuously occurred in previous year(s), and zero if the spell survives.

$\mathrm{IQ}_{o(k-1)}$ denotes the IQ of exporters, that is, the SSA countries, which lags by 1 year, to reduce potential endogeneity/reverse causality where bilateral trade flows may influence IQ (Álvarez et al., 2018; Nunn & Trefler, 2014). Álvarez et al. (2018) also note that institutions likely affect trade with a time lag. With the estimate of $\mathrm{IQ}_{o(k-1)}$, we test H1a, that is, higher IQ of SSA exporters leads to longer bilateral trade duration. We iterate the regression for the overall exporter IQ and each dimension of IQ (Table 3.1).

The binary variable prod_p refers to the classification into agricultural commodities (zero; less differentiated) and processed food products (one; more differentiated), which we expect to influence the costs of establishing trade links and hence trade duration (Besedeš & Prusa, 2006b; Rauch & Watson, 2003). Given that switching between different suppliers, from a buyer's perspective, is easier in the case of homogeneous commodities than with differentiated products, we anticipate longer trade durations for processed food products (Besedeš & Prusa, 2006b). The vector τ_{od} in Eq. 3.4 captures several trade cost variables such as countries' landlocked status as well as trading partners' colonial ties, language conformity, and bilateral distance. Studies on trade duration show that being landlocked, having no colonial ties or a common official language, and a longer bilateral distance may increase trade costs and lead to a shorter trade duration (Bacchetta et al., 2012; Besedeš, 2010; Nitsch, 2009).

Vector $X_{odp(k-1)}$ includes time-variant control variables such as the GDPs of exporters and importers as measures of economic size and the exporters' exchange rate as a proxy for an economy's stability (Bojnec & Fertő, 2012). We consider these variables typically used in gravity models and commonly introduced in duration analyses to control for their effects on the duration of SSA agri-food exports to the EU-28 (*e.g.,* Bacchetta et al., 2012; Besedeš & Prusa, 2006b; Hess & Persson, 2011). Better economic performance (higher GDPs) may implicate longer, more stable trade relations (Besedeš & Prusa, 2006b). A longer trade duration may involve a higher exchange rate of the exporting country as weaker currencies stimulate exports due to relatively cheaper prices for importing countries and, in turn, enhance the probability of trade survival (Krugman, Obstfeld, & Melitz, 2011). $X_{odp(k-1)}$ also captures variables of exporters' experience, that is, the number of EU destination countries per product and the number of products traded to one destination. Greater diversification, and thus, more experience with the export of specific products and markets may lead to a longer trade duration (Brenton, Saborowski, & von Uexkull, 2010; Hess & Persson, 2011). All the time-variant covariates are included in the model with a one-year lag to reduce potential biases associated with reverse causality.

We introduce exporter-specific fixed effects (λ_o), importer-specific fixed effects (λ_d), and time dummies (λ_k). Incorporating exporter and importer fixed effects captures remaining country-specific differences that are not explicitly identified by the introduced country-specific variables. They are regularly used in the empirical gravity model specification of international trade flows, capturing the outward and inward multilateral resistance terms, that is, the exporters' ease of market access to and importers' ease of market access from all countries in the trade network, respectively (Yotov, Piermartini, Monteiro, & Larch, 2016). The use of yearly time fixed effects controls for common shocks such as global economic booms or slowdowns in a given year (Baldwin & Taglioni, 2006). ε_{odpk} is the error term.

To examine the impact of institutional dissimilarity of trading partners on trade survival, we use Eq. 3.4 and estimate effects of the dissimilarity of IQ (overall and different dimensions) $\mathrm{IQ}_{o(k-1)-d(k-1)}$ instead of the IQ of exporters $\mathrm{IQ}_{o(k-1)}$, which addresses H2a, that is, greater similarity in the IQ of an SSA country and an EU-28 country, the higher is the probability of achieving longer bilateral trade duration.

We calculate marginal effects of the regression coefficients to assess the sizes of the IQ (overall and different dimensions) effects on the probability of trade failure. Additionally, we standardize the IQ indicators' marginal effects and consider confidence intervals to evaluate the differences in the effect among the three dimensions, thereby addressing H1b and H2b, that is, the various dimensions of IQ and of the similarity in IQ differ with respect to their effects on the trade duration.[11]

3.4 Data and descriptive statistics

For our analysis, we use annual trade data from the UN Commodity Trade Statistics Database (Comtrade) at HS 6-digit level for 1996–2017 (United Nations, n.d.). The sample includes agri-food trade flows from each SSA country to each EU-28 country. Tables A3.3 and A3.4 (in the Appendix) show the SSA countries and product groups included in the analysis. We use the import data reported by the EU-28 as import statistics are more reliable than export statistics (Jacob, 2016).

The trade data are limited to a specific period, *i.e.*, censored (Verbeek, 2008), either flows/spells ongoing in 1996 or flows/spells ongoing in 2017 (Besedeš & Prusa, 2006b; Verbeek, 2008). The first (left-) censoring is problematic, leading to estimation bias, whereas we can neglect right-censoring in duration analyses (Hess & Persson, 2012). Following Peterson et al. (2017), we use the trade data available before the investigation period (limited by the data availability of the WGIs) starting from 1988 to control for left-censored spells.

We consider the six IQ indicators retrieved from the World Bank's WGI database (Kaufmann & Kraay, 2021). For assessing a country's IQ, (A) the government selection, monitoring, and replacement; (B) the governmental efficiency of policy formulation and implementation; and (C) the respect of citizens and state for institutions are relevant characteristics (Kaufmann et al., 2010). Table 3.1 describes the three dimensions (A–C) and the underlying indicators of the World Bank's WGIs. The WGIs are in standard normal units ranging from approximately -2.5 to 2.5. The higher the value, the better the IQ (Kaufmann et al., 2010). These data are available from 1996 to 2017; however, from 1996 to 2002, they were only published for every second year, leading to three missing (1997, 1999, and 2001) observation years. We follow Lin et al. (2019) and use the values of each previous year for the missing observations. Looking at the WGI scores of all SSA and EU-28 countries in 2017 (Tables A3.1 and A3.2 in the Appendix) shows that the IQ of the EU-28 (μ=1.02,sd=0.54) is higher than the IQ of SSA countries (μ=-0.69,sd=0.72).[12]

[11] Following Menard (2004), we partially standardize the marginal effects with the standard deviations of the explanatory variables.

[12] Finland is the country with the best IQ (WGIs range from 1.08 to 2.22) among all EU and SSA countries, whereas Somalia scores lowest (-2.31 to -1.72).

The six IQ indicators are highly correlated (see Table A3.5 in the Appendix). To avoid the problem of multicollinearity, we aggregate the six indicators into a single index, which provides the overall impact of IQ. In addition, we examine the three major dimensions (A–C) of the World Bank's WGIs in separate regressions to identify the effects of the different aspects of IQ, following (Asongu & Nwachukwu, 2016; Bojnec & Fertő, 2012; Daude & Stein, 2007; Globerman & Shapiro, 2002). For the aggregation, we employ Principle Component Analysis (PCA). We use the first components of the PCAs that suit the Kaiser–Guttman criterion as their eigenvalues are greater than one in each of the PCAs (Ismail, 2008) and capture high shares of the overall variance of their underlying indicators (see results of the PCAs in Table A3.6 in the Appendix).[13]

The dissimilarity index is calculated as the absolute difference between the exporter and importer IQ index for the six indicators ($|IQ_o - IQ_d|$), and then we apply PCA to calculate an aggregated dissimilarity index and one for each dimension. Our main analysis consists of estimating eight regressions: the first four consider the impact of the overall exporters' IQ and the three dimensions of IQ on trade duration; the following four use the dissimilarity indices instead of the exporters' IQ indices.

Table A3.7 in the Appendix presents an overview of our main variables, the control variables, their definitions, and sources. Table 3.2 provides descriptive statistics. The statistics of the three IQ dimensions suggest heterogeneity of their underlying data, for example, the IQ (A) in terms of the government selection and monitoring in the SSA countries (μ=0.98,sd=1.99) range from -6.05 to 5.37 across countries and time. The means of the binary variables show that for more than three-fourths of the reported trade links, countries are not landlocked, do not have any colonial ties, and do not share a common language. Additionally, there is a large gap between the GDPs of SSA (μ=102,sd=149) and EU (μ=16,906,sd=73,579) countries.

3.5 Results

Our data reveal substantial entries and exits in agri-food trade flows between SSA and EU-28 countries, with mean and median lengths of spell of 2.53 years and 1 year, respectively. The KM survivor function of these trade flows (Figure 3.1) shows the unconditional survival probability of trade links for every year of trade duration. The probability of trade failure increases with each additional year of spell length.

[13] For the aggregation to the three dimensions, one can alternatively calculate the mean or sum of the underlying WGIs; see Groot, Linders, and Rietveld (2005); Groot et al. (2004); and Linders, Slangen, Groot, and Beugelsdijk (2005). We apply the sum approach as a robustness check.

TABLE 3.2: Descriptive statistics of the variables

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Trade relation failure	0.25	0.43	0	1	274,329
IQ dimension (A)	0.98	1.99	-6.05	5.37	273,094
IQ dimension (B)	-0.18	0.48	-2.37	1.98	273,093
IQ dimension (C)	-0.07	0.12	-1.45	1.16	273,094
Dissimilarity of IQ, dimension (A)	0.01	1.19	-2.13	5.11	270,997
Dissimilarity of IQ, dimension (B)	0.01	0.30	-2.11	2.12	270,997
Dissimilarity of IQ, dimension (C)	0.03	0.13	-3.39	2.28	270,997
Landlocked	0.19	0.39	0	1	274,329
Colonial ties	0.16	0.36	0	1	274,329
Common language	0.21	0.41	0	1	274,329
Distance (km)	6,631	1,969	2,183	10,487	274,329
Exchange rate (ln of LCU/USD)	4.38	2.58	-4.60	22.63	261,746
Exporter's product diversification	61.52	78.90	0	788	274,329
Exporter's market diversification	5.50	5.72	0	28	274,329
GDP exporter (bn USD const. 2010)	102.40	149.75	0.12	464.00	264,697
GDP importer (bn USD const. 2010)	16,906	73,579	11.07	44,200	272,413
Product classification	0.26	0.44	0	1	274,329

Source: Own calculations based on data extracted from various databases (CEPII, 2021; Kaufmann & Kraay, 2021; United Nations, n.d.; World Bank, n.d.-b, n.d.-c).
Remark: Trade relation failure: 0 = survival, 1 = failure; Landlocked: 0 = no country is landlocked, 1 = at least one trade partner is landlocked; colonial ties: 0 = no colonial ties, 1 = colonial ties; common language: 0 = no common language, 1 = common language;exporter's product diversification = number of products exported to the destination; exporter's market diversification = number of destinations the product is exported to, product classification: 0 = agricultural commodity, 1 = food product.

After 1 year of trade, trade links fail with a probability of 60%. Until the end of the first 3 years, there is an 84% probability of failure. Only a small fraction of spells achieves durations longer than 10 years. We find higher failure rates and a lower mean of duration than other studies that show failure rates between 33% and 61% in the first year of trade and means of duration between 2.7 and 5.9 years (Besedeš & Prusa, 2006b; Nitsch, 2009; Rudi et al., 2012). This instability of trade relations is consistent with Rudi et al. (2012), who find particularly low survival rates of export flows from Africa.

Findings reveal that exporters with high IQ achieve longer trade durations than exporters with low IQ, and thus, support hypothesis H1a. In Table 3.3, we show the impact of the overall indicator of exporters' IQ (Column 1) and its different dimensions (Columns 2 to 4) on the probability of trade failure. The marginal effect of the overall quality indicator shows a 0.78% reduction in the probability of survival of agri-food exports from SSA to EU-28. When differentiating between IQ dimensions, all dimensions (A–C) negatively impact the trade failure rate, that is, an increase in IQ reduces trade failure. A one-unit increase of the exporter's IQ dimensions decreases the probability of trade failure by 1.11 to 1.79 percentage points.

TABLE 3.3: Probit marginal effects—Exporters' institutional quality

	Overall IQ index	**(A) Government selection**	**(B) Efficiency of policy**	**(C) Respect for institutions**
Inst. quality exporter	-0.01***	-0.01***	-0.01***	-0.02***
	[-0.01, -0.01]	[-0.01, -0.01]	[-0.02, -0.01]	[-0.03, -0.01]
Exchange rate	-0.00	-0.01***	-0.01***	-0.01***
	[-0.01, 0.00]	[-0.01, -0.00]	[-0.01, -0.00]	[-0.01, -0.00]
Product classification	-0.01***	-0.02***	-0.02***	-0.02***
	[-0.01, -0.008]	[-0.02, -0.01]	[-0.02, -0.01]	[-0.02, -0.01]
Exporter's product	-0.00***	-0.00***	-0.00***	-0.00***
diversification	[-0.00, -0.00]	[-0.00, -0.00]	[-0.00, -0.00]	[-0.00, -0.00]
Exporter GDP	-0.01***	0.0003	-0.02*	-0.02**
	[-0.02, -0.01]	[-0.02, 0.02]	[-0.03, -0.00]	[-0.03, -0.01]
Importer GDP	-0.02***	-0.00	-0.00	-0.00
	[-0.02, -0.02]	[-0.00, 0.00]	[-0.00, 0.00]	[-0.00, 0.00]
Exporter's market	-0.02***	-0.04***	-0.04***	-0.04***
diversification	[-0.02, -0.02]	[-0.04, -0.04]	[-0.04, -0.04]	[-0.04, -0.04]
Language	-0.02***	-0.02***	-0.02***	-0.02***
	[-0.03, -0.01]	[-0.03, -0.01]	[-0.03, -0.01]	[-0.03, -0.01]
Colonial ties	-0.00	-0.01	-0.01	-0.01
	[-0.01, 0.01]	[-0.01, 0.00]	[-0.01, 0.00]	[-0.01, 0.00]
Landlocked	-0.01	0.05**	0.03	0.02
	[-0.03, 0.02]	[0.02, 0.08]	[-0.01, 0.06]	[-0.01, 0.05]
Distance	0.03*	0.01	0.01	0.01
	[0.01, 0.06]	[-0.02, 0.03]	[-0.02, 0.03]	[-0.02, 0.03]
LogLik	-114,846	-116,448	-116,462	-116,460
AIC	229,903	233,098	233,126	233,123
N	238,886	238,886	238,886	238,886

Source: Own calculation based on data sources indicated in Table A3.7.

Remark: All time-variant variables are one-year lagged; Logarithms are taken of the distance, GDPs, and the exchange rate; Estimations with importer, exporter, and time FE; Lower and upper limits of 95% CI in parentheses; *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

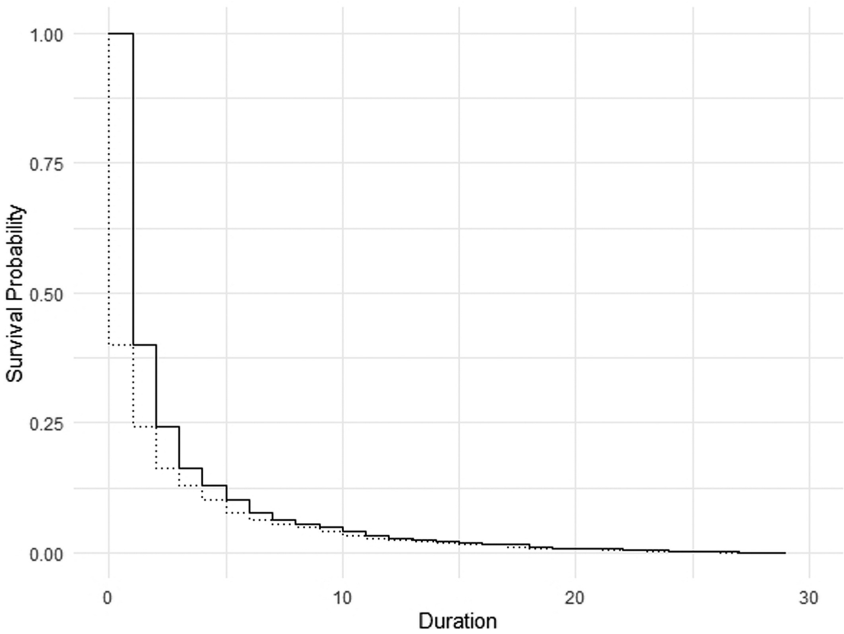

FIGURE 3.1: Kaplan–Meier survival function

Note: The Kaplan–Meier survival function shows the decreasing survival probability for each length of spell (*i.e.*, the duration) of SSA's agri-food exports (see Appendix S1 for SSA countries and Appendix S1 for product groups) to the individual EU-28 countries from 1988 to 2017.

Source: Own calculation and illustration based on UN Comtrade data (United Nations, n.d.).

Our results (Table 3.4) also suggest that greater dissimilarity of SSA-EU trade partners IQ is associated with smaller bilateral trade durations, supporting hypothesis H2a. The marginal effect (Column 1) indicates that a one-unit increase in the institutional dissimilarity indicators increases the probability of trade failure by 0.29 percentage points. This is consistent with the study of Álvarez et al. (2018), who state that less familiar institutional environments in partner countries lead to a reduction in trade quantities due to higher transaction costs. Similarly, we find the positive impact of institutional dissimilarity across different dimensions on the trade duration. The results indicate that a 1% increase in IQ dissimilarity of one of the three dimensions increases the probability of export failure by 0.3% to 1.4%. Businesses might resist risking a bad reputation because of ongoing trade relations with a corrupt country and prefer to trade with partners having similar ethical standards in this respect.

Figure 3.2 shows the relative importance of the impact of each IQ dimension by standardizing the marginal effects (of one SD difference). Our results partly support H1b, that is, the dimensions of IQ have different effects on the trade duration. The standardized marginal effect of dimension (A) reflecting government selection, monitoring, and replacement (voice and accountability and political stability and

TABLE 3.4: Probit marginal effects—Dissimilarity of institutional quality

	Overall IQ index	**(A) Government selection**	**(B) Efficiency of policy**	**(C) Respect for institutions**
Dissim. of inst. quality	0.00 **	0.00 **	0.01 ***	0.01 ***
	[0.00, 0.01]	[0.00, 0.01]	[0.01, 0.02]	[0.01, 0.02]
Exchange rate	-0.00	-0.01 ***	-0.01 ***	-0.01 ***
	[-0.01, 0.00]	[-0.01, -0.00]	[-0.01, -0.00]	[-0.01, -0.00]
Product classification	-0.01 ***	-0.02 ***	-0.02 ***	-0.02 ***
	[-0.01, -0.01]	[-0.02, -0.01]	[-0.02, -0.01]	[-0.02, -0.01]
Exporter's product div.	-0.00 ***	-0.00 ***	-0.00 ***	-0.00 ***
	[-0.00, -0.00]	[-0.00, -0.00]	[-0.00, -0.00]	[-0.00, -0.00]
Exporter GDP	-0.01 ***	-0.02 *	-0.01	-0.01
	[-0.01, -0.00]	[-0.03, -0.00]	[-0.03, 0.00]	[-0.02, 0.01]
Importer GDP	-0.02 ***	-0.00	-0.00	-0.00
	[-0.02, -0.02]	[-0.00, 0.00]	[-0.00, 0.00]	[-0.00, 0.00]
Exporter's market div.	-0.02 ***	-0.04 ***	-0.04 ***	-0.04 ***
	[-0.02, -0.02]	[-0.04, -0.04]	[-0.04, -0.04]	[-0.04, -0.04]
Language	-0.02 ***	-0.02 ***	-0.02 ***	-0.02 ***
	[-0.03, -0.01]	[-0.03, -0.01]	[-0.03, -0.01]	[-0.03, -0.01]
Colonial ties	-0.00	-0.01	-0.01	-0.01
	[-0.01, 0.01]	[-0.01, 0.00]	[-0.01, 0.00]	[-0.01, 0.00]
Landlocked	-0.01	0.03	0.03	0.05 **
	[-0.03, 0.02]	[-0.01, 0.06]	[0.00, 0.06]	[0.01, 0.08]
Distance	0.03 *	0.00	0.00	0.01
	[0.01, 0.06]	[-0.02, 0.03]	[-0.02, 0.03]	[-0.02, 0.03]
LogLik	-113,873	-115,388	-115,385	-115,376
AIC	227,957	230,976	230,969	230,953
N	237,014	237,014	237,014	237,014

Source: Own calculation based on data sources indicated in Table A3.7.

Remark: All time-variant variables are one-year lagged; Logarithms are taken of the distance, GDPs, and the exchange rate; Estimations with importer, exporter, and time FE; Lower and upper limits of 95% CI in parentheses; *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

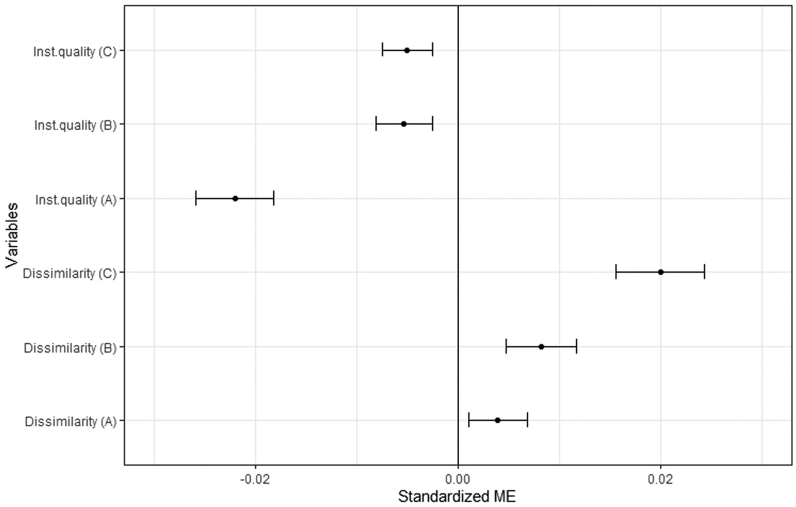

FIGURE 3.2: Standardized marginal effects of the different dimensions of IQ

Note: A, B, and C represent the three WGI dimensions: (A) Government selection, monitoring and replacement; (B) Efficiency of policy formulation and implementation; and (C) Respect of citizens and state for institutions; Inst. quality = IQ of exporters; Dissimilarity = institutional dissimilarity of importer and exporter; We show the standardized marginal effects with their 90% confidence intervals.

Source: Own calculations and illustration based on United Nations (n.d.) and Kaufmann and Kraay (2021) WGI database.

absence of violence/terrorism) differ significantly from dimensions (B) and (C) at 90% confidence level. However, the exporters' quality in dimensions (B) and (C) show insignificantly different effects on trade duration.

The standardized marginal effects (Figure 3.2) of the dissimilarity of the different IQ dimensions between SSA and EU also only partly support H2b. We find that the effect of dimension (C) —the respect of citizens and state for institutions— on trade duration is statistically different from and larger than those of dimensions (A) and (B), which themselves are statistically indistinguishable. This result suggests that mutual agreements regarding the rule of law and corruption control is more important for the stability of trade links than other aspects of IQ. This is reasonable, since (C) directly represents the behavior and legal working environment of operators involved in international trade as well as the degree of common understanding of acceptable legal practices. This might be crucial for trading partners' compliance with standards and quality requirements that play an increasingly important role in agri-food trade (Bojnec et al., 2014; European Commission, n.d.). A better institutional environment in this respect might therefore increase the duration of bilateral trade relationships.

Findings underline the relevance of IQ when establishing trade relations in terms of the consideration of institutional adjustments and/or choosing the right trade partner to enhance the duration of trade relations.[14] Countries can foster durations of their existing or potential trade relationships by improving their institutions and/or by trading with partners with similar IQ. From exporters' point of view, higher trade duration can result from institutional adjustments, mainly concerning governmental selection, monitoring, and replacement. From both trade partners' viewpoints, the right trade partner is the one with the most similar IQ levels, mainly, along the respect of citizens and state for institutions.

Our estimation results also show the impact of further control variables on the trade duration in the context of SSA's agri-food exports. The marginal effect of the level of product differentiation reveals a positive impact on trade duration (see Table 3.4). This is consistent with Besedeš and Prusa (2006b) and Rauch and Watson (2003), though our estimated coefficients are lower compared to these studies, perhaps reflecting that agricultural and food products are relatively more homogeneous than the manufacturing products considered in those studies (see *e.g.,* Brenton et al., 2010). The same official language in the two trading countries leads to longer spells, as expected. In contrast to Hess and Persson (2011), who show that being an old colony has a positive effect on the trade duration, we find no significant effects of colonial ties. Perhaps colonial ties not only contribute to countries' greater attachment but also to tensions and conflicts leading to more vulnerable trade relations (Bulhan, 2015). Moreover, as our investigated period is later than that of Hess and Persson (2011), old colonial ties might have lost importance over time. The exporter's exchange rate shows negative effects on the hazard rate of spells. An increase in nominal exchange rate (*i.e.*, exporter's domestic currency depreciates) is associated with a lower probability of trade failure. This is also in line with Hess and Persson (2011), who conclude that a higher relative real exchange rate of non-EU exporters increases the trade duration for EU imports. The negative signs of coefficients for product and export diversification show that greater product and export market diversity reduces the trade failure rate (Tables 3.3 and 3.4), which imply that an increased trade experience, *i.e.*, the learning-by-doing effect, enhances trade duration (Besedeš, 2010; Hess & Persson, 2011; Nitsch, 2009).

As a robustness check, we re-estimate the models using the logit model. Results across all IQ dimensions only slightly differ in magnitude (Tables A3.8 and A3.9 in the Appendix); thus, are robust against the estimation technique. We also perform

[14]We also use the likelihood ratio test to compare our models with the (nested) model in which the IQ variables are omitted (see Verbeek, 2008), and find that the inclusion of the IQ variables significantly improves the goodness of fit and therefore contributes to explaining the duration of trade.

a robustness check for the method of aggregating institutional indices. We sum the underlying WGIs under the three IQ dimensions (A–C) and estimate the results using a probit model (Table A3.10 and A3.11 in the Appendix). In contrast to the main results, the dissimilarity in terms of (A) governmental selection, monitoring, and replacement does not show an impact on the probability of trade failure. The remaining results are similar to the estimation results based on the PCA approach. Finally, instead of considering all spells, we only use the first spells to perform probit estimations of the regression with the overall exporters' IQ and institutional similarity indicators. Estimation results (Table A3.12 in the Appendix) are largely unaffected by the consideration of the different spell types, as also pointed out by others (*e.g.,* Bojnec & Fertő, 2018; Hess & Persson, 2011).

3.6 Conclusions

The stability of agri-food trade relationships is important for importers' product accessibility and variety as well as exporters' income generation and economic development. Institutional Quality (IQ) is potentially important to these relationships, and associated trade flows. We explore the duration of agri-food exports at the 6-digit level from SSA to the EU countries over the period 1996-2017, and investigate the impact of IQ factors on export flows and their duration, using the World Bank World Governance Indicators (WGI) as indicators of IQ. We use survival analysis to investigate the probability of the failure of trade links, and apply a discrete-time analysis to investigate how the IQ of exporters and the similarity with the IQs from partner countries along different dimensions affect export duration.

Our results show that, on average, export flows have a duration of 2.5 years. The probability of the failure of trade links is very high in the early years of exporting, with the probability of failure of 60% in the first year and 84% by the end of the third year. We find that higher IQ of the SSA exporters contributes to a lower failure rate in their bilateral trade links. SSA's similarity to the IQ of the EU destination country also favors longer trade duration. We distinguish between the impact of three major dimensions of IQ ("government selection, monitoring and replacement"; "efficiency of policy formulation and implementation"; and "respect of citizens and state for institutions") by comparing their standardized marginal effects. We show that the quality of governmental selection, monitoring, and replacement (*i.e.*, voice and accountability, political stability, and absence of violence/terrorism) in SSA countries, that is, the most related IQ dimension to enhance firms' investment and productivity and the stability of their business environment, has the largest effect on their export duration. In terms of dissimilarity, the institutional dimension evaluating the respect of citizens and state for institutions (*i.e.*, rule of law and control of corruption) is the most important. This suggests that improving trade partners' compliance with common rules and standards are important for agri-food trade.

The positive impact of IQ and its dimensions reveals that institutional adjustments in exporting countries can enhance the stability of (potential) trade relations. The differences of the impact across different attributes of institutional adjustments suggest targeting specific attributes may be important to increase the stability of trade relationships and associated flows. Considering that levels of IQ in most SSA countries are low compared to the global average, there is substantial scope for IQ improvements. The positive impact of the similarity of the institutional environment of trading partners motivates exporters and importers to select the appropriate partner as a strategy to accomplish long-term trade partnerships, especially, regarding partner countries' rule of law and corruption control. Given the significantly lower IQs of many SSA countries compared to the individual EU-28 countries, institutional adjustments can further enhance trade by increasing the common understanding of trade partners' mutual business environment.

Different dimensions of IQ might substitute or complement each other in determining the overall impact of IQ on the stability of trade relations. Considering the interaction between the different IQ dimensions (*e.g.*, complementarity effects), and then drawing from the impact of those interactions on trade duration offers potential scope for further research. Further, the interaction of IQs with some other trade-related factors may provide insights about where the IQ measures play greater roles with regard to trade risks and uncertainty.

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3.A Appendix

TABLE A3.1: WGI scores of EU-28 countries in 2017

EU-28	VA	PSNV	GE	RQ	RL	CC
AUT	1.34	1.05	1.46	1.44	1.81	1.53
BEL	1.38	0.43	1.18	1.24	1.34	1.50
BGR	0.38	0.33	0.26	0.63	-0.04	-0.16
CYP	1.06	0.54	0.92	1.03	0.88	0.78
CZE	0.97	1.00	1.01	1.23	1.12	0.57
DEU	1.39	0.59	1.72	1.78	1.61	1.84
DNK	1.52	0.87	1.80	1.62	1.86	2.19
ESP	1.03	0.28	1.03	0.94	1.01	1.24
EST	1.21	0.65	1.11	1.64	1.28	1.21
FIN	1.55	1.08	1.94	1.82	2.03	2.22
FRA	1.15	0.28	1.35	1.16	1.44	1.26
GBR	1.33	0.33	1.41	1.71	1.68	1.84
GRC	0.71	-0.07	0.41	0.24	0.08	-0.14
HRV	0.51	0.69	0.57	0.42	0.33	0.19
HUN	0.37	0.81	0.52	0.65	0.53	0.09
IRL	1.29	1.00	1.29	1.59	1.43	1.55
ITA	1.05	0.31	0.50	0.70	0.32	0.19
LTU	0.99	0.78	0.97	1.16	0.99	0.55
LUX	1.52	1.33	1.68	1.69	1.74	1.99
LVA	0.80	0.46	0.90	1.15	0.93	0.54
MLT	1.17	1.25	1.00	1.28	1.14	0.74
NLD	1.57	0.92	1.85	2.05	1.83	1.87
POL	0.78	0.52	0.64	0.88	0.47	0.72
PRT	1.21	1.12	1.33	0.91	1.13	0.87
ROM	0.52	0.06	-0.17	0.49	0.39	0.03
SVK	0.94	0.91	0.80	0.82	0.57	0.22
SVN	1.00	0.87	1.17	0.58	1.02	0.74
SWE	1.58	0.98	1.84	1.80	1.94	2.14
EU-28 (average)	1.08	0.69	1.09	1.17	1.10	1.01

Source: Own calculations based on Kaufmann and Kraay (2021).

Remark: The annual indicators are created by Kaufmann and Kraay using an unobserved component model (UCM). They are based on 31 data sources and are available from 1996.

Table A3.2: WGI scores of SSA countries in 2017

SSA	**VA**	**PSNV**	**GE**	**RQ**	**RL**	**CC**
AGO	-1.10	-0.33	-1.03	-1.04	-1.10	-1.41
BDI	-1.57	-2.01	-1.34	-0.84	-1.40	-1.28
BEN	0.38	0.03	-0.65	-0.47	-0.62	-0.55
BFA	0.06	-0.93	-0.58	-0.44	-0.40	-0.11
BWA	0.39	1.02	0.44	0.46	0.52	0.80
CAF	-1.11	-2.01	-1.77	-1.48	-1.73	-1.17
CIV	-0.27	-1.09	-0.76	-0.36	-0.63	-0.53
CMR	-1.05	-1.10	-0.81	-0.82	-1.03	-1.20
COG	-1.12	-0.53	-1.20	-1.33	-1.10	-1.33
COM	-0.30	0.04	-1.57	-1.04	-1.05	-0.68
CPV	0.97	0.77	0.17	0.20	0.42	0.83
ERI	-2.17	-0.73	-1.72	-2.20	-1.56	-1.20
ETH	-1.44	-1.68	-0.70	-1.01	-0.45	-0.56
GAB	1.06	0.10	-0.93	-0.79	0.68	-0.82
GHA	0.60	0.09	-0.11	-0.14	0.13	-0.23
GIN	-0.74	-0.70	-1.04	-0.84	-1.23	-1.01
GMB	-0.62	-0.08	-0.65	-0.45	-0.43	-0.63
GNB	-0.80	-0.50	-1.77	-1.18	-1.44	-1.56
GNQ	-1.97	-0.17	-1.44	-1.40	-1.49	-1.83
KEN	-0.20	-1.13	-0.32	-0.23	-0.41	-0.95
LBR	-0.02	-0.36	-1.34	-0.75	-0.37	-0.66
LSO	-0.40	-0.19	-0.86	-0.32	-0.27	-0.03
MDG	-0.34	-0.30	-1.14	-0.69	-0.86	-1.05
MLI	-0.25	-1.91	-0.94	-0.57	-0.79	-0.64
MOZ	-0.42	-0.93	-0.89	-0.73	-0.99	-0.83
MRT	-0.80	-0.23	-0.57	-0.78	-0.90	-0.75
MUS	0.19	0.09	0.90	1.00	0.68	0.20
NAM	0.63	0.20	-0.19	0.24	0.32	0.32
NER	-1.27	-1.27	-1.20	-0.68	-0.68	-0.66
NGA	-0.34	-2.00	-1.01	-0.89	-0.87	-1.08
RWA	0.14	0.09	0.27	0.15	0.19	0.63
SDN	-1.84	-1.98	-1.43	-1.56	-1.11	-1.53
SEN	-0.35	-0.05	-0.32	-0.15	-0.14	-0.09
SLE	-0.19	-0.04	-1.18	-0.92	-0.78	-0.57
SOM	-1.78	-2.26	-2.32	-2.29	-2.31	-1.72
SSD	1.82	-2.45	-2.48	-1.94	-1.94	-1.71
STP	0.30	0.19	-0.75	-0.83	-0.70	0.17
SWZ	1.43	-0.27	0.54	0.56	0.28	0.27
SYC	0.19	0.79	0.41	0.16	0.10	0.68
TCD	-1.37	-1.29	-1.47	-1.21	-1.30	-1.43
TGO	-0.62	-0.88	-1.12	-0.79	-0.72	-0.71
TZA	-0.28	-0.56	-0.63	-0.58	-0.45	-0.46
UGA	-0.59	-0.57	-0.58	-0.22	-0.30	-1.04
ZAF	0.63	-0.28	0.29	0.23	-0.04	-0.02
ZAR	-1.44	-2.35	-1.64	-1.47	-1.69	-1.42
ZMB	-0.34	0.15	-0.63	-0.47	-0.33	-0.54
ZWE	-1.20	-0.71	-1.19	-1.56	-1.38	-1.27
SSA (average)	-0.56	-0.62	-0.84	-0.74	-0.72	-0.68

Source: Own calculations based on Kaufmann and Kraay (2021).

Remark: The average in SSA across all WGIs is -0.69. The annual indicators are created by Kaufmann and Kraay using an unobserved component model (UCM). They are based on 31 data sources and are available from 1996.

TABLE A3.3: Exporting countries of SSA included in the study

Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Democratic Republic of Congo, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe.

Source: Own illustration based on World Bank Group (n.d.).

TABLE A3.4: Product classification

Agricultural commodities:
HS 01 – Live animals
HS 02 – Meat, edible
HS 03 – Fish, crustaceans
HS 05 – Other animal originated products
HS 06 – Trees and other plants
HS 07 – Edible vegetables
HS 08 – Edible fruits, nuts
HS 09 – Coffee, tea, spices
HS 10 – Cereals
HS 12 – Oilseeds
HS 13 – Lac, gums, resins
HS 14 – Vegetable products and plaiting materials
HS 15 – Fats, animal and vegetable
Food products:
HS 04 – Dairy products
HS 11 – Milling products
HS 16 – Meat and fish preparations
HS 17 – Sugars
HS 18 – Cocoa
HS 19 – Cereal, flour, starch
HS 20 – Vegetable and fruit preparations
HS 21 – Miscellaneous edible preparations
HS 22 – Beverages
HS 23 – Food industry residues and animal fodder

Source: Own illustration based on USDA (n.d.).

TABLE A3.5: Correlations of institutional quality indicators

Exporter WGIs						
	RL	CC	GE	VA	RQ	PS
RL	1.00					
CC	0.88	1.00				
GE	0.91	0.85	1.00			
VA	0.80	0.71	0.74	1.00		
RQ	0.88	0.75	0.88	0.76	1.00	
PS	0.79	0.69	0.69	0.66	0.65	1.00
Importer WGIs						
	RL	CC	GE	VA	RQ	PS
RL	1.00					
CC	0.94	1.00				
GE	0.94	0.94	1.00			
VA	0.93	0.90	0.89	1.00		
RQ	0.90	0.88	0.87	0.87	1.00	
PS	0.59	0.55	0.57	0.59	0.54	1.00
WGI distance (exporter WGI - importer WGI)						
	RL	CC	GE	VA	RQ	PS
RL	1.00					
CC	0.88	1.00				
GE	0.92	0.87	1.00			
VA	0.76	0.65	0.71	1.00		
RQ	0.87	0.75	0.86	0.74	1.00	
PS	0.65	0.51	0.56	0.59	0.57	1.00

Source: Own calculation based on Kaufmann and Kraay (2021) database.

TABLE A3.6: PCA results for World Governance Indicators

IQ of Sub-Sahara African countries:			Dissimilarity of IQ:	
	Comp.1	**Comp.2**	**Comp.1**	**Comp.2**
(A)				
Voice and accountability	0.707	-0.707	0.707	0.707
Political stability	0.707	0.707	0.707	-0.707
Standard deviation	1.290	0.583	1.190	0.764
Proportion of variance	0.830	0.170	0.708	0.292
Eigenvalue	1.660	0.340	1.417	0.583
(B)				
Governmental effectiveness	0.707	0.707	0.707	0.707
Regulatory quality	0.707	0.707	0.707	-0.707
Standard deviation	1.373	0.3396	1.263	0.637
Proportion of variance	0.942	0.0577	0.798	0.202
Eigenvalue	1.885	0.115	1.596	0.404
(C)				
Rule of law	0.707	-0.707	0.707	0.707
Control of corruption	0.707	0.707	0.707	-0.707
Standard deviation	1.370	0.3469	1.376	0.325
Proportion of variance	0.940	0.0602	0.947	0.053
Eigenvalue	1.880	0.120	1.895	0.105

Source: Own calculation based on Kaufmann and Kraay (2021) database.

TABLE A3.7: Definition of variables and their relation to trade

Variable	Definition	Data Source	Theoretical background
Institutional quality of exporter	The first components of the three PCAs are capturing the dimensions based on Kaufmann et al. (2010): • A: Government selection, monitoring and replacement • B: Efficiency of policy formulation and implementation • C: Respect of citizens and state for institutions	WGI	Countries with higher institutional quality show better legal security, lower uncertainty, and thus, foster bilateral trade relations and trade duration as e.g., uncertainty is detected as one important factor for high hazard rates in the first years of trade.
Dissimilarity of inst. quality of imp. and exporter	The first components of PCAs represent the dissimilarity between importer and exporters in the dimensions (see above).	WGI	More similar institutional environments of two countries lead to lower transaction costs for bilateral trade as there are more familiar with each other's institutions.
Landlocked	One if at least importer or exporter are landlocked, zero otherwise.	CEPII	Typical gravity variables that influence the trade/transaction costs of bilateral trade flows.
Colonial ties	One if exporter and importer have a common colonial history, zero otherwise.	CEPII	For coastal locations, countries with colonial ties, a common language, and a lower distance trade/transaction costs are lower, enhancing long-lasting trade relations.
Common language	One if exporter and importer share the same official language, and zero otherwise.	CEPII	Common language makes trade negotiations easier.
Distance	Distance between two trading countries calculated based on longitudes and latitudes of main cities in terms of population.	CEPII	Distance has a trade-enhancing effect and makes establishing long-lasting trade relations easier.
Exchange rate	Local currency over USD (period average).	World Bank database	Higher exchange rate of an export country stimulates exports due to resulting relatively cheaper prices for importing countries, enhancing probability of survival Krugman et al. (2011).
Number of export products	Number of products traded between two countries in the observed year.	UN Comtrade	Higher number of products traded enhances the experience on the bilateral market, reducing uncertainty before entering in a trade relation, which should lower the failure rate of trade.
Number of destination markets	Number of EU countries importing the specific product from one exporter in the observed year.	UN Comtrade	Greater number of destination markets represents exporter experience in exporting one particular product, reducing a country's delivery uncertainty, leading to higher trade survival rates.
GDPs	Importer or exporter GDP in constant USD (2010).	World Bank database	Gravity model: Countries with higher GDPs trade more and show more stable trade relations.
Product classification	One if processed food product (product group 04,11,16-23) and zero if agricultural good (01-03,05-10,12-15).	UN Comtrade	Important to consider the type of products traded as it is also indicating higher product differentiation.

Source: Own illustration based on various data sources (CEPII, 2021; Kaufmann & Kraay, 2021; United Nations, n.d.; World Bank, n.d.-c, n.d.-d).

TABLE A3.8: Estimation results logit model–Exporters' institutional quality

	Overall IQ indicator	**(A)**	**(B)**	**(C)**
Inst. quality exporter	-0.00 ***	-0.01 ***	-0.01 **	-0.02 ***
	[-0.01, -0.00]	[-0.01, -0.01]	[-0.02, -0.00]	[-0.02, -0.01]
Exchange rate	-0.01 ***	-0.01 ***	-0.01 ***	-0.00 ***
	[-0.01, -0.01]	[-0.01, -0.00]	[-0.01, -0.00]	[-0.01, -0.00]
Product class.	-0.00	-0.02 ***	-0.02 ***	-0.02 ***
	[-0.00, 0.00]	[-0.02, -0.01]	[-0.02, -0.01]	[-0.02, -0.01]
Exporter's product div.	-0.01 ***	-0.00 ***	-0.00 ***	-0.00 ***
	[-0.01, -0.01]	[-0.00, -0.00]	[-0.00, -0.00]	[-0.00, -0.00]
Exporter GDP	-0.01 ***	0.00	-0.01 *	-0.01 *
	[-0.01, -0.01]	[-0.01, 0.02]	[-0.03, -0.00]	[-0.03, -0.00]
Importer GDP	-0.02 ***	-0.00	-0.00	-0.00
	[-0.02, -0.02]	[-0.00, 0.00]	[-0.00, 0.00]	[-0.00, 0.00]
Exporter's market div.	-0.00 ***	-0.04 ***	-0.04 ***	-0.04 ***
	[-0.00, -0.00]	[-0.04, -0.04]	[-0.04, -0.04]	[-0.04, -0.04]
Language	-0.02 ***	-0.02 ***	-0.02 ***	-0.02 ***
	[-0.02, -0.01]	[-0.02, -0.01]	[-0.02, -0.00]	[-0.02, -0.01]
Colonial ties	-0.01	-0.01	-0.01	-0.01
	[-0.01, 0.00]	[-0.01, 0.00]	[-0.01, 0.00]	[-0.01, 0.00]
Landlocked	-0.01	0.05 **	0.02	0.03
	[-0.03, 0.01]	[0.02, 0.09]	[-0.01, 0.05]	[-0.00, 0.06]
Distance	0.03 **	-0.00	-0.00	-0.00
	[0.01, 0.05]	[-0.030, 0.02]	[-0.03, 0.02]	[-0.03, 0.02]
LogLik	-123,345	-115,886	-115,898	-115,899
AIC	246,902	231,974	231,998	232,000
N	238,886	238,886	238,886	238,886

Source: Own calculation based on data sources indicated in Table A3.7

Remark: (A)=Government selection, monitoring, and replacement, (B)=Efficiency of policy formulation and implementation, (C)=Respect of citizens and state for institutions; Aggregation to dimensions by taking the sum of the underlying WGIs; All time variant variables are one-year lagged; Logarithms are taken for distance, GDPs, and exchange rate; Estimations with importer, exporter, and time FE; Lower and upper limits of 95% CI in parentheses; $***p < 0.001$, $**p < 0.01$, $*p < 0.05$.

TABLE A3.9: Estimation results logit model–Dissimilarity of institutional quality

	Overall IQ indicator	**(A)**	**(B)**	**(C)**
Dissim. of inst. quality	0.00 *	0.00 *	0.01 ***	0.01 ***
	[0.00, 0.00]	[0.00, 0.01]	[0.00, 0.01]	[0.01, 0.02]
Exchange rate	-0.01 ***	-0.00 ***	-0.01 ***	-0.01 ***
	[-0.01, -0.01]	[-0.01, -0.00]	[-0.01, -0.00]	[-0.01, -0.00]
Product class.	-0.00	-0.02 ***	-0.02 ***	-0.02 ***
	[-0.00, 0.00]	[-0.02, -0.01]	[-0.02, -0.01]	[-0.02, -0.01]
Exporter’s product div.	-0.01 ***	-0.00 ***	-0.00 ***	-0.00 ***
	[-0.01, -0.01]	[-0.00, -0.00]	[-0.00, -0.00]	[-0.00, -0.00]
Exporter GDP	-0.01 ***	-0.01 *	-0.01	-0.00
	[-0.01, -0.01]	[-0.03, -0.00]	[-0.02, 0.01]	[-0.02, 0.01]
Importer GDP	-0.02 ***	-0.00	-0.00	-0.00
	[-0.02, -0.02]	[-0.00, 0.00]	[-0.00, 0.00]	[-0.00, 0.00]
Exporter’s market div.	-0.001 ***	-0.04 ***	-0.04 ***	-0.04 ***
	[-0.001, -0.001]	[-0.04, -0.04]	[-0.04, -0.04]	[-0.04, -0.04]
Language	-0.02 ***	-0.02 ***	-0.02 ***	-0.02 ***
	[-0.02, -0.01]	[-0.02, -0.01]	[-0.02, -0.01]	[-0.02, -0.01]
Colonial ties	-0.01	-0.00	-0.00	-0.01
	[-0.01, 0.00]	[-0.01, 0.00]	[-0.01, 0.00]	[-0.01, 0.00]
Landlocked	-0.01	0.03 *	0.04 *	0.05 **
	[-0.03, 0.01]	[0.00, 0.06]	[0.01, 0.07]	[0.02, 0.08]
Distance	0.03 **	-0.00	-0.00	-0.00
	[0.01, 0.05]	[-0.03, 0.02]	[-0.03, 0.02]	[-0.03, 0.02]
LogLik	-122,244	-114,802	-114,799	-114,790
AIC	244,700	229,803	229,798	229,781
N	237,014	237,014	237,014	237,014

Source: Own calculation based on data sources indicated in Table A3.7.
Remark: (A)=Government selection, monitoring, and replacement, (B)=Efficiency of policy formulation and implementation, (C)=Respect of citizens and state for institutions; Aggregation to dimensions by taking the sum of the underlying WGIs; All time variant variables are one-year lagged; Logarithms are taken for distance, GDPs, and exchange rate; Estimations with importer, exporter, and time FE; Lower and upper limits of 95% CI in parentheses; ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

Table A3.10: Sum aggregation: Estimation results–Exporters' institutional quality

	Overall IQ indicator	**(A)**	**(B)**	**(C)**
Inst. quality exporter	-0.00	-0.01 ***	-0.01 **	-0.02 ***
	[-0.01, 0.01]	[-0.01, -0.00]	[-0.01, -0.00]	[-0.03, -0.02]
Exchange rate	-0.01 ***	-0.01 ***	-0.01 ***	-0.01 ***
	[-0.01, -0.01]	[-0.01, -0.00]	[-0.01, -0.00]	[-0.01, -0.00]
Product class.	-0.00	-0.02 ***	-0.02 ***	-0.02 ***
	[-0.00, 0.00]	[-0.02, -0.01]	[-0.02, -0.01]	[-0.02, -0.01]
Exporter's product div.	-0.02 ***	-0.00 ***	-0.00 ***	-0.00 ***
	[-0.02, -0.01]	[-0.00, -0.00]	[-0.00, -0.00]	[-0.00, -0.00]
Exporter GDP	-0.01 ***	-0.01	-0.01	0.01
	[-0.02, -0.01]	[-0.03, 0.00]	[-0.03, 0.01]	[-0.01, 0.02]
Importer GDP	-0.02 ***	-0.00	-0.00	-0.00
	[-0.02, -0.02]	[-0.00, 0.00]	[-0.00, 0.00]	[-0.00, 0.00]
Exporter's market div.	-0.00 ***	-0.04 ***	-0.04 ***	-0.04 ***
	[-0.00, -0.00]	[-0.04, -0.04]	[-0.04, -0.04]	[-0.04, -0.04]
Language	-0.02 ***	-0.02 ***	-0.02 ***	-0.02 ***
	[-0.03, -0.01]	[-0.03, -0.01]	[-0.03, -0.01]	[-0.03, -0.01]
Colonial ties	-0.01	-0.01	-0.01	-0.01
	[-0.01, 0.00]	[-0.01, 0.00]	[-0.01, 0.00]	[-0.01, 0.00]
Landlocked	-0.02	0.03	0.03	0.07 ***
	[-0.04, 0.01]	[-0.00, 0.06]	[-0.00, 0.06]	[0.03, 0.10]
Distance	0.04 **	0.01	0.007	0.007
	[0.02, 0.07]	[-0.02, 0.03]	[-0.02, 0.03]	[-0.02, 0.03]
LogLik	-123,196	-116,459	-116,462	-116,434
AIC	246,604	233,119	233,127	233,071
N	238,886	238,886	238,886	238,886

Source: Own calculation based on data sources indicated in Table A3.7.
Remark: (A)=Government selection, monitoring, and replacement, (B)=Efficiency of policy formulation and implementation, (C)=Respect of citizens and state for institutions; Aggregation to dimensions by taking the sum of the underlying WGIs; All time variant variables are one-year lagged; Logarithms are taken for distance, GDPs, and exchange rate; Estimations with importer, exporter, and time FE; Lower and upper limits of 95% CI in parentheses; ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

TABLE A3.11: Sum aggregation: Estimation results–Dissimilarity of institutional quality

	Overall IQ indicator	**(A)**	**(B)**	**(C)**
Dissim. of inst. quality	0.01 **	0.00	0.01 ***	0.01 ***
	[0.00, 0.02]	[0.00, 0.00]	[0.00, 0.01]	[0.01, 0.02]
Exchange rate	-0.01 ***	-0.01 ***	-0.01 ***	-0.01 ***
	[-0.01, -0.01]	[-0.01, -0.00]	[-0.01, -0.00]	[-0.01, -0.00]
Product class.	-0.00	-0.02 ***	-0.02 ***	-0.02 ***
	[-0.01, 0.00]	[-0.02, -0.01]	[-0.02, -0.01]	[-0.02, -0.01]
Exporter's product div.	-0.02 ***	-0.00 ***	-0.001320 ***	-0.00 ***
	[-0.02, -0.02]	[-0.00, -0.00]	[-0.00, -0.00]	[-0.00, -0.00]
Exporter GDP	-0.01 ***	-0.02 **	-0.01	-0.00
	[-0.02, -0.01]	[-0.03, -0.01]	[-0.03, 0.00]	[-0.02, 0.01]
Importer GDP	-0.02 ***	-0.00	-0.00	-0.00
	[-0.02, -0.02]	[-0.00, 0.00]	[-0.00, 0.00]	[-0.00, 0.00]
Exporter's market div.	-0.00 ***	-0.04 ***	-0.04 ***	-0.04 ***
	[-0.00, -0.00]	[-0.04, -0.04]	[-0.04, -0.04]	[-0.04, -0.04]
Language	-0.02 ***	-0.02 ***	-0.02 ***	-0.02 ***
	[-0.03, -0.01]	[-0.03, -0.01]	[-0.03, -0.01]	[-0.03, -0.01]
Colonial ties	-0.005	-0.007	-0.006	-0.01
	[-0.01, 0.00]	[-0.01, 0.00]	[-0.01, 0.00]	[-0.01, 0.00]
Landlocked	-0.02	0.02	0.03 *	0.05 **
	[-0.04, 0.01]	[0.00, 0.06]	[0.00, 0.06]	[0.01, 0.08]
Distance	0.04 **	0.01	0.00	0.01
	[0.01, 0.06]	[-0.02, 0.03]	[-0.02, 0.03]	[-0.02, 0.03]
LogLik	-122,921	-115,391	-115,384	-115,376
AIC	244,394	230,981	230,952	230,952
N	237,014	237,014	237,014	237,014

Source: Own calculation based on data sources indicated in Table A3.7.
Remark: (A)=Government selection, monitoring, and replacement, (B)=Efficiency of policy formulation and implementation, (C)=Respect of citizens and state for institutions; Aggregation to dimensions by taking the sum of the underlying WGIs; All time variant variables are one-year lagged; Logarithms are taken for distance, GDPs, and exchange rate; Estimations with importer, exporter, and time FE; Lower and upper limits of 95% CI in parentheses; $***p < 0.001$, $**p < 0.01$, $*p < 0.05$.

TABLE A3.12: Estimation results probit model–First spells

	Overall IQ indicator	
Inst. quality exporter	-0.02 ***	
	[-0.02, -0.01]	
Dissim. of inst. quality		0.01 ***
		[0.01, 0.01]
Exchange rate	-0.04 ***	-0.04 ***
	[-0.04, -0.04]	[-0.04, -0.04]
Product class.	-0.01 *	-0.01 *
	[-0.01, 0.00]	[-0.01, -0.00]
Exporter's product diversification	-0.00 ***	-0.00 ***
	[-0.00, -0.00]	[-0.00, -0.00]
Exporter GDP	-0.05 ***	-0.05 ***
	[-0.05, -0.04]	[-0.05, -0.04]
Importer GDP	-0.04 ***	-0.04 ***
	[-0.04, -0.03]	[-0.04, -0.03]
Exporter's market diversification	-0.03 ***	-0.03 ***
	[-0.03, -0.03]	[-0.03, -0.03]
Language	0.00	0.00
	[-0.01, 0.01]	[-0.01, 0.01]
Colonial ties	-0.00	-0.00
	[-0.01, 0.01]	[-0.01, 0.01]
Landlocked	-0.02	-0.02
	[-0.06, 0.02]	[-0.06, 0.02]
Distance	-0.01	-0.02
	[-0.06, 0.03]	[-0.06, 0.03]
LogLik	-84,335	-83,520
AIC	168,899	167,269
N	155,311	153,968

Source: Own calculation based on data sources indicated in Table A3.7.
Remark: All time variant variables are one-year lagged; Logarithms are taken for the distance, GDPs, and exchange rate; Estimations with importer, exporter and time FE; Lower and upper limit of 95% CI in parentheses;$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$.

Chapter 4

Stringency and dissimilarity of Maximum Residue Levels affect bilateral agri-food trade stability[†]

Abstract: Food standards are rising in both prevalence and stringency. They protect consumers and may enhance demand stability but also pose compliance challenges to producers with ambiguous effects on the stability of trade relationships. We analyze the impact of importers' Maximum Residue Levels (MRLs) along with bilateral MRL dissimilarity between trade partners on trade duration and volatility. We find that stricter MRLs in importing countries enhance, whereas MRL dissimilarities reduce trade stability. The results suggest that importers with less strict MRLs than their trade partners can improve trade stability by reducing MRL dissimilarities. However, when importers have stricter MRLs, they might face a trade-off between benefits of lowering discrepancies for trade stability and the downsides of reduced stringency for food safety.

***Keywords**: Food safety standards, regulatory harmonization, trade duration, trade volatility*

[†]This chapter is published as Engemann, H., Jafari, Y., & Heckelei, T. (2025). Stringency and dissimilarity of Maximum Residue Levels affect bilateral agri-food trade stability. Applied Economic Perspectives and Policy, 2025:1–29, https://doi.org/10.1002/aepp.13509.

4.1 Introduction

As countries strive to improve food safety to lower consumers' health risks, the number and stringency of food safety standards are on the rise (Faour-Klingbeil and Todd, 2018; Ferro et al., 2015; Fiankor et al., 2020; Winchester et al., 2012).[1] These standards influence trade volumes, prices as well as the welfare of actors involved, and a considerable strand of research examining these relations exists (*e.g.,* Beghin et al., 2015; Fiankor et al., 2021; Swinnen, 2016; Swinnen et al., 2015; Swinnen and Vandemoortele, 2011). However, their impact on the stability of agri-food trade relations has received little attention. Recent shocks to the international trade system, such as Covid-19 and the Russia-Ukraine war (Engemann and Jafari, 2022; Khadka et al., 2025; Ruta, 2022; WTO, 2021b), underscore the need for stable and diversified trade to ensure consistent food availability and variety (Jafari et al., 2024).

Theoretically, higher standards can affect trade stability in two contrasting ways: by stabilizing demand through quality assurance as well as trading partners' fixed cost lock-ins, or by destabilizing trade due to exporters' compliance challenges, fairness concerns— such as whether the standards serve protectionist or food safety purposes[2]— and additional variable costs. The opposing effects may hinge not only on the stringency of a country's food quality standards, but also on differences between countries' levels of standards (Swinnen, 2016). If countries align their standards more closely, the risk of exporters (importers) seeking alternative buyers (suppliers) may decrease or increase. Formulating policies that account for both food safety —as reflected by food quality standards— and agri-food import stability is crucial, and necessitates an examination of whether food safety standards contribute to or counteract stability of trade relations.

In this study, we investigate the role of stringency levels in importing countries' food safety standards, the dissimilarity in stringency levels between trade partners, and the direction of this dissimilarity in the import stability of agricultural and food products. We use Maximum Residue levels (MRLs)[3] as a measure of product quality standards; MRLs are regulatory standards based on scientific assessments that define the legally tolerated volume of specific substances, such as pesticides or veterinary medicines, on products used for food and feed, and can be set by (individual) governments and

[1] According to WTO rules, countries can set their own standards as long as they are based on science. This results in a rising number of food safety standards. Contrarily, the WTO aims to harmonize these regulations internationally in order to achieve a more transparent and efficient trade system (FAO/WTO, 2017).

[2] Standards may also act as non-tariff barriers to trade (Kareem et al. 2018), which can be particularly challenging for less developed countries that generally have lower standards (Curzi et al., 2018; Jongwanich, 2009).

[3] Also sometimes referred to as Maximum Residue Limits (*e.g.,* FAO/WHO, nd).

organizations (European Commission, 2008; European Medicines Agency, 2024). For the analysis of the stability of bilateral trade relationships, we consider two dimensions: i) the persistence of uninterrupted trade flows of a given product between two trading partners over consecutive years, *i.e.,* trade duration, and ii) the fluctuations in trade values and volumes across years, *i.e.,* trade volatility.

We construct the measures of MRLs (*e.g.,* Ferro et al., 2015; Winchester et al., 2012), trade duration (*e.g.,* Hess and Persson, 2012; Peterson et al., 2018), and trade volatility (*e.g.,* Guerra et al., 2019) at product level (225 different agri-food products at HS6-digit level) for 164 countries worldwide from 2005 to 2020. We then estimate the impact of MRLs (stringency and similarity) on trade duration and volatility applying discrete-time duration models (Hess and Persson, 2012) and the Poisson-Pseudo Maximum Likelihood (PPML) estimator (Santos Silva and Tenreyro, 2006; Yotov et al., 2016), respectively.

The impact of importing countries' product quality standards and their dissimilarity to those of the exporting countries on import stability is complex and ambiguous. Superior quality products involve a greater consumer appreciation for the product, which, in turn, tends to decrease the importers' demand elasticity in response to price changes (Chenavaz, 2017; Feenstra and Romalis, 2014; Hallak and Schott, 2011). When initiating a trade relation, stringent importers bear higher fixed search costs to find an exporter that complies with the requirements. These higher costs reduce the risk of switching to alternative sourcing countries once the trade link is established (Rauch and Watson, 2003). However, stricter food safety standards in importing countries may also contribute to the destabilization of imports due to the potential difficulty exporters face in consistently meeting these stringent criteria (Mitchell 2003) and concerns over fairness by exporters towards markets characterized by demanding and potentially trade-restrictive regulations. Dissimilarity on MRLs between importer and exporter can stabilize (established) trade relations through good reputation if the exporter adheres to stricter MRLs, or higher fixed compliance costs if the importer imposes stricter MRLs. Conversely, trade relations may be destabilized if product prices of an exporter with stricter MRLs are not competitive, or if variable compliance and control costs make the bilateral trade unprofitable when the importer enforces stricter standards.

We have found no study that analyses the effects of countries' stringency or (direction of) incompatibility in terms of food safety standards on the duration and volatility of trade. Peterson et al. (2018) investigate the impact of the presence of exporters' sanitary and phytosanitary (SPS) requirements on US import failure rates of fruits and vegetables, finding a positive effect. Additionally, empirical studies examine the impact of food safety standards on the trade participation and intensity of agricultural and food products for different regions and product groups. Some of those studies find that standards have a positive impact on trade (Fiankor et al., 2019; Yang and Du, 2023),[4] while others show a negative impact (Arita et al., 2015; Disdier et al., 2008; Fernandes et al., 2019; Ferro et al., 2015; Fiankor et al., 2020; Fontagné et al., 2015; Hejazi et al., 2022) or no effect (Xiong and Beghin, 2012). Other studies find that heterogeneity of trading partners' standards reduces bilateral trade (Hejazi et al., 2022; Winchester et al., 2012). Even though these studies do not directly analyse the impacts of standard stringency on trade stability, they provide insights into impact channels associated with stability.

We contribute to the literature in three ways. First, we provide a literature-based theoretical framework on the impact of importers' MRL stringency on the stability of trade relationships, leading us to our hypotheses. Second, we identify the impact channels of trade partners' dissimilarity in MRLs on the trade stability based on literature and theory considering also the "direction" of this bilateral dissimilarity, and thereby we contribute to the ongoing debate on the harmonization of standards as pursued by the WTO and negotiated in regional trade agreements. Third, we empirically analyse the impacts of both importers' MRL stringency and bilateral differences in those on the stability of trade duration and trade volatility. To this end, we provide a comprehensive understanding of trade dynamics driven by MRLs.

Our results show that a more stringent MRL policy of importing countries leads to longer trade duration and lower trade volatility. This indicates that stringent MRLs may not only contribute to food safety (utilization dimension of food security) but also to the import stability of agri-food products (availability dimension of food security). However, larger deviations in MRL standards between the bilateral trading partners imply shorter bilateral trade duration and higher volatility of trade. This finding shows that buyers and sellers in countries having a similar level of MRL stringency achieve longer trade relations, and highlights the need for more comprehensive global harmonization.

The remainder of this paper is structured as follows. Section 2 discusses the relevance of food safety standards including MRLs, presents channels through which MRL

[4]Fiankor et al. (2019) find a trade-enhancing effect of GlobalGAP standards when exporting to high-value markets, and Yang and Du (2023) show that both voluntary and mandatory standards increase the volume of agricultural trade between China and the Belt & Road countries.

standards can affect trade stability in terms of import variety and imported amounts, and derives hypotheses. Section 3 specifies the regressions and the choice of estimation approaches for assessing the impact of MRL standards on trade stability. Sections 4 describes the data, and provides some descriptive statistics of them. Section 5 presents the results and discussions, section 6 gives policy implications, and finally section 7 concludes.

4.2 Background and derived hypotheses

Under the WTO's Sanitary and Phytosanitary Agreement, countries are allowed to set standards that deviate from international standards, provided these are based on scientific evidence (FAO/WTO, 2017). Food safety concerns and protectionist practices have led countries often set their own standards (Kareem et al., 2018), leading to a diverse array of requirements that exporters must meet to access different markets. As consequences, to reduce the compliance costs of meeting many different parallel standards, the WTO seeks to harmonize food safety standards globally.

One product standard highly relevant for food safety is the MRL. When importing countries set their own MRL standards, producers—both domestic and those exporting to the market—must comply with these standards in accordance with the non-discriminatory rules of the WTO (WTO, nd). Ensuring the adherence to MRLs might involve changes in the production, as well as regulatory oversight, testing and monitoring processes. Therefore, MRLs may affect the decisions of producers and consumers in importing as well as exporting countries, and thus influence not only the safety but also the stability dimensions of food security.

Understanding the influence of MRLs on the stability of agri-food has become increasingly important, as the trade network historically and also more recently experienced instabilities. The instability of trade relationships has become increasingly evident since the 2008 financial crisis (Bennett et al., 2016; Jafari et al., 2023,2), and more recently with events such as Covid-19 (Engemann and Jafari, 2022) and the Ukraine-Russia war (Hussein and Knol, 2023). Both historical and more recent instabilities stress the need to analyze factors that might contribute to or counteract trade stability (*e.g.*, Besedeš and Prusa, 2006b; Engemann et al., 2023; Hess and Persson, 2011; Peterson et al., 2018). The question is how do MRLs affect the stability of bilateral trade relationships?

TABLE 4.1: Overview of MRLs' impact channels

		Impact channels	Stability impact
Importers' stringency		Risk reduction of consumers' purchasing decisions	+
		Lower product price elasticity of demand	+
		Higher search costs for buyers	+
		Less/costlier diversification possibilities for importers	+
		Higher sunk costs for exporters to establish trade relations	+
		Higher risk of ban/rejection by importers (e.g. because of exporters' non-compliance)	-
		Fairness concerns of exporters towards standards	-
Dissimilarity	Stricter importer	Higher fixed compliance/implementation costs faced by exporters	+
		Higher variable compliance/controlling costs faced by exporters	-
	Stricter exporter	Higher prices in less quality-stringent importing countries due to additional (unnecessary) costs incurred in more-quality stringent countries	-
		Good reputation of exporters, which can lower price elasticity of demand	+

The impact of MRLs on the stability of trade relationships depends on several factors related to the behavior of both consumers and producers by affecting their utility and profit, respectively. Any change in those factors may result in importers' and exporters' reconsideration of trade decisions (Esteves and Rua, 2015). MRL standards may impact the fixed as well as the variable costs in exporting countries and add fixed and variable costs to importers (Xiong and Beghin, 2014). Accordingly, although sticking to MRLs may ensure certain product quality linked to the utility of consumers, it may also drive up costs allowing for mutually beneficial trade only if consumers are willing to pay for the costs of the stricter requirements. Table 4.1 summarizes the impact channels discussed in the following.

More stringent standards (lower MRLs) reduce the purchasing risk of consumers in importing countries by ensuring product quality, increasing the transparency between trade partners and reducing their information asymmetries (Besedeš and Prusa, 2011; Fiankor et al., 2020; Mitchell, 2003; Xiong and Beghin, 2014). Stricter MRL standards, which imply higher quality of food products, may also contribute to lower price elasticity of demand (Chenavaz, 2017), *i.e.,* price changes of products with a higher quality lead, ceteris paribus, to smaller changes in demand when compared to the same price change of products with lower quality. The extent of appreciation for product quality and thus elasticities may vary across countries depending on demand side factors (Feenstra and Romalis, 2014; Hallak and Schott, 2011).

MRLs may also increase the stability because importers need to establish a trade link that aligns with the requirements, which involves fixed search and compliance/training cost (Rauch and Watson, 2003). When considering these search and compliance/training expenses, identifying a suitable supplier tends to be more costly for importers with more stringent MRLs.[5] Among all possible suppliers, buyers (importers) search for the supplier (exporter) of a needed product with a certain quality to the lowest price possible (Rauch and Watson, 2003). With higher requirements of importers in terms of product standards, search and compliance costs would increase and the number of appropriate suppliers decrease. Once a trade relation has been established, higher fixed costs of establishing those trade relationships means that importers would be less willing to shift to alternative suppliers resulting in more stable trade relations. The lower number of suitable suppliers due to relatively strict import standards as well means that the importer has less opportunities to diversify and might be more concerned to maintain existing trade relationships. This is supported by Peterson et al. (2018), who find that a lower number of suppliers reduces the competition leading to lower hazard rates.

MRLs also involve fixed and variable costs of production affecting the stability of suppliers' export behaviour (Disdier et al., 2008; Ferro et al., 2015; Hejazi et al., 2022). When starting a trade relationship, exporters expect that paying the fixed costs to fulfil the importers' quality requirements is profitable (see Melitz, 2003). The existence of fixed costs to fulfil the quality requirements implies that suppliers may be less likely to shift to alternative destination markets. However, as MRLs also involve variable costs for suppliers, significant (and unexpected) increases in the MRL-related variable costs can outweigh sunk fixed costs, making it unprofitable to continue selling to this market.

[5] We note that these search and compliance costs also depend on further characteristics such as the differentiation level of the products (Besedeš and Prusa, 2006a).

Risk of rejection by importers and fairness concerns from the exporters' perspective are additional mechanisms that may play a role for the impact of importers' MRL stringency on trade stability. Exporters might face difficulties in consistently meeting strict MRLs set by the importing country (Mitchell, 2003), which increases the risk/probability of bans or rejections due to non-compliance of exporter. This can result in less stable and inconsistent import patterns (EC, 2022; Kubiak-Hardiman et al., 2023). Furthermore, comparably high stringency in MRLs of importers can be perceived as unfairly strict and trade-restrictive (Kubiak-Hardiman et al., 2023). Such fairness concerns of exporters can lead to trade disputes and, in turn, may cause bilateral trade disruptions. For example, the EU's relatively stringent MRLs of several substances have raised trade concerns by the United States and some other countries (WTO, 2021a).

Empirical studies analyzing the impact of standard stringency on trade duration and import volatility are notably limited. Peterson et al. (2018) examine the existence of SPS measures in exporting countries on survival of US fruit and vegetable imports, concluding that SPS requirements (*e.g.,* water treatment, fumigation) significantly increase hazard rates of trade. Besedeš and Yan (2018) examine the effects of product quality on trade duration and find a positive relation. While the two studies address trade stability in terms of duration, neither examines the impact of importers' standards. Other studies that consider importers' standards analyze their impact on trade levels but overlook stability. The overall findings of those studies remain ambiguous (Santeramo and Lamonaca, 2022).[6] For example, Xiong and Beghin (2014) find that strict MRLs foster import demand as higher food safety is guaranteed, while the exports by the MRL setting country decrease. Given that many of the theoretical channels outlined above support a positive impact of the importer's product quality standards on stability (see Table 4.1), we hypothesize that a higher stringency of the importer relative to all other countries[7] leads to an increase in import stability, more specifically to a longer trade duration (H1a) and lower volatility of bilateral trade values/volumes (H1b).

Besides the stringency level of the importer, the degree of (dis-) similarity in MRLs of trade partners may also play a role for the stability of trade relations. For the similarity, bilateral variations in MRLs set by both importer and exporter are relevant. Depending on which partner has the stricter MRL, those differences can imply the

[6] Several studies find a negative impact on trade (*e.g.,* Arita et al., 2015; Disdier et al., 2008; Fernandes et al., 2019; Fiankor et al., 2021; Fontagné et al., 2015), whereas others (Fiankor et al., 2019; Yang and Du, 2023) a positive effect on trade.

[7] The MRL stringency of importers shows the stringency level relative to all other countries. Therefore, it does not reflect the bilateral differences between importer and exporter.

excess or deficit in product quality of exporters compared to importers. How do dissimilarities in MRLs with the importer being stricter affect the stability of trade relations? In this case, exporters may pay fixed and variable costs to comply that might increase with higher dissimilarity of MRLs between the bilateral trading partners (Fontagné et al., 2015; Xiong and Beghin, 2014). Fixed costs to establish the trade link and to comply with the relatively higher stringency may increase with higher dissimilarities as investments in new production techniques get necessary (Fiankor et al., 2020). Variable (trade) costs can be induced by adjusting the input use (*e.g.,* less-toxic treatment), logistics and quality controls needed to ensure that the product standards of the import market are met (Fontagné et al., 2015; Xiong and Beghin, 2014). The higher fixed costs may imply that suppliers are less likely to divert away from their import partner, once they established the trade link. Nonetheless, the supply to the import destination might be disrupted in case suppliers cannot comply due to factors that increase variable cost elements.

If the exporter's MRLs are more stringent than importer MRLs, the quality of the exported product may be superior and imply costs unnecessary for compliance (Mitchell 2003), inducing higher prices. The stability might be enhanced due to a good reputation of the exporter (Colen et al., 2012), increasing import demand from this country and a decreasing price elasticity for higher quality products. Nonetheless, companies located in countries with high quality standards may be less likely to export to markets with lower quality standards (Crinò and Epifani, 2012). Thus, it is questionable whether consumers in the importing country are willing to bear these additional costs of importing from a stricter partner, and not rather switch to another supplier with lower complying requirements. This would induce more instability to the trade relation.

We are not aware of any study examining the impact of bilateral dissimilarity on trade stability. However, examining the MRLs' effect on trade values, empirical research indicates that differences in standards tend to reduce trade. For instance, Drogué and DeMaria (2012) show a trade-impeding effect of regulatory heterogeneousness in the case of MRLs of apples, pears and related processed products. Fiankor et al. (2024) find that MRL heterogeneity reduces imports of Swiss firms. Similarly, Foletti and Shingal (2014) demonstrate that harmonizing MRL standards increases trade along intensive and extensive margin of trade.

This background suggests that bilateral differences of trading partners in MRLs matter beyond the stringency level of the importer. The overall impact of these differences on the stability of trade links can be either positive or negative, depending on the weight and interaction of the different channels (see Table 4.1). We expect that the destabilizing channels — namely, the variable costs faced by the exporter (when importer is stricter) and the potentially higher prices (when exporter is stricter) — outweigh the stabilizing channels, such as the fixed costs (when importer is stricter) and exporters' reputation (when exporter is stricter). This expectation is based on the observation that trade flows are more sensitive to changes in variable trade costs compared to changes in fixed costs (Jafari and Britz, 2018). Therefore, we hypothesize that higher bilateral differences of MRLs in established trade relations decrease the trade duration (H2a) and increase the trade volatility (H2b). Further, considering the different theoretical channels based on either the excess or deficit exporters' standards compared to importers, we hypothesize that the extent of the impact of dissimilarity on trade duration (H3a) and trade volatility (H3b) differ depending on which trading partner is stricter.

4.3 Methodology

To examine the effects of importers' MRL standards and the bilateral differences therein on trade stability —specifically, the duration of import trade relations and the volatility of import values/volumes— our methodological approach employs two different regression models. For the analysis of the impact of MRLs on trade duration, we rely on a discrete-time hazard model (Hess and Persson, 2012) since our data is reported in discrete units of yearly length.[8] We test hypotheses H1a, H2a and H3a based on the following specification:

$$\begin{aligned} y_{odpkt} = {} & \delta_0 + \delta_1 \text{MRL}_{odp(t-1)} + \delta_2 \Delta\text{MRL}_{odp(t-1)} * \text{RI}_{odp(t-1)} \\ & + \delta_3 \Delta\text{MRL}_{odp(t-1)} * \left(1 - \text{RI}_{odp(t-1)}\right) \\ & + \text{Controls}_{odpkt(t-1)} \delta_4 + \lambda_k + \lambda_p + \lambda_t + \alpha_{odp} + \varepsilon_{odpkt}, \end{aligned} \tag{4.1}$$

where y_{odpkt} is the dependent binary duration variable that equals zero if the spell k for the bilateral import of product p from origin country o to destination country d survives in time t, and one if the spell fails. A trade spell is the period of consecutive years of trade in a trade relation without interruption, *i.e.,* the period from the first (re-)occurrence to the last occurrence of origin-destination-product specific trade

[8] Many studies use the Cox models.[9] However, Hess and Persson (2012) discuss several drawbacks: (i) difficulties to control for unobserved heterogeneity, (ii) continuous-time specification, but data is grouped into discrete units, and (iii) limits the independent variables from exerting a constant effect on the hazard rate.

(Besedeš et al., 2016; Hess and Persson, 2011). Thus, the binary duration variable informs about whether the duration of the trade spell *k* is prolonged or determined in *t*. We consider single and first spells,[10] and also the spells that reoccur after one or more failures in the same trade relation, called multiple spells (*e.g.,* Hess and Persson, 2011; Jaghdani et al., 2024).

Our specification includes several regressors of interest (Eq. 4.1). With the importer's restrictiveness in MRL standards for product *p* at time $t-1$, $MRL_{dp(t-1)}$, we want to examine whether a higher stringency of the importer relative to all other countries lead to longer trade duration (lower the rate of trade failure). Thus, for H1a, we test $\delta_1 < 0$. Second, to examine H2a and H3a, we incorporate the bilateral difference in MRL stringency for product p between origin o and destination d, $\Delta MRL_{dp(t-1)}$, and interact this difference with two binary variables indicating which trading partner has the stricter standard: i) $RI_{odp(t-1)}$, being one if the exporter has a deficit in MRL stringency for product p in time t compared to the importer, and zero otherwise; ii) the inverse of this index $1 - RI_{odp(t-1)}$, being one if the exporter has an excess in or same MRL stringency for product p in time t compared to the importer, and zero otherwise. Consequently, if $\delta_2 + \delta_3 > 0$ holds, differences in MRLs of importer and exporter increase the duration of bilateral trade relations supporting H2a. Further, we use Chi-square and Z-tests to evaluate if $\delta_2 \neq \delta_3$ holds true, indicating whether it matters which trading partner is having the stricter MRLs (H3a). To further reduce potential biases associated with endogeneity that are not captured by the fixed effects, we take the one-year lags of all time-variant covariates included in the model. Nonetheless, regarding a potential reverse causality, we conjecture that the stability of trade relationships (trade duration and volatility) may not systematically influence the stringency of MRLs for two main reasons: 1) Many MRLs are set by Codex Alimentarius and are considered non-protectionist standards with science-based reference levels (Li and Beghin, 2014). For those MRLs that exceed Codex levels, several factors significantly reduce the incentive to use MRLs as protectionist measures. As implied by the national treatment principle of the WTO, MRLs must be met by both foreign and domestic producers. Moreover, many MRLs are established by supranational organizations, such as the EU, ASEAN, or the Gulf Cooperation Council. 2) Although we do not rule out the influence of trade on MRLs, we note that the likelihood that the stability of trade relationships influence the stringency of MRLs is significantly lower, if existing at all.

[10]If a specific trade link has not been previously established, its initial occurrence is referred to as the first spell of trade. If this trade flow ceases and is later resumed, this initial trade period is a single spell (Hess and Persson, 2011).

MRLs are quantitative measures that can be aggregated into indices enabling comparability across products and countries. We follow Ferro et al. (2015) and construct the MRL stringency of each importer *d* for product *p* at time *t*, MRL_{dpt} (see Eq. 4.2). We normalize the MRL stringency for each combination of product *p* and active substance *a* at time *t* (MRL_{dpta}) relative to the maximum and minimum MRLs across countries, MAX_{pta} and MIN_{pta}, and take the average across active substances *a* for each importer *d* and product *p* in year *t*:

$$\mathrm{MRL}_{dpt} = \frac{1}{N(a)} \left(\sum_{n(a)=1}^{N(a)} \frac{\mathrm{MAX}_{pta} - \mathrm{MRL}_{dpta}}{\mathrm{MAX}_{pta} - \mathrm{MIN}_{pta}} \right) \tag{4.2}$$

This stringency index ranges from zero to one, where zero corresponds to the least restrictive and one to the most restrictive MRLs at country-product-time level.

The dissimilarity index follows Winchester et al. (2012). ΔMRL_{odpt} is the normalized absolute bilateral dissimilarity of MRLs (see Eq. 4.3) between origin country o and destination country d in year t considering all relevant active substances a for products p. The dissimilarity index is zero when importer and exporter MRLs are equal, and one when origin and destination countries have the most and the least stringent MRLs of a product. Unlike the index used by Xiong and Beghin (2014), which takes the exponential of the difference, we do not assume that compliance becomes marginally more difficult as stringency increases. Different from our MRL stringency measure, the dissimilarity measure is based on the MRLs set by both the importer and the exporter, thus also directly considering exporters' variation in MRLs:

$$\Delta\mathrm{MRL}_{odpt} = \frac{1}{N(a)} \left(\sum_{n(a)=1}^{N(a)} \frac{|\mathrm{MRL}_{opta} - \mathrm{MRL}_{dpta}|}{\mathrm{MAX}_{pta} - \mathrm{MIN}_{pta}} \right) \tag{4.3}$$

Our regression specification (Eq. 4.1) includes controls related to trade cost variables capturing whether countries are landlocked, have colonial ties, the same languages and common Regional Trade Agreements (RTAs). It also captures bilateral physical distances, bilateral product specific applied tariffs, and product-importer-specific SPS and TBT notifications to the WTO. Trade duration studies[11] show that factors

[11] In standard heterogeneous-firm trade models, higher trade barriers lead to negative effects for the extensive margin of trade (Chaney, 2008; Crozet and Koenig, 2010; Melitz, 2003), which is supported by empirical trade duration studies (*e.g.*, Bacchetta et al., 2012; Besedeš and Prusa, 2006a; Engemann et al., 2023; Hess and Persson, 2011; Nitsch, 2009) finding that variables related to higher trade costs cause higher failure rates.

that reduce trade costs are beneficial for the achievement of longer trade duration. Further, we include GDPs of exporters and importers as measures of economic size and the initial trade volume of the spell to control for the size of the specific spell (Besedeš et al., 2024). We expect that both, greater economic size and the size of the spell imply more stable trade relations (Besedeš et al., 2024; Besedeš and Prusa, 2006a; Bojnec and Fertő, 2012).

Further, we introduce λ_p, λ_t, and λ_k as product group, time and spell fixed effects, respectively. α_{odp} denotes the exporter-importer-product random effect. ε_{odpkt} is the idiosyncratic error term. Product fixed effects control for differences across product groups, as we expect these differences to, for example, affect the costs of establishing trade links (Besedeš and Prusa, 2006a; Rauch and Watson, 2003). By introducing yearly time fixed effects, we account for common shocks, *e.g.,* global economic booms or slowdowns across years (Baldwin and Taglioni, 2006). The spell fixed effect captures experiences gained in previous spells in the trade relationship. Using relationship specific random effects controls for unobserved heterogeneity that is constant within trade relationships (Besedeš et al., 2024; Hess and Persson, 2012). We use random effects rather than fixed effects to address the incidental parameter problem, a common issue in non-linear models with panel data that feature a large number of individuals over a limited number of years (Lancaster, 2000).

To estimate Equation 4.1, we follow the reasoning of Hess and Persson (2012) and rely on the conventional regression techniques for panel data with binary outcome variables, applying the probit estimator. We also test the robustness of our results using logit and cloglog estimators. We set up a second specification to estimate the effects on trade volatility vol_{odpt} as follows:

$$\begin{aligned} vol_{odpt} = \exp \Big[& \delta_0 + \delta_1 \text{MRL}_{dp(t-1)} + \delta_2 \Delta\text{MRL}_{odp(t-1)} * \text{RI}_{odp(t-1)} \\ & + \delta_3 \Delta\text{MRL}_{odp(t-1)} * \big(1 - \text{RI}_{odp(t-1)}\big) \\ & + \delta_4 \text{Controls}_{odpkt(t-1)} + \lambda_{od} + \lambda_{otp} + \lambda_{dtp} \Big] * \varepsilon_{odpkt}, \end{aligned} \tag{4.4}$$

With this specification, we target to examine hypotheses H1b ($\delta_1 < 0$), H2b ($\delta_2 + \delta_3 > 0$), and H3b ($\delta_2 \neq \delta_3$) as discussed above with respect to the estimation of the impact of MRLs on trade duration (Eq. 4.1).

The dependent variable is the trade volatility between origin o and destination d for each product p at time t, vol_{odpt}. To quantify this variable, capturing positive and negative fluctuations around bilateral trade patterns, we use the standard deviation of the actual bilateral trade values x_{odpt} from expected trade values $\hat{x}_{odpt}$ following Guerra et al. (2019):

$$vol_{odpt} = \sqrt{(x_{odpt} - \hat{x}_{odpt})^2}, \tag{4.5}$$

whereas the expected trade values are obtained by estimating:

$$\hat{x}_{odpt} = \hat{\alpha} + \hat{\beta}t. \tag{4.6}$$

with ordinary least squares (OLS) regression. The constant $\hat{\alpha}$ and the coefficient $\hat{\beta}$ multiplied by time *t* yield the fitted values for the linear trend, *i.e.,* the expected trade values $\hat{x}_{odpt}$.

We follow the gravity model literature and include importer-time-product (λ_{dtp}) and exporter-time-product fixed effects (λ_{otp}) to control for outward and inward multilateral resistances along with country-size effects, and importer-exporter fixed effects (λ_{od}) to capture time-invariant trade costs and to mitigate endogeneity issues (Anderson and Yotov, 2020; Baier and Bergstrand, 2007; Fiankor et al., 2021; Hummels, 1999). Since time-invariant country pair variables are captured by the fixed effects in this specification, we here only include the time variant controls, namely SPS and TBT notifications, bilateral tariffs, and regional trade agreements as controls.

To estimate Equation 4.4, we rely on the PPML estimator addressing heteroskedasticity and the inclusion of zeros (Santos Silva and Tenreyro, 2006). In gravity-style trade models with high-dimensional fixed effects, the incidental parameter problem is less severe than in binary discrete-time models, as the PPML estimator can handle a large number of fixed effects (Weidner and Zylkin, 2021).

4.4 Data

The MRL data comes from the Lexagri International's Homologa database. The data includes MRLs for 72 reporters, 742 products and 2028 substances[12] that can be different chemical residues such as pesticides, mycotoxins and veterinary drugs. We map the reporter and the product classification in Homologa to individual countries

[12]We have retrieved the data from (Homologa, 2021) the in June 2021. MRLs are reported at different levels (i) individual country level and (ii) supranational organization level (EU, Gulf Cooperation Council, ASEAN cooperation, Codex Alimentarius binding for all WTO members). See Tables A4.1 and A4.2 for a list of products and countries covered by the reported MRLs. The list of substances is available upon request.

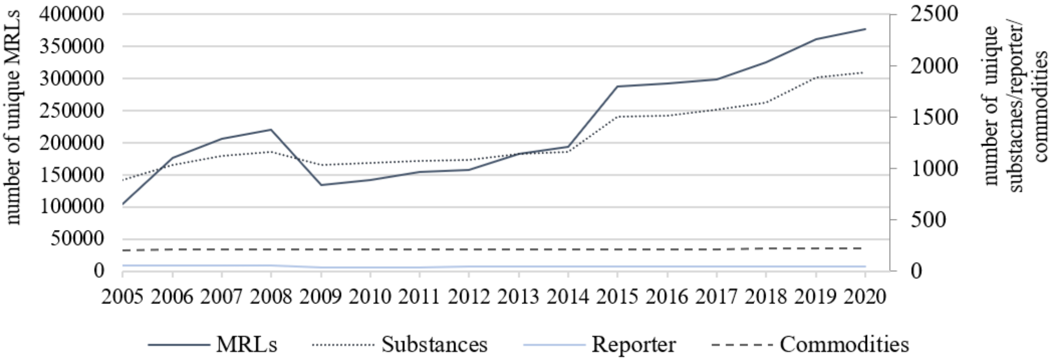

FIGURE 4.1: Evolution of different MRLs across countries

Note: MRLs are unique values per substance and product (at HS6-digit level) across all countries in each year. Reporter are individual countries and supranational organizations, such as Codex Alimentarius, EU, Gulf Cooperation Council and ASEAN Cooperation.
Source: Illustration based on data from the Homologa database (Homologa, 2021).

and products at 6-digit level of the Harmonized Systems (HS) to match with the other data, resulting in a dataset of 164 countries (see Table A4.1) and 225 product groups at HS6 level. The temporal scope of the data is 2005 to 2020. Figure 4.1 depicts the number of reporters, and the evolution of the variety of substances and products, as well as unique MRLs reported per substance and product. If two or more countries report the exact same MRL, we count it as one MRL, therefore reflecting on the number of (dis)harmonized MRLs globally. The figure reveals an increasing global trend in the number of different MRLs, with 2015 being the year with the largest rise within our study period driven by a significant expansion of substances reported. We observe a decrease in the number of MRLs in 2009 because of the EU wide harmonization of MRLs based on the Regulation (EC) No 396/2005 that came into effect in September 2008. In 2009, the number of substances significantly decreased and the individual EU countries stop setting their own MRLs reducing the number of reporters to 39 (from 61 in 2008). In all other years, the number of regulated substances rises strongly, while the number of products and reporters increases only marginally.

If there is no MRL reported by an individual country in a given year, we take the value reported in the previous year (assuming an unchanged MRL). If a country has previously either not reported an MRL or has reported a less stringent MRL than the one set by the supranational organization to which it belongs (*i.e.,* EU, Gulf Cooperation Council, ASEAN cooperation, Codex Alimentarius), we adopt the MRL provided by the supranational organization. Furthermore, if the supranational organization has also not set an MRL, we assume that the country has the least restrictive MRL stringency for that specific substance-product pair across countries (see *e.g.,* Drogué and DeMaria, 2012; Fernandes et al., 2019; Ferro et al., 2015; Fiankor et al., 2021).

To construct bilateral trade stability measures (duration and volatility), we extract import values and quantities from the United Nations' Commodity Trade Statistics (UN COMTRADE, 2022) database at HS-6-digit level. We interpret the missing observations as zero trade flows (World Bank 2010).[13] As annual trade data is available before 2005, we control for left-censoring in the duration analysis.[14] Trade values are deflated by the consumer price index (The World Bank, 2022a).

The duration of bilateral trade relations is often short (*e.g.,* Besedeš and Prusa, 2006a; Engemann et al., 2023; Peterson et al., 2018). To analyze the duration of bilateral trade relations in our data set, we apply the Kaplan and Meier (1958) estimator. It calculates the expected time until a bilateral trade relation fails after different length of spells (Besedeš et al. 2016). Figure 4.2 (Panel a) depicts the cumulative survival probability at each annual length of a spell k based on the non-parametric survival estimator of the hazard function.[15] It indicates that only 50.5% of all trade relations survive after one year of trade at the HS-6-digit level. The survival rate reduces to 14.0% after seven years. In subsequent years, the annual failure rate is substantially lower (up to 2.1%) and decreasing over time. In our dataset, only 4.4% of trade spells are still active after 15 years. Overall, considering the investigation period in this study, the average number of consecutive years that a trade spell survives (*i.e.,* trade duration) is 3.62 years. These findings are also in line with the literature that has found relatively short-lived duration of trade flows at a similar product resolution level (*e.g.,* Besedeš and Prusa, 2006a; Engemann et al., 2023; Peterson et al., 2018).

Bilateral trade values are also volatile. Figure 4.2 (Panel b) depicts the annual average volatility across products and countries, which is the normalized mean of product specific standard deviations of the deflated trade values across the years. The figure indicates that the agri-food trade system has witnessed fluctuations, particularly in

[13] Replacing missing values with zeros is common when using UN Comtrade data. According to the World Bank (2010) "No trade information for any given product (or product category) indicates a non-traded product according to the reporting country". Kareem and Kareem (2019) state "[. . .] the UN COMTRADE data reports trade values, even for very small values (up to $1), indicating that rounding to zeros is not an important cause of zero observation as most zeros are caused by economic reasons such as lack of profitability." Linders and De Groot (2006) also refer to the Comtrade data and mention "We assume that all missing observations in principle indicate that bilateral exports are considered to be absent by the reporting country."

[14] Left-censoring means that the trade spell was already ongoing before the study period, which can lead to estimation biases (Hess and Persson, 2012). To control for that, we follow Peterson et al. (2018) and use the preceding data.

[15] The Kaplan-Meier (KM) survival estimator is calculated by multiplying the ratios of observations without the event $(n_j - d_j)$ over those at risk n_j over time$\hat{S}(t) = \prod_{t(j)<t} \frac{n_j - d_j}{n_j}$ (Kaplan and Meier, 1958).

2009 and 2011, during the period of the financial crisis (2008-2009) to the onset of the economic crisis in many high-income countries in 2012 when the aggregate demand for agricultural products weakened significantly (Beckman et al., 2017).

We obtain information on countries' GDP from the World Bank database (The World Bank, 2022b), on bilateral applied tariffs from the United Nations Commission on Trade and Development (UNCTAD) provided by the World Integrated Trading System (WITS) database, on SPS and NTM notifications from the wiiw NTM database (Ghodsi et al., 2017), and on RTAs from the WTO Regional Trade Agreements database. We only consider RTAs that include goods. The remaining control variables are retrieved from the CEPII database (Conte et al., 2022). Table 4.2 shows the descriptive statistics of the variables used in the regression estimations and some additional variables. Descriptive statistics of the binary duration show that 18% of the observations represent a failure of a trade relation emphasizing the short duration depicted in Figure 4.2, Panel a. Furthermore, 27% of the active spells are multiple spells with up to seven spells within a trade relationship; the remaining part are first or single spells of a bilateral trade relationship. The trade volatility measure clearly demonstrates fluctuations from the linear trend, with a right skewed distribution. Importers' stringency and bilateral differences in MRLs are normalized values between zero and one, with means of 0.35 and 0.31 units.[16] The statistics of the binary restrictiveness index indicate that, in 39% of the observations the importer is stricter than the exporter, and in 61% of the observations they have either the same level of stringency or the exporter is stricter.

4.5 Results and discussions

The main results are shown in Figure 4.3. First, we test the hypothesis that a higher stringency of the importer relative to all other countries lead to more stability in terms of import trade duration (H1a) and trade volatility (H1b). We find a negative effect of importers' MRL stringency on the failure of bilateral trade relationships (see Figure 4.3, Panel A; Table A4.3 in the Appendix), which implies that relatively stricter importer MRLs induce longer bilateral trade duration. The results of the PPML estimates suggest that stricter importer MRLs lead to lower trade volatility in terms of trade values. We also find a negative impact on trade volatility of volumes, however, not significant based on conventionally used significance levels (Figure 4.3, Panel B; Table A4.4). Thus, we find support for H1a and H1b.

[16]The correlation of the importer MRL stringency and MRL dissimilarity is 0.147.

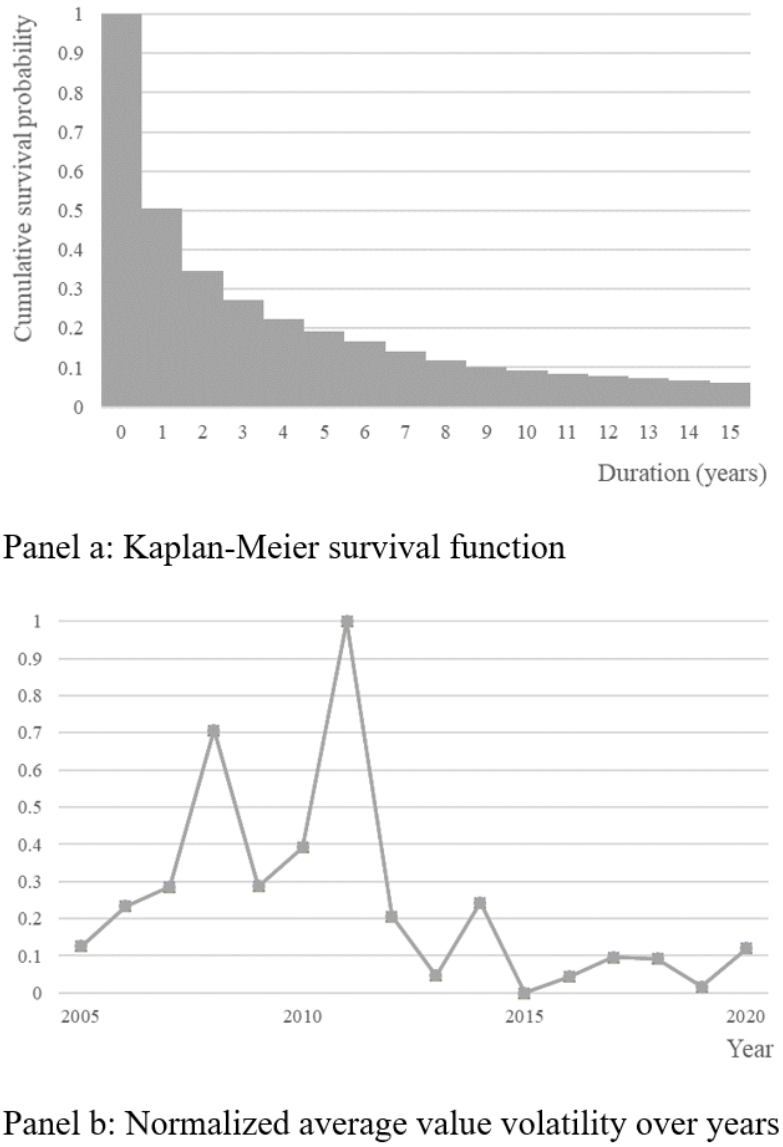

FIGURE 4.2: Trade survival and trade volatility

Source: Calculations and illustration based on data from the UN Comtrade database (UN COMTRADE 2022).

TABLE 4.2: Descriptive statistics of data

	Mean	**Std. Dev.**	**Min**	**Max**	**Obs.**
Importer MRL stringency	0.35	0.37	0	1	5,589,475
Bilateral MRL differences	0.31	0.39	0	1	5,589,475
MRL stringency "direction"	0.39	0.49	0	1	5,589,475
Duration (survival=0/failure=1)	0.18	0.38	0	1	2,376,840
Trade (yes=0/no=1)	0.63	0.48	0	1	5,589,475
Trade volatility (th. tons)	1.21	56.89	0	60,058	5,589,475
Trade volatility (million USD)	0.95	19.95	0	11,917	5,589,475
Trade volume (th. tons)	1.10	56.89	0	60,058	5,589,475
Trade value (million USD)	0.88	19.95	0	11,917	5,589,475
Initial volume (th. tons)	2.03	60.73	0	16,341	2,376,840
Spell count	1.38	0.70	1	7	2,376,840
Multiple spell	0.27	0.44	0	1	1,951,729
Common language (binary)	0.15	0.35	0	1	5,410,115
Colonial ties (binary)	0.05	0.22	0	1	5,410,115
Landlocked (binary)	0.26	0.44	0	1	5,410,115
Bilateral distance (km)	5,238	4,355	59.62	19,772	5,410,115
Importer GDP (bn USD)	957	2,443	0.04	19,975	5,581,559
Exporter GDP (bn USD)	1,370	3,174	0.03	19,975	5,571,843
TBT (count)	17.19	44.33	0	924	5,589,475
SPS (count)	38.02	178.75	0	4,436	5,589,475
Tariff (ad valorem)	11.32	40.66	0	3,000	5,589,475
RTA (binary)	0.49	0.50	0.00	1.00	5,589,475

Source: Calculation based on data retrieved from Conte et al. (2022); Ghodsi et al. (2017); Homologa (2021); The World Bank (2022a,2); UN COMTRADE (2022); and UNCTAD and WITS databases.

The increase in duration might be driven by the less elastic demand of consumers in the importing country due to higher product quality and the risk reduction for consumers. Further, this importers' stringency is relative to all other countries' stringency, which implies that for a relatively stricter importer, trade diversification is more challenging. Shifting to other trade partners is costlier and more difficult due to fewer already compliant export partners, or higher costs to comply with the standards. Our findings indirectly align with those of previous studies suggesting import enhancing/stabilizing impacts through higher product quality, higher costs for establishing a trade relation (*e.g.,* search costs, fixed compliance costs) and reduction of information uncertainty (*e.g.,* Besedeš and Yan, 2018; Chenavaz, 2017; Fiankor et al., 2021; Xiong and Beghin, 2014).

Second, we examine whether higher bilateral differences in MRLs between importer and exporter lower the import duration (H2a) and increase the import volatility (H2b). Compared to the importer MRL stringency, the bilateral MRL measure captures directly the variation of exporter's standard setting. Our results (Figure 4.3) show that higher bilateral differences in trading partners' MRL stringency increase trade failure and volatility ($\delta_2 + \delta_3 > 0$), thus supporting the two hypotheses, H2a and H2b. We further run regressions excluding the interaction terms, supporting our findings (see Table A4.5 and A4.6 in the Appendix).

Third, we analyze if the impacts of bilateral differences in MRLs change depending on whether the exporter or the importer is stricter (Table 4.3). The results depict that in both cases MRL dissimilarities tend to promote trade failure and volatility. We fail to reject the null hypothesis that $\delta_2 = \delta_3$, which implies no support for H3a, hypothesizing that the effect on trade duration is different conditioned on the direction of dissimilarity in stringency. Further, we do not find clear evidence that the effect of trading partners' MRL differences on trade volatility is significantly different depending on the direction of stringency excess (H3b). We reject $\delta_2 = \delta_3$ for trade value volatility, but fail to reject the null for trade volume volatility based on the tests shown in Table 4.3. In this respect, impacts on trade volume volatility are, on average, larger when importers are in stricter countries than exporters, compared to the same discrepancies when the exporters' country is stricter. This suggests that the variable compliance cost channel (see Table 4.1) has the most pronounced effect in this dimension of trade stability.

TABLE 4.3: Equality tests of the impact of bilateral MRL differences, depending on stringency direction, on import stability

Stability dimension	**Model**	**z-value**	**p-value**	χ^2	**p-value**
Duration	Probit	0.606	0.545		
	Logit	1.051	0.293		
	Cloglog	1.256	0.209		
Volatility	Value	2.360	0.018	5.899	0.015
	Volume	1.248	0.212	1.984	0.159

Note: Based on z- and χ^2-tests for the duration analysis and trade volume volatility, we fail to reject the null hypothesis that the coefficients of the two interaction terms (bilateral MRL differences with restrictiveness indices) are equal. This suggests that the effect of MRL stringency differences on trade duration does not significantly differ depending on the direction of the stringency gap. However, for trade value volatility, we reject H_0 at $p < 0.05$, indicating that the direction of the stringency excess matters for this aspect of trade stability.

Shorter import duration associated with higher MRL differences may be driven by

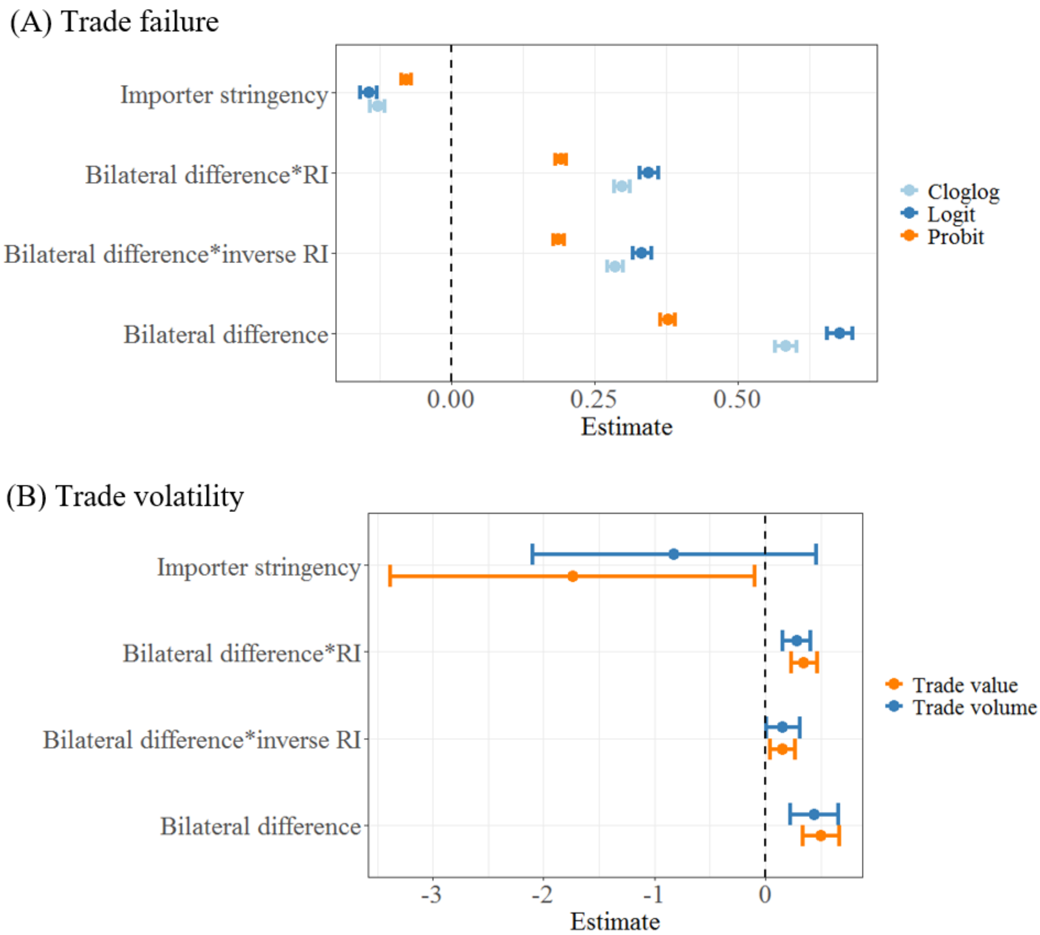

FIGURE 4.3: Impact of MRL standards on the failure and volatility of trade relations

Note: 95% confidence intervals are reported. Product, year and spell fixed effects and importer-exporter-product random effects are included in binary choice models shown in Panel A (see also Table A4.3 in the Appendix). Importer-year-product, exporter-year-product and exporter-importer fixed effects are included in the regression models of trade volatility shown in Panel B (see also Table A4.4 in the Appendix). The impact of the overall MRL difference is calculated based on the estimates of the interaction terms of the bilateral difference and the directions of stringency excess ($\delta_2 + \delta_3$).

compliance costs. This is in line with the trade duration literature finding that higher bilateral trade costs lead to shorter lengths of trade relations (see Bacchetta et al., 2012; Besedeš and Prusa, 2006a; Hess and Persson, 2011). Where the exporter is stricter than the importer, additional production costs unnecessary to meet the importer's standard result in higher prices for consumers. This may in turn result in importers shifting to alternative sources. When the importer is stricter than the exporter, the compliance and controlling costs that increase with larger standard differences may lead exporters to divert to other destinations (higher trade failure). This is the case, if these costs are higher than the extra revenue that exporters might receive in the importing countries due to recognition of their product quality, making the trade relation unprofitable, against previous expectations of the trading partners (Xiong and Beghin, 2014). Looking at the impact of MRL dissimilarities on the volatility of trade values/volumes, we also consider the mentioned channels as relevant. These channels seem to outweigh the possible trade stabilizing effect through exporters' good reputation of higher product quality, and higher fixed compliance costs that reduce switching to another seller/buyer.

In addition to our main findings, the coefficients of control variables (Tables A4.3 and A4.5) suggest that trade failures have a positive relationship with bilateral tariffs and distances, and a negative relation with the other control variables, namely importers' TBT and SPS, common RTAs, common language, colonial ties, initial trade volumes, GDPs, and being landlocked. Trade volatility (Tables A4.4 and A4.6) has a negative relationship with tariffs but positively relates to importers' number of TBTs and SPSs. This is in contrast to the relation of these control variables with trade failure. We expect that higher tariffs may result in firms completely leaving the trade link or fewer firms with higher productivity to stay on the trade link and sell to a smaller fraction of consumers that have lower demand elasticity to price changes. The former might explain why higher tariffs increase trade failure and the latter why trade of those that stay in the trade relationship remains less volatile. Differences in the relations with SPS and TBTs may arise from the various fixed and variable costs and demand-shifting effects associated with these trade policies that can influence trade duration and trade volatility differently. Also, theory does not provide a conclusive implication on the direction of the correlation.

4.6 Policy implications

The results suggest that an increase in importers' MRL stringency, when controlling for the dissimilarity of their MRLs with trading partners, enhances trade stability by reducing both trade failure and volatility. Additionally, when the MRLs of trading partners are more similar, controlling for the importers' stringency, trade volatility decreases. Since changes in MRLs may affect these dissimilarities, drawing policy implications regarding the impacts of MRLs on import stability requires a simultaneous consideration of both the effects of MRL stringency and dissimilarity with trade partners.

This simultaneous consideration suggests that when importers have less stringent MRLs than exporters, ambitious food safety policies aimed at protecting consumer health—reflected by lower MRLs—can also improve food security by enhanced import stability. In this case, the enhanced stability would result from both the direct impact of MRL setting and the alignment of regulatory standards. When importers have more stringent MRLs than their trade partners, setting even stricter MRLs may not be desirable t as larger dissimilarity lowers trade stability. The results further imply that countries should not set strict MRLs without considering the consequences for bilateral MRL dissimilarity. This emphasizes—again—the importance of policies that aim at global regulatory harmonization based on scientific evidence.

The results also have implications for trade partner selection and harmonization efforts that could contribute to stable trade relationships: choosing trade partners with the same or close standards can contribute to food security by stabilizing import trade relations. The effect of MRL harmonization on trade stability may depend on how the harmonization is implemented. Harmonizing MRLs may enhance trade stability for importers with relatively less strict MRLs, but it could reduce stability for importers with currently more stringent MRLs. These costs are particularly likely to arise when the MRLs of set by countries genuinely relate to product quality rather than protectionist purposes. The potentially different impacts of MRL harmonization on importers with high versus low MRLs suggest the existence of a tipping point for MRLs with optimal import trade stability. Coordinated efforts are desirable that not only to reduce excessively strict MRL standards hindering trade, but also raise low MRL standards to a level that promotes adequate product quality. Since substantial dissimilarities in MRL standards are related to different country income groups, investing in capacity building, research and collaboration efforts can support low-income countries to comply with stringent MRL standards, thereby enabling access to these export markets (Curzi et al., 2018; Jongwanich, 2009).

4.7 Conclusions

Both food safety and food availability in variety and volume are important policy goals directly linked to achieving food security. Food safety standards, such as MRLs, play a crucial role in promoting food safety; their number and stringency are on rise and vary between countries. This may affect stability of import trade relationships, which is key for keeping a steady availability of food.

This study analyses the impact of the stringency of MRLs and dissimilarities among trade partners therein on the duration of trade relations and volatility of import values, using discrete-time hazard and fixed effects models. Our analysis involves data on 225 agri-food products at the HS 6-digit level and 164 countries, spanning the years 2005 to 2020.

Results show that more stringent MRLs of importing countries enhance the trade stability (lower trade failure and trade volatility). In a similar vein, the stability of trade relations increases with lower differences in MRL standards of importers' and exporters' countries. The negative effects of bilateral MRL differences on both trade failure and trade value volatility are similar regardless of which country—exporter or importer—is stricter.

The simultaneous consideration of the results implies that, when importers have relatively high MRLs, *i.e.,* low MRL stringency, setting their MRLs to a stricter level is not implying a trade-off between food safety and stability of food availability, but rather contributes to stable food availability by reducing import failure. When importers have already relatively low MRLs, *i.e.,* stringent MRLs compared to other countries, further tightening these standards may come at the cost of negative impacts caused by the growing disparity between their standards and those of their trade partners. Accordingly, importers that already set standards stricter than the global average should consider that such discrepancies may destabilize trade relationships, especially if these standards hinder trade rather than being based on scientific evidence.

Our findings regarding MRL dissimilarity extend prior evidence on the benefits of regulatory harmonization for food trade in general to food trade stability. Furthermore, the trade-offs regarding the impact of MRL stringency and dissimilarity on trade stability suggest that harmonization may also negatively affect trade stability for importers with relatively strict MRLs, who may need to relax them. Therefore, harmonizing MRLs should balance between trade stability and their role in ensuring product safety.

We explicitly do not draw implications for the case of food standards in general. MRLs are important but there exist numerous food safety standards that might play an important role for stability of trade relationships either standalone or via interaction with MRLs. We focus on MRL data because of its particular relevance for agri-food products and data accessibility for many countries and products, which is not the case for other standards. Further, we look at the overall effects of MRL policies for each product and do not distinguish between different substances. Examining the effect on bilateral trade values, Hejazi et al. (2022) find that insecticides are most trade-restrictive among chemicals, whereas strict herbicide policies have a potential demand-enhancing effect. While these discoveries pertain to alterations in trade values rather than stability of trade, it is important to note that different substances possess their own unique characteristics in terms of the compliance cost and consumers risk perception. These distinctive attributes can lead to varying effects on trade stability. Finally, countries' quality of institutions may play a role for the standard enforcement (Swinnen, 2016). Thus, considering the impact of different types of substances and/or their interactions to identify possible contrary or mutually re-enforcing effects, and the interaction of standards with countries institutional quality on the stability of trade offer potential scope for future research.

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4.A Appendix

TABLE A4.1: List of countries

Code	Name	ISO3	Code	Name	ISO3	Code	Name	ISO3
4	Afghanistan	AFG	276	Germany	DEU	586	Pakistan	PAK
8	Albania	ALB	288	Ghana	GHA	591	Panama	PAN
12	Algeria	DZA	300	Greece	GRC	598	Papua New Guinea	PNG
28	Antigua and Barbuda	ATG	308	Grenada	GRD	600	Paraguay	PRY
31	Azerbaijan	AZE	320	Guatemala	GTM	604	Peru	PER
32	Argentina	ARG	324	Guinea	GIN	608	Philippines	PHL
36	Australia	AUS	328	Guyana	GUY	616	Poland	POL
40	Austria	AUT	340	Honduras	HND	620	Portugal	PRT
44	Bahamas	BHS	348	Hungary	HUN	624	Guinea-Bissau	GNB
48	Bahrain	BHR	352	Iceland	ISL	634	Qatar	QAT
50	Bangladesh	BGD	356	India	IND	642	Romania	ROU
51	Armenia	ARM	360	Indonesia	IDN	643	Russian Federation	RUS
52	Barbados	BRB	372	Ireland	IRL	646	Rwanda	RWA
56	Belgium	BEL	376	Israel	ISR	659	Saint Kitts and Nevis	KNA
64	Bhutan	BTN	380	Italy	ITA	660	Anguila	AIA
68	Bolivia	BOL	384	Côte d'Ivoire	CIV	662	Saint Lucia	LCA
70	Bosnia Herzegovina	BIH	388	Jamaica	JAM	670	St. Vincent and the Grenadines	VCT
72	Botswana	BWA	392	Japan	JPN	682	Saudi Arabia	SAU
76	Brazil	BRA	398	Kazakhstan	KAZ	686	Senegal	SEN
84	Belize	BLZ	400	Jordan	JOR	690	Seychelles	SYC
90	Solomon Isds	SLB	404	Kenya	KEN	694	Sierra Leone	SLE
96	Brunei Darussalam	BRN	410	Rep. of Korea	KOR	702	Singapore	SGP
100	Bulgaria	BGR	414	Kuwait	KWT	703	Slovakia	SVK
104	Myanmar	MMR	417	Kyrgyzstan	KGZ	704	Viet Nam	VNM
108	Burundi	BDI	418	Lao People's DR	LAO	705	Slovenia	SVN
112	Belarus	BLR	422	Lebanon	LBN	710	South Africa	ZAF
116	Cambodia	KHM	426	Lesotho	LSO	716	Zimbabwe	ZWE
120	Cameroon	CMR	428	Latvia	LVA	724	Spain	ESP
124	Canada	CAN	434	Libya	LBY	740	Suriname	SUR
132	Cape Verde	CPV	440	Lithuania	LTU	748	Eswatini	SWZ
144	Sri Lanka	LKA	442	Luxembourg	LUX	752	Sweden	SWE
152	Chile	CHL	450	Madagascar	MDG	756	Switzerland	CHE
156	China	CHN	454	Malawi	MWI	760	Syria	SYR
170	Colombia	COL	458	Malaysia	MYS	762	Tajikistan	TJK
174	Comoros	COM	462	Maldives	MDV	764	Thailand	THA
184	Cook Islands	COK	466	Mali	MLI	768	Togo	TGO
188	Costa Rica	CRI	470	Malta	MLT	780	Trinidad and Tobago	TTO
191	Croatia	HRV	480	Mauritius	MUS	784	United Arab Emirates	ARE
196	Cyprus	CYP	484	Mexico	MEX	792	Turkey	TUR
203	Czechia	CZE	498	Rep. of Moldova	MDA	798	Tuvalu	TUV
204	Benin	BEN	499	Montenegro	MNE	800	Uganda	UGA
208	Denmark	DNK	500	Montserrat	MSR	804	Ukraine	UKR
212	Dominica	DMA	504	Morocco	MAR	807	North Macedonia	MKD
214	Dominican Rep.	DOM	508	Mozambique	MOZ	818	Egypt	EGY
218	Ecuador	ECU	512	Oman	OMN	826	United Kingdom	GBR
222	El Salvador	SLV	516	Namibia	NAM	834	United Rep. of Tanzania	TZA
231	Ethiopia	ETH	524	Nepal	NPL	840	USA	USA
233	Estonia	EST	528	Netherlands	NLD	854	Burkina Faso	BFA
242	Fiji	FJI	548	Vanuatu	VUT	858	Uruguay	URY
246	Finland	FIN	554	New Zealand	NZL	860	Uzbekistan	UZB
250	France	FRA	558	Nicaragua	NIC	862	Venezuela	VEN
258	French Polynesia	PYF	562	Niger	NER	876	Wallis and Futura Isl.	WLF
266	Gabon	GAB	566	Nigeria	NGA	882	Samoa	WSM
268	Georgia	GEO	578	Norway	NOR	894	Zambia	ZMB
270	Gambia	GMB	583	FS Micronesia	FSM			

Table A4.2: List of included products (HS-6-digit)

02 - Meat and edible meat offal
020110 020120 020130 020210 020220 020230 020311 020312 020319 020321 020322 020329 020410 020421 020422 020423 020430 020441 020442 020443 020510 020511 020519 020610 020621 020622 020629 020630 020641 020649 020690 020711 020712 020713 020714 020721 020722 020723 020731 020739 020741 020742 020743 020750 020900
04 - Dairy produce; birds' eggs; natural honey etc.
040110 040120 040210 040221 040229 040291 040299 040700 040811 040819 040891 040899
06 - Trees and other plants
060290 060314
07 - Vegetables and certain roots and tubers; edible
070110 070190 070200 070310 070320 070390 070410 070420 070511 070521 070610 070690 070700 070810 070820 070910 070920 070930 070940 070951 070959 070970 070990 071040 071120 071130 071140 071220 071233 071320 071333 071335 071340 071350 071410 071420 071490
08 - Fruit and nuts, edible; peel of citrus fruit or melons
080119 080120 080130 080211 080221 080231 080240 080250 080290 080300 080410 080420 080430 080440 080450 080510 080520 080540 080550 080590 080610 080711 080720 080810 080820 080910 080920 080930 080940 081010 081020 081030 081040 081050 081060 081070 081090 081190 081310 081320 081330
09 - Coffee, tea, mate and spices
090111 090210 090411 090500 090610 090700 090810 090820 090830 090910 090920 090930 090940 090950 091010 091020 091030 091040 091050 091099
10 - Cereals
100110 100190 100200 100300 100400 100510 100590 100610 100630 100700 100810 100820 100890
11 - Products of the milling industry; malt, starches, inulin, wheat gluten
110100 110210 110220 110290
12 - Oil seeds and oleaginous fruits; miscellaneous grains, etc.
120100 120210 120400 120510 120600 120710 120720 120740 120750 120760 120791 120799 120810 120910 120921 120922 120925 120930 121110 121120 121190 121291 121299 121300 121410 121490
14 - Vegetable plaiting materials; vegetable products nes
140110 140490
15 - Animal or vegetable fats and oils and their cleavage products
150710 150790 150910 150990 151110 151211 151219 151221 151229 151311 151319 151521
17 - Sugars and sugar confectionery
170310
18 - Cocoa and cocoa preparations
180100 180400 180500
20 - Preparations of vegetables, fruit, nuts or other parts of plants
200911 200912 200919 200920 200930 200940 200950 200960 200970 200980 200990
24 - Tobacco and manufactured tobacco substitutes
240110 240120 240130 240310 240391 240399

TABLE A4.3: Impact of MRL standards on the trade failure—Main results

	(1) Probit	(2) Logit	(3) Cloglog
Importer stringency	-0.080***	-0.145***	-0.130***
	[-0.088, -0.071]	[-0.160, -0.130]	[-0.143, -0.117]
Bilateral difference*RI	0.191***	0.345***	0.298***
	[0.182,0.201]	[0.329,0.361]	[0.285,0.311]
Bilateral difference*inverse RI	0.187***	0.333***	0.286***
	[0.178,0.196]	[0.317,0.348]	[0.273,0.299]
Tariff	0.021***	0.035***	0.030***
	[0.019,0.022]	[0.032,0.038]	[0.027,0.032]
TBT & SPS	-0.000***	-0.000***	-0.000***
	[-0.000, -0.000]	[-0.000, -0.000]	[-0.000, -0.000]
RTA	-0.067***	-0.116***	-0.099***
	[-0.073, -0.061]	[-0.126, -0.105]	[-0.108, -0.090]
Common language	-0.078***	-0.078***	-0.066***
	[-0.089, -0.067]	[-0.090, -0.065]	[-0.076, -0.055]
Colonial ties	-0.049***	-0.135***	-0.113***
	[-0.055, -0.043]	[-0.155, -0.116]	[-0.130, -0.097]
Landlocked	-0.046***	-0.086***	-0.073***
	[-0.053, -0.038]	[-0.096, -0.075]	[-0.081, -0.064]
Distance	0.042***	0.071***	0.058***
	[0.039,0.045]	[0.065,0.076]	[0.054,0.063]
GDP importer	-0.029***	-0.048***	-0.042***
	[-0.030, -0.027]	[-0.052, -0.047]	[-0.044, -0.040]
GDP exporter	-0.075***	-0.128***	-0.107***
	[-0.076, -0.073]	[-0.131, -0.126]	[-0.109, -0.105]
Initial trade volume	-0.080***	-0.138***	-0.117***
	[-0.080, -0.079]	[-0.139, -0.137]	[-0.118, -0.116]
Constant	2.447***	4.262***	3.210***
	[2.389,2.505]	[4.162,4.362]	[3.127,3.292]
Overall MRL difference	0.378**	0.678*	0.584**
	[0.365, 0.391]	[0.656, 0.700]	[0.565, 0.602]
Observations	2,167,173	2,167,173	2,167,173
Relationships	372,822	372,822	372,822
Log Likelihood	-983,077	-985,354	-987,8854
ρ	0.118***	0.098***	0.109***

Note: 95% confidence intervals are reported in brackets. ***p < 0.001; **p < 0.01; *p < 0.05. Standard errors are heteroskedasticity robust. Spell and year fixed effects and country pair-product random effects are included in all regressions. ρ is the variance of the random effect, which is significant across models. The impact of the overall MRL difference is calculated based on the estimates of the interaction terms with the directions of stringency excess ($\delta_2 + \delta_3$). Continuous variables are in natural logarithm, and time-invariant variables are lagged by one year.

TABLE A4.4: Impact of MRL standards on the volatility of trade values and volumes

	(1) Volume	(2) Value
Importer stringency	-0.822	-1.738*
	[-2.103, 0.459]	[-3.380, -0.096]
Bilateral difference*RI	0.284***	0.350***
	[0.158, 0.409]	[0.232, 0.468]
Bilateral difference*inverse RI	0.158*	0.155**
	[0.006, 0.311]	[0.044, 0.266]
Bilateral difference	0.442***	0.504***
	[0.224, 0.660]	[0.338, 0.671]
TBT & SPS	0.016***	0.015***
	[0.007, 0.024]	[0.007, 0.023]
Tariff	-0.185***	-0.241***
	[-0.210, -0.160]	[-0.267, -0.215]
RTA	0.052	0.057
	[-0.137, 0.240]	[-0.033, 0.147]
Observations	5,151,437	5,151,437
(Pseudo) R^2	0.936	0.920

Note: 95% confidence intervals are reported in brackets. ***p < 0.001; **p < 0.01; *p < 0.05. Standard errors are clustered at the country-pair level. Exporter-importer, importer-year-product, and exporter-year-product fixed effects are included in both regressions. The impact of the overall MRL difference is calculated based on the estimates of the interaction terms with the directions of stringency excess ($\delta_2 + \delta_3$).

TABLE A4.5: Impact of MRL standards on the duration of trade including overall bilateral differences

	(1) Probit	(2) Logit	(3) Cloglog
Importer stringency	-0.08***	-0.14***	-0.13***
	[-0.09, -0.07]	[-0.15, -0.13]	[-0.14, -0.11]
Bilateral difference	0.19***	0.34***	0.29***
	[0.18, 0.20]	[0.33, 0.35]	[0.28, 0.30]
Tariff	0.02***	0.04***	0.03***
	[0.02, 0.02]	[0.03, 0.04]	[0.03, 0.03]
TBT & SPS	-0.00***	-0.00***	-0.00***
	[-0.00, -0.00]	[-0.00, -0.00]	[-0.00, -0.00]
RTA	-0.07***	-0.12***	-0.10***
	[-0.07, -0.06]	[-0.13, -0.11]	[-0.11, -0.09]
Common language	-0.05***	-0.08***	-0.06***
	[-0.05, -0.04]	[-0.09, -0.06]	[-0.08, -0.05]
Colonial ties	-0.08***	-0.14***	-0.11***
	[-0.09, -0.07]	[-0.16, -0.12]	[-0.13, -0.10]
Landlocked	-0.05***	-0.09***	-0.07***
	[-0.05, -0.04]	[-0.10, -0.08]	[-0.08, -0.06]
Distance	0.04***	0.07***	0.06***
	[0.04, 0.04]	[0.07, 0.08]	[0.05, 0.06]
GDP importer	-0.03***	-0.05***	-0.04***
	[-0.03, -0.03]	[-0.05, -0.05]	[-0.04, -0.04]
GDP exporter	-0.07***	-0.13***	-0.11***
	[-0.08, -0.07]	[-0.13, -0.13]	[-0.11, -0.11]
Initial trade volume	-0.08***	-0.14***	-0.12***
	[-0.08, -0.08]	[-0.14, -0.14]	[-0.12, -0.12]
Constant	2.45***	4.26***	3.21***
	[2.39, 2.50]	[4.16, 4.36]	[3.13, 3.29]
Observations	2,167,173	2,167,173	2,167,173
Relationships	371,822	371,822	371,822
Log Likelihood	-983,078	-985,354	-987,886
ρ	0.118***	0.098***	0.101***

Note: 95% confidence intervals are reported in brackets. ***p < 0.001; **p < 0.01; *p < 0.05. Standard errors are heteroskedasticity robust. Year, product group, and spell fixed effects, and exporter-importer-product random effects are included in all regressions. ρ is the variance of the random effect, which is significant across estimations. Continuous variables are in natural logarithm and time-invariant variables are lagged by one year.

TABLE A4.6: Impact of MRL standards on the volatility of trade values and volumes including overall bilateral differences

	(1) Volume	(2) Value
Importer stringency	-0.791	-1.691*
	[-2.074, 0.493]	[-3.341, -0.041]
Bilateral difference	0.217***	0.248***
	[0.108, 0.327]	[0.165, 0.331]
TBT & SPS	0.016***	0.015***
	[0.007, 0.024]	[0.007, 0.023]
Tariff	-0.185***	-0.241***
	[-0.210, -0.160]	[-0.267, -0.215]
RTA	0.051	0.058
	[-0.137, 0.240]	[-0.032, 0.147]
Observations	5,151,437	5,151,437
(Pseudo) R^2	0.936	0.920

Note: 95% confidence intervals are reported in brackets. ***p < 0.001; **p < 0.01; *p < 0.05. Standard errors at the country-pair level. Exporter-importer, importer-year-product, and exporter-year-product fixed effects are included in the regressions. Continuous variables are in natural logarithm and time-invariant variables are lagged by one year.

Chapter 5

The relationship between firms' labor market power and export activities: Evidence from the French food processing industry

Abstract: Distortions from competitive labor market conditions due to market power of firms or workers affect firms' profitability and, consequently, their export activities. Exporting can also influence firms' labor market power through several channels, such as productivity effects, wage adjustments, and output price variations. This paper investigates the labor market power of French food and beverage firms and how this power relates to their export activities. Firm-specific markdowns, which reveal their labor market power and are calculated based on production function estimations, exhibit labor markdowns below one. This indicates that firms pay wages above competitive levels. Extended regression models with instrumental variables show that firms' export experience and higher export intensity reduce labor markdowns, thereby strengthening workers' positions. Reciprocally, firms' higher labor markdowns decrease their export intensity. Results suggest the relevance of wage and productivity components for the simultaneous relation of labor markdown and export intensity.

Keywords: *Export activities, Labor markdown, French food processing*

5.1 Introduction

Labor shortages or employees backed by strong unions may prompt firms to pay wages above competitive levels. Conversely, under weak competition for employees, firms may suppress wages. Such labor market structures imply imperfect competition on the labor market, which can impact firms' ability to export due to profitability losses or gains. Once firms engage in international trade, their competitiveness in labor input markets might be affected as well. Particularly, when exporting to competitive global markets, they may face additional pressure to balance labor costs with productivity. In contrast, exporting might enhance profits, potentially enabling firms to offer higher wages or improve working conditions.

In this paper, we estimate the labor market power in the French food and beverage industry and analyze its simultaneous relation with firms' export activities. We examine whether being an exporter influences firms' labor market power compared to non-exporters, and then, separately assess the effects of firms' entry into export markets, their continuation of export activities, as well as their export intensity on labor market power. We define export intensity as the ratio of firms' export revenue to their total revenue. Furthermore, we investigate the impact of firms' labor market power on the named dimensions of firms' export activities and examine the relevance of different components of labor markdown in this simultaneous relationship. These components encompass wages, total factor productivity, and the residual component of the marginal value of labor productivity, which captures factors related to output prices and labor productivity (deviating from total productivity).

We focus on the food industry, which is facing multiple labor-related challenges, including labor shortages, unfavorable working conditions, and high shares of short-term contracts (Caroli et al., 2009; Cérou, 2024; Ministère du Travail et de l'Emploi and Ministère de l'Agriculture et de l'Alimentation, 2019). In France, it is a leading manufacturing sector in terms of turnover and the number of employees (USDA, 2024). The sector is known for its high-quality products, contributing to France being among the main food exporters of the EU (USDA, 2024). The French labor market exhibits a strong workforce with most employees being part of a collective bargaining agreement (98% in 2018; OECD and AIAS, 2021). Further, the comprehensive French labor law strengthens employee bargaining power and enforce minimum standards, determining, for instance, a minimum wage (11.88€/h gross wage in October 2024, Ministère du Travail et de l'Emploi (2024)), restricting the firms' ability to suppress wages. Comparably high labor costs are consequently a characteristic of the French food sector, where the majority of jobs are blue-collar jobs (Caroli et al., 2009). These characteristics suggest a low labor market power of firms, which is also supported by Jafari et al. (2023), who find that wages paid by French food and beverage firms are, on average, above competitive levels.

The impact of exporting on labor market power is generally under-explored; however, several recent studies have started to fill this gap. For example, Felix (2022) investigates the effects of tariff reductions on wage markdowns of Brazilian firms, Amodio et al. (2024b) analyze the impact of exporting on labor market power in Latin American countries, and Mertens (2019) examines the link of firms' international trade and labor market distortions of manufacturing trade between Germany and China. These studies find that exporting has a positive impact on firms' labor market power. Mertens (2020) shows that trade can amplify existing labor market structures, and thus increase market inefficiencies. Other empirical evidence exists on the impact of export participation or intensity on different factors of markdown, such as wages, productivity, and prices (Bernard et al., 1995, 2006; Melitz and Redding, 2014; Schank et al., 2007). This literature presents an inconclusive picture regarding the overall impact of exporting on labor market power.

We are not aware of any study analyzing the effect of labor market power on export activities, but studies exist on how factors of labor markdown influence trade. Firms' productivity positively affects export participation and intensity (Bernard et al., 2003, 2006). Depending on income and quality standards in destinations countries, higher output prices and quality of firms might also increase export activities. Wages can affect firms export positively and negatively. Lower wages can imply higher export participation through increasing competitiveness of the firm (Melitz and Redding, 2014). At the same time, suppressing wages might reduce the motivation and productivity of the workers inducing the counteracting effect (Steinmetz et al., 2014; Strain, 2019).

With this paper, we contribute to the literature in four ways. First, we estimate firm-level labor markdown of French food and beverage firms between 2010 and 2020 based on production function estimation (De Loecker and Warzynski, 2012; Jafari et al., 2023). Looking at differences between exporting and non-exporting firms over time and across sectors, we contribute to the existing knowledge on labor market structures in France. A previous study, looking at manufacturing sectors in France, Japan, and Netherlands, shows that, in the years 1986 to 2001, the French labor market is dominated by an efficient bargaining regime in favor of the workers (Dobbelaere et al., 2015). Further, Jafari et al. (2023) find that employees in the French food and beverage industry wield market power (with an average labor markdown of 0.42) between 2011 and 2019; and Caselli et al. (2021) reveal that wages paid by French manufacturing firms (excluding food and beverages) between 1994 and 2007 exceeded competitive levels by 56% on average.

Second, we are providing evidence on the impact of firms' export activities and labor market power using these estimated markdowns. There are a few studies looking at the impact of firms' exports on markdowns in the labor input market (Amodio et al., 2024a; Felix, 2022; Mertens, 2019, 2020). However, we additionally consider several dimensions of firms export activities, namely participation, entry, continuation, and intensity, and improve causal identification by using an instrumental variable approach with extended regression models.

Third, we also contribute by examining the impact of firms' labor market power on the aforementioned dimensions of export activities, which, to our knowledge, has not been previously investigated.

Fourth, we add to the understanding of this mutual relationship by analyzing the role of the different components of labor market power for export activities, and vice versa. To do so, we examine how the estimated effects change when adjusting the firms' labor markdown by the heterogeneity of firms' wages, productivity, or both. Subsequent re-estimations of the main regressions with the "adjusted markdowns" deliver insights on the relevance of these components for the relation between firms' export activities and labor market power.

For our analysis, we use the data from Orbis including 8565 French firms and find that 94% (in 2020) of those firms have a labor markdown below one, demonstrating that they pay wages above the marginal revenue product they earn per extra worker. In 32% of our observations, firms are exporting. Our regression analyses suggest that firms' export participation (after one year of trade) and intensity negatively affect their labor markdowns, and higher labor markdowns of firms decrease their export intensities. The bidirectional relation between export intensity and labor markdown indicates that higher export intensity reduces firms' labor market power, strengthening workers' position, which in turn may further enhance firms' export intensity. Looking at the different channels of this relation, we find that the negative effect of participation on labor markdowns is primarily explained by changes in the heterogeneity of productivity[1] and wage components of labor markdowns. Regressions with the different "adjusted markdowns", suggest that all analyzed components are relevant for the impacts between export intensity and labor markdown. Contrary to the overall labor markdown as well as wage-adjusted and productivity-adjusted markdowns, the result of firms' entry to export markets on the wage- and productivity-adjusted markdown suggests that export entry increases labor markdown components other than wage and total factor productivity. This may be channeled by factors inducing higher labor productivity and/or output prices.

The remainder of this paper is structured as follows. Section 2 discusses the simultaneous relation of labor market power and exporting, and derives hypotheses. Section 3 specifies the empirical framework for assessing the labor markdown, the causal relation, and the relevance of the labor markdown components. Sections 4 describes the data sources, and provides some descriptive statistics. Section 5 presents the results and discussions, and finally section 6 summarizes and concludes.

5.2 Background and derived hypotheses

In perfectly competitive labor input markets, wages paid to workers are equal to the value of the marginal labor productivity of the firm. However, in reality, labor markets normally exhibit imperfect competition (*e.g.,* Lamadon et al., 2022; Strain, 2019; Yeh et al., 2022). Firms with input market power can suppress wages below the value of their marginal labor productivity, while other firms face workers with strong bargaining power and might have to pay wages above the value of marginal labor productivity. In both situations, labor market power exists which can be reflected by labor markdown, the ratio of the value of marginal productivity of labor over wages paid to the worker, that is unequal one. Unless explicitly stated as labor productivity, "productivity" in this study refers to total factor productivity, and with "markdown" we mean labor markdown.

Firms decide to export if they expect that entering foreign markets is profitable (Melitz, 2003). Since they have to pay initial fixed costs and further costs to trade, only the competitive firms enter and succeed in the export market. These more competitive exporting firms are generally larger and more productive than non-exporters. In the labor market, exporting and non-exporting firms compete for workers. When (most productive) firms start or expand their export activities, labor demand of these firms increases, resulting in higher labor market concentration (Melitz, 2003).

[1] In our study, "productivity" refers to total factor productivity unless explicitly stated labor productivity.

5.2.1 Impact of firms' export activities on their labor markdown

Exporting implies changes in firms' labor markdown through several channels, such as wages paid, productivity, bargaining power, output prices, and product quality. Since labor markdown is defined by firms' labor productivity, output prices and wages, changes in these components driven by firms' export activities have direct implications for markdown. Changes in bargaining power and product quality, driven by export activities, may also affect these three components and thereby indirectly influence labor markdown.

Empirical evidence on trade and (labor) market power rather focuses on the implications of import competition on labor market power, or of exports on output market power. We find only a few studies looking at the impact of firms' export activities on their labor market power. The first analyzing the causal relation of firms' exports and imports with labor market power was Mertens (2019). Studying the German manufacturing sector, he shows that more exports to China increase firms' labor market power. In another study looking at manufacturing trade between Germany and China and the mechanisms behind the effects on labor market power, Mertens (2020) finds that trade can amplify prevalent labor market distortions. Therefore, exporting might increase either workers' or firms' market power depending on which actor already has had power on the labor market, *i.e.,* the share of firms' marginal value of labor productivity they pass on to their workers might decrease or increase. In both cases, increasing labor market distortions reduce market efficiency and, with it, overall gains from trade.

Looking at the 15 top export sectors of 16 Latin America and Caribbean countries, Amodio et al. (2024b) find that exports have a positive effect on firms' labor market power, and that firms' labor market power is higher in countries where unions, collective bargaining, and unemployment protection are less prevalent. Felix (2022) analyzes the effect of exporting on labor market power based on Brazilian firm-level data. She reveals that exporting increases the labor market concentration, which is driven by firms' market exit and related worker reallocation to exporters paying comparably higher wages. This, in turn, induces higher labor market power of remaining firms which decrease their wages compared to the value of marginal productivity of labor.

Other studies relevant for the effects of exporting on labor market power examine different channels. Exporting might increase or decrease the wages paid by a firm. If everything else constant, these changes imply also higher or lower wages relative to the value of marginal productivity of labor. Literature largely finds that exporters may offer better wages to attract workers driven by foreign demand (for high-quality products) (Schank et al., 2007). For example, Bernard and Jensen (1999); Bernard et al. (1995); and Schank et al. (2007) show that wages are positively related to firms' export participation and intensity. For the Italian manufacturing sector, Macis and Schivardi (2016) find that an increase in firms' export shares (during the 1992 devaluation) cause an increase in wages. On the other hand, exporters may pay lower wages to stay competitive on export markets. The competition in international markets can lead to downward pressure on wages to maintain competitive prices and profitability (Munch and Skaksen, 2008). The effect of exporting on wages might also differ between and within firms depending on the skill level (*e.g.,*, high vs. low skilled) and the type of job (*e.g.,*, white vs. blue collar; Deardorff and Hakura, 1993; Munch and Skaksen, 2008; Verhoogen, 2008).

International trade also influences bargaining power due to changes in firms' financial conditions, the tightness of the labor market, and reservation wage of firms and workers (Brock and Dobbelaere, 2006). A tight labor market implies higher bargaining power of workers. Since high export rates might increase the tightness of the local labor market, this also increases workers'/unions' bargaining power. Further, the reservation wage of firms, which is the maximum wage that still implies non-negative profits, might be affected because of export-related changes of firms' financial conditions. Workers' reservation wage means the alternative wage that is possible to earn as the worker switches jobs, which might be also influenced by exporting. Brock and Dobbelaere (2006) analyze the effect of globalization of Belgian manufacturing firms on workers' bargaining power and find that export intensity to OECD countries increases workers' bargaining power, while total export intensity has a negative impact. According to the authors, the positive influence on workers' bargaining power when considering only OECD destinations might be driven by export-induced technological change. Further, Dobbelaere and Kiyota (2018) reveal a positive relation between export status and workers' bargaining power considering manufacturing firms in Japan between 1994 and 2012.

Exporting has also implications for firms' productivity. Entering into export markets enlarges a firm's market, inducing economies of scale and making investments into productivity-enhancing activities more profitable, stimulating the adoption of new technologies and innovations (Bustos, 2011; Lileeva and Trefler, 2010). In line, Bernard et al. (2006); Lileeva and Trefler (2010); and Melitz and Redding (2014) find that higher exposure to international trade increases productivity gains within plants/firms through knowledge transfer, also referred to as learning by exporting.

Product quality-upgrading because of exporting has direct (but ambiguous) implications for labor markdown (Kugler and Verhoogen, 2008; Verhoogen, 2008), since producing a higher product quality is related to changes in the output prices, but also productivity and input prices.

In the first year of exporting, firms' price setting strategies to enter international markets could have direct implications for markdowns. For example, lowering the price to penetrate export markets or adjustment to price levels of destination markets would directly change the value of marginal productivity of labor and thus the markdown (*e.g.,* Bernard et al., 2003; Dean, 1976; Melitz and Ottaviano, 2008). Further, costs to enter export markets might affect markdown by forcing firms to reduce other costs to stay profitable (*e.g.,* lower wages). Therefore, the first year of trade might have different effects on markdowns than subsequent years of trade.

Given these potential effects a firm's exporting activity can lead to either a negative or positive effect on labor market power; beyond that, the characteristics of the French food sector are relevant for deriving hypotheses. France is known for high-quality foods (USDA, 2024). Exporting high-quality products in international markets is related to lower competition (Vandenbussche, 2014), which suggests potential for realizing higher prices and potentially higher markdowns. However, French consumers' willingness to pay for foods with high quality and 'made in France' is comparably high and would suggest low potential for higher prices in export markets compared to the domestic market. The overall labor market conditions in France may also play a role for the possible implications of exports on markdown. The relatively high unemployment rate suggests a non-tight labor market (OECD, 2024), which favors firms that want to reduce wages. Contrarily, the firms' ability to suppress wages is limited by the strong presence of collective bargaining agreements and the French minimum wage (Ministère du Travail et de l'Emploi, 2024; OECD and AIAS, 2021).

Against this background, primarily driven by the empirical studies (Amodio et al., 2024b; Felix, 2022; Mertens, 2019) and the theoretical channels suggesting a positive effect of exporting on labor markdown due to productivity increases, we hypothesize that, except for export entry, the positive impacts of exporting on markdowns outweigh the negative ones. However, for export entry, the negative effect of market penetration strategies may be most pronounced, while productivity gains and wage adjustments have not yet been realized. Therefore, we hypothesize that (H1a) labor markdown of exporting firms is higher than that of non-exporting firms. Further, while (H1b) export entry decreases, (H1c) continuation and (H1d) higher intensity of firms' exports increase labor markdowns.

5.2.2 Impact of firms' labor markdown on their export activities

Exerting power in the labor market means distortions from competitive input markets, which can favor either firms or employees. This is linked to firms' profitability, and consequently, to their export activities. Theoretically, labor market power indicates inefficiency, in other words, the deviations from a competitive labor market condition. Depending on the direction of the deviations, this can imply a cost (dis)advantage for firms with respect to labor, and wages (above) below competitive wages for workers. Power in the labor market by firms (by workers enforced by unions) imply an increase (reduction) in the firms' competitiveness on output markets compared to the case of competitive input markets because of changes in costs and quantities (Martin and Maskus, 2001).

Empirically, several studies analyze the impact of different components of labor markdown on export activities that suggest mixed implications for the impact of labor markdown on export activities. These components of labor markdown are related to (labor) productivity, output prices, and wages. Firms' productivity is one of the most important determinants for its export activities (Eaton and Kortum, 2002; Melitz, 2003). When everything else constant, higher labor productivity imply a higher value of marginal labor productivity, which means higher labor markdowns. Such higher labor productivity leads to cost advantages, improving firms' competition on the (export) market, and thereby might increase the probability of export participation and firms' export intensity. This is also found by Bernard et al. (2003) and Bernard et al. (2006). However, if the expansion of revenues from the domestic market exceeds revenue increases from the export market, labor productivity can also negatively affect export intensity.

Another component of the value of marginal labor productivity is the product price. Everything else constant, higher output prices, which are often related to higher product quality, lead to a higher value of marginal labor productivity, and thus, higher labor markdowns. Higher prices and product quality (contributing to higher markups) might increase export intensity and the probability that a firm will participate in export markets (Jafari et al., 2023). Nevertheless, price premiums for product quality can have an adverse effect when aiming to export to lower-quality destinations (Crinò and Epifani, 2012). This indicates that the impact of product quality and prices might depend on quality standards and income levels of the domestic and destination countries.

Unionization and strong bargaining power of employees can drive wages up[2], which implies lower labor markdowns, and can positively and negatively affect export activities. Directly, higher wages imply higher costs, thereby reducing firms' competitiveness on the (export) market (Melitz and Redding, 2014). Indirectly, higher wages might be positively related to motivation and longer employment time due to better working conditions and higher satisfaction (Steinmetz et al., 2014; Strain, 2019). Higher wages are related to productivity gains (Strain, 2019), which can offset wage increases and enhance firms' competitiveness, and therefore, export activities.

In sum, we hypothesize that firms' labor markdown increases export (H2a) participation, ((H2b) entry and (H2c) continuation), and (H2d) intensity.

5.3 Methodology

Prior to the analysis of the simultaneous relationship between firms' labor market power and export activities, we need to estimate the firm-specific labor markdown, which reveals the exerted labor market power, and to specify the export variables.

5.3.1 Estimation of labor markdowns

We estimate the production function to identify firms' markdowns in the labor market following Jafari et al. (2023), who estimate markups based on the approach on De Loecker and Warzynski (2012) but have augmented it to account for market power in input markets.

We estimate the gross output production function

$$\begin{aligned} y_{ft} = G_f + \beta_k k_{ft} + \beta_l l_{ft} + \beta_m m_{ft} + \beta_{kk} k_{ft}^2 + \beta_{ll} l_{ft}^2 + \beta_{mm} m_{ft}^2 \\ + \beta_{kl} k_{ft} l_{ft} + \beta_{km} k_{ft} m_{ft} + \beta_{lm} l_{ft} m_{ft} + \omega_{ft} + \varepsilon_{ft}, \end{aligned} \tag{5.1}$$

[2]An empirical analysis of Fisher et al. (2024) shows that US farmers that are union members have higher hourly wages, receive more often a bonus and health insurances from the employer compared to employees that are not members.

where subscripts f and t indicate firm and year, respectively, y_{ft} denotes output, k_{ft} capital, l_{ft} labor, and m_{ft} material, with all variables being in logarithms. ω_{ft} is the productivity of firms, and ε_{ft} a random error term. Number of employees and firms' fixed assets are included as labor and capital, while we use deflated revenues as physical output and deflated material costs as material input, since physical quantities are not available for output and materials.[3] This introduces some degree of bias to the estimates, which we try to reduce by price-deflating revenues for export and domestic quantities, and by including firm-fixed effects (G_f) that may capture deviations from average prices (De Loecker and Scott, 2016). ω_{ft} is also unobserved and therefore proxied by material demand that is a function of firm's productivity, capital, export status in the previous year, and firm-fixed effects. We apply a two-step generalized method of moment (GMM) estimator following Ackerberg et al. (2015); De Loecker (2013); and Jafari et al. (2023) to estimate the output elasticities with respect to the inputs of labor, materials, and capital, which are used for the calculation of labor markdown of firms. Building on the mentioned studies, we know that the ratio of the markdown of material inputs $\psi_{m,ft}$ to markdown of labor $\psi_{l,ft}$ equals the inverse ratio of the expenditure shares $w_{i,ft}x_{i,ft}$ of the two inputs i, multiplied by the ratio of their output elasticities θ_i

$$\frac{\psi_{m,ft}}{\psi_{l,ft}} = \frac{w_{l,ft}x_{l,ft}}{w_{m,ft}x_{m,ft}} \frac{\theta_{m,ft}}{\theta_{l,ft}}. \tag{5.2}$$

Assuming a competitive input market for materials ($\psi_{m,ft} = 1$), allows us to identify the labor markdown for each firm f in time t, using observed expenditure shares of inputs and the estimated elasticities.

The markdown $\psi_{l,ft}$ in the labor input market can also expressed as

$$\psi_{l,ft} = \frac{MRPL_{ft}}{wage_{ft}} = \frac{MPL_{ft} * p_{ft}}{wage_{ft}}, \tag{5.3}$$

where it is defined as the ratio of marginal revenue products of labor ($MRPL$) and wages. The $MRPL$ is the firms' additional revenue generated by employing one more worker, thereby capturing labor productivity (*i.e.,* additional output produced per extra worker, MPL) and output prices (p). In perfect competition, the wage equals $MRPL$ implying a labor markdown equal to one. Higher (lower) wages than the $MRPL$ imply a lower (higher) markdown than one, respectively. For further

[3] Following Jafari et al. (2023) we use the harmonized index of consumer prices for food and beverages in France (Eurostat, 2024a) to deflate domestic revenues, create a industry-specific price deflator for the deflation of export revenues based on export quantities and values (Eurostat, 2024c), and use the French producer price index (Eurostat, 2024b) to deflate material cost and capital.

discussions on the derivation of the labor markdown based on the production function estimation, we refer to De Loecker and Warzynski (2012) and Jafari et al. (2023) including their online appendix.

5.3.2 Specifications of main regressions

To obtain a comprehensive picture on how firms' export activities influence their power on labor markets, we use four different regression specifications. Targeting the first objective (the differences in labor market power of exporters and non-exporters), we analyze the impact of being an exporter on firms' power in the labor market (H1a), using

$$ln\psi_{ft} = \delta_0 + \delta_1 lagln\psi_{ft} + \delta_2 Participation_{ft} + X_{ft}\delta_3 + \lambda_s + \lambda_t + \epsilon_{ft}. \quad (5.4)$$

$Participation_{ft}$ is the binary explanatory variable of interest that equals one if the firm f exports in t and zero if not. The use of the one year lag of labor markdowns, $lagln\psi_{ft}$, as explanatory variable allows us to capture the change of a firm's labor markdown compared to the one in the previous year following from export participation (*e.g.,* Fernandes and Isgut, 2005; Jafari et al., 2023). X_{ft} denotes a vector of control variables. To control for factor intensity and firm size, we include firm's capital, number of employees, and material cost. Additionally, firm age and a set of dummies specifying the legal form are included to capture experience and potential regulatory differences across firms, respectively. The legal form implies differences in several firm characteristics such as the extent of liability, and social and fiscal regimes of firms. The vast majority of firms in our sample are simplified limited companies and limited liability companies. We further include sector fixed effects at NACE-4-classification (λ_s) and time (λ_t) fixed effects to control for unobserved heterogeneity across industries, global, or macroeconomic shocks that vary over time, thereby reducing omitted variable bias. ϵ_{fst} is the error term. We are mainly interested in δ_2 indicating the change in the markdown due to export participation. Since we want to estimate the effect of firms' export activities on their labor market power in more detail (targeted to analyze H1b and H1c), we modify the equation and introduce export entry and continuation as two separate variables that are captured by export participation in the previous equation. Therefore, we are interested in δ_2 and δ_3 that show how starting and continuing to export might affect labor markdown differently:

$$ln\psi_{ft} = \delta_0 + \delta_1 lagln\psi_{ft} + \delta_2 Entry_{ft} + \delta_3 Continue_{ft} + X_{ft}\delta_4 + \lambda_s + \lambda_t + \epsilon_{ft}. \quad (5.5)$$

$Entry_{ft}$ is a binary variable equal to one if the firm f starts to export in time *t*, and zero otherwise. $Continue_{ft}$ equals one if the firm f exports in *t* and already exported in *t-1*, and otherwise is zero. Lastly, we include the export intensity as $ExpInt_{ft}$ to investigate H1d:

$$ln\psi_{ft} = \delta_0 + \delta_1 lagln\psi_{ft} + \delta_2 ExpInt_{ft} + X_{ft}\delta_3 + \lambda_s + \lambda_t + \epsilon_{ft}. \tag{5.6}$$

The export intensity is defined as the share of export revenues from all revenues of the firm, therefore reveals the firms' orientation towards exporting.

We are also interested in the implications of firms' labor markdown on the different export dimensions, bringing us to a set of five different specifications, with the following pattern:

$$ExpActivity_{ft} = \delta_0 + \delta_1 ln\psi_{ft} + X_{ft}\delta_2 + \lambda_s + \lambda_t + \epsilon_{ft}. \tag{5.7}$$

Related to H2a, we include the firm's f participation in t as $ExpActivity_{ft}$. Then, to examine this effect further, we replace $ExpActivity_{ft}$ by export entry (H2b), export continuation (H2c), and export intensity (H2d) in three separate regressions.

5.3.3 Identification strategy

We clearly face endogeneity issues in our analysis, since the simultaneity persists across all the specified regressions. We apply instrumental variables to capture exogenous characteristics of firms' labor market power and export activities. Therefore, we construct instruments for export activities and the labor markdown following the Bartik (1991)-style.

The Bartik-instrument for the export activities $Exp\hat{A}ct_{ft}$ is defined as the export intensity of firm f in the initial year $ExpInt_{ft_{initial}}$ multiplied by the annual growth of the global GDP excluding France in t:

$$ExpAct_{ft} = ExpInt_{ft_{initial}} * (1 + GDP\_Growth_{t,global}). \tag{5.8}$$

Since this instrument is relevant for export participation, entry, continuation, and intensity, it is used in the Equations 5.4 to 5.6 as instrumental variable for all dimensions of export activities. While the initial export intensity captures firm-specific variation and reduces reverse causality, the global economic growth captures time-specific variation and is exogenous to firms' individual decisions.

Similarly, the instrument for labor market power used in the regressions based on Equation 5.7 is constructed as the firm's labor markdown in the initial year $\psi_{ft_{initial}}$ times the annual sector-specific growth of the average labor markdown in France except firm f in t, $(1 + \psi\_Growth_{s,t})$:

$$\psi_{ft} = \psi_{ft_{initial}} * (1 + \psi\_Growth_{s,t}). \tag{5.9}$$

We employ extended regression models (using eprobit or eregress from StataCorp, 2023) and use the mentioned instruments for the endogenous covariates to estimate our specifications involving combinations of endogenous continuous (binary) dependent variables and binary (continuous) endogenous covariates, conditional on exogenous covariates. Using maximum likelihood functions, the models determine parameters based on the product of the cumulative joint distributions of error terms and marginal distributions of residuals (Bartus and Roodman, 2014). Extended regression models allow also for robust estimations when two endogenous covariates are included, such as $Entry$ and $Continue$ in Equation 5.5, that are simultaneously determined with labor markdowns. Estimations of a probit model in the first stage with a linear regression in the second stage can be combined or, where suitable, vice versa.

To check the robustness of our results, we drop the bakery sector as this main sector constitutes a large share of overall observations with relatively few are exporters (see Appendix A5.1). With this, we want to ensure that results are not driven by this sector, although including sector-fixed effects in the main regressions. Re-estimations with simple ordinary least squares (OLS), two-stage least squares (2SLS), and probit estimators constitute further robustness checks. We use the double hurdle model with control functions to estimate the markdown's impact on export participation and intensity in two stages, which is also a suitable approach for this research question as it includes both export activities in two stages and meaningfully considers zero export values (García, 2013).

5.3.4 Identification of relevant markdown components

We aim to identify the importance of the markdown components in driving the estimated impacts. Therefore, we regress the labor markdown on the firms' wages and total factor productivity, separately and simultaneously, and use each obtained residual as "adjusted markdowns" in different regression analyses instead of the firms' overall labor markdown (*e.g.,* Jafari et al., 2023). The wages are directly available from our data set, while productivity is the hicks neutral total factor productivity estimated with the production function. These adjusted markdowns capture the components of labor markdown except wages (*i.e.,* wage-adjusted markdown), productivity (*i.e.,* productivity-adjusted markdown), or both (*i.e.,* wage- and productivity-adjusted markdown). This approach allows us to determine whether wages and/or productivity are the main sources of the estimated effects of the simultaneous relation between markdown and export activities, or whether the impacts mainly arise from the remaining heterogeneity of the labor markdown, other than wages and productivity. This remaining part includes variations through channels like output prices and labor productivity that is deviating from the total factor productivity.

5.4 Data

We use annual French firm-level data from the Orbis database spanning from 2009 to 2020. The firms are classified in NACE 4-digit level; we include all firms that are involved in food and beverage manufacturing (*i.e.,* firms belonging to category 10 and 11 in NACE 2-digit). For our data analysis, we drop the firms with less than five employees, most of them being small bakeries that solely sell to the domestic market and are not expected to enter international markets. This results in 25587 observations of 8565 firms. The Orbis data includes financial information and the other firm-specific variables employed for the production function estimation and the regression models, including export revenue, total revenue, number of employees, amount of fixed assets, material costs, date of incorporation, and the legal form. With an increasing share over time, around 31.95% of the firm-level observations in our sample are exporting in a given year. On average, exporters generate 18.64% of their total revenues from exports. The halve of the exporters earn below 7.47% of their revenues from exporting, while 12.50% of the exporters obtain more than 50% of their revenues from export markets. The data reveals that exporters are on average roughly six times larger (*e.g.,* in terms of number/cost of employees) than, and twice as old as non-exporters. 45% of out observations are active in the bread sector (NACE: 1071), followed by the meat sector with 8% (NACE: 1013), and the wine sector with 6%, which has the most exporting firms (1102; see Figure A5.1 in the Appendix). Please see also Table 5.1 for further firm characteristics of the whole data set. Besides the Orbis data, we use price indices from Eurostat and FAOSTAT for deflation (Eurostat, 2024a,2; FAO, 2024), and GDPs from the Worldbank (2024) for the construction of our instruments.

TABLE 5.1: Summary statistics

Variable	Mean	SD	Min	Max	10th Perc.	90th Perc.	N
Revenue	34225.55	170509.5	4.95	5149256	469.86	57529.9	27479
Costs of employees	3814.83	15713.33	1.03	549237.6	181.72	6999.71	27479
Number of employees	67.43	247.21	5	7925	5	135	27479
Export revenue	6565.16	60140.56	0	3977924	0	4826.87	27479
Export participation	0.32	0.47	0	1	0	1	27479
Export intensity	0.06	0.16	0	1	0	0.19	27479
Export entry	0.03	0.18	0	1	0	0	27479
Export continuation	0.23	0.42	0	1	0	1	27479
Export exit	0.03	0.17	0	1	0	0	27479
Fixed assets	5443.75	27955.97	0	1313964	31.43	9268.16	27479
Material costs	27207.76	143877.5	5.22	5097854	221.21	45477.14	27479
Age	24.7	19.43	0	120	3	54	16058

Note: Values are in thousand USD. Export intensity is the share of firm's export revenue in total revenues.

5.5 Results and discussions

5.5.1 Estimated labor markdowns

We find that the labor markdown in the French food and beverage industry between 2010 and 2020 is, on average, 0.306 (sd=3.420). When capturing the heterogeneity of firms' size by weighting the firms by their number of employees, the weighted average of the labor markdown is 0.452. This is well below one, indicating that wages are above competitive levels, suggesting that most firms cannot exert labor market power, whereas workers do. The distributions shown in Figure 5.1 depict that exporters often have larger markdowns than the firms selling on the domestic markets only. Overall, only 6% of the firms pay wages above competitive levels (markdown above one). Markdown increases over time indicating a shift of power towards firms (Figure A5.2 in the Appendix). Markdown distributions also differ markedly across sub-sectors (NACE-4-classification; see Figure A5.3 in the Appendix). This supports the inclusion of the time and sector fixed effects in the regressions.

5.5.2 Impact of firms' export activities on their labor markdown

In Table 5.2, we show the regression results based on the Equations 5.4 to 5.6. We find that a firm's export participation can be associated with a reduction in their labor markdown (see Column 1), which is in contrast to H1a. This implies that, compared to non-exporters, exporting firms pay higher wages relative to what they earn per extra worker. Column 2 shows that in the year of export entry, firms' labor

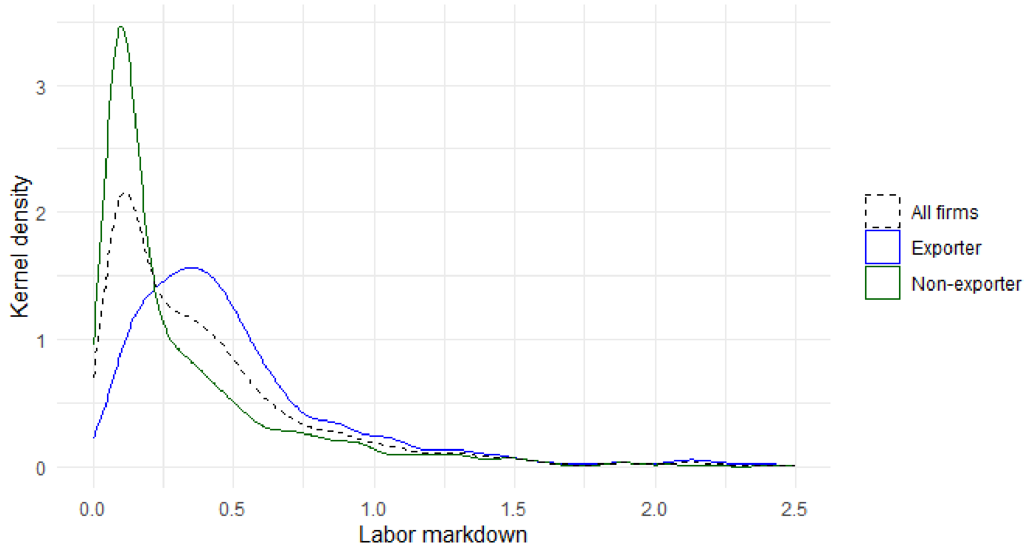

FIGURE 5.1: Distribution of labor markdown in 2020

markdown is not influenced by exporting. Results on export continuation (continue in Column 2) suggest that the effect of exporting more than one year drive the negative impact on labor markdown found for export participation. Therefore, there are no signs of changes in labor markdowns due to export market penetration, but effects of exporting arise with a time lag. This is in line with the learning by exporting theory implying that changes in firms' marginal revenue product of labor and wage setting due to exporting are implied by export experience in previous year(s) of trade, while no effect is found for the initial export year. Consequently, we do not find support for H1b, and contrasting effects than hypothesized in H1c.

As shown in Column 3, firms' export intensity significantly decreases their labor markdown. The more export oriented firms are, the higher wages they pay relative to their marginal revenue product of labor. This finding is not in line with our hypothesized effect of export intensity on labor markdown (H1d); however, based on our calculated labor markdown, which is below one for the vast majority of French food processing firms, our finding is in line with Mertens (2020), who shows that labor market distortions increase with higher export intensity in the direction of the prevalent distortion, *i.e.,* a further decrease of markdown in our case. This is also in line with the literature that suggests relatively higher wages of exporting firms (*e.g.,* Bernard and Jensen, 1999; Bernard et al., 1995; Schank et al., 2007), since higher markdowns might result if wages increase over-proportionally to gains in the value of marginal productivity of labor.

The instruments used to address covariate endogeneity pass weak instrument tests and endogeneity can be rejected for export entry and participation, but not for continuation. Re-estimation without the bakery sector (NACE: 1071, see Figure A5.1 in the Appendix), which has a disproportionate share of all observations with most firms selling on the domestic market, reveal insignificant effects of export participation, entry, and continuation on labor markdown (Columns 1 & 2 in Table A5.1 in the Appendix), suggesting that this sector drives the overall effects found above. Therefore, implications of being an exporter should be interpreted with caution. The impacts of export intensity on markdowns, however, are robust throughout the estimations without bakeries (Column 3). Similar results are also shown when employing simple OLS and 2SLS regressions (see Figure A5.2 in the Appendix).

5.5.3 Impact of firms' labor markdown on their export activities

The estimated impacts based on Equation 5.7 are presented in Table 5.3. We find no impact of labor markdown on participation (see Column 1). Further, Column 2 (3) indicates positive (negative) implications of firms' markdown on export entry (continuation), but effects are insignificant within conventional significance levels. Based on these results, we do not find support for hypotheses H2a to H2c. This could be driven by the multitude of channels that may increase or decrease export activities and in sum lead to no effect. For example, higher labor markdown because of lower wages related to a less motivated workforce (Becchetti et al., 2013; Steinmetz et al., 2014) could imply lower export activities, while higher labor productivity through technological changes could enhance export activities.

Firms' labor markdown, however, affects their export intensity negatively (see Column 4). This finding is in contrast to hypothesis H2d, and indicates that having a relatively higher ratio of marginal revenue product of labor over the wages paid leads to a decline in their export orientation. With respect to the theoretical effect of labor market power on exporting, this is counterintuitive, since on average workers have market power meaning that an increase in labor markdown should increase labor market efficiency. Therefore, increasing export intensity was hypothesized. One explanation of this impact might be that relatively higher payments to workers (*i.e.,* lower markdown) increase their motivation (Becchetti et al., 2013; Steinmetz et al., 2014), which might lead to a higher expansion of exports than sales on the domestic market. Conversely, low wages might limit firms' ability to expand their export activities since workers are less motivated

TABLE 5.2: Estimated effects of export activities on labor markdown

	(1)	(2)	(3)
Second stage			
Participation	-0.047*		
	[-0.091,-0.002]		
Entry		0.021	
		[-0.028,0.069]	
Continuation		-0.044**	
		[-0.071,-0.018]	
Intensity			-0.061***
			[-0.090,-0.032]
LaglogMD	0.772***	0.773***	0.770***
	[0.749,0.795]	[0.761,0.784]	[0.759,0.782]
logl	-0.204***	-0.202***	-0.206***
	[-0.226,-0.182]	[-0.213,-0.191]	[-0.217,-0.195]
logm	0.190***	0.189***	0.188***
	[0.168,0.211]	[0.178,0.199]	[0.178,0.199]
logk	0.013***	0.012***	0.013***
	[0.008,0.017]	[0.008,0.015]	[0.010,0.017]
Constant	-2.411***	-2.654***	-2.409***
	[-2.757,-2.065]	[-2.790,-2.518]	[-2.605,-2.213]
First stages			
Participation	2.624***		
	[2.204,3.044]		
Entry		-1.698***	
		[-2.094,-1.303]	
Continue		2.765***	
		[2.505,3.024]	
Intensity			0.778***
			[0.764,0.792]
Correlations			
e.participation,e.MD	0.160		
	[-0.012,0.333]		
e.entry,e.MD		-0.103	
		[-0.244,0.039]	
e.continue,e.MD		0.162**	
		[0.055,0.268]	
e.intensity,e.MD			0.022
			[-0.006,0.050]
Number of obs	8501	8501	8501
Log likelihood	-78.579	-1155.613	11016.728
Chi2	304655.026	277851.459	282221.013

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. 95% confidence intervals are reported. MD refers to labor markdown. Fixed effects for years, sectors, and legal form and age are included in all models. We exclude the 1st and last percentile of observations based on labor markdown.

This relationship is also revealed, when excluding the large bakery sector that is mainly selling on the domestic market (see Column 4 in Table A5.3 in the Appendix), and in further robustness checks employing OLS and 2SLS estimators (see Column 4 & 5 in Table A5.4 in the Appendix). We also apply the double hurdle model, which supports our results showing that labor markdown has no significant effect on export participation, but intensity is negatively influenced by firms' labor markdown (see Table A5.5 in the Appendix). The negative relationship may suggest that reducing markdowns due to increasing wages or improving workers' conditions by firms, or through policies that favor these developments could potentially also enhance export intensity for firms.

TABLE 5.3: Estimated effects of labor markdown on export activities

	(1) Participation	(2) Entry	(3) Continuation	(4) Intensity
Second stage				
logMD	0.045	0.088	-0.039	-0.042***
	[-0.120,0.209]	[-0.166,0.342]	[-0.201,0.124]	[-0.063,-0.022]
logl	0.160*	-0.033	0.105	-0.024**
	[0.018,0.301]	[-0.248,0.182]	[-0.035,0.244]	[-0.042,-0.007]
logm	0.200**	0.005	0.255***	0.044***
	[0.064,0.337]	[-0.202,0.213]	[0.120,0.389]	[0.028,0.061]
logk	0.003	0.013	0.000	0.006***
	[-0.020,0.026]	[-0.023,0.050]	[-0.024,0.024]	[0.003,0.009]
Constant	-4.204***	-1.877	-5.033***	-0.697***
	[-6.046,-2.363]	[-4.688,0.933]	[-6.850,-3.216]	[-0.920,-0.473]
First stage				
MD instrument	0.306***	0.306***	0.306***	0.306***
	[0.287,0.325]	[0.287,0.325]	[0.287,0.325]	[0.287,0.325]
Correlations				
e.logMD,e.part	-0.061*			
	[-0.109,-0.013]			
e.logMD,e.entry		-0.028		
		[-0.102,0.047]		
e.logMD,e.cont.			-0.024	
			[-0.072,0.024]	
e.logMD,e.intensity				-0.017
				[-0.054,0.020]
Number of obs	15062	15062	15062	15062
Log likelihood	-8150.300	-3794.599	-7917.860	5054.392
Chi2	8428.933	11805.016	4306.127	3035.843

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. 95% confidence intervals are reported. MD refers to labor markdown. Fixed effects for years and sectors are included in all models. We exclude the 1st and last percentile of observations based on labor markdown.

5.5.4 Relevance of various labor markdown components

In the following, we discuss the relevance of the different components of labor markdown and their implications for the simultaneous relation with firms' export activities. We examine the role of components such as firms' wages, total factor productivity (referred to as productivity, if not further specified), and the remaining factors that channel the relationship beyond wages and productivity, using the adjusted markdowns. The remaining part of the wage- and productivity-adjusted markdown includes factors that influence output prices and labor productivity but are not captured by firms' wages and total productivity, *e.g.,* product quality, market concentration, demand-side factors.

Export participation reduces labor markdown; however, once firms' markdown is adjusted for wages and/or productivity, this effect becomes insignificant (see Panel A, Figure 5.2). The smallest coefficient, observed when estimating the impact on the productivity-adjusted markdown, suggests that productivity is a crucial channel through which export participation lowers firms' markdown. While the impact on the wage-adjusted markdown also becomes insignificant at conventional significance levels, its coefficient exhibits a higher magnitude than the impact on the "non-adjusted" markdown, suggesting that exporting might have stronger associations for heterogeneity in the others components although not significant. The wage- and productivity-adjusted markdown is not significantly influenced by participation but, unlike in the previous regressions, displays a positive sign. These findings indicate that the negative effect of participation on markdowns is driven by changes in the productivity and the wage components. This positive tendency suggests that firms' export participation may be associated to increases in markdown components related to labor productivity and/or output prices.

The export entry does not significantly influence labor markdown, which is also the case when we separately adjust for wage or productivity components of markdown (see Panel B, Figure 5.2). However, we find a positive effect of firms' export entry on its wage- and productivity-adjusted markdown. In the first year of exporting, this adjusted labor markdown increases, on average, by 4.2%. These differences in the impact based on the markdown adjustments highlight the complexity of the various components that might counteract in their effects on markdown. The increase in the adjusted markdown due to export entry is in contrast to pricing strategies for market penetration with lower output prices, however, suggests relative increases in labor productivity and/or output price components due to export entry. Economies of scale that increase the output per worker when extending the market might be the reason for this increase in the labor productivity component (De Loecker and Warzynski, 2012). With respect to the pricing component, firms' might upgrade product quality because of export entry and since French food products are known for high quality products its plausible that firms are not relying on market penetration strategies. Instead, the quality of their products can evoke higher output prices. This is in line with the finding that competitive pressure on international markets in higher-quality segments is lower (Vandenbussche, 2014). To summarize, the positive effect of export entry on the wage- and productivity-adjusted markdown indicates that firms might be able to increase their marginal revenue product of labor due to entering the export market.

When firms continue to export, there is a tendency to reduce labor markdowns (see Panel B, Figure 5.2). The size of the coefficient substantially decreases and the significance of the effect vanishes for the productivity-adjusted, and the wage- and productivity-adjusted markdowns, hinting towards productivity as driver for markdown reductions related to export continuation.

Firms' export intensity has a negative effect on labor markdown, and also on the markdown adjusted by wage, productivity, or both (see Figure 5.2). The estimated effect of firms' export intensity on the productivity-adjusted markdown stays at the same extent as on the total labor markdown (*i.e.,* decrease of 6.1%). The impact is most pronounced on the wage-adjusted markdown, therefore export intensity might explain more variation in the other components of markdown such as (labor) productivity and output prices. Wage- and productivity-adjusted labor markdowns are still affected by a 5.7% decrease, when export intensity increases by 1 percentage point. Consequently, the impact of export intensity negatively affects labor markdowns related to all components analyzed.

As we find markdowns below one for most firms and a labor environment favored by the bargaining agreement and union density in France, firms with higher export intensity might need to share additional revenues over-proportionally with their workforce. Although productivity and other components of markdown play a role for changes in markdown through export orientation, firms with higher export intensity might need to attract workers by higher wages, contributing to the lower markdown. As long as the absolute profit earned through the increase of exports are still higher than without the expansion, firms would gain from exporting and increase their export intensity. Since France is a producer of differentiated and high-quality foods, often with long traditions, knowledge transfer and quality-upgrading due to export expansion may not lead to a significant productivity growth (which would ceteris paribus imply higher labor markdowns) (Gao et al., 2014; USDA, 2024).

Labor markdown of firms does not affect their participation, entry, and, continuation in export markets. These findings hold also when adjusting the markdown by the different

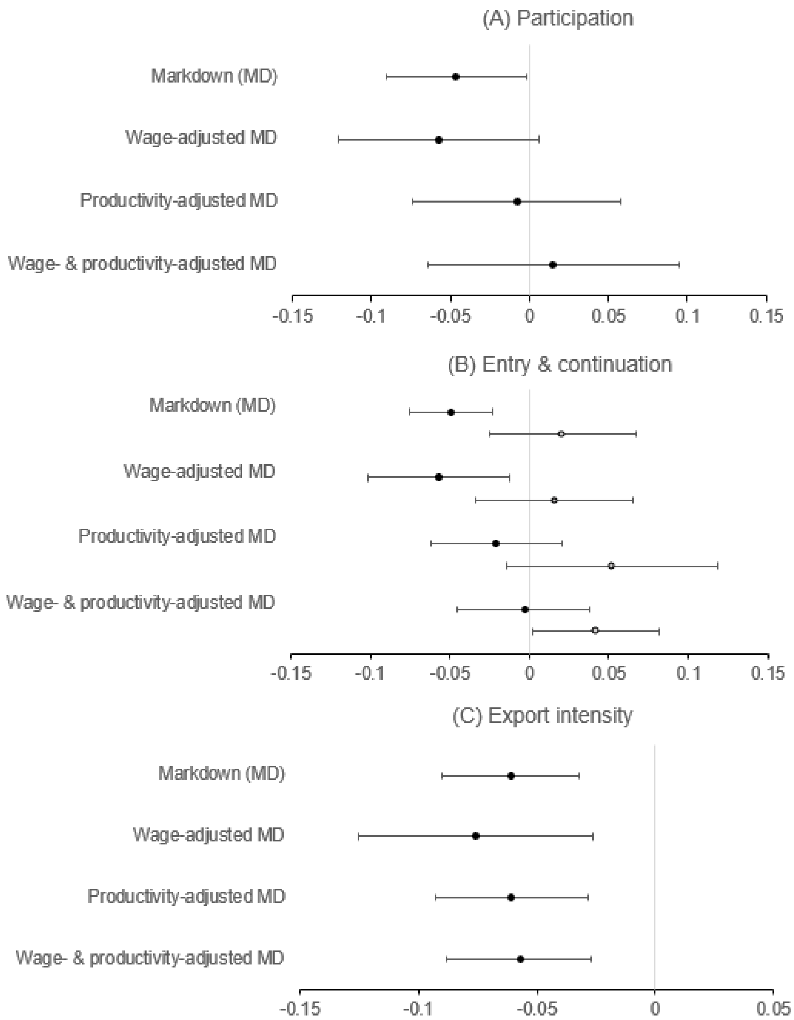

FIGURE 5.2: Impact of export activities on (adjusted) markdowns

Note: In Panel C, gray dots refer to the coefficients of export entry, while the black dots show results for export continuation. We report here confidence intervals at 95% levels. MD refers to labor markdown. See Tables A5.6 to A5.8 in the Appendix for complete regression outputs.

components (see Figure 5.3). However, firms' labor markdown negatively influences firms' export intensity. The significant effect persists with different magnitudes when adjusting for wage, productivity, and both, implying that heterogeneity in all of the three markdown components are relevant for the effect on export intensity. The impact of wage- and productivity-adjusted markdowns on export intensity is the largest, a reduction by 5.4 percentage points with an increase of adjusted markdown by 1%.

Based on these results, decreasing labor markdowns related to any of its components increase export orientation of French food firms. For instance, relatively higher wages and lower output prices (*i.e.,* lower markdown) might increase export intensities by employing more motivated workers and reaching more buyers, respectively.

Lower labor markdowns might increase export intensity, and, as discussed above, this higher export intensity, in turn, decrease labor markdown again. This interplay suggests a reinforcing mechanism: more export oriented firms hire workers paying higher wages compared to the additional revenue per worker (*i.e.,* lower markdowns) leading, again, to the ability to further expand their export orientation (*i.e.,* increase export intensity).

Current French labor policies likely contribute to the strong standing of the workers, with the majority of food processing firms having a markdown below one, and consequently, also influence export activities. If policy makers change the labor law in favor of firms' (or workers') market power, this may reduce (enhance) firms' export intensity, which would again lead to increases (decreases) in the labor markdowns. As well, export promoting (prohibiting) policies that would imply higher (lower) export intensities of firms might decrease (increase) labor markdowns, which in turn might promote (prohibit) export intensity again.

These reinforcing impacts can lead to discrepancies between firms that serve mainly the export market and low/non-exporting firms with respect to the (different components of) labor markdown. Since we find that the wage component of markdown is playing a crucial role for the impacts, there is potential of increasing income inequality between workers of international operating firms and domestic firms. Further, the tendency of reduced value of labor productivity relative to wages due to export expansion should be considered as a possible adverse business implication of policy measures when aiming to promote export intensities.

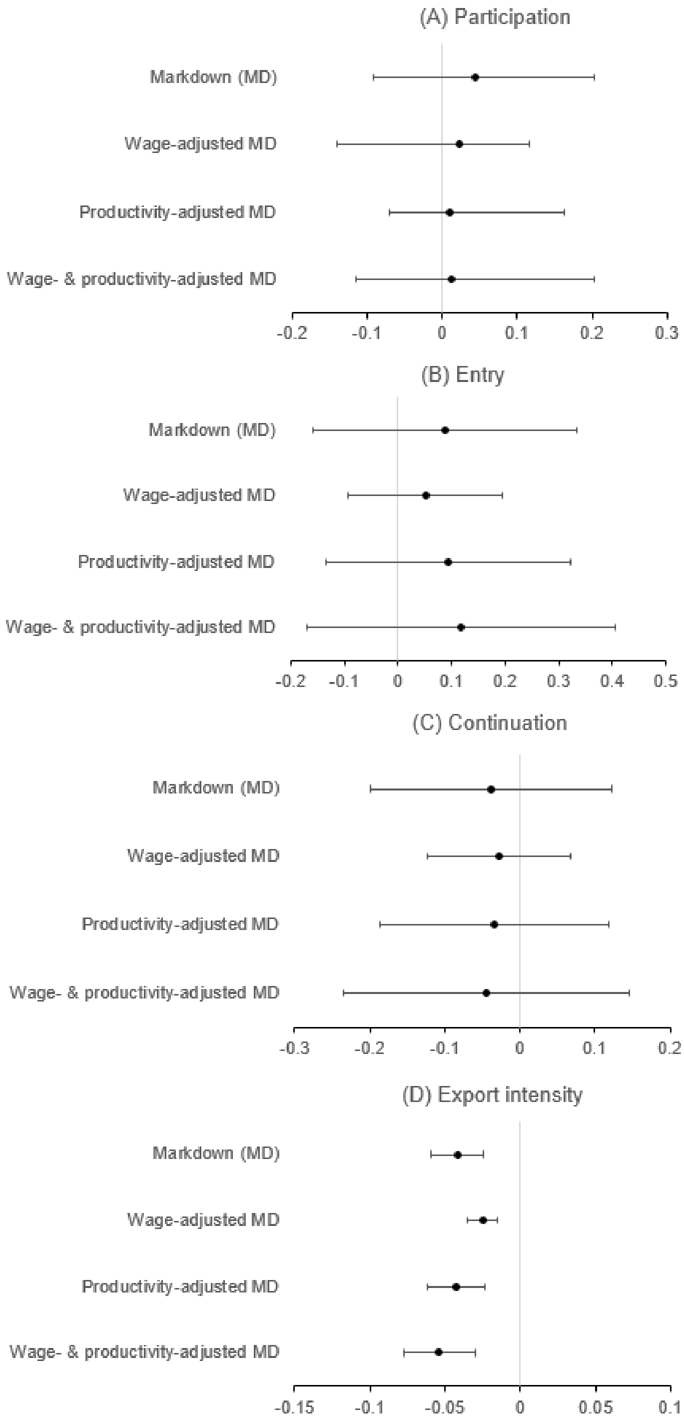

FIGURE 5.3: Impact of (adjusted) markdowns on export activities

Note: In Panel C, gray dots refer to the coefficients of export entry, while the black dots show results for export continuation. We report here confidence intervals at 95% levels. MD refers to labor markdown. See Tables A5.9 to A5.12 Appendix for complete regression outputs.

5.6 Summary and concluding remarks

In this paper, we examine the labor markdown of French food and beverage firms and its relationship with their export activities. For this, we use the data from Orbis in the years between 2010 and 2020 that covers 8565 French firms. Most of the firms have a markdown below one, demonstrating that they pay wages above competitive levels, which is in line with previous findings in the relevant literature (Caselli et al., 2021; Dobbelaere et al., 2015; Jafari et al., 2023). 32% of the observed firms are exporters, in the remaining cases, firms sell the produced food products and beverages on the domestic market only.

We estimate firm-specific markdowns following Jafari et al. (2023), who modify the De Loecker and Warzynski (2012) production function approach to allow for imperfections in input and output markets. Subsequently, we analyze the two-way relation of export activities and labor markdown by using several regression specifications. To reduce endogeneity issues, we employ fixed effects and use instrumental variables.

Our main results show that while there are no effects in the initial year of exporting, continued export participation and export intensity negatively affect labor markdowns. Reciprocally, higher labor markdowns of firms decrease their export intensities, but do not affect export participation, entry, and continuation. This two-sided impacts between export intensity and labor markdown suggest that increasing export intensity lowers the firms' labor market power, favoring the workers' position, which, in turn, contributes to an increase in firms' export intensity.

We are further interested in the components of labor markdown and their importance for these mutual impacts. Therefore, we adjust the markdown by wages, productivity, or both, and use these "adjusted markdowns" for re-estimations of our regression specifications. The negative effect of participation on markdown is driven by changes in the productivity and wage components. Additionally, the wage- and productivity-adjusted markdown increases when firms enter export markets, suggesting that export entry relates to changes in the markdown components related to labor productivity and/or output prices. There is no effect of adjusted labor markdowns on export participation, entry, and continuation. Regressions with all three "adjusted markdowns" reveal that the reciprocal relation with export intensity is driven by variations in all analyzed markdown components.

These results imply that firms aiming to exert more labor market power and, at the same time, to increase their export intensity have counteracting goals, which might be associated to the French labor market and export conditions. This interaction may also be of interest to policymakers who establish and adapt labor market or export-promoting measures. It should be considered in relation to potential indirect implications for exports, labor market inefficiencies, and (income) inequalities between exporters and non-exporters.

Several limitations of our research need to be acknowledged that provide pathways for future investigation. First, our findings have limited external validity. We focus on the French food and beverage industry with its specific labor and export market conditions. Applying a similar approach to countries with different conditions would help assess what generalizations on the relationship between domestic labor market power and export activities are possible. Second, the estimated markdown should be interpreted with some caution. Since physical output and material rely on the deflation of total revenues and material costs, some variation might not be captured although firm-specific price indices were used. If data would be available, the incorporation of input and output quantities can reduce such biases. Third, we neglect firms' export market diversification and possible implications of different characteristics of destinations markets. Linking the data set with specific custom data would allow to look into the implications of different destinations for the analyzed relation. Depending on the export destination, firms might be able to realize higher or lower prices and benefit from knowledge transfers, which may result in changes of export revenues and the marginal value of labor productivity; and therefore, would be an interesting angle for future research.

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5.A Appendix

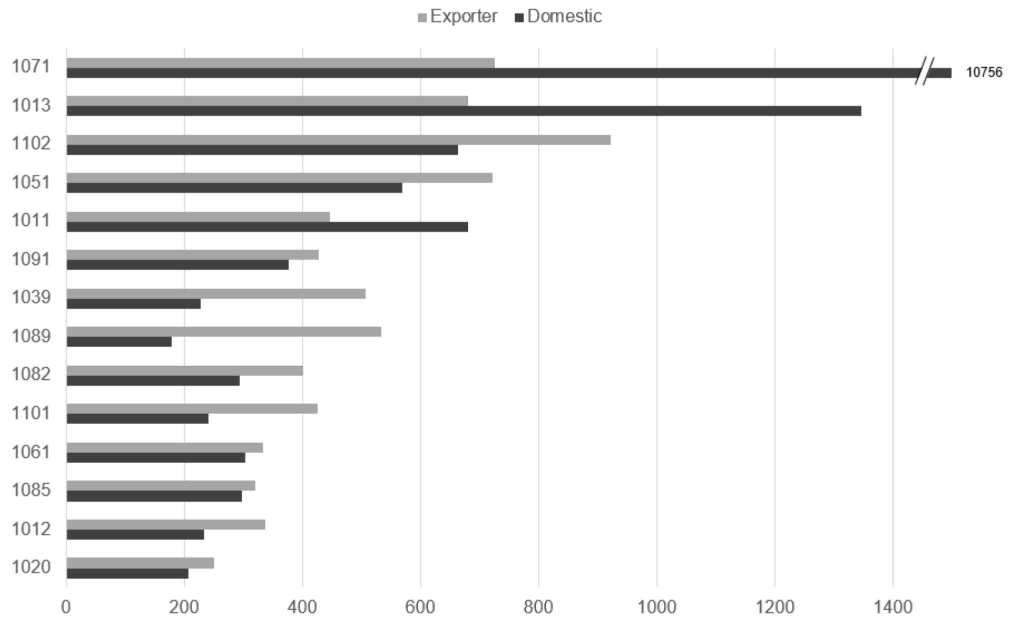

FIGURE A5.1: Observations per NACE classification - TOP 15 food and beverage subsectors

Note: We show the number of observations of exporting and non-exporting firms in the different NACE-4-digit classifications of the 15 main sectors according to observations in our dataset. In the bakery sector (1071), we have 10756 observations that are selling solely on the domestic market, however included a break for better illustration.

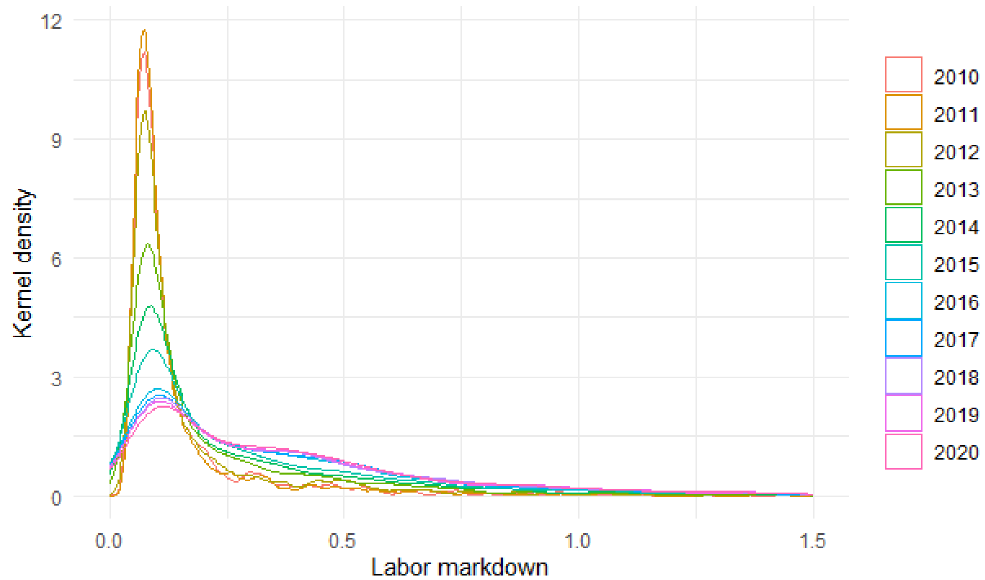

FIGURE A5.2: Distribution of labor markdown across years

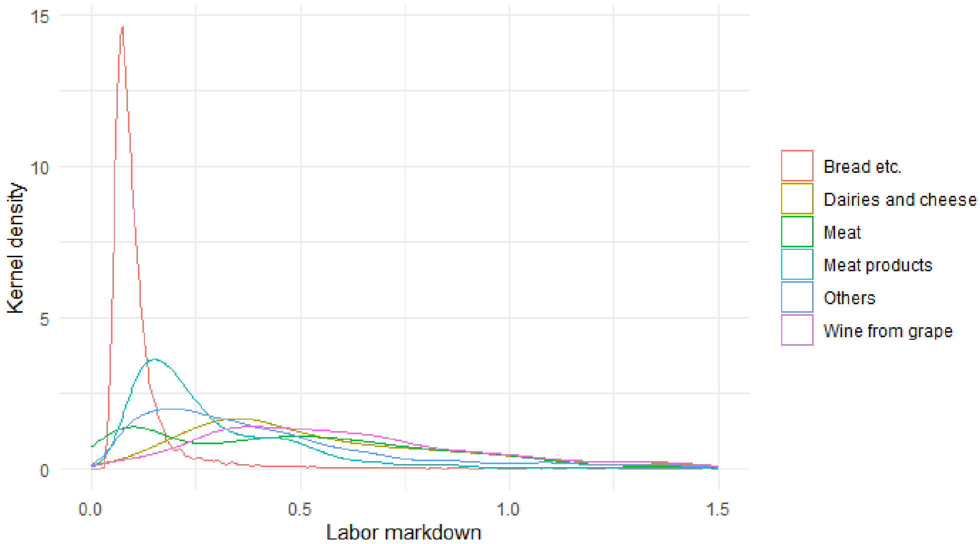

FIGURE A5.3: Distribution of labor markdown across sectors for all years

Note: NACE classifications of the different sectors: bread etc.=1071, dairies and cheese=1051 , meat=1011 , meat products=1013, wine from grape=1102.

TABLE A5.1: Estimated effects of export activities on labor markdown without bakery sector

	(1)	(2)	(3)
Second stage			
Participation	-0.021		
	[-0.055,0.013]		
Entry		0.028	
		[-0.008,0.063]	
Continuation		-0.025	
		[-0.054,0.004]	
Intensity			-0.057***
			[-0.089,-0.025]
LaglogMD	0.808***	0.809***	0.804***
	[0.775,0.841]	[0.777,0.842]	[0.789,0.820]
logl	-0.177***	-0.176***	-0.181***
	[-0.209,-0.145]	[-0.208,-0.144]	[-0.196,-0.166]
logm	0.160***	0.159***	0.162***
	[0.128,0.192]	[0.128,0.190]	[0.149,0.176]
logk	0.012***	0.012***	0.013***
	[0.006,0.019]	[0.005,0.019]	[0.008,0.018]
Constant	-2.247***	-2.236***	-2.294***
	[-2.667,-1.827]	[-2.652,-1.820]	[-2.485,-2.103]
First stage			
Export instrument			
Participation	2.523***		
	[2.069,2.977]		
Entry		-1.556***	
		[-2.007,-1.105]	
Continuation		2.612***	
		[2.214,3.011]	
Intensity			0.757***
			[0.736,0.778]
Correlations			
e.part.,e.logMD	0.088		
	[-0.058,0.235]		
e.entry,e.logMD		-0.111	
		[-0.231,0.009]	
e.contin.,e.logMD		0.115	
		[-0.015,0.244]	
e.intensity,e.logMD			0.027
			[-0.014,0.069]
Number of obs	4006	4006	4006
Log likelihood	-34.227	-701.655	4840.812
Chi2	104346.152	105198.048	103203.466

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. 95% confidence intervals are reported. Fixed effects for years, sectors, and legal form are included in all models. We exclude the 1st and last percentile of observations based on labor markdown (MD = markdown)

TABLE A5.2: Estimated effects of export activities on labor markdown using OLS & 2SLS

	OLS	OLS	OLS	2SLS
Participation	-0.01			
	[-0.01,0.00]			
Entry		0.00		
		[-0.01,0.02]		
Continuation		-0.01		
		[-0.02,0.00]		
Intensity			-0.05***	-0.06***
			[-0.07,-0.02]	[-0.09,-0.03]
LaglogMD	0.77***	0.77***	0.77***	0.77***
	[0.75,0.80]	[0.75,0.80]	[0.75,0.79]	[0.75,0.79]
logl	-0.20***	-0.20***	-0.21***	-0.21***
	[-0.23,-0.18]	[-0.23,-0.18]	[-0.23,-0.18]	[-0.23,-0.18]
logm	0.19***	0.19***	0.19***	0.19***
	[0.16,0.21]	[0.16,0.21]	[0.17,0.21]	[0.17,0.21]
logk	0.01***	0.01***	0.01***	0.01***
	[0.01,0.02]	[0.01,0.02]	[0.01,0.02]	[0.01,0.02]
Constant	-2.37***	-2.37***	-2.40***	-2.41***
	[-2.71,-2.03]	[-2.71,-2.03]	[-2.74,-2.05]	[-2.75,-2.06]
N	8501	8501	8501	8501
R2	0.97	0.97	0.97	0.97

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. 95% confidence intervals are reported. Fixed effects for years, sectors, and legal form are included in all models. We exclude the 1st and last percentile of observations based on labor markdown (MD = markdown).

TABLE A5.3: Estimated effects of labor markdown on export activities without bakery sector

	(1) Participation	(2) Entry	(3) Continuation	(4) Intensity
Second stage				
logMD	0.013	0.081	-0.059	-0.072***
	[-0.181,0.207]	[-0.215,0.377]	[-0.247,0.129]	[-0.102,-0.042]
logl	0.171*	-0.025	0.119	-0.051***
	[0.005,0.336]	[-0.276,0.225]	[-0.041,0.279]	[-0.076,-0.025]
logm	0.193*	-0.000	0.234**	0.069***
	[0.030,0.355]	[-0.245,0.245]	[0.078,0.391]	[0.044,0.094]
logk	-0.027*	-0.008	-0.024	0.010***
	[-0.053,-0.001]	[-0.049,0.034]	[-0.049,0.002]	[0.006,0.014]
Constant	-3.650***	-1.501	-4.339***	-1.095***
	[-5.823,-1.476]	[-4.799,1.797]	[-6.435,-2.243]	[-1.430,-0.759]
First stage				
MD instrument	0.277***	0.277***	0.277***	0.277***
	[0.252,0.301]	[0.252,0.301]	[0.252,0.301]	[0.252,0.301]
Correlations				
e.logMD,e.participation	-0.049			
	[-0.105,0.006]			
e.logMD,e.entryr		-0.025		
		[-0.110,0.060]		
e.logMD,e.continuation			-0.015	
			[-0.069,0.040]	
e.logMD,e.intensity				-0.020
				[-0.063,0.023]
N	9750	9750	9750	9750
Log likelihood	-6370.195	-2636.756	-6510.796	1657.008
Chi2	5143.049	10207.545	1475.493	1879.683

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. 95% confidence intervals are reported. Fixed effects for years and sectors are included in all models. We exclude the 1st and last percentile of observations based on labor markdown (MD = markdown).

TABLE A5.4: Estimated effects of labor markdown on export activities using probit, OLS, & 2SLS

	Participation Probit	Entry Probit	Continuation Probit	Intensity OLS	Intensity 2SLS
logMD	-0.10***	0.02	-0.12***	-0.03***	-0.04***
	[-0.16,-0.03]	[-0.08,0.11]	[-0.19,-0.05]	[-0.03,-0.02]	[-0.06,-0.02]
logl	0.03	-0.08	0.00	-0.01***	-0.02***
	[-0.03,0.10]	[-0.17,0.02]	[-0.06,0.07]	[-0.02,-0.01]	[-0.04,-0.01]
logm	0.34***	0.06	0.32***	0.03***	0.04***
	[0.28,0.40]	[-0.02,0.14]	[0.25,0.38]	[0.03,0.04]	[0.03,0.06]
logk	0.00	0.01	-0.01	0.00***	0.01***
	[-0.02,0.02]	[-0.02,0.04]	[-0.03,0.01]	[0.00,0.01]	[0.00,0.01]
Constant	-5.99***	-2.68***	-5.83***	-0.54***	-0.70***
	[-6.76,-5.23]	[-3.77,-1.59]	[-6.63,-5.04]	[-0.61,-0.47]	[-0.92,-0.47]
N	25571	25530	25587	25587	15062
R2				0.25	0.24

Note: * p<0.1, ** p<0.05, *** p<0.01. 95% confidence intervals are reported. Fixed effects for years and sectors are included in all models. We exclude the 1st and last percentile of observations based on labor markdown (MD = markdown).

TABLE A5.5: Estimated effects of labor markdown on export participation and intensity using the double hurdle model

s	(1) Intensity	(2) Selection
logMarkdown	-0.056***	0.087
	(0.020)	(0.087)
logl	-0.045**	0.142*
	(0.018)	(0.077)
logm	0.049***	0.156**
	(0.017)	(0.074)
logk	0.006*	0.007
	(0.004)	(0.013)
LagIntensity	1.236***	3.492***
	(0.018)	(0.123)
Constant	-0.887***	-3.586***
	(0.236)	(0.996)
Observations	12,767	12,767
Sector Dummy	Yes	Yes
Year Dummy	Yes	Yes
Average marginal effect		
logMD	-0.014***	-0.007

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

TABLE A5.6: Impact of export participation on adjusted markdowns

	(1) Markdown	(2) Wage-adj.	(3) Prod.-adj.	(4) Wage-&prod.-adj.
Second stage				
Participation	-0.047*	-0.057	-0.008	0.015
	[-0.091,-0.002]	[-0.121,0.006]	[-0.074,0.058]	[-0.064,0.095]
LaglogMD	0.772***	0.853***	0.836***	0.746***
	[0.749,0.795]	[0.820,0.885]	[0.816,0.857]	[0.725,0.767]
logl	-0.204***	-0.053**	-0.161***	-0.266***
	[-0.226,-0.182]	[-0.094,-0.013]	[-0.182,-0.141]	[-0.287,-0.245]
logm	0.190***	0.069***	0.089***	0.153***
	[0.168,0.211]	[0.033,0.104]	[0.074,0.105]	[0.137,0.169]
logk	0.013***	-0.000	0.011***	0.013***
	[0.008,0.017]	[-0.007,0.007]	[0.006,0.016]	[0.009,0.018]
Constant	-2.411***	-0.587*	-0.885***	-1.495***
	[-2.757,-2.065]	[-1.093,-0.082]	[-1.118,-0.652]	[-1.694,-1.296]
First stage				
Exp. instrument	2.624***	2.638***	2.360***	2.332***
	[2.204,3.044]	[2.221,3.056]	[1.934,2.786]	[1.867,2.798]
Correlations				
e.part.,e.logMD (adj.)	0.160	0.120	0.021	-0.076
	[-0.012,0.333]	[-0.032,0.272]	[-0.235,0.278]	[-0.409,0.258]
Number of obs	8501	8501	6925	6925
Log likelihood	-78.579	-4242.202	-10.093	483.230
Chi2	304655.026	87638.766	113975.759	131041.911

Note: * p<0.1, ** p<0.05, *** p<0.01. 95% confidence intervals are reported. Fixed effects for years, sectors, and legal form are included in all models. We exclude the 1st and last percentile of observations based on labor markdown (MD = markdown).

TABLE A5.7: Impact of export entry and continuation on adjusted markdowns

	(1) Markdown	(2) Wage-adj.	(3) Prod.-adj.	(4) Wage- & prod. adj.
Second stage				
Entry	0.021	0.016	0.052	0.042*
	[-0.025,0.067]	[-0.034,0.065]	[-0.014,0.118]	[0.002,0.082]
Contin.	-0.049***	-0.057*	-0.021	-0.003
	[-0.075,-0.023]	[-0.102,-0.012]	[-0.062,0.021]	[-0.045,0.038]
LaglogMD (adj.)	0.773***	0.853***	0.837***	0.747***
	[0.762,0.784]	[0.820,0.885]	[0.817,0.857]	[0.726,0.767]
logl	-0.203***	-0.052*	-0.160***	-0.265***
	[-0.214,-0.191]	[-0.093,-0.012]	[-0.180,-0.139]	[-0.286,-0.244]
logm	0.189***	0.068***	0.090***	0.154***
	[0.178,0.200]	[0.033,0.103]	[0.075,0.104]	[0.140,0.169]
logk	0.012***	-0.000	0.011***	0.013***
	[0.009,0.016]	[-0.008,0.007]	[0.006,0.016]	[0.008,0.018]
Constant	-2.402***	-0.580*	-0.890***	-1.510***
	[-2.600,-2.205]	[-1.081,-0.080]	[-1.116,-0.663]	[-1.691,-1.329]
First stage				
Instr. entry	-1.693***	-1.681***	-1.616***	-1.601***
	[-2.089,-1.297]	[-2.109,-1.252]	[-2.019,-1.213]	[-2.007,-1.195]
Instr. contin.	2.759***	2.780***	2.516***	2.506***
	[2.499,3.018]	[2.394,3.166]	[2.132,2.901]	[2.115,2.898]
Correlations				
e.entry,e.logMD (adj.)	-0.109	-0.085	-0.133	-0.078
	[-0.242,0.024]	[-0.174,0.004]	[-0.318,0.052]	[-0.222,0.065]
e.contin.,e.logMD (adj.)	0.178***	0.131*	0.080	0.004
	[0.075,0.280]	[0.016,0.246]	[-0.079,0.239]	[-0.180,0.189]
Number of obs	8501	8501	6925	6925
Log likelihood	-1136.318	-5301.789	-872.368	-379.033
Chi2	278529.666	89267.670	.	132930.657

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. 95% confidence intervals are reported. Fixed effects for years, sectors, and legal form are included in all models. We exclude the 1st and last percentile of observations based on labor markdown (MD = markdown).

Table A5.8: Impact of export intensity on adjusted markdowns

	(1) Markdown	(2) Wage-adj.	(3) Prod.-adj.	(4) Wage- & prod.
Second stage				
Intensity	-0.061***	-0.076**	-0.061***	-0.057***
	[-0.090,-0.032]	[-0.125,-0.026]	[-0.093,-0.028]	[-0.088,-0.027]
LaglogMD (adj.)	0.770***	0.851***	0.834***	0.743***
	[0.759,0.782]	[0.818,0.883]	[0.813,0.855]	[0.723,0.764]
logl	-0.206***	-0.055**	-0.163***	-0.268***
	[-0.217,-0.195]	[-0.096,-0.015]	[-0.184,-0.142]	[-0.289,-0.247]
logm	0.188***	0.066***	0.091***	0.156***
	[0.178,0.199]	[0.031,0.101]	[0.076,0.105]	[0.142,0.170]
logk	0.013***	0.000	0.011***	0.014***
	[0.010,0.017]	[-0.007,0.008]	[0.006,0.016]	[0.009,0.018]
Constant	-2.409***	-0.573*	-0.901***	-1.536***
	[-2.605,-2.213]	[-1.074,-0.072]	[-1.125,-0.678]	[-1.713,-1.360]
First stage				
Intensity	0.778***	0.777***	0.758***	0.758***
	[0.764,0.792]	[0.744,0.810]	[0.720,0.795]	[0.720,0.796]
Correlations				
e.intensity,e.logMD (adj.)	0.022	0.028	0.033	0.027
	[-0.006,0.050]	[-0.001,0.057]	[-0.001,0.068]	[-0.009,0.062]
Number of obs	8501	8501	6925	6925
Log likelihood	11016.728	6853.341	8787.367	9278.814
Chi2	282221.013	88878.338	.	132312.723

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. 95% confidence intervals are reported. Fixed effects for years, sectors, and legal form are included in all models. We exclude the 1st and last percentile of observations based on labor markdown (MD = markdown).

Table A5.9: Impact of adjusted markdowns on export participation

	(1)	(2)	(3)	(4)
Second stage				
logMD (adj.)	0.045	0.022	0.010	0.013
	[-0.114,0.204]	[-0.071,0.116]	[-0.141,0.162]	[-0.177,0.203]
logl	0.160*	0.138***	0.130	0.133
	[0.025,0.294]	[0.063,0.213]	[-0.007,0.267]	[-0.043,0.309]
logm	0.200**	0.221***	0.230***	0.229***
	[0.070,0.331]	[0.150,0.293]	[0.143,0.318]	[0.117,0.340]
logk	0.003	0.004	0.004	0.004
	[-0.020,0.027]	[-0.020,0.028]	[-0.020,0.029]	[-0.020,0.029]
Constant	-4.204***	-4.524***	-4.620***	-4.604***
	[-5.967,-2.442]	[-5.342,-3.705]	[-5.493,-3.747]	[-5.699,-3.509]
First stage				
MD instrument	0.306***	0.522***	0.347***	0.277***
	[0.297,0.315]	[0.508,0.536]	[0.323,0.372]	[0.257,0.298]
Correlations				
e.logMD (adj.),e.part.	-0.061*	-0.065**	-0.082**	-0.084**
	[-0.108,-0.014]	-0.109,-0.020]	[-0.132,-0.032]	[-0.138,-0.031]
Number of obs	15062	15062	14293	14293
Log likelihood	-8150.300	-15249.574	-9888.187	-7714.912
Chi2	4542.277	4542.238	7974.708	7769.254

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. 95% confidence intervals are reported. Column (1) includes the overall labor markdown, (2) wage-adjusted markdowns, (3) productivity-adjusted markdowns, and (4) wage- and productivity-adjusted markdowns (MD = markdown). Fixed effects for years and sectors are included in all models. We exclude the 1st and last percentile of observations based on labor markdown.

Table A5.10: Impact of adjusted markdowns on export entry

	(1)	(2)	(3)	(4)
Second stage				
logMD (adj.)	0.088	0.051	0.094	0.117
	[-0.158,0.333]	[-0.093,0.195]	[-0.135,0.323]	[-0.170,0.405
logl	-0.033	-0.070	-0.024	0.001
	[-0.240,0.175]	[-0.185,0.045]	[-0.228,0.180]	[-0.263,0.266]
logm	0.005	0.041	0.023	0.007
	[-0.194,0.205]	[-0.067,0.149]	[-0.106,0.152]	[-0.157,0.172]
logk	0.013	0.015	0.015	0.015
	[-0.023,0.049]	[-0.022,0.051]	[-0.022,0.053]	[-0.022,0.052]
Constant	-1.877	-2.444***	-2.333***	-2.177**
	[-4.564,0.809]	[-3.676,-1.212]	[-3.614,-1.052]	[-3.795,-0.558]
First stage				
MD instrument	0.306***	0.522***	0.347***	0.277***
	[0.297,0.315]	[0.508,0.536]	[0.323,0.372]	[0.257,0.298]
Correlations				
e.logMD (adj.), e.entry	-0.028	-0.025	-0.038	-0.041
	[-0.102,0.047]	[-0.096,0.046]	[-0.118,0.041]	[-0.126,0.043]
Number of obs	15062	15062	14293	14293
Log likelihood	-3794.599	-10895.872	-5884.773	-3712.079
Chi2	159.250	159.225	11561.434	11534.847

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. 95% confidence intervals are reported. Column (1) includes the overall labor markdown, (2) wage-adjusted markdowns, (3) productivity-adjusted markdowns, and (4) wage- and productivity-adjusted markdowns (MD = markdown). Fixed effects for years and sectors are included in all models. We exclude the 1st and last percentile of observations based on labor markdown.

Table A5.11: Impact of adjusted markdowns on export continuation

	(1)	(2)	(3)	(4)
Second stage				
logMD (adj.)	-0.039	-0.028	-0.034	-0.045
	[-0.200,0.123]	[-0.122,0.067]	[-0.186,0.118]	[-0.235,0.145]
logl	0.105	0.117**	0.110	0.099
	[-0.032,0.242]	[0.041,0.194]	[-0.027,0.247]	[-0.077,0.275]
logm	0.255***	0.243***	0.244***	0.251***
	[0.122,0.387]	[0.171,0.315]	[0.156,0.332]	[0.140,0.363]
logk	0.000	-0.000	0.004	0.005
	[-0.024,0.025]	[-0.025,0.024]	[-0.021,0.029]	[-0.020,0.029]
Constant	-5.033***	-4.826***	-4.897***	-4.974***
	[-6.817,-3.249]	[-5.658,-3.994]	[-5.777,-4.017]	[-6.077,-3.871]
First stage				
MD instrument	0.306***	0.522***	0.347***	0.277***
	[0.297,0.315]	[0.508,0.536]	[0.323,0.372]	[0.257,0.298]
Correlations				
e.logMD (adj.),e.contin.	-0.024	-0.032	-0.082**	-0.086**
	[-0.072,0.024]	[-0.077,0.014]	[-0.132,-0.032]	[-0.139,-0.032]
Number of obs	15062	15062	14293	14293
Log likelihood	-7917.860	-15016.938	-9682.721	-7507.906
Chi2	3923.387	3923.588	8056.006	8038.199

Note: * p<0.1, ** p<0.05, *** p<0.01. 95% confidence intervals are reported. Column (1) includes the overall labor markdown, (2) wage-adjusted markdowns, (3) productivity-adjusted markdowns, and (4) wage- and productivity-adjusted markdowns (MD = markdown). Fixed effects for years and sectors are included in all models. We exclude the 1st and last percentile of observations based on labor markdown.

TABLE A5.12: Impact of adjusted markdowns on export intensity

	(1)	(2)	(3)	(4)
Second stage				
logMD (adj.)	-0.042***	-0.025***	-0.043***	-0.054***
	[-0.060,-0.025]	[-0.035,-0.015]	[-0.062,-0.024]	[-0.078,-0.030]
logl	-0.024**	-0.007	-0.026**	-0.038***
	[-0.039,-0.010]	[-0.015,0.002]	[-0.043,-0.010]	[-0.060,-0.016]
logm	0.044***	0.027***	0.032***	0.039***
	[0.030,0.058]	[0.019,0.035]	[0.021,0.042]	[0.026,0.052]
logk	0.006***	0.005***	0.006***	0.006***
	[0.004,0.009]	[0.003,0.008]	[0.003,0.009]	[0.003,0.009]
Constant	-0.697***	-0.425***	-0.438***	-0.510***
	[-0.887,-0.506]	[-0.512,-0.338]	[-0.536,-0.339]	[-0.637,-0.383]
First stage				
MD instrument	0.306***	0.522***	0.347***	0.277***
	[0.297,0.315]	[0.508,0.536]	[0.323,0.372]	[0.257,0.298]
Correlations				
e.logMD (adj.),e.intensity	-0.017	-0.027	-0.000	0.012
	[-0.050,0.016]	[-0.059,0.004]	[-0.040,0.040]	[-0.030,0.054]
Number of obs	15062	15062	14293	14293
Log likelihood	5054.392	-2038.330	2529.381	4695.052
Chi2	4744.108	4747.258	2956.811	2951.907

Note: * $p<0.1$, ** $p<0.05$, *** $p<0.01$. 95% confidence intervals are reported. Column (1) includes the overall labor markdown, (2) wage-adjusted markdowns, (3) productivity-adjusted markdowns, and (4) wage- and productivity-adjusted markdowns (MD = markdown). Fixed effects for years and sectors are included in all models. We exclude the 1st and last percentile of observations based on labor markdown.