ISSN 2280-6180
www.fupress.net




BAE

VOL. 13, NO. 3, 2024

Bio-based and Applied Economics




FIRENZE UNIVERSITY PRESS

Bio-based and Applied Economics is the official journal of the Italian Association of Agricultural and Applied Economics – AIEAA (www.aieaa.org; E-mail: info@aieaa.org).

Journal Contacts:
Silvia Coderoni, Dipartimento di Bioscienze e Tecnologie Agro-Alimentari e Ambientali, Via Balzarini 1, 64100 Teramo; E-mail: scoderoni@unite.it
Fabio Bartolini, Dipartimento di Scienze Chimiche, Farmaceutiche ed Agrarie, Via L. Borsari 46, 44121 Ferrara; E-mail: fabio.bartolini@unife.it

Available online at: http://www.fupress.com/bae

Università degli Studi di Firenze
Firenze University Press
via Cittadella, 7 - 50144 Firenze, Italy
www.fupress.com
E-mail: journals@fupress.com

ISSN 2280-6180 (print)
ISSN 2280-6172 (online)
Direttore Responsabile: Corrado Giacomini
Registrata al n. 5873 in data 10 maggio 2012
del Tribunale di Firenze

BAE

Bio-based and Applied Economics

Volume 13, Issue 3 - 2024

Special Issue of the 12th AIEAA Conference,
June 22-23th, 2023, Milano, Italy

Firenze University Press

Bio-based and Applied Economics
http://www.fupress.com/bae

Published by Firenze University Press

Firenze University Press
Università degli Studi di Firenze
via Cittadella, 7, 50144 Firenze, Italy
www.fupress.com

BAE
Bio-based and Applied Economics

AIEAA
ASSOCIAZIONE ITALIANA DI ECONOMIA AGRARIA E APPLICATA

OPEN ACCESS

Citation: Pagliacci, F., Raimondi, V., & Salvatici, L. (2024). Guns, Germs and Climate: Food Security and Food Systems in a Risky World. *Bio-based and Applied Economics* 13(3): 219-223. doi: 10.36253/bae-16423

Received: August 5, 20024
Accepted: August 6, 2024
Published: October 16, 2024

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Editor: Fabio Bartolini

ORCID
FP: 0000-0002-3667-7115
VR: 0000-0002-5431-7885
LS: 0000-0003-1791-1663

Editorial. Guns, Germs and Climate: Food Security and Food Systems in a Risky World

Francesco Pagliacci[1,*], Valentina Raimondi[2], Luca Salvatici[3]

[1] *Department Territorio e Sistemi Agro-forestali (TESAF), Università degli Studi di Padova, Italy*
[2] *Dipartimento di Scienze e Politiche Ambientali, Università degli Studi di Milano, Italy*
[3] *Dipartimento di Economia e Centro Rossi-Doria, Università degli Studi Roma Tre, Italy*
* Corresponding author. E-mail: francesco.pagliacci@unipd.it

The 2023 AIEAA Conference in Milano emphasized markets' long-term and recent evolution, especially food, fertilizers and energy. Out of the 90 papers presented at the Conference, 7 were submitted to be included in this Special Issue.

Food inflation reached critical levels in recent years, with double-digit rates recorded in most of the world. Though food prices have since fallen from their peaks, the crisis persists and has resulted in expanding numbers of people affected by hunger and malnutrition, especially the poorest, who spend over 60% of their income on food. The number of undernourished people has risen to more than 800 million globally (FAO, IFAD, UNICEF, WFP and WHO, 2022). Russia's February 2022 invasion of Ukraine is often cited as the triggering event for these soaring figures, but the truth is that the situation was already dire before the war began. A legacy of high agricultural input costs (i.e., fertilizers, energy, fuel), years of insufficient yield growth, and weather shocks led to low stocks of several vital commodities. It raised international prices, leaving markets susceptible to shocks. The war triggered new disruptions on the supply side, pushing prices further up. In a way, it was just the most recent in a series of crises – conflict, climate change, COVID-19, etc. – highlighting the structural drivers underlying the current situation (Global Network against Food Crises, 2024).

Recurrent shocks, enhancing price volatility, are driving up acute food insecurity. Food crises around the world are the result of interconnected, mutually reinforcing drivers: conflict and insecurity, economic shocks, and weather extremes. These key drivers were associated with the lingering socioeconomic impacts of COVID-19, the knock-on effects of the war in Ukraine, and repeated droughts and other weather extremes.

In this issue, the article by Yalew et al. (2024) (*The implications of the Russia-Ukraine war for African economies: A CGE analysis for Ethiopia*) examines the impact of the 2022 world market price increases for wheat, fuels, and fertilizers on Ethiopia's economy. Using a computable general equilibrium (CGE) model, the study shows that GDP, wage rates, and house-

Firenze University Press | www.fupress.com/bae

hold' consumption in the country decline. The effects of fertilizer and petroleum price changes are particularly notable and unequal across production sectors. Crop growing activities tend to substitute inorganic fertilizers with animal manure. The overall effects on urban households are relatively severe compared to the impact on rural households. Increasing fertilizer prices tighten the competition for using animal manure as fertilizer (in crop cultivation) and as fuel (by households).

To have a proper assessment of the shock impacts, it is essential to take into account the whole value chain. The article by Gattone (2024) (*Participation of Farmers in Market Value Chains: A Tailored Antràs and Chor Positioning Indicator*) goes in this direction and presents a micro-level indicator of farmers' positioning in the market chain based on the conceptual framework outlined by Antràs and Chor (2013, 2018). The indicator considers the selling location of a farming household and its crop buyers. Using panel data from the World Bank's 'Living Standards Measurement Study: Integrated Surveys on Agriculture' for Ethiopia and Nigeria, the article empirically applies the proposed indicator and showcases its superior performance compared to the micro-level alternatives. Furthermore, by analyzing the dynamics of farmers' food and total consumption over time and controlling for various household and production characteristics, as well as potential confounding factors, it shows that moving towards a downstream position in the market chain has a positive impact on farmers' food and total consumption levels.

Most of the shocks that affect and will affect the agri-food sector are related to climate change, as one of the main environmental problems of the 21st century. Consequently, there is an increasing call for efforts directed at detecting best practices of climate change adaptation in agriculture and understanding the factors behind producers' willingness to implement such adaptation strategies. The article by Pagliacci and Salpina (2024) (*Producer, farm, production or perception? What really drives adaptation to climate change in the case of producers of Geographical Indications?*) focuses on the agri-food sector certified productions. It analyses the results of a questionnaire-based online survey administered to 137 producers of agri-food Geographical Indications in the Veneto Region (in north-eastern Italy) in 2022. Using a multinomial logit model, the study highlights the factors explaining adaptation strategies distinguishing three different cases: (i) farmers who have already implemented adaptation strategies; (ii) farmers who are willing to implement them in the future; (iii) farmers who neither have implemented them in the past nor are willing to do so in the future. Significant factors revolve around socio-demographic characteristics, farm management and networks, production type, and direct climate change perception.

Governance mechanisms along the agri-food supply chains are also increasingly important, especially in ecological transition. Under the conceptual and analytical lens of Neo Institutional Economics, the article by Ciliberti et al. (2024) (*Exploring preferences for contractual terms in a scenario of ecological transition for the agri-food sector: a latent class approach*) explores farmers' preferences towards a variety of clauses usually adopted in production contracts. To this purpose, a discrete choice experiment was conducted among 190 durum wheat producers in Italy. Results from a latent class model show that producers were mainly interested in fixed price formulas and joining shared production rules but revealed little or no interest in compelling sustainable cultivation techniques and providing technical assistance. However, these preferences are heterogeneous across farmers and vary depending on their level of education and previous use of contractual arrangements, with relevant implications for contract design and management.

In recent years, agricultural policies have also largely changed in both low-income and high-income countries, being transformed by the demands of a new economy. Coupled and decoupled subsidies and trade policies remain centre-stage in many global government initiatives. But digitalization, the green transition, and geopolitical imperatives have multiplied the objectives that agricultural policy is tasked with. This creates inevitable tensions and some trade-offs among economic agents. For example, focusing on products at zero distance to spur local economic development makes the green transition more costly. Multiple goals require multiple instruments – a lesson that many governments have yet to internalize (Juhász et al., 2023). They also require thinking of agricultural policies in somewhat different ways from what economists are accustomed to.

The image that economists have of agricultural policy goes something like this: a group of bureaucrats (a) design some incentives that favored products are to receive (e.g., export subsidies, import protection, etc.), and (b) select the products that are to be incentivized in this fashion. They may then formulate additional rules regarding what kind of farms qualify for the incentives, the specific farm actions or performance criteria on which the incentives are conditioned, and the consequences (or penalties) for non-performance. Ideally, the bureaucrats keep lobbies at arms' length throughout the process and thereafter to provide them with insulation against political manipulation and rent-seeking (Juhász et al., 2023).

However, this description of the hard, insulated state does not quite do justice to the reality of economic policy. As Juhász et al. (2023) have argued, successful governments combine autonomy from private interest groups with "embeddedness" in social ties that provide "institutionalized channels for the continual negotiation and re-negotiation of goals and policies." Economists might worry that such close relationships with private firms could have made the government more prone to capture. But Juhasz et al. (2023) also argue that these links are essential to ensure governments have access to the information needed to design workable policies, adjust to changing circumstances, and prod firms along new technological trajectories in the most effective ways possible.

Policies aimed at enhancing agricultural productivity growth, such as investments in R&D, strengthening economic incentives for farmers, infrastructure, and rural education and extension, have been found to narrow the yield gap effectively. However, it is also crucial to consider food security, sustainability, and agrifood system resilience as critical elements in productivity growth. In the same vein, access to land is one of the key factors of farm growth, while at the same time, related research is characterised by important gaps, particularly facing the change over time in the nature and role of drivers of the land market. The research in this area can support policymakers in designing policies to promote the survival and growth of farms and facilitate land investment by reducing barriers to land acquisition. In a forthcoming issue, the article by Russo et al. (2024) (*Farm characteristics and exogenous factors influencing the choice to buy land in Italy*) aims to identify the endogenous and exogenous factors that affect the decision to purchase land in Italy between 2013 and 2020. Probit models are implemented to understand the role of different determinants in land investment decisions. The results show that factors related to capital in machinery and equipment, energy production, the inflation rate and the presence of a successor positively influence the purchase decision, while the cost of capital, the ratio of rented land to utilised agricultural area and of family work units to total work units play the opposite role. The role of Utilised Agricultural Area and Gross Saleable Production per hectare varies depending on the specialisation considered.

It is natural, in times of crisis, to respond with some emergency measures, but we should not lose sight of the long term. Single, one-off policies will not provide a way out of the current predicament. There is no simple or standard solution to such a complex situation. Safeguarding food security and making the food system work will take a whole-system approach. Interventions should target the food system, the economic environment, governance, and other key elements in this crisis's broader, longer-term dimensions. These challenges are complex, but their urgency should not be underestimated; systemic actions should be taken sooner rather than later; otherwise, problems will continue to compound, and the costs of inaction will inevitably increase. Recognizing the multi-dimensionality of this crisis and responding to it is imperative to building resilient food systems and future global food security.

Another important way to mitigate future shocks and promote food security is to step up the fight against climate change and biodiversity loss, both of which featured prominently in discussions for global action, highlighting the critical climate-biodiversity-food nexus. European soils and their status are a matter of concern that has entered the policy arena. A common regulatory framework is currently discussed in the Soil Monitoring Law but has not yet been developed. The soil health narrative has been lately adopted as part of the European Union agenda; however, how far such a concept is integrated into current policy instruments is under investigation. The article by Winkler et al. (2024) (*Soils and ecosystem services: policy narratives and instruments for soil health in the EU*) is based on content analysis and scoping review and aims to evidence which soil ecosystem services are currently targeted or neglected by the available policy instruments, both regulatory and incentive-based. While primary productivity, nutrient cycles and carbon storage were frequently found, services such as biodiversity, habitat preservation, human well-being, and cultural heritage still appear underrepresented in European soil-related policies.

Finally, the article by Sogari et al. (2024) (*Intention and behavior toward eating whole grain pasta on a college dining campus: Theory of Planned Behavior and message framing*) contributes to individuate gaps and provide relevant information for upcoming policy needs. The consumption of whole grains has several health benefits. However, most US consumers – including young adults – do not meet the recommended intake. A survey based on the Theory of Planned Behavior (TPB) was developed and administered to US college students to understand the underlying factors affecting the intention and consumption of whole-grain pasta. The effects of message interventions on the TPB measures and other variables are examined. 325 participants received different messages on the health benefits of whole grain in the forms of gain- (treatment 1) or loss-framed (treatment 2) for four weeks or did not receive any message (control). The authors evaluate variables at two-time points: Time

1 (when the first message was received, week 0) and Time 2 (one month after the intervention, week 4). The results suggest that attitude, subjective norm, and perceived behavioral control are positively associated with intention, and intention can accurately predict young adults' behavior. On the other hand, the framing does not affect the TPB variables.

The crises we have faced have roots in multiple shocks or long-term pressures – in this case, the slow recovery from the global pandemic, conflicts, and climate-related disasters – and are becoming increasingly common, especially as climate change advances, and more and more intertwined. These crises overlap and amplify disruptive impacts on food production and markets, at different territorial scales. Such complex situations will likely drive rising numbers of food-insecure and malnourished people, disrupt farmers' livelihoods and leave long-lasting implications for well-being. For example, the links between drought, war, and food insecurity are evident in several places.

Our experience with the current food price crisis offers several key policy lessons. Foremost among them is the critical role of trade in ensuring food security. Keeping markets open for food and fertilizers – and expanding the number of producers and markets – can reduce price volatility and help ensure the delivery of food where it is needed. Grain and vegetable oil supplies can also be increased in the short term by suspending biofuel mandates and avoiding taking land out of food and feed production. When managed well, trade can help improve and strengthen opportunities and choices for producers and consumers, providing alternative sources to secure food supplies and thus stabilizing prices.

While trade is essential, it only works well with varied sources of food, feed, and agricultural inputs, both regarding the diversity of products and of producing and exporting countries. Yet the war has highlighted an apparent lack of such diversity due to the world's dependence on imports from Ukraine and Russia, as grain and fertilizer prices have risen to their highest levels since 2008.

Putting all your eggs in one basket is never a smart strategy, but neither is shifting all the eggs from one basket to another. Providing more options can help to avert such problems when the next shock hits. We need more flexibility in where and how food, feed, and agricultural inputs are produced and consumed. Improved diversity, in turn, will increase the resilience of local, national, regional, and global food systems. However, expanding flexibility will require significantly growing public and private investment in research and development to sustainably and rationally expand production, as well as promoting trade strategies that support the diversification of import sources (both in terms of countries and companies) and reducing food loss and waste along supply chains.

Finally, humanitarian assistance for those most in need and well-targeted social protection, through food or cash transfers, can prevent hunger and malnutrition and deter the devastating long-term impacts of a global food crisis. Still, these should not detract from efforts to meet long-term development goals and build resilience to future shocks. In the medium term, countries can invest in increasing sustainable food production. As more countries develop resilient and competitive agricultural systems, importing countries will have access to more trade partners and be able to diversify their sources of imports.

REFERENCES

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

Antràs, P., Chor, D. (2018). On the Measurement of Upstreamness and Downstreamness in Global Value Chains. World Trade Evolution: Growth, Productivity and Employment, 126–194. Taylor & Francis Group.

Ciliberti S., Frascarelli A., Martino G., and Marchini A. (2024). Exploring preferences for contractual terms in a scenario of ecological transition for the agri-food sector: a latent class approach. *Bio-based and Applied Economics*, 13(3), 285-299. https://doi.org/10.36253/bae-1537

FAO, IFAD, UNICEF, WFP, WHO (2022). The State of Food Security and Nutrition in the World 2022. Repurposing food and agricultural policies to make healthy diets more affordable. Rome, FAO. https://doi.org/10.4060/cc0639en

Gattone T. (2024). Participation of Farmers in Market Value Chains: A Tailored Antràs and Chor Positioning Indicator. *Bio-based and Applied Economics*, 13(3), 245-264. https://doi.org/10.36253/bae-15464

Global Network against Food Crises (2024). 2023 Financing Flows and Food Crises Report.

Juhász, R., Lane, N.J., Rodrik, D. (2023). The new economics of industrial policy. NBER Working Paper Series 31538. http://www.nber.org/papers/w31538

Pagliacci, F., Salpina, D. (2024). Producer, farm, production or perception? What really drives adaptation to climate change in the case of producers of Geographical Indications? *Bio-Based and Applied Economics*, 13(3), 265-283. https://doi.org/10.36253/bae-15221

Russo, S., Raggi, M., Bimbati, B., Povellato, A., Viaggi, D. (2024). Farm characteristics and exogenous factors influencing the choice to buy land in Italy. *Bio-Based and Applied Economics*, *Just Accepted*. https://doi.org/10.36253/bae-15548

Sogari G., Wongprawmas R., Andreani G., Lefebvre M., Pellegrini N., Gómez M.I., Mora C., Menozzi D. (2024). Intention and behavior toward eating whole grain pasta on a college dining campus: Theory of Planned Behavior and message framing. *Bio-based and Applied Economics*, 13(3), 301-316. https://doi.org/10.36253/bae-15456

Winkler, G., Pagano, L., Vergamini, D., Bartolini, F. (2024). Soils and ecosystem services: policy narratives and instruments for soil health in the EU. *Bio-Based and Applied Economics*, *Just Accepted*. https://doi.org/10.36253/bae-15466

Yalew, A. W., Nechifor, V., Ferrari, E. (2024). The implications of the Russia-Ukraine war for African economies: A CGE analysis for Ethiopia. Bio-Based and Applied Economics, 13(3), 225-243. https://doi.org/10.36253/bae-15364

BAE
Bio-based and Applied Economics

AIEAA
ASSOCIAZIONE ITALIANA DI ECONOMIA AGRARIA E APPLICATA

OPEN ACCESS

Citation: Yalew, A.W., Nechifor, V., & Ferrari, E. (2024). The implications of the Russian invasion of Ukraine for African economies: A CGE analysis for Ethiopia. *Bio-based and Applied Economics* 13(3): 225-243. doi: 10.36253/bae-15364

Received: November 19, 2023
Accepted: March 11, 2024
Published: October 16, 2024

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Editor: Francesco Pagliacci, Valentina Raimondi, Luca Salvatici

ORCID
AWY: 0000-0002-1778-8477
VN: 0000-0001-8034-4070
EF: 0000-0003-0031-7190

The implications of the Russian invasion of Ukraine for African economies: A CGE analysis for Ethiopia

Amsalu Woldie Yalew[1,2,*], Victor Nechifor[3], Emanuele Ferrari[3]

[1] *Ca' Foscari University of Venice, Via Torino 155, 30172 Venice, Italy*
[2] *Euro-Mediterranean Center on Climate Change (CMCC), Via della Liberta 12, 30175 Venice, Italy*
[3] *European Commission, Joint Research Centre (JRC), Seville, Spain*
*Corresponding author. E-mail: amsaluwoldie.yalew@unive.it

Abstract. The Russian invasion of Ukraine contributed to soaring world market prices of many commodities with severe repercussions for many African countries. This study examines the implications of the 2022 world market price increases for wheat, fuels, and fertilizers for Ethiopia. Using a computable general equilibrium (CGE) model, the study shows negative impacts on GDP, wage rates, and households' consumption in the country. The effects of fertilizer and petroleum price changes are notable and unequal across production sectors. With increasing import prices of inorganic fertilizers, crop growing activities substitute inorganic fertilizers with animal manure reducing the use of manure as cooking fuel. The effects on urban households are more severe than the effects on rural households. Policies supporting biofuels and biogas digesters may dampen the adverse effects stemming from petroleum price surges.

Keywords: Commodity markets, Trade, CGE, Russia-Ukraine war, Ethiopia
JEL Codes: C68, F10, L66.

1. INTRODUCTION

The Russian invasion of Ukraine and the subsequent war have caused a wide-range of crises with short- and long-term implications to the global economy. The repercussions of the war range from disruption of global commodity markets to long-term effects on the prospects of globalization and geopolitical order (Garicano et al., 2022; Ruta, 2022). The disruptions in the global supply chains increased the synchronization of grain, energy, and fertilizer prices at the global level (Ihle et al., 2022). This resulted in contagion across food and non-food markets which would restrict the ability of consumers to mitigate the adverse effects of food and energy price spikes by resorting to inexpensive alternatives (Ihle et al., 2022). The disruptions in global food, fertilizer and energy markets threaten to further increase the number of poor and malnourished people, especially in developing countries (Guan et al., 2023; Osendarp et al., 2022).

Firenze University Press | www.fupress.com/bae

The type and size of the effects will differ across countries as these are determined by the trade, production and consumption structures, and government responses in different countries (Garicano et al., 2022). It is therefore necessary to understand how the war in Ukraine affects individual economies (Ruta, 2022) to underpin country-specific policy measures increasing the resilience of each economy.

The short- and long- term implications of the war in Ukraine for African countries are worrisome (Badiane et al., 2022; UNCTAD, 2022). From the 107 economies highly exposed to the shocks due the war in Ukraine, 41 are in Africa (UN, 2022a). Since many African countries are net importers of cereals, vegetable oils and fertilizers, the implications of the war to food security are substantial (Badiane et al., 2022). Higher import prices represent negative terms-of-trade for African economies in which poor households face the hardest hit (Arndt et al., 2008). Besides, many African countries have limited fiscal and borrowing capacities to respond to global energy and food market crises, particularly after various spending measures and tightening of monetary policies to cope with and recover from the COVID-19 pandemic crisis.

The effects on Ethiopia are of particular interest (Diao et al., 2022) as it depends almost entirely on imported petroleum and inorganic fertilizers (Mengistu et al., 2019); the two commodities that felt the highest and immediate effects of the war on Ukraine in 2022 (Ruta, 2022; World Bank, 2023). Ethiopia has also been subject to multiple shocks in recent years (e.g., COVID-19 pandemic, droughts, and armed conflicts) leaving the country with little fiscal space to cushion the adverse spillover effects from the Russian invasion of Ukraine.

This study examines the economy-wide implications of changes in world prices for three commodities– wheat, fertilizers, and petroleum oil– highly significant for the Ethiopian food and energy systems. It applies a computable general equilibrium (CGE) model, which tracks the direct and induced economy-wide effects of the changes in world prices for the three major Ethiopian imports. Quantifying such effects and understanding their transmission mechanisms would provide lessons for possible policy responses in the advent of similar incidents with implications for global markets in the future.

The study explicitly represents the sectors and commodities linked to agrifood and energy systems and applied case-specific nesting of production and consumption functions to investigate the implications of world market prices changes to the food-energy nexus in Ethiopia and other low-income countries. The model combined production nesting features which are common in equilibrium model applications with detailed representation for energy (e.g., Feng & Zhang, 2018; Hutagalung et al., 2019) and agriculture (e.g., Hertel et al., 1996; Brunelle et al., 2015) sectors. The production nests allow for the imperfect substitution between different fuels (petroleum fuels, electricity, and biomass fuels) and, for growing crops, limited substitution between organic (animal manure) and inorganic (chemical) fertilizers, and then between composite fertilizer and land.

The study contributes to the literature on the transmission of shocks from global-to-domestic markets and their economy-wide impacts (e.g., Arndt et al., 2008; Dillon & Barrett, 2016; von Arnim et al., 2018), and the food-energy nexus (e.g., Mekonnen et al., 2017) in African countries.

The remainder of the paper is organized as follows. Section 2 presents the materials and methods of the study. Section 3 presents the results followed by Section 4 for the discussions. Section 5 concludes the paper.

2. MATERIALS AND METHODS

Given their detailed coverage of commodity and factor markets, and that of the circular flow of income, CGE models are widely applied for many trade, development, and fiscal policy issues of developing countries (Devarajan & Robinson, 2013). Single-country CGE modelling approach particularly helps to assess the direct and indirect effects of exogenous changes on different parts of the economy by comprehensively accounting for the country-specific interlinkages between production and consumption, and agrifood and energy sectors.

2.1. Model description

The Dynamic Equilibrium Model for Economic Development, Resources and Agriculture (DEMETRA) model is an extension of the STAGE_DEV model (McDonald et al., 2016). DEMETRA is a single-country recursive-dynamic small open-economy CGE model. The model allows for an advanced characterization of impacts of shocks at different levels: sectoral (output and production costs), household (income and consumption demand), factors (demand and income), and national (GDP, employment, and trade). DEMETRA incorporates behavioral equations that represent the economic relationships in developing countries: nested production and consumption functions and factor market segmentations (JRC, 2021; McDonald et al., 2016). The model and the underlying database have been applied in studies focusing on food security and agricultural policies in developing countries (Nechifor et al., 2021; Boulanger et al., 2022; Ntah et al., 2024). Further information and documentation about the model are available in JRC (2021).

2.2. Model calibration

The model assumes perfect competition in factor and commodity markets. Therefore, both the sellers and buyers in the factor and commodity markets take the prices determined by market supply and demand forces as given. Ethiopia is a small open-economy and thus its domestic price changes do not affect world market prices whereas world market price changes (of the country's exports and imports) are exogenous. In line with the Armington assumption (Armington, 1969), the imported and domestically produced varieties of commodities are imperfect substitutes. The elasticities used in production, commodity, and households' consumption nests are *ad hoc* values (summarized in Table A2 in the appendix) within the range found in the existing literature relevant for low-income countries and increase from agriculture to service sectors (e.g., Lofgren, 1994; Diao et al., 2012; Hertel & van der Mensbrugghe, 2019).

The production activities are disaggregated into sub processes captured by nested constant elasticity of substitution (CES) and Leontief production functions, which combine primary factors and intermediate inputs at different stages. The substitutions are driven by relative price changes. The decisions of production activities at different stages are driven by cost minimization goals constrained by market prices (of inputs and outputs) and production technology. The production technology nest of activities (Figure A1) is flexible and allows substitution possibilities among different factors and intermediate inputs at different levels. The top level is specified as Leontief aggregation of a composite intermediate input, and a composite valued-added-energy input, assuming a perfect complementarity between the two aggregates. The composite (aggregate) intermediate input is a Leontief aggregation of non-energy and non-fertilizer intermediate inputs. The composite value-added is a CES aggregation of a composite labor (of unskilled, semi-skilled, and skilled), a composite capital (of livestock, agricultural capital, non-agricultural capital), and a composite land (of irrigated or non-irrigated, and composite fertilizer) inputs. The composite energy input is a CES aggregate of energy commodities (electricity, fossil fuels, and bioenergy – fuelwood in hotels or biofuels in transport). Such nesting between energy and factor inputs resembles recent CGE applications (e.g., Feng & Zhang, 2018; Hutagalung et al., 2019). The value-added nest for crop-growing activities comprises a fertilizer nest which is a CES aggregation of animal manure (domestic) and inorganic (imported) fertilizers. This nest better represents the contexts in the country (Metaferia et al., 2011; AgSS, 2020) and allows for substitutability between them due to relative price changes which would not be allowed within the Leontief structure. In the recent five harvest seasons, about 45-50% and 11-13% of crop area cultivated by smallholder farmers in Ethiopia applies synthetic (inorganic) and natural (organic) fertilizers (AgSS, 2020). The composite fertilizer (of organic and inorganic types) is then treated as an imperfect substitute for cropland. The nesting structure for crop activities is also related to previous research on factor substitution in agriculture (e.g., Binswanger, 1974; Hertel, 1989; Ali & Parikh, 1992; Hertel et al., 1996; Dalton et al., 1997), and in agricultural land-use (e.g., Brunelle et al., 2015; Lungarska et al., 2023).

Households maximize their consumption utility subject to a nested Stone-Geary (or Linear Expenditure System – LES – demand) and CES functions (Figure A2), and to income constraints. In the Stone-Geary/LES utility function, at the top of the utility nest, household consumption demand consists of 'subsistence' demand and 'discretionary' demand. The commodities in the LES demand function are defined as 'broad' commodity groups, which are either aggregates of 'natural' commodities or individual 'natural' commodities that are deemed sufficiently distinctive as to justify the assumption that they are characterized by having a distinct level of 'subsistence' demand (JRC, 2021). The second level of the utility functions nest is defined with CES preferences. It consists of six commodity categories representing cereals (6 commodities), livestock (7 commodities including fish), energy (8 commodities in which the 2 are electricity from off-grid and grid sources), processed food and beverages (4 commodities), sweets (sugar and honey), and transport services (equines and modern transport services). Two of the energy commodities (crop residues and biogas), and one of the transport services (from equines) are consumed only by rural households. Additionally, animal manure, crop residues, and biofuel are by-products from livestock, crops, and sugar manufacturing.

Households' consumption expenditure is a residual of household income after deducting direct (income) taxes, savings, and their net transfers to other institutions (i.e., to the other household group, to enterprises, to the government, and to the rest of the world). Households' income sources include factors of production they own and supply, and net transfers from the rest of institutions. Households' consumption demand is therefore expected to be affected by changes in both households'

Table 1. Macro SAM of Ethiopia (2015/2016, billion birr).

	Activities	Commodities	Factors	Households	Enterprises	Government	Taxes	Investment	RestOfWorld	Total
Activities		2159.70								2159.70
Commodities	742.26	456.68		1096.46		148.84		591.58	123.21	3159.04
Factors	1425.11								7.83	1432.93
Households			1268.15		11.15	11.32			126.23	1416.84
Enterprises			158.60			5.52			0.28	164.40
Government				8.19	26.72		181.22		28.35	244.49
Taxes	-7.67	118.59		29.21	41.09					181.22
Investment				280.33	84.83	73.06			153.36	591.58
RestOfWorld		424.07	6.19	2.64	0.61	5.75				439.26
Total	2159.70	3159.04	1432.93	1416.84	164.40	244.49	181.22	591.58	439.26	

Source: Authors' elaboration.

income and commodity prices.

Factors can be mobile across activities (labor and land factors[1]) or activity-specific (capital and livestock factors). For the mobile factors, flexible average economy-wide wage rates equate their demand and supplies whereas flexible activity-specific wage distortion factors (proportions) equilibrate the markets for activity-specific factors. The supplies of primary factors of production are fixed at their base levels. Government and foreign savings are fixed at their base levels. The external (foreign sector) balance is maintained by a flexible exchange rate. All tax rates are fixed at the benchmark level.

2.3. Model database

The CGE model is calibrated to a modified version of the 2015/2016 social accounting matrix (SAM) for Ethiopia (Mengistu et al., 2019).[2] The adjusted SAM consists of 71 production activities (Table A1). The agriculture activities comprise 30 crop-growing activities, 7 livestock raising activities, and 4 other allied activities to agriculture. There are 8 industrial and 6 service activities. The remaining 16 activities are related to energy sectors.

The modified SAM comprises 51 commodities of which 28 are exportable. Synthetic (inorganic) fertilizers and petroleum oils are virtually all imported. There are 17 primary factor accounts representing different labor (3 by level of skill), land (rainfed and irrigated), capital (5 by primary use of the capital), and livestock (7 by species). There are four tax accounts representing domestic sales taxes, import tariffs and duties, direct (income) taxes, and subsidies to selected electricity producing activities (recorded in the SAM as negative taxes in Table 1). The SAM comprises five accounts representing two households (rural and urban), enterprises, government, and the rest of the world. The remainder of the SAM accounts represent trade and transport margin (or transaction costs), and disaggregated investment accounts.

Primary factors account for 66% of the production costs. Approximately 90% of the factor incomes goes to households. Imports account for about 14% of the supply of commodities. Consumption (77%) and savings (20%) are the main households' expenditure items whereas public services (61%) and savings (30%) are the main government expenditures. The inflows from the rest of the world include foreign saving (which is current account deficit for Ethiopia) (35%), remittances (29%) and export earnings (28%). Households' consumption (35%), intermediate inputs (23.5%), and investment demand (18.7%) are the main sources of demand for domestically supplied goods and services while export demand accounts for approximately 4%. Factor incomes (88.5%) followed by remittances (8.9%) are the main sources of households' income. Taxes are the main source of government revenue as they account for 74% of the total government income. About 65% of tax revenues are collected from commodities (on imports and on domestic sales) followed by income taxes from households and enterprises (30%). Production subsidies (applicable only to the power sector) account for - 4% of the total tax revenue. Ethiopian households and foreign sources contribute to 47% and 26% of the total national saving, with the remaining saving coming from enterprises and the government. Imports constitute about 97% of the total outflows from Ethiopia to the rest of the world.

The 2015/2016 SAM was updated using the recursive features of DEMETRA to the year 2022 using actual and

[1] Sensitivity analysis was performed with partially and entirely activity-specific croplands.

[2] Additional notes regarding adjustment of the SAM are given in the Appendix.

forecasted growth rates of GDP (IMF, 2022) and population (UN, 2022b). The forecasted real GDP growth rate for 2022 was 3.8% (IMF, 2022). We assume this GDP growth rate, which is lower than the country's five-year average of 8% growth rate (IMF, 2022; NBE, 2023), accounted mainly for the impacts of recent crises on Ethiopia but little for anticipated cascading effects from the Russia's invasion of Ukraine war impacts on world markets.

The calibration process and the adjusted SAM represent the contexts of the country and make the model suitable to address the study's research question. The production nest for crops along with the households' utility nest for energy commodities allow capturing the competition between agriculture and energy for animal manure (Mekonnen et al., 2017). The possibility of substitution between different fuel types (agricultural residues, fuelwood, petroleum products and electricity services) captures the "fuel stacking" behavior of Ethiopian households (Yalew, 2022).

2.4. World price change impact scenarios

The effects of global commodity supply, transport and logistics disruptions, the sanctions against Russia, the export bans adopted by some countries, and speculative market behaviors that ensued Russia's invasion of Ukraine have tremendously affected the prices for different world commodities in 2022 (World Bank, 2022). Although prices for some commodities showed a downward trend by the end of 2022 their level remained higher than in 2021 (World Bank, 2023).

Prices of many agrifood and energy commodities in Ethiopia increased in the past decade (ESS, 2023). Yet, the impacts of the recent domestic crises (e.g., armed conflicts, droughts) and international crises (e.g., COVID-19 pandemic and Russia's invasion of Ukraine) are conspicuous (NBE, 2023; EGTE, 2023). The annual average price indices for petroleum oil and wheat in the global and Ethiopian markets exhibit similar trends (Figure 1) substantiating the high inflation trends in Ethiopia in the past decade (ESS, 2023) as the local price changes grew faster compared to the world market prices. Likewise, domestic fertilizer prices increase might be larger than increases in world market fertilizer prices (Abay et al., 2024).

Global price changes would contribute to (or exacerbate) the domestic price changes which is why it is imperative to examine the implications of global commodity market shocks, such as those followed the war on Ukraine, for Ethiopia.

This study considers the impacts of world import price changes for three commodities (wheat, fertilizer, and petroleum products) which play substantial roles in the food and energy markets in Ethiopia and experienced more than 30% annual average real price changes in 2022 compared to 2021 (Table 2). The simulation scenarios are designed in a way to: (i) assess the potential losers from each commodity price change, (ii) identify the dominant impact channel, and (iii) assess the com-

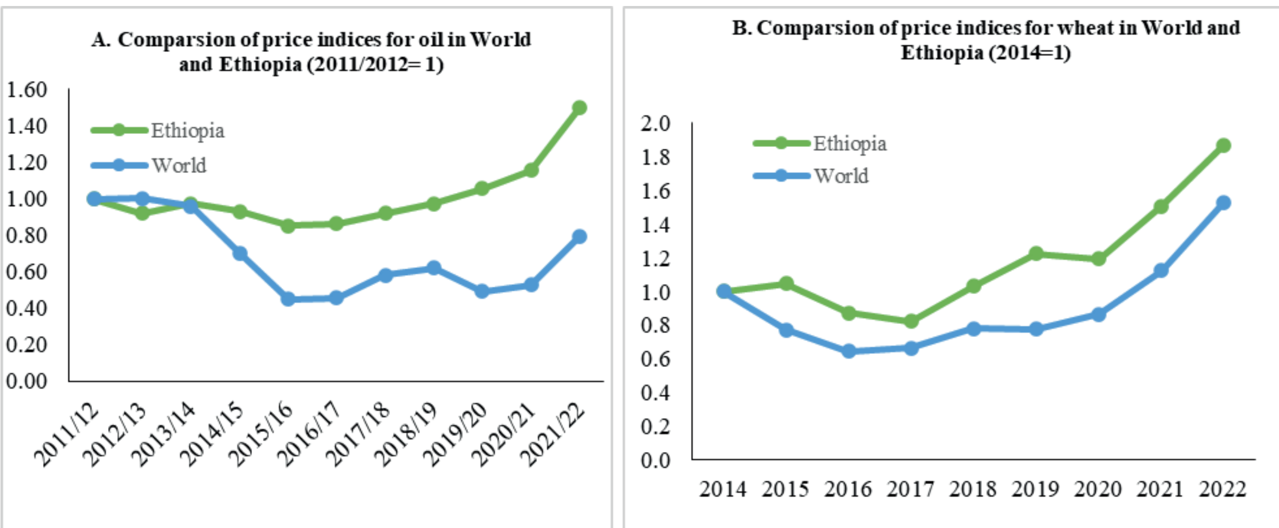

Figure 1. Comparison of local and world price indices for wheat and petroleum oil. Source: Authors' illustration based on data compiled from various reports by the National Bank of Ethiopia (retail gasoline price in Addis Ababa, Ethiopia), the Ethiopian Grain Trade Enterprise (wholesale wheat price in Ethiopia), and World Bank (2023) (crude oil and wheat prices in world markets). Trends for fertilizer prices were not presented here due to lack of publicly available local price data.

Table 2. Summary of the simulation scenarios.

Scenario	Description	Import price shocks
Wheat	World wheat import price changes	+ 34%
Fertilizer	World fertilizer import price changes	+ 54%
Petroleum	World petroleum oils import price changes	+ 50%
Combined	Combination of the above impact scenarios	

Source: Authors' calculations from World Bank (2023).
Note: The annual average real price changes, between 2022 and 2021, were calculated as of February 2023.

bined effects of the increase in the import prices of the three commodities.

Equations 1 to 4 capture the mechanisms to transmit the impacts of world import price changes to the Ethiopia's economy in DEMETRA:

$$PM_c = [PWM_c * (1 + TM_c)] * ER \tag{1}$$

$$QQ_c = \alpha_c * \; [\delta_c . QM_c{}^{-\rho_c} + \; (1 - \delta_c). QD_c{}^{-\rho_c}]^{\frac{1}{-\rho_c}}, \quad \forall c \in (cm \neq 0 \cap cd \neq 0) \tag{2a}$$

$$QQ_c = QM_c \; , \; \forall c \in cd = 0 \tag{2b}$$

$$\frac{QM_c}{QD_c} = \left[\frac{PD_c}{PM_c} * \frac{\delta_c}{(1-\delta_c)}\right]^{\frac{1}{(1+\rho c)}}, \quad \forall c \in (cm \neq 0 \cap cd \neq 0) \tag{3}$$

The domestic price of competitive imports for commodity c (PM_c) is a product of the world price of imports (PWM_c, denominated in foreign currency, assumed to be exogenously determined and fixed by the world markets), the exchange rate (ER, domestic per foreign currency), and the import tariff rate (TM_c) (Equation 1). The equation applies for wheat, fertilizer, and petroleum fuels. Imported (QM_c) and domestic (QD_c) varieties are imperfect substitutes whose CES (or Armington) aggregation (QQ_c, the aggregate domestic supply of commodity c) is influenced by the share (δ), the elasticity of substitution (ρ), and the shift (α) parameters, for all commodities, such as wheat, which have both domestically produced (cd) and import (cm) varieties (Equation 2a). However, for some commodities such as fertilizers and petroleum oil their domestic supplies supply is composed of imports only (Equation 2b). The cost minimization behavior of domestic agents (i.e., deriving the first order conditions of Equation 2a), determines the optimal mix of supplies from domestic and foreign (import) producers depending on the relative price of domestic (PD_c) and import (PM_c) varieties of the same commodity (Equation 3).

For each cropping activity a, we endogenize land productivity to consider the yield improving role of chemical fertilizer application. Crop yields ($Y_{l,a}$) endogenously respond to the relative changes to the chemical fertilizer application, i.e., the application in the new scenario ($D^N_{f,a}$) relative to the application in the base scenario ($D^B_{f,a}$). The response factor (μ_f) consider the crop phenological responses to chemical fertilizer application, and thus translating into a change in crop yield per unit of cultivated land (Equation 4).

$$Y^N_{l,a} = Y^B_{l,a} * \left[\frac{D^N_{f,a}}{D^B_{f,a}}\right]^{\mu_f} \tag{4}$$

The value of response factors (was obtained from a relevant study (Sheahan et al., 2016) and can be interpreted as a 1% increase (decrease) in fertilizer application leads to a 0.21% increase (decrease) in crop yield. Although the yield responses to fertilizer use could vary by crop type (Hertel et al., 1996; Rashid et al., 2013), due to lack of information, we applied a uniform response rate for all crops, which we acknowledge as a limitation.

The three commodities considered are essential items in both production and final consumption sectors. They account for one-fifth of the total spending for merchandise imports in Ethiopia (NBE, 2023). Ethiopia is a net importer of wheat with imports accounting for a quarter of the wheat supply. According to the SAM, wheat accounts for 3.3% of total imports of goods and services and it is consumed as an intermediate input (26%) and as food by households (74%). The LES-CES utility functions nest employed in the model allows the possibility that households substitute wheat by other cereals such as teff, barley, maize, and sorghum depending on their relative price changes.

Ethiopia depends on imported chemical fertilizers and petroleum products. Fertilizer imports comprise approximately 2% of the total good and services imports in the SAM. Fertilizers are used as inputs in crop-growing activities and more than 50% of the supply is used in growing major cereal crops e.g. wheat, maize, teff, barley, and sorghum. In wheat and maize, chemical fertilizers account for up to 6.5% of the total production costs. Increasing chemical fertilizer prices are expected to reduce the use of chemical fertilizers by crop growing activities, and partly cropland productivity (Equation 4).

Petroleum fuels account for about 10% of imports of goods and services in the SAM. They are consumed as inputs in agriculture (0.4%), industry (28.1%), electricity (2.7%), transport (51.3%), and the rest of services (10.7%). Households' demand represents 6.8% of the demand for petroleum fuels while petroleum fuels account for only 0.4% and 0.5% of rural and urban households' consumption expenditure. The bigger proportion of petroleum fuel price change impact on households' welfare is expected through indirect effects (i.e., higher commodity prices due to increased production costs in most of the sectors as consequence of higher petroleum prices).

3. RESULTS

The subsections below present the impacts of world commodity price increases on different components of Ethiopian economy. All results are presented as percentage changes relative to the base scenario, which represents the counterfactual Ethiopian economy in 2022 without economic repercussions from Russia's invasion of Ukraine. One could consider the impact scenarios as "what if" scenarios in which the information on world import price changes (Table 2) were projected and communicated in advance as soon as the war on Ukraine began (say as early warnings). This would have helped Ethiopian producers and consumers plan and undertake anticipatory measures (e.g., factor allocations and adjustments in consumption demand) in response to the anticipated repercussions from the global market shocks but no significant investment and policy changes.

3.1. Impacts on the macroeconomy

The combined world price changes could reduce Ethiopia's real GDP (by 0.65%), imports (by 5.5%), private consumption (by 2.7%), and investment demand (by 1.3%) (Table 3). Likewise, the absorption, which measures the domestic expenditure on goods and services, falls by 2%. The effects are driven by the fertilizer and fuel price changes although wheat prices have a marked impact on the trade balance. Increasing wheat import price decreases wheat imports (and hence total imports) but increases domestic wheat production as well as its substitute cereals (to meet the supply gap) which would pull factors from other sectors including those contributing to exports such as coffee, oilseeds, and manufactured foods and beverages.

As production in some activities contract (and hence factor employment and income) direct tax and total government revenue decline by 4.1% and 0.54% in the combined impacts scenario.

Table 3. The impacts on the macroeconomy (% changes).

Variable	Import price change scenarios			
	Wheat	Fertilizer	Petroleum	Combined
GDP	-0.04	-0.32	-0.27	-0.65
Private consumption	-0.32	-0.74	-1.64	-2.70
Investment demand	0.13	-0.10	-1.34	-1.34
Absorption	-0.16	-0.46	-1.39	-2.01
Government consumption	-0.12	0.22	0.25	0.39
Imports	-0.87	-0.83	-3.81	-5.53
Exports	-1.21	-0.25	2.12	0.55

Source: DEMETRA simulations.

Table 4. The impacts on domestic production by activity groups (% changes).

Activities	Import price change scenarios			
	Wheat	Fertilizer	Petroleum	Combined
Crops	0.35	-1.48	1.7	0.52
Livestock	-0.17	-0.07	-0.14	-0.35
Primary sectors – grazing, fishing, forestry, mining	-0.19	0.27	-0.41	-0.35
Food and Beverages	-0.87	-0.13	0.42	-0.57
Textiles, clothes, leather, and wood processing	-0.07	0.31	-0.32	-0.04
Rest of manufacturing	-0.08	0.59	0.09	0.68
Utilities - electricity and water	-0.08	-0.06	-2.72	-2.87
Construction	0.08	-0.04	-1.06	-1.03
Services - Private	-0.15	0.08	-2.59	-2.69
Services - Public	-0.11	0.16	0.07	0.14

Source: DEMETRA simulations.

3.2. Impacts on production activities

The domestic production in different sectors respond differently to the aggregate and individual commodity price changes (Table 4). The sectors with the highest contraction of output in the combined impacts scenario are services, construction and utilities largely driven by the fuel price changes. Production in the rest of manufacturing, natural resources-based primary sectors, and public services slightly expand (under fertilizer price changes) and in crops and food and beverages (under fuel price changes). Petroleum price change results in a wider range of output impacts (Figure 2).

Disaggregated results show that the impacts are highly scattered across sectors (Figure 2). Rising wheat prices expand domestic wheat production by 2.5%.

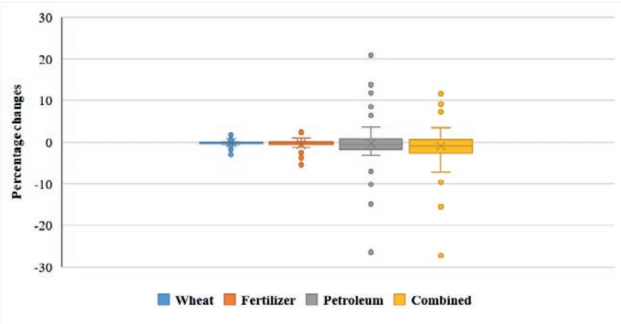

Figure 2. The impacts on domestic production activities (% changes). Source: DEMETRA simulations.

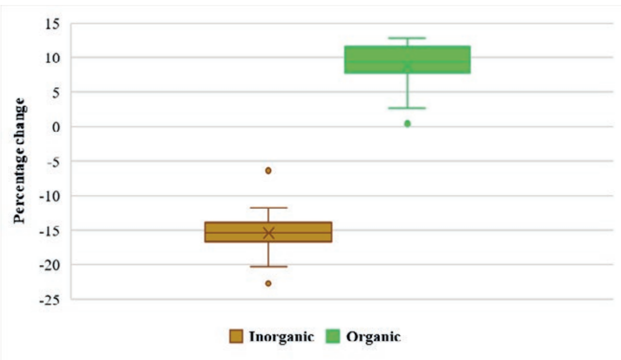

Figure 3. Fertilizer demand under inorganic fertilizer price increase scenario (% changes). Source: DEMETRA simulations.

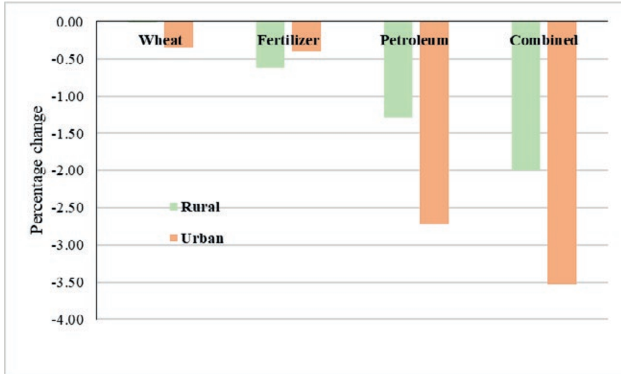

Figure 4. The impacts on households' consumption expenditure (% changes). Source: DEMETRA simulations.

Under petroleum price changes, domestic production expands in activities with substantial contribution to exports (oilseeds, coffee, vegetables, cotton, and tea) and electricity-powered transport services. The expansion of production in export-oriented agricultural activities derived from the depreciating exchange rates (due to higher import bills) making Ethiopian exports cheaper in the world markets and thus to balancing the increasing import costs. In contrast, rising fuel prices reduce the outputs from fuel-powered transport services, diesel-powered electricity (from grid and off-grid systems), and other private (commercial) services which includes hotels, financial intermediaries, and other business services. Consequently, exports from fuel-powered transport services and, slightly, electricity utilities decline.

Production in most cropping activities contracts following the rise in world chemical fertilizer prices (Table 4) with negligible size except for oilseeds, wheat, and maize which declined by 5.4%, 3.8%, and 3.2%. The marginal effects on the other crop growing activities are explained by the small shares of inorganic fertilizer inputs in the base scenario and from the substitution by manure (organic) for inorganic fertilizers (Figure 3). This, however, reduces manure available for household energy (Table 6).

3.3. Impacts on households' consumption

Rising import prices affect households' consumption demand directly (due to increased prices) and indirectly (declining household incomes as factor incomes fall due to contraction of production). In the combined impacts scenario, factor income decreases in thirteen of the seventeen factors. For instance, labor factor incomes decline by approximately 2% for unskilled to approximately 4% for semi-skilled and skilled labor categories whereas households' income from enterprises decline by about 10% (of which 7% is due to the petroleum price increases).

The decline in households' income and the resulting decrease in demands for commodities (due to higher prices) result in declining households' consumption by 2% for rural and 3.5% for urban households (Figure 4). The effects on the household groups vary across import price change scenarios. Urban households are worse off when it comes to wheat and fuel price changes whereas rural households are worse off under fertilizer price changes. The adverse effects on both household groups are mostly driven by petroleum price increases because petroleum products are inputs in almost all activities (and thus the rise in fuel prices increases in the costs of production and reduces factor demands and incomes) and as final demand product by households (and thus increasing price reduces quantity demanded).

3.4. Implications for food security

Of the four dimensions of food security, i.e., availability, accessibility, utilization, and stability (Peng and

Table 5. Implications for food security (% changes).

Scenario	Food Production Index	Food Price Index		Food Consumption	
		Rural	Urban	Rural	Urban
Wheat	0.10	0.80	0.34	0.14	-0.19
Fertilizer	-1.19	0.80	0.41	-0.41	-0.21
Petroleum	1.49	0.00	-0.08	-1.17	-2.39
Combined	0.35	1.48	0.60	-1.53	-2.84

Source: DEMETRA simulations.

Table 6. Impacts on household energy demand (% changes).

Fuels	Fertilizer		Petroleum	
	Rural	Urban	Rural	Urban
Residues	-1.39		0.65	
Wood	-0.12	0.02	-0.03	-0.76
Manure	-5.42	-3.20	-0.98	-1.33
Petroleum	-1.78	-0.98	-45.95	-31.38
Biogas	-0.81		0.16	
Ethanol	-1.26	-0.67	13.55	7.12
Electricity, off-grid	-0.41	-0.16	-9.06	-6.24
Electricity, grid	-0.66	-0.31	-5.16	-3.84

Source: DEMETRA simulations.

Berry, 2019); the rise in world import prices are expected to directly affect food *availability* (i.e., reduced wheat imports and reduced agricultural output due to expensive fertilizers and to some extent fuel prices), *accessibility* (i.e., increased transport costs and/or reduced transport services), and *stability* (i.e., the ability of the country's food system to withstand other natural and man-made shocks in the future due to reduced economic growth and government revenue).

Except for rural households under the wheat price change scenario, rural and urban households' food consumption decline (Table 5). Mirroring the impacts on crop production (Table 4), the index of food production, which includes crops, sugar, processed foods, and fish, declines (by 1.2%) only under the fertilizer price scenario (Table 5). The increase in food production index under petroleum price change is explained by increased agricultural exports, as discussed earlier.

The impacts on food production (Table 5) are negligible in most cases except under higher world prices for inorganic fertilizers due to Ethiopia's low dependence on food imports while many food staples (including teff and sorghum) are not traded internationally in large volumes (Diao et al., 2022). Yet, the index of food production increase includes overall crop production, most of which go to exports rather than to households in this scenario. That is why food consumption in both rural and urban households decreased despite the increased food production index (Table 5). The possibility of substitutions (e.g., wheat by other cereals, inorganic fertilizer by animal manure) allowed by the model contributed to relieve some of the price increase burdens on households' consumption.

3.5. Implications for household energy

The repercussions on households' energy consumption have implications for the food-energy nexus in Ethiopia (Mekonnen et al., 2017; Yalew, 2022). Agricultural wastes (e.g., crop residues, and animal dung) and products (e.g., biogas, ethanol) are important sources of household energy but using agricultural waste as fuel reduces organic fertilizer available for cropping activities.

The changes in demand for energy fuels are higher in rural households (Table 6) because they have a wider option of fuels, and hence their demand for a specific fuel is set to be relatively elastic compared to that in urban households. Petroleum prices affect households' energy prices directly (e.g., gas and kerosene) and indirectly (e.g., electricity from diesel generators). Indeed, as discussed in Section 2, the demand for petroleum in production activities is also significant. The decrease in petroleum fuel demand entails an increase in ethanol consumption in both household groups. Since ethanol is mostly produced from sugar molasses, in the long-term, this is an additional motive to expand sugar manufacturing capacities in the country. The combination of these mechanisms results in a differentiated price increase of the aggregate energy for households (by 1.5% for rural and by 3.5% for urban households). The combined share of electricity and ethanol in the total households' energy consumption is 5% while grid electricity accounts for about 18% of the urban households' energy consumption expenditure. As such, part of the decline in electricity demand is also associated with decreasing households' income in addition to its price change relative to other fuels. Rising inorganic fertilizer price increases the demand for animal manure as organic fertilizer (Figure 3) and hence reduces the amount of manure consumed as fuel by households. Demand for animal manure used as household energy declines by 5.4% and 3.2% in rural and urban households (Table 6). Increasing petroleum prices induces a slight increase in the use of biogas by rural households. This has positive implication for the domestic (household) biogas sector which converts cattle dung to fuel (biogas) and fertilizer (bio-slurry). As such, although the biogas sector in Ethiopia is yet at its niche phase (Kamp & Forn, 2016; Yalew, 2021), support for the biogas sector has the potential to help agrifood and energy sectors in the face of world petroleum price crises.

3.6. Senstivity analysis

Finally, we performed sensitivity analyses for the Armington (import) substitution elasticities (as the exogenous shocks analysed are related to import price changes) and two main assumptions pertaining to the crop sector (as the sector is important source of domestic food supply and exports). First, the overall results and conclusions remain less sensitive to increasing or decreasing the Armington import substitution elasticities by 30% (Table A3). An exception is that with higher elasticity of import substitutions, as import prices increase, the demand for imported goods become relatively elastic and decline further with which the aggregate exports decrease as exchange rates depreciates lesser compared to the case with low import elasticities. Second, the severity of the impacts partly depends on the crop phenological response factor to inorganic fertilizer use. For instance, if crop yields would be less sensitive to the amount of inorganic fertilizer applied, the combined impact on the real GDP drops to -0.39% (Table A4). Third, we deviated from our initial assumption regarding the flexibility of cropland allocations. We assumed cropland is partially mobile by fixing the land for 14 perennial crops (of the total 32 land-based activities). We then assumed all land is crop-specific (fixed to all activities), i.e., land cannot be reallocated in responses to shocks compared to the initial assumption such that farmers would easily and quickly switch between the crops they want to cultivate in response of actual and anticipated shocks. The sensitivity results (Table A4) show that adverse effects worsen when cropland is assumed to be immobile across activities. The impacts are notable on the export sector which decline by 0.91% compared to an increase by 0.55% when cropland is assumed to be freely allocable (or mobile) to growing different crops. The contraction of exports implies that there will be lesser resources to finance imports, and thus total imports decline by 6.2% compared to by 5.5% under the assumption of fully mobile cropland.

4. DISCUSSIONS

The Russian invasion of Ukraine, since February 2022, had profound implications for the global and African economies. The war caused massive supply chain disruptions and mounting trade costs globally (UNCTAD, 2022) producing price spikes for many globally traded commodities (World Bank, 2022). In Ethiopia, information from the past decade shows that local price changes for domestic commodities with competitive imports exhibit similar trends to that of world price changes. This implies that global price changes would contribute or exacerbate the price changes due to domestic market conditions. This necessitates to evaluate the implications of global commodity market shocks for Ethiopia.

This study showed that the global market repercussions due to the war on Ukraine are likely to have negatively affected the aggregate imports, households' consumption, and labor wage rates in Ethiopia. The effect on the real GDP is approximately -0.65% and is comparable to Diao et al. (2022). Nevertheless, the impacts are unevenly distributed among different sectors and households. Crop growing activities substitute animal manure (domestic) for inorganic (imported) fertilizers that eventually could dampen the adverse effects on crop production. This, however, would reduce manure available as cooking fuel which substantiates the relevance of the food-energy nexus in the country (Mekonnen et al., 2017; Yalew, 2022). The impacts on consumption are worse for urban households compared to rural ones except under fertilizer import price changes. The results of this study are comparable to previous studies showing the detrimental effects of world commodity market impacts on African economies (Arndt et al., 2008; Dillon & Barrett, 2016; von Arnim et al., 2018).

Three caveats apply to this analysis. First, the behavioral and crop phenology parameters used in the model (i.e. model elasticities) influence the simulation results. Despite the model and the adjusted SAM employed allow capturing several contexts of the Ethiopian economy, as in most CGE models, the results are still influenced by the neoclassical assumptions of perfect competition in the CGE model. Likewise, in line with the tradition in CGE model calibrations (Lofgren, 1994; Devarajan & Robinson, 2013), most of the production, international trade, and consumption are *ad hoc* values in the range of previous literature and economic theory. We therefore performed several sensitivity analyses for a selected set of parameters and assumption affecting import substitutions (Table A3) and crop activities (Table A4). The results from the sensitivity analysis regarding cropland mobility across activities are in accordance with the findings of previous research (e.g., Salazar-Espinoza et al., 2015; Martey et al., 2022) which showed farmers shift land use away from cash and permanent crops (and thus Ethiopian exports fall) and devote more to growing staple crops in response to adverse natural and man-made shocks. The sensitivity analysis also substantiates the important role of inorganic fertilizers to enhance cropland productivity (Rashid et al., 2013; Sheahan et al., 2016) and of crop agriculture in Ethiopia (Mengistu et al., 2019; NBE, 2023). Our findings that farmers substitute animal manure for inorganic fertilizers are similar to Abay et al. (2024). The study, citing survey data, indicated that the surge in inorganic fertilizer price in recent years might have encouraged Ethiopian farmers to shift to organic fertilizers. However, more research on the empirical estimates for the elasticities of substitution between organic and inorganic fertilizers, and between land and fertilizer for Ethiopia and other agrarian countries is highly needed.

Second, the study does not explicitly incorporate the impacts from interactions with domestic crises (e.g., armed conflicts, droughts) that have severely impacted Ethiopia in 2022. The armed conflicts in northern Ethiopia, between 2020-2022, might have pushed additional 3 million peoples deeper into poverty (Endale, 2023) while the droughts in the southern and southeastern parts of the country had affected an estimated population of 24 million in 2022 (ACAPS, 2023). We assumed that the impacts due to the domestic crises are accounted in the projected GDP growth rate (IMF, 2022) which is used to calibrate the baseline scenario. This could be a limitation as such compounding factors could influence the magnitude of the impacts from world market shocks (Headey & Fan, 2008; Abbott & Borot de Battisti, 2011; Meyimdjui & Combes, 2021). Thirdly, we assumed the Government of Ethiopia would not consider the possibility of adopting policy responses counteracting these global shocks. Government responses to global commodity market shocks such as social protection programs, export restrictions, price caps, subsidies, and tax reliefs (Abay et al., 2023) could have dampened the adverse impacts on production and consumption but mostly by transferring the burden to fiscal deficits (Headey & Fan, 2008; Ntah et al., 2024). Future research examining the interactions, and the combined effects of domestic and international market disruptions will be helpful.

5. CONCLUSIONS

This study assessed the consequences of the global commodity price changes in 2022, which followed from Russia's invasion of Ukraine, on Ethiopia. The results show that repercussions from global commodity market price increases adversely affect imports and households' consumption in Ethiopia. Rising petroleum prices increase households' demand for ethanol and biogas that can be considered as co-benefits to expanding sugar manufacturing and household biogas digesters. Rising fertilizer prices tighten the competition for the use of animal manure between cropping activities (as fertilizer) and households (as fuel). Policy measures to support the expansion of household (domestic) biogas digesters producing biogas (fuel) and bio-slurry (fertilizer) could be one mechanism to promote an optimal use of animal manure at the time of contemporaneous shocks to fertilizer and petroleum oil prices.

The study gleaned insights on how the different parts of the Ethiopian economy would respond to the world global commodity market shocks without explicitly incorporating other important internal natural and man-made crises that have battered the country in and around 2022. Further research on how these multiple impacts have interacted is highly needed to identify policy measures to build an economy resilient to simultaneous domestic and global market crises. The nature and size of these additional adverse conditions may become clearer in the medium-term.

DISCLAIMER

The views expressed in this paper are the sole responsibility of the authors and do not necessarily reflect the views of the European Commission.

REFERENCES

Abay, K.A., Assefa, T.W., Berhane, G., Abate, G.T., & Hebebrand, C. (2024). Grappling with compounding crises in domestic fertilizer markets in Africa: The case of Ethiopia. Research Post, IFPRI Blog. https://www.ifpri.org/blog/grappling-compounding-crises-domestic-fertilizer-markets-africa-case-ethiopia

Abay, K.A., Breisinger, C., Glauber, J., Kurdi, S., Laborde, D., & Siddig, K. (2023). The Russia-Ukraine war: Implications for global and regional food security and potential policy responses. *Global Food Security*, 36, 100675. https://doi.org/10.1016/j.gfs.2023.100675

Abbott, P., & Borot de Battisti, A. (2011). Recent Global Food Price Shocks: Causes, Consequences and Lessons for African Governments and Donors. *Journal of African Economies*, 20, 1: i12–i62. https://doi.org/10.1093/jae/ejr007

ACAPS. (2023). Impact of drought: Oromia and Somali regions. ACAPS, Geneva. https://www.acaps.org/en/

AgSS. (2016). Agricultural Sample Survey 2015/2016. Central Statistical Agency, Addis Ababa.

AgSS. (2020). Agricultural Sample Survey 2019/2020. Central Statistical Agency, Addis Ababa.

Ali, F., & Parikh, A. (1992). Relationships among labor, bullock and tractor inputs in Pakistan agriculture. *American Journal of Agricultural Economics*, 74, 2: 371-377. https://doi.org/10.2307/1242491

Armington, P. S. (1969). A Theory of Demand for Products Distinguished by Place of Production. *IMF Staff Papers*, 16, 1: 159–178.

Arndt, C., Benfica, R., Maximiano, N., Nucifora, A. M. D., & Thurlow, J. T. (2008). Higher fuel and food prices: Impacts and responses for Mozambique. *Agricultural Economics*, 39, 497–511. https://doi.org/10.1111/j.1574-0862.2008.00355.x

Badiane, O., Fofana, I., Sall, L. M., & Ceesay, B. (2022). Contagion and Exposure of African Countries to Global Wheat Trade Disruptions. Ukraine Crisis Brief Series, No. 01. AKADEMIYA2063, Kigali. www.akademiya2063.org

Binswanger, H.P. (1974). A Cost Function Approach to the Measurement of Elasticities of Factor Demand and Elasticities of Substitution. *American Journal of Agricultural Economics*, 56, 2: 377-386. https://doi.org/10.2307/1238771

Boulanger, P., Dudu, H., Ferrari, E., Mainar-Causapé, A. J., & Ramos, M. P. (2022). Effectiveness of fertilizer policy reforms to enhance food security in Kenya: A macro–micro simulation analysis. *Applied Economics*, 54, 8: 841–861. https://doi.org/10.1080/00036846.2020.1808180

Brunelle, T., Dumas, P., Souty, F., Dorin, B., & Nadaud, F. (2015). Evaluating the impact of rising fertilizer prices on crop yields. *Agricultural Economics*, 46: 653–666. https://doi.org/10.1111/agec.12161

Cai, Y., & Arora, V. (2015). Disaggregating electricity generation technologies in CGE models: A revised technology bundle approach with an application to the U.S. Clean Power Plan. *Applied Energy*, 154: 543-455. http://dx.doi.org/10.1016/j.apenergy.2015.05.041

Chepeliev, M. (2020). GTAP-Power 10a Database: a Technical Note. Research Memorandum No. 31. GTAP. Purdue University.

Dalton, T.J., Masters, W.A., & Foster, K.A. (1997). Production costs and input substitution in Zimbabwe's smallholder agriculture. *Agricultural Economics*, 17: 201-209. https://doi.org/10.1111/j.1574-0862.1997.tb00474.x

Devarajan, S., & Robinson, S. (2013). Contribution of Computable General Equilibrium Modeling to Policy Formulation in Developing Countries. *In Handbook of Computable General Equilibrium Modeling* (Vol. 1, pp. 277–301). https://doi.org/10.1016/B978-0-444-59568-3.00005-5

Diao, X., Dorosh, P. A., Kedir Jemal, M., Smart, J., Taffesse, A. S., & Thurlow, J. (2022). Ethiopia: Impacts of the Ukraine and global crises on poverty and food security. International Food Policy Research Institute (IFPRI), Washington, D.C. https://doi.org/10.2499/p15738coll2.135948

Diao, X., Thurlow, J., Benin, S., & Fan, S. (Eds.). (2012). Strategies and priorities for African agriculture: Economywide perspectives from country studies. International Food Policy Research Institute (IFPRI), Washington, D.C. https://doi.org/10.2499/9780896298125

Dillon, B. M., & Barrett, C. B. (2016). Global Oil Prices and Local Food Prices: Evidence from East Africa. *American Journal of Agricultural Economics*, 98, 1:154–171. https://doi.org/10.1093/ajae/aav040

EAPP. (2014). Regional Power System Master Plan: Volume II. Eastern Africa Power Pool (EAPP), Addis Ababa.

EGTE. (2023). Market Statistics. Ethiopian Grain Trade Enterprise (EGTE), Addis Ababa. https://www.egteethiopia.com/en/in-t-market/market-statistics.html

Endale, A. (2023). Conflict pushes 3m deeper into poverty. The Reporter. Addis Ababa. https://www.thereporterethiopia.com/34088/

ESC. (2019). Investment Opportunities in Ethiopian Sugar Industry. Ethiopian Sugar Corporation (ESC), Addis Ababa.

ESS. (2023). Country and Regional Level Consumer Price Indices. Information No. 49. Ethiopian Statistics Service (ESS), Addis Ababa.

Feng, S., & Zhang, K. (2018). Fuel-factor nesting structures in CGE models of China. *Energy Economics*, 75: 274-284. https://doi.org/10.1016/j.eneco.2018.08.030

Garicano, L., Rohner, D., & di Mauro, B. W. (Eds.). (2022). Global Economic Consequences of the War in Ukraine: Sanctions, Supply Chains and Sustainability. Centre for Economic Policy Research (CEPR), London.

GSE & JICA. (2015). The Project for Formulating Master Plan on Development of Geothermal Energy in Ethiopia: Executive Summary Final Report. Geological Survey of Ethiopia (GSE) and Japan International Cooperation Agency (JICA), Addis Ababa.

Guan, Y., Yan, J., Shan, Y., and et al. (2023). Burden of the global energy price crisis on households. *Nature Energy*, 8, 3: 304–316. https://doi.org/10.1038/s41560-023-01209-8

Hagos, F., Makombe, G., Namara, R. E., & Awulachew, S. B. (2009). Importance of irrigated agriculture to the Ethiopian economy: Capturing the direct net benefits of irrigation. Research Report 128, International

Water Management Institute (IWMI), Colombo, Sri Lanka.

Headey, D., & Fan, S. (2008). Anatomy of a crisis: The causes and consequences of surging food prices. *Agricultural Economics*, 39: 375–391. https://doi.org/10.1111/j.1574-0862.2008.00345.x

Hertel, T., & van der Mensbrugghe, D. (2019). Chapter 14: Behavioral Parameters: GTAP Resource No. 5950. Purdue University. https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=5950

Hertel, T.W. (1989). Negotiating Reductions in Agricultural Support: Implications of Technology and Factor Mobility. *American Journal of Agricultural Economics*, 71, 3: 559-573. https://doi.org/10.2307/1242012

Hertel, T.W., Stiegert, K., & Vroomen, H. (1996). Nitrogen-land substitution in corn production: A reconciliation of aggregate and farm-level evidence. *American Journal of Agricultural Economics*, 78, l: 30–40. https://doi.org/10.2307/1243776

Hutagalung, A.M., Hartono, D., Arentsen, M.J., & Lovett, J.C. (2019). Economic implications of domestic natural gas allocation in Indonesia. *International Journal of Energy Sector Management*, 13,2:424-449. https://doi.org/10.1108/IJESM-05-2018-0003

IFPRI. (2014). Ethiopia Social Accounting Matrix (SAM), 2007. International Food Policy Research Institute (IFPRI). [dataset]. https://doi.org/10.7910/DVN/28527

Ihle, R., Bar-Nahum, Z., Nivievskyi, O., & Rubin, O. D. (2022). Russia's invasion of Ukraine increased the synchronisation of global commodity prices. *Australian Journal of Agricultural and Resource Economics*, 66, 4: 775–796. https://doi.org/10.1111/1467-8489.12496

IMF. (2022). War sets back the global recovery. International Monetary Fund (IMF), Washington, D.C. https://www.imf.org/en/Publications/WEO/Issues/2022/04/19/world-economic-outlook-april-2022

JRC. (2021). DEMETRA: Dynamic Equilibrium Model for Economic Development, Resources and Agriculture. European Commission Joint Research Center (JRC). https://datam.jrc.ec.europa.eu/datam/model/DEMETRA/index.html

Kamp, L.M., & Forn, E.B. (2016). Ethiopia's emerging domestic biogas sector: current status, bottlenecks and drivers. *Renewable and Sustainable Energy Reviews*, 60:475–488. https://doi.org/10.1016/j.rser.2016.01.068

Kruger, W., Stuurman, F., & Alao, O. (2019). Ethiopia Country Report. Report 5: Energy and Economic Growth Research Programme, Oxford.

LMSIS. (2017). Report on Large and Medium Scale Manufacturing and Electricity Industries Survey 2016/2017. Central Statistical Agency, Addis Ababa.

Lofgren, H. (1994). A Brief Survey of Elasticities for CGE Models. A Technical Report, Ford Foundation. https://doi.org/10.13140/RG.2.1.1295.6563

Lungarska, A., Brunelle, T., Chakir, R., Jayet, P., Prudhomme, R., De Cara, S., & Bureau, J. (2023). Halving mineral nitrogen use in European agriculture: Insights from multi-scale land-use models. *Applied Economic Perspectives and Policy*, 45, 3: 1529–1550. https://doi.org/10.1002/aepp.13391

Martey, E., Goldsmith, P., & Etwire, P.M. (2022). Farmers' response to COVID-19 disruptions: The case of cropland allocation decision. *Sustainable Futures*, 4, 100088. https://doi.org/10.1016/j.sftr.2022.100088

McDonald, S., Thierfelder, K., & Ariagie, E. (2016). A Static Applied General Equilibrium Model: Technical Documentation: STAGE_DEV Version 2. CGEMOD. https://cgemod.org.uk/

Mekonnen, D., Bryan, E., Alemu, T., & Ringler, C. (2017). Food versus fuel: Examining tradeoffs in the allocation of biomass energy sources to domestic and productive uses in Ethiopia. *Agricultural Economics*, 48, 4: 425–435. https://doi.org/10.1111/agec.12344

Mengistu, A. T., Woldeyes, F. B., Dessie, E., Ayalew, Z., Mainar Causapé, A. J., & Ferrari, E. (2019). Ethiopia social accounting matrix 2015/16. Publications Office of the European Union, Luxemburg. https://data.europa.eu/doi/10.2760/974668

Metaferia, F., Cherenet, T., Gelan, A., Abnet, F., Tesfay, A., Ali, J.A., & Gulilat, W. (2011). A review to improve estimation of livestock contribution to the national GDP. Ministry of Finance and Economic Development (MoFED), Addis Ababa.

Meyimdjui, C., & Combes, J.-L. (2021). Food Price Shocks and Household Consumption in Developing Countries: The Role of Fiscal Policy. IMF Working Paper No. 2021/012. International Monetary Fund (IMF), Washington, D.C.

MoFECC. (2017). Ethiopia Forest Sector Review. Ministry of Environment, Forest, and Climate Change (MoFECC), Addis Ababa.

MoFED. (2012). Ethiopian National Accounts: Concepts, Sources and Methods. Ministry of Finance and Economic Development (MoFED, Addis Ababa.

MoWIE. (2013). Updated Rapid Assessment and Gap Analysis on Sustainable Energy for All (SE4All). Ministry of Water, Irrigation, and Energy (MoWIE), Addis Ababa.

MoWIE. (2019). Energy Balance 2017/2018. Ministry of Water, Irrigation, and Electricity (MoWIE), Addis Ababa.

NBE. (2020). Annual Economic Report 2018/2019. National Bank of Ethiopia (NBE), Addis Ababa.

NBE. (2023). Annual Economic Report: 2021/2022. National Bank of Ethiopia (NBE), Addis Ababa.

NCDS. (2017). National Cotton Development Strategy (2018-2032) and Road Map. SOFRECO.

Nechifor, V., Ramos, M. P., Ferrari, E., Laichena, J., Kihiu, E., Omanyo, D., Musamali, R., & Kiriga, B. (2021). Food security and welfare changes under COVID-19 in Sub-Saharan Africa: Impacts and responses in Kenya. *Global Food Security*, 28, 100514. https://doi.org/10.1016/j.gfs.2021.100514

NEP. (2019). National Electrification Program 2.0: Integrated Planning for Universal Access. Ministry of Water, Irrigation, and Electricity (MoWIE), Addis Ababa.

Ntah, M.N., Nechifor, V., Ferrari, E., Nandelenga, M.W., & Yalew, A.W. (2024). The impacts of Russia's invasion of Ukraine on the Kenyan economy: Evidence from an economy-wide model. *African Development Review*, 1–14. https://doi.org/10.1111/1467-8268.12728

Osendarp, S., Verburg, G., Bhutta, Z., and et al. (2022). Act now before Ukraine war plunges millions into malnutrition. *Nature*, 604: 620–624. https://doi.org/10.1038/d41586-022-01076-5

Pappis, I., Sahlberg, A., Walle, T., Broad, O., Eludoyin, E., Howells, M., & Usher, W. (2021). Influence of Electrification Pathways in the Electricity Sector of Ethiopia – Policy Implications Linking Spatial Electrification Analysis and Medium to Long-Term Energy Planning. *Energies*, 14, 4: 1209. https://doi.org/10.3390/en14041209

Peng, W., & Berry, E. M. (2019). The Concept of Food Security. In *Encyclopedia of Food Security and Sustainability* (pp. 1–7). https://doi.org/10.1016/B978-0-08-100596-5.22314-7

Peters, J.C. (2016). The GTAP-Power Data Base: Disaggregating the Electricity Sector in the GTAP Data Base. *Journal of Global Economic Analysis*, 1,1: 209–250. https://doi.org/10.21642/JGEA.010104AF

Rashid, S., Tefera, N., Minot, N., & Ayele, G. (2013). Can modern input use be promoted without subsidies? An analysis of fertilizer in Ethiopia. *Agricultural Economics*, 44, 6:595–611. https://doi.org/10.1111/agec.12076

Ruta, M. (Ed.). (2022). The Impact of the War in Ukraine on Global Trade and Investment. World Bank, Washington, D.C. http://hdl.handle.net/10986/37359

Salazar-Espinoza, C., Jones, S., & Tarp, F. (2015). Weather shocks and cropland decisions in rural Mozambique. *Food Policy*, 53: 9–21. https://doi.org/10.1016/j.foodpol.2015.03.003

Sheahan, M., Ariga, J., & Jayne, T. S. (2016). Modeling the Effects of Input Market Reforms on Fertiliser Demand and Maize Production: A Case Study from Kenya. *Journal of Agricultural Economics*, 67, 2: 420–447. https://doi.org/10.1111/1477-9552.12150

Sue Wing, I. (2008). The synthesis of bottom-up and top-down approaches to climate policy modeling: electric power technology detail in a social accounting framework. *Energy Economics*, 30, 2: 547–573. https://doi.org/10.1016/j.eneco.2006.06.004

Tesfaye, G. (2020). Clean cooking with ethanol. Policy Brief. www.projectgaia.com. Accessed on May 03, 2021.

Tilahun, H., Telku, E., Michael, M., Fitsum, H., & Awulachew, S.B. (2011). Comparative Performance of Irrigated and Rainfed Agriculture in Ethiopia. *World Applied Sciences Journal*, 14, 2: 235–44.

Trimble, C., Kojima, M., Arroyo, I., & Mohammadzadeh, F. (2016). Financial Viability of Electricity Sectors in Sub-Saharan Africa: Quasi-Fiscal Deficits and Hidden Costs. Policy Research Working Paper 7788. World Bank, Washington, DC.

UN. (2022a). Global Impact of war in Ukraine on food, energy and finance systems. Brief No. 01. United Nations, New York. https://unsdg.un.org/resources/global-impact-war-ukraine-food-energy-and-finance-systems-brief-no1

UN. (2022b). World Population Prospects 2022. United Nations, New York. https://population.un.org/wpp/

UNCTAD. (2022). The Impact on Trade and Development of the War in Ukraine. United Nations Conference on Trade and Development (UNCTAD), Geneva. https://unctad.org/system/files/official-document/osginf2022d1_en.pdf

von Arnim, R., Tröster, B., Staritz, C., & Raza, W. (2018). Commodity price shocks and the distribution of income in commodity-dependent least-developed countries. *Journal of Policy Modeling*, 40, 2: 434–451. https://doi.org/10.1016/j.jpolmod.2018.02.008

World Bank. (2022). Commodity Markets Outlook: The Impact of the War in Ukraine on Commodity Markets, April 2022. World Bank, Washington, D.C. https://hdl.handle.net/10986/37223

World Bank. (2023). World Bank Commodity Price Data (The Pink Sheet)– February 2023. World Bank, Washington, D.C.

Yalew, A.W. (2021). Economic contributions and synergies of biogas with the SDGs in Ethiopia. *Energy Nexus*, 3, 100017. https://doi.org/10.1016/j.nexus.2021.100017

Yalew, A.W. (2022). The Ethiopian energy sector and its implications for the SDGs and modeling. *Renewable and Sustainable Energy Transition*, 2, 100018. https://doi.org/10.1016/j.rset.2022.100018

APPENDIX

1. Notes on SAM adjustment

This study used a modified version of the 2015/2016 SAM for Ethiopia (Mengistu et al., 2019). Important adjustments were made particularly pertaining to the agriculture, forestry, electricity, and transport sectors. For 14 crop growing activities, irrigated farming was separated from rainfed farming using information from agricultural surveys (AgSS, 2016) and other research reports (NCDS, 2017; Tilahun et al., 2011; Hagos et al., 2009). The livestock sector was further disaggregated to explicitly account for 7 types of activities (cattle, sheep, goats, camels, equines, poultry, and beekeeping) using information from agricultural survey (AgSS, 2016) and national income accounts (MoFED, 2012). Animal feed

Table A1. List of activities in the SAM and their group for reporting results.

Group	Activity	Group	Activity
Crops	Growing *rainfed* teff	*Primary sectors*	Managed natural grass fodder
Crops	Growing *irrigated* teff	*Primary sectors*	Fish
Crops	Growing *rainfed* barley	*Primary sectors*	Forestry
Crops	Growing *irrigated* barley	*Primary sectors*	Mining and quarrying
Crops	Growing *rainfed* wheat	*Food & Beverages*	Processed and manufactured foods
Crops	Growing *irrigated* wheat	*Food & Beverages*	Sugar
Crops	Growing *rainfed* maize	*Food & Beverages*	Beverages and tobacco
Crops	Growing *irrigated* maize	*Textiles, clothes…*	Textile, leather, clothes, and wood processing
Crops	Growing *rainfed* sorghum	*Rest of manufacturing*	Rest of manufacturing
Crops	Growing *irrigated* sorghum	*Construction*	Construction
Crops	Growing *rainfed* pulses	*Utilities*	Water supply
Crops	Growing *irrigated* pulses	*Utilities*	Off-grid electricity, diesel
Crops	Growing *rainfed* oilseeds	*Utilities*	Off-grid electricity, solar
Crops	Growing *irrigated* oilseeds	*Utilities*	Grid electricity, hydro, Abbay basin
Crops	Growing *rainfed* vegetables	*Utilities*	Grid electricity, hydro, Omo basin
Crops	Growing *irrigated* vegetables	*Utilities*	Grid electricity, hydro, Awash basin
Crops	Growing *rainfed* fruits	*Utilities*	Grid electricity, hydro, Tekeze basin
Crops	Growing *irrigated* fruits	*Utilities*	Grid electricity, hydro, Wabi-Shebele basin
Crops	Growing coffee	*Utilities*	Grid electricity, hydro, Rest of basins
Crops	Growing enset	*Utilities*	Grid electricity, wind
Crops	Growing *rainfed* sugarcane	*Utilities*	Grid electricity, geothermal
Crops	Growing *irrigated* sugarcane	*Utilities*	Grid electricity, solar
Crops	Growing *rainfed* chat	*Utilities*	Grid electricity, municipal waste
Crops	Growing *irrigated* chat	*Utilities*	Grid electricity, diesel
Crops	Growing tea	*Utilities*	Grid electricity, transmission & distribution
Crops	Growing *rainfed* cotton	*Private Services*	Transport services, electricity-based
Crops	Growing *irrigated* cotton	*Private Services*	Transport services, fuel-based
Crops	Growing *rainfed* crops nec	*Private Services*	Rest of private commercial services
Crops	Growing *irrigated* crops nec.	*Public Services*	Public administration
Crops	Forage & bioenergy crops	*Public Services*	Education services
Crops	Cut flower	*Public Services*	Health services
Livestock	Cattle	*Public Services*	Health services
Livestock	Sheep		
Livestock	Goats		
Livestock	Camel		
Livestock	Poultry		
Livestock	Beekeeping		
Livestock	Equines		
Livestock	Domestic biogas		

sources include grass fodder, crop residues, animal forages, and proceed animal feed (AgSS, 2016). Forest products were disaggregated into three distinct products – wood fuel, industrial wood, and non-timber forest products (NTFPs) using product shares from the national income (MoFED, 2012) and forest sector accounts (MoFECC, 2017). Electricity production is disaggregated into off-grid and grid connections (MoWIE, 2013), and then by technology using information on installed capacities information (LMSIS, 2017; NBE, 2020; Pappis et al., 2021; GSE & JICA, 2015; EAPP, 2014) in line with the recent discussion regarding the power sector in CGE models (e.g., Chepeliev, 2020; Peters et al., 2016; Cai & Arora, 2015; Sue Wing, 2008). Electricity output also accounts for electricity from bagasse as byproduct from sugar manufacturing (ESC, 2019; Kruger et al., 2019). Further adjustment was made to account for the implicit subsidies to the state-owned electricity utility enterprise (Trimble et al., 2016) and export to neighboring countries (NBE, 2020). Electricity-based transport services (of Ethio-Djibouti Railway and Addis Ababa Urban Light Rail services) are distinguished from fuel-based (road and air transport) services. To better account for the interlinkages between agriculture and energy sectors, the adjusted SAM also contains biogas (activity and commodity) (Yalew, 2021) and biofuel (mainly as a byproduct from sugar molasses in sugar manufacturing (ESC, 2019; Tesfaye, 2020). Finally, compared to the initial SAM (Mengistu et al., 2019), the adjusted SAM contains highly aggregated manufacturing (as rest of manufacturing) and private services (as rest of commercial services). For some of the adjustments, when correspondence allows, cross-checks were made with the supply and use tables of the 2005/2006 SAM for Ethiopia (IFPRI, 2014).

2. Model calibration

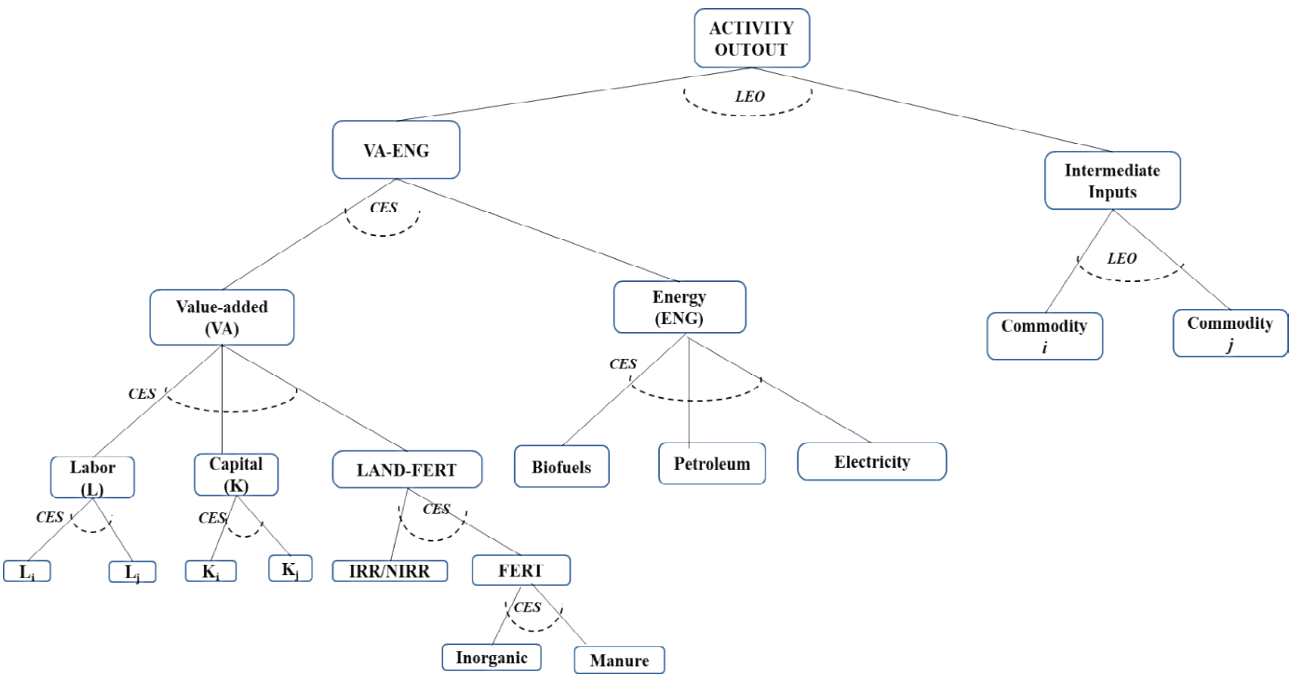

Figure A1. Production technology nest structure (author's elaboration).

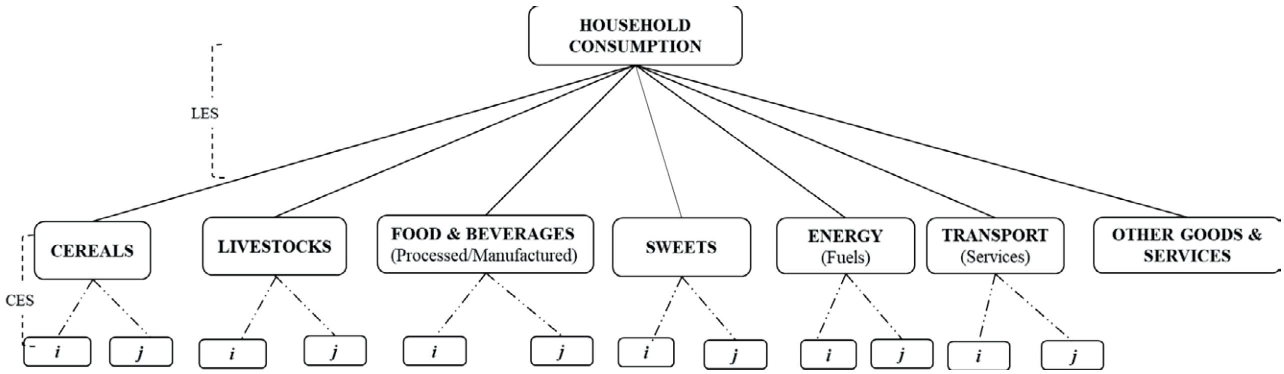

Figure A2. Households' utility nest (authors' elaboration).

Table A2. Range of production, trade, and consumption elasticities.

Type	Nest	Description	Range
Production	L	Elasticities of substitutions among different labor categories (e.g., skilled, semi-skilled, unskilled workers).	0.30–1.50
	K	Elasticities of substitutions among different capital categories (e.g., animal draught power, agricultural machinery, and non-agricultural capital).	0.20–1.50
	FERT	Elasticities of substitutions between organic and inorganic fertilizers.	0.70
	LAND-FERT	Elasticities of substitution between composite fertilizer and land factor.	0.30
	ENG	Elasticities of substitution between energy commodities for intermediate consumption (e.g., wood fuel, biofuel, petroleum oil, electricity).	0.30
	VA	Elasticities of substitutions among composite primary factors (e.g., labor, land, capital)	0.30–1.50
	VA-ENG	Elasticities of substitutions between composite energy and value-added.	0.30
	Intermediate	Elasticities of substitution among different intermediate inputs other than fertilizers and petroleum fuels.	0.00
	Top level	Elasticities of substitution between composite VA-ENG and intermediate inputs at the top of the nest.	0.00
Trade	Imports	Elasticities of substitution between import and domestic varieties of a commodity	0.80–3.00
	Exports	Elasticities of transformation between exports and domestic varieties of a commodity	0.80-3.00
Consumption	Households	Elasticity of substitution among consumption goods (only for those under CES nests)	0.75–2.50
	Households	Income elasticity of consumption demand	0.50–1.20
	Households	Frisch parameter	-1.50

3. Sensitivity analysis

Table A3. Sensitivity of simulation results to Armington (import) substitution elasticities.

Level	Variable	Armington elasticities [Table A2-30%]				Armington elasticities [Table A2]				Armington elasticities [Table A2 +30%]			
		WHT	FRT	PTR	CMB	WHT	FRT	PTR	CMB	WHT	FRT	PTR	CMB
Macroeconomic Indicators	GDP	-0.04	-0.33	-0.28	-0.66	-0.04	-0.32	-0.27	-0.65	-0.05	-0.32	-0.27	-0.65
	Private consumption	-0.33	-0.74	-1.63	-2.69	-0.32	-0.74	-1.64	-2.70	-0.31	-0.74	-1.65	-2.70
	Investment demand	0.07	-0.13	-1.36	-1.44	0.13	-0.10	-1.34	-1.34	0.18	-0.09	-1.33	-1.26
	Absorption	-0.18	-0.46	-1.39	-2.03	-0.16	-0.46	-1.39	-2.01	-0.14	-0.46	-1.40	-2.00
	Government consumption	-0.06	0.27	0.31	0.56	-0.12	0.22	0.25	0.39	-0.16	0.18	0.21	0.26
	Imports	-0.82	-0.81	-3.61	-5.24	-0.87	-0.83	-3.81	-5.53	-0.90	-0.85	-3.98	-5.76
	Exports	-0.77	-0.19	2.56	1.49	-1.21	-0.25	2.12	0.55	-1.55	-0.29	1.73	-0.23
Activity Outputs	Crops	0.25	-1.45	1.67	0.45	0.35	-1.48	1.70	0.52	0.43	-1.51	1.73	0.59
	Livestock	-0.15	-0.06	-0.17	-0.36	-0.17	-0.07	-0.14	-0.35	-0.18	-0.07	-0.12	-0.34
	Primary sectors – grazing, fishing, forestry, mining	-0.14	0.27	-0.46	-0.35	-0.19	0.27	-0.41	-0.35	-0.23	0.27	-0.37	-0.34
	Food and Beverages	-0.80	-0.16	0.24	-0.74	-0.87	-0.13	0.42	-0.57	-0.93	-0.12	0.58	-0.43
	Textiles, clothes, leather, and wood processing	-0.02	0.25	-0.61	-0.36	-0.07	0.31	-0.32	-0.04	-0.12	0.34	-0.09	0.18
	Rest of manufacturing	-0.01	0.52	-0.22	0.35	-0.08	0.59	0.09	0.68	-0.15	0.62	0.32	0.88
	Utilities - electricity and water	-0.06	-0.07	-2.72	-2.87	-0.08	-0.06	-2.72	-2.87	-0.09	-0.05	-2.73	-2.88
	Construction	0.04	-0.07	-1.14	-1.18	0.08	-0.04	-1.06	-1.03	0.11	-0.01	-0.99	-0.91
	Services - Private	-0.11	0.05	-2.46	-2.57	-0.15	0.08	-2.59	-2.69	-0.18	0.10	-2.71	-2.82
	Services - Public	-0.06	0.20	0.11	0.28	-0.11	0.16	0.07	0.14	-0.14	0.13	0.03	0.04
Consumption	Rural	-0.01	-0.59	-1.25	-1.93	-0.01	-0.62	-1.29	-2.00	0.00	-0.64	-1.31	-2.04
	Urban	-0.26	-0.38	-2.70	-3.39	-0.35	-0.41	-2.72	-3.52	-0.42	-0.42	-2.74	-3.62

Source: DEMETRA simulations.
Notes: WHT – Wheat, FRT – Fertilizer, PTR – Petroleum, and CMB – Combined price scenarios.

Table A4. Sensitivity of simulation results to assumptions affecting crop activities.

Level	Variable	Crop phenology is less sensitive to the level of chemical fertilizer				Land partially mobile across activities				Land immobile across activities			
		WHT	FRT	PTR	CMB	WHT	FRT	PTR	CMB	WHT	FRT	PTR	CMB
Macroeconomic Indicators	GDP	-0.05	-0.05	-0.28	-0.39	-0.04	-0.32	-0.29	-0.67	-0.04	-0.32	-0.33	-0.71
	Private consumption	-0.33	-0.33	-1.64	-2.28	-0.32	-0.75	-1.64	-2.70	-0.31	-0.75	-1.67	-2.72
	Investment demand	0.15	-0.12	-1.43	-1.41	0.14	-0.09	-1.44	-1.42	0.18	-0.07	-1.67	-1.58
	Absorption	-0.16	-0.23	-1.41	-1.79	-0.15	-0.46	-1.42	-2.03	-0.14	-0.46	-1.48	-2.08
	Government consumption	-0.13	0.10	0.36	0.34	-0.12	0.20	0.34	0.46	-0.17	0.18	0.67	0.70
	Imports	-0.83	-0.53	-4.06	-5.38	-0.83	-0.82	-4.06	-5.72	-0.68	-0.74	-4.77	-6.15
	Exports	-1.10	0.56	1.54	1.03	-1.10	-0.20	1.54	0.14	-0.74	0.03	-0.18	-0.91
Activity Outputs	Crops	0.35	-0.41	1.61	1.54	0.33	-1.40	1.55	0.44	0.40	-1.36	1.19	0.19
	Livestock	-0.19	0.01	-0.04	-0.22	-0.12	-0.26	0.21	-0.15	-0.12	-0.25	0.34	-0.03
	Primary sectors – grazing, fishing, forestry, mining	-0.19	0.13	-0.41	-0.46	-0.12	0.14	-0.38	-0.37	-0.14	0.12	-0.31	-0.33
	Food and Beverages	-0.88	-0.08	0.48	-0.48	-0.87	-0.13	0.46	-0.53	-0.92	-0.07	0.61	-0.36
	Textiles, clothes, leather, and wood processing	-0.08	0.13	-0.19	-0.14	-0.07	0.29	-0.22	0.03	-0.13	0.26	0.16	0.31
	Rest of manufacturing	-0.11	0.26	0.29	0.47	-0.10	0.57	0.26	0.82	-0.20	0.52	0.89	1.27
	Utilities - electricity and water	-0.08	-0.05	-2.72	-2.86	-0.07	-0.06	-2.74	-2.88	-0.09	-0.06	-2.72	-2.88
	Construction	0.09	-0.08	-1.11	-1.10	0.09	-0.03	-1.12	-1.08	0.11	-0.02	-1.24	-1.18
	Services - Private	-0.16	0.02	-2.56	-2.71	-0.15	0.07	-2.59	-2.69	-0.19	0.05	-2.46	-2.61
	Services - Public	-0.12	0.07	0.15	0.11	-0.11	0.14	0.14	0.20	-0.15	0.12	0.41	0.40
Consumption	Rural	0.01	-0.28	-1.44	-1.75	0.02	-0.64	-1.41	-2.12	0.09	-0.60	-1.93	-2.48
	Urban	-0.36	-0.08	-2.74	-3.19	-0.34	-0.44	-2.72	-3.53	-0.34	-0.42	-2.79	-3.57

Source: DEMETRA simulations.
Notes: WHT – Wheat, FRT – Fertilizer, PTR – Petroleum, and CMB – Combined price scenarios. Under 'land partially mobile' sensitivity test, cropland for selected crops (i.e., fruits, coffee, tea, sugarcane, enset, chat, cotton, forage and bioenergy crops, grass fodder, and cut flower) was assumed to be activity-specific and hence cannot be reallocated in response to the anticipated impacts.

BAE
Bio-based and Applied Economics

AIEAA
ASSOCIAZIONE ITALIANA DI ECONOMIA AGRARIA E APPLICATA

OPEN ACCESS

Citation: Gattone, T. (2024). Participation of farmers in market value chains: A tailored Antràs and Chor positioning indicator. *Bio-based and Applied Economics* 13(3): 245-264. doi: 10.36253/bae-15464

Received: November 29, 2023
Accepted: April 19, 2024
Published: October 16, 2024

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Editor: Francesco Pagliacci, Valentina Raimondi, Luca Salvatici

ORCID
TG: 0000-0002-7727-8049

Participation of farmers in market value chains: A tailored Antràs and Chor positioning indicator

Tulia Gattone

Department of Social Sciences and Economics, Sapienza University of Rome, Italy
E-mail: tulia.gattone@uniroma1.it

Abstract. This study presents a micro-level indicator of farmers' positioning in the market chain, based on the conceptual framework outlined by Antràs and Chor (2013, 2018). The indicator considers the selling location of a farming household and its crop buyers. Using panel data from the World Bank's 'Living Standards Measurement Study: Integrated Surveys on Agriculture' for Ethiopia and Nigeria, this paper applies the proposed indicator empirically and showcases its superior performance in comparison to existing alternatives at the micro-level. Furthermore, by analyzing the dynamics of farmers' food and total consumption over time and controlling for various household and production characteristics, as well as potential confounding factors, this study shows that moving towards a downstream position in the market chain has a positive impact on farmers' food and total consumption levels. The results are validated through sensitivity analysis and robustness checks.

Keywords: value chains, economic development, market chain, farming households.
JEL-Codes: Q12, O12, O13, C23.

INTRODUCTION

The discourse on the effects of farmers' participation in global markets remains nuanced. One segment of the literature highlights that smallholder farmers' engagement in traditional markets catalyzes pro-poor outcomes through a cycle of enhanced household income, increased consumption, greater food security, and improved nutrition (Bellemare, 2012; Montalbano et al., 2018). Conversely, another segment postulates that market participation might not significantly benefit those unable to leverage increased market orientation's advantages (von Braun, 1995; Carletto et al., 2017).

Market chain participation encompasses essential activities for food production delivery to consumers, including trading (Kaplinsky & Morris, 2001). In development scenarios, farmers often find themselves limited to lower-value activities, positioning them at the backward stages of the market value chain, which contrasts with increased employment, better jobs, resources, governance, and food security associated with downstream positioning (Minten et al., 2009; Cattaneo & Miroudot, 2013; African Development Bank et al., 2014; Swinnen, 2014; Swinnen & Vandeplas, 2014). Antràs and Chor (2013) offer a foundational model on positioning, illustrating a dependency of downstream stages on upstream activities, yet discussions on the structuring of the most upstream sectors within value chains remain limited.

This research merges insights from trade and development literature on value chain positioning, focusing on supplier positioning in global chains as per Antràs and Chor (2013; 2018), and the commercialization decisions of rural farmers as detailed by Migose et al. (2018), Minten et al. (2018), and Montalbano et al. (2018). It introduces a novel downstreamness measure for rural farmers in market value chains, inspired by Antràs and Chor's framework. This study tests the new positioning indicator using the LSMS-ISA dataset for Ethiopian households, selected for its detailed commodity exchange market data, and conducts parallel testing with Nigerian LSMS-ISA data and analyses related to food quantity and market positioning. The indicator outperforms traditional measures in empirical tests.

The study examines how farmers' market positioning affects their consumption levels. Findings show that improved positioning significantly boosts farmers' food and total consumption, supporting existing literature on agricultural commercialization's impact, validated through extensive sensitivity and robustness checks. The paper is organized as follows: Section 2 reviews the literature and theoretical framework. Section 3 introduces the market positioning indicator. Section 4 details crop value chain structure and methodology. Section 5 describes the data and statistics. Section 6 discusses the empirical strategy and results. Section 7 concludes the study, summarizing key findings and implications.

2. LITERATURE REVIEW

Agricultural commercialization is widely regarded as a key mechanism for poverty alleviation in rural settings, underpinned by literature suggesting its positive impact on rural households' development (von Braun & Kennedy, 1994; de Janvry & Sadoulet, 2006). This transition allows smallholder farmers to shift from subsistence farming practices to the cultivation of market-specific crops, facilitating specialization, the adoption of modern agricultural technologies, and ultimately, higher productivity (van Asselt & Useche, 2022). Studies like those of Key et al. (2000), Yanagizawa (2009). and Svensson & Jensen (2010) have documented that market participation and positioning are affected by access costs and risk preferences, affirming the benefits of effective market positioning. However, agricultural trade may yield several effects on production constraints, land use, and environmental sustainability (Minten et al., 2007), with smallholder farmers facing barriers such as low productivity, stringent standards compliance, and elevated transaction costs that limit market entry (Montalbano et al., 2015).

Vertical market integration turns out to be critically relevant in these contexts characterized by fragmented markets, weak contract enforcement, and political instability (Fackler & Goodwin, 2001). The nature of the crop buyer significantly influences market positioning, with farmers navigating interactions with intermediaries, large processing firms, and state-managed markets. Despite the perception of intermediaries as monopolistic rent-seekers (Montalbano et al., 2018), empirical evidence suggests that farmers' involvement in contract schemes and export chains generally yields positive outcomes for smallholders (Minten et al., 2009; Barrett et al., 2012; Bellemare, 2012; Subervie & Vagneron, 2013; Bellemare & Novak, 2017).

The interaction between global and local value chains raises questions about the impact of global market participation on local agricultural systems and food consumption. While some argue that global value chains can undermine traditional local markets (Ríos Guayasamín et al., 2016), others point to the competition for resources that such integration entails (Feyaerts et al., 2020). The debate extends to the efficacy of local versus global value chains, with some evidence suggesting local markets may offer better performance or serve as gateways to global chains (D'Souza & Jolliffe, 2014; Wegerif & Martucci, 2019). The importance of market positioning within these distribution networks cannot be overstated, yet the lack of comprehensive data and theoretical frameworks for micro-level analysis underscores the complexity of drawing definitive conclusions (Feyaerts et al., 2020). Selling to immediate social circles is often seen as a strategy of last resort for farmers constrained by high transaction costs or market access issues, highlighting the challenges faced by rural farmers in developing economies (Timmer, 1997; Key et al., 2000; Fackler & Goodwin, 2001; Fafchamps & Hill, 2005).

Given the disparate nature of existing studies, often limited to specific case studies, this paper aims to bridge the gap by proposing a micro-level measure of market positioning. This contribution seeks to enrich the ongoing discussion on the nuanced relationship between market participation and food consumption, providing a new analytical lens to examine the intricate dynamics at play in agricultural commercialization and its broader socioeconomic impacts.

3. THE PROPOSED POSITIONING MEASURE

Value chain downstream positioning, which denotes the proximity of production to final demand, integrates development and trade concepts, highlighting the importance of geographical distance and market access on agricultural decision-making (von Thünen, 1966; Chamberlin & Jayne, 2013; Oosting et al., 2014; Montalbano & Nenci, 2022). This approach reveals the profound effect of location on farming strategies, extending beyond mere physical distance to include factors like travel costs (Nanyeenya et al., 2007; Duncan et al., 2013).

Kaplinsky and Morris (2001) outline three value chain elements: key buyers, transaction dynamics, and critical factors. Montalbano et al. (2018) further refine this by introducing a "Positioning Dummy", based on the identity of market outlets, for distinguishing between upstream and downstream positions, highlighting the significance of broader market access. However, the challenge remains in developing a theoretical model that accurately captures value chain participation, especially the volume of sales, a crucial aspect in Global Value Chains (GVCs) discussions (Nenci, 2020). Traditional Input-Output (I-O) tables, despite their utility, fall short in detailing the entire value chain network (Montalbano & Nenci, 2022).

Antràs and Chor (2018; 2022) expand on this by incorporating the sequence of production stages into the analysis, defining upstreamness (U) as the weighted average distance of a stage from final demand, and downstreamness from the proximity to primary production factors. The formula for upstreamness is given by:

$$U_i^r = 1 \times \frac{F_i^r}{Y_i^r} + 2 \times \frac{\sum_{s=1}^{S}\sum_{j=1}^{J} a_{ij}^{rs} F_j^s}{Y_i^r} + \cdots. \quad (1)$$

where a_{ij}^{rs} represents the dollar amount of each country's sector needed to produce one dollar's worth of industry output in another country (i.e., $a_{ij}^{rs} = \frac{Z_{ij}^{rs}}{Y_j^s}$). Downstreamness is similarly defined, focusing on the distance from primary factors, emphasizing the role of value addition in determining chain positioning.

Applying theoretical models to agricultural value chains reveals challenges, notably with data limitations and the non-linear structure of these chains, which often resemble "flatter" or "spider" configurations, complicating the application of Antràs and Chor's (2018) framework. Antràs & Chor (2019) distill market positioning into the share of output sold directly to consumers, creating a micro-level downstreamness indicator. However, this indicator faces limitations in capturing the intricacies of market chains due to data scarcity. Building on the insights from Veugelers et al. (2013), Giunta et al. (2022), and Nenci et al. (2022), who examine value chain participation through the share of imported intermediates, this study proposes a refined indicator for agricultural value chain positioning that accounts for the sequence of intermediaries from farmers to final retailers, emphasizing the critical role of selling positions within the chain. It accounts for the intermediary sequence from farmers to end retailers, highlighting the critical role of selling positions within the chain. This is quantitatively represented as:

$$D_i^r = \text{Selling Position n.1} \times \frac{C_i^r}{Y} + \text{Selling Position n.2} \times \frac{C_i^r}{Y} + \cdots; \quad (2)$$

where the first integer term indicates the Selling Position number (i.e., the chain positioning of acquiring intermediaries), C_i^r equals the quantity of crop sold by each household, and Y is the total quantity of that crop sold along the crop-selling chain.

The current literature reveals numerous shortcomings: the absence of a comprehensive, standalone indicator; incomplete data that lead to partial interpretations; and a neglect of the impact of vertical integration on positioning. These deficiencies underscore the necessity for a refined micro-level downstreamness indicator. This improved indicator should account for the selling position, incorporate the geographical selling location, and consider the multiplicity of buyers. Furthermore, it should integrate the welfare effects of positioning, net of geographical distance, and the impact of trade costs on positioning (Fafchamps & Hill, 2005; Mancini et al., 2023). To address these concerns, an enhanced formula is proposed:

$$D_i^r = p_i^r \times \frac{C_i^r}{Y} \times l_i^{r\,1/(1-\rho)}; \quad (3)$$

where p_{ij}^{rs} equals $\frac{\textit{Selling Position Number}}{\textit{Total Number of Selling Positions}}$, l_{ij}^{rs} equals $\frac{\textit{Selling Location Number}}{\textit{Total Number of Selling Locations}}$, C_i^r equals the quantity of crop sold, and Y equals the total quantity of that crop sold along the crop market selling chain. It is important to note that farming households are commonly involved in multiple crop value chains. Hence, the resulting positioning value attached to them will be the average of their positioning score in each single crop selling chain. The proposed indicator, following the theory of Antràs and Chor (2013), incorporates crop demand elasticities as a tuning parameter, suggesting that lower elasticity values (ρ) increase the likelihood of vertical integration in the value chain. This tuning parameter, formulated as 1/(1 - ρ), reflects the observation that own-price elasticities are negative for most commodities, as indicated by Deaton & Muellbauer (1980), and particularly low for crops like maize and sorghum, which exhibit among the lowest values (Tafere et al., 2010). Finally, the proposed indicator facilitates comparability across different types of value chains and fields by being structured as an index ranging from 0 to 1.

The adaptation of Antràs and Chor's framework assumes farmers as a type of firm, with the analysis specifically targeted at a singular stage of the chain. The investigation is confined to the dynamics of selling chains, under the premise that scrutinizing solely the farmers' roles does not encompass the evaluation of added value. Additionally, it is assumed that farmers have the capability to engage in multiple crop value chains simultaneously, illustrating a diversified strategy to market participation. The proposed approach integrates elements from development and trade literature, such as "selling position," "selling location," and "crop ratio," while updating the model to reflect non-sequential production stages and the diverse nature of agricultural sales, as suggested by recent insights (Davis et al., 2018; Antràs & Chor, 2022).

4. EMPIRICAL FRAMEWORK

In the establishment of the empirical framework for this analysis, Figure 1 systematically delineates the array of market outlets available to smallholder farmers. By illustrating the comprehensive network through which agricultural products transition from production to the end consumer, Figure 1 methodically outlines the agricultural value chain, beginning with input suppliers – such as seeds, fertilizers, pesticides, and herbicides – primarily provided by either agricultural development agencies or private entities (Audet-Bélanger et al., 2013; Ugonna et al., 2015; Ayele et al., 2021).

Notably, village collectors often constitute the initial market entry point in countries such as Nigeria and Ethiopia (Ayele et al., 2021; Babama'aji et al., 2022), leading to further engagement with agricultural cooperatives and processors. These entities are instrumental in vertical integration, offering essential services like free storage and facilitating transactions with exporters, or local food agencies (Gabre-Madhin & Goggin, 2006; USAID, 2017 Additionally, the figure highlights the role of wholesale markets situated in main districts, which acquire crops either directly from farmers or via intermediaries, thereby augmenting access to storage and communication channels (Ayele et al., 2021).

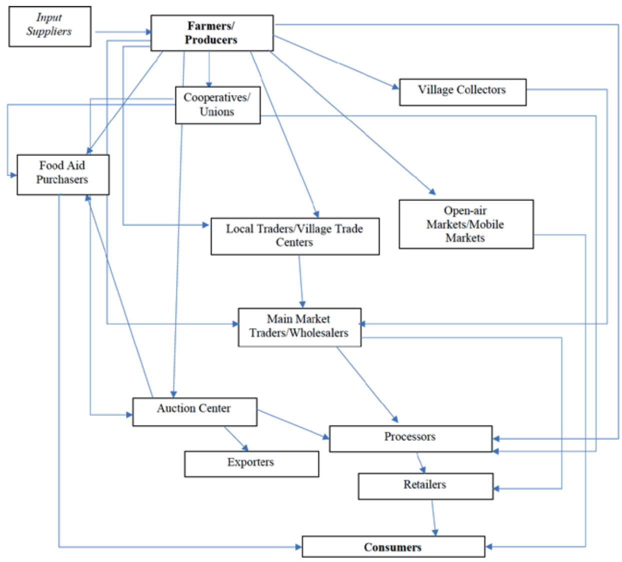

Figure 1. A Standard Crop Value Chain in Ethiopia and Nigeria. Source: Author's adaptation from Gabre-Madhin & Goggin (2006); Rashid & Negassa (2013), Gashaw & Kibret (2018); FAO (2020); Ayele et al. (2021); Babama'aji et al. (2022).

The significance of private companies in providing downstream positioning benefits is also emphasized, noting their contribution to higher income levels and the facilitation of technology spillovers, which in turn enhance income stability and food security (Case, 1992; Bandiera & Rasul, 2006; Matuschke & Qaim, 2009; Barrett et al., 2017). The analysis further acknowledges the importance of mobile markets and commodity exchange markets as additional, critical conduits connecting smallholders with formal market segments (FAO, 2020). The variability in the length of value chains necessitates that farmers engage at various stages, with their positioning influenced by external contingencies such as natural disasters (Biggeri et al., 2018).

Leveraging insights from Montalbano et al. (2018), this research assumes that direct sales to primary markets or private entities potentially yield higher profitability, indicative of sophisticated management expertise. Consequently, market outlets are classified into seven distinct groups, spanning from upstream positions, characterized by lesser reward, to downstream positions, associated with greater economic benefit. Specifically,

- Outlet n.1: Roadside → Selling Position n.1
- Outlet n.2: Agricultural Cooperatives → Selling Position n.2
- Outlet n.3: Farm-Based Association → Selling Position n.2

· Outlet n.4: Government Agencies → Selling Position n.3
· Outlet n.5: Political Leader → Selling Position n.3
· Outlet n.6: Private Trader in Local Market → Selling Position n.4
· Outlet n.7: Local Merchant/Grocery → Selling Position n.4
· Outlet n.8: Local Market → Selling Position n.5
· Outlet n.9: Mobile Market → Selling Position n.5
· Outlet n.10: Private Trader in Main Market → Selling Position n.6
· Outlet n.11: Main Market → Selling Position n.6
· Outlet n.12: Private Company → Selling Position n.7
· Outlet n.13: Auction Market → Selling Position n.7

Also, a final note must be made for selling locations, whose score scale of 3 is defined, due to limited observations, as follows[1]:

– Selling Location n.1: Selling within the village or near the village
– Selling Location n.2: Selling near the town or near the district
– Selling Location n.3: Selling outside the district or outside the region

5. DATA AND DESCRIPTIVE STATISTICS

This study utilizes the LSMS-ISA dataset from Ethiopia and Nigeria, gathered by the Ethiopian Central Statistics Agency, the National Bureau of Statistics of Nigeria, and the World Bank across three survey waves from 2010 to 2016. The final dataset, nationally representative, comprises approximately 1460 and 1178 observations for Ethiopian and Nigerian farmers, respectively, commercializing their crops.

The analysis draws from household and agricultural data within the LSMS-ISA dataset, focusing on farmers' responses about their main crop buyers, encapsulated in a network roster of over 30 actors, allowing identification of primary and secondary commercial partners. Variable definitions and descriptive statistics for household variables are detailed in Tables A.1 (variable descriptions), A.2 (Ethiopia - summary statistics), and A.3 (Nigeria - summary statistics) in the Appendix, noting omissions in the Nigerian dataset due to missing data. Geographical analysis reveals that households are generally located far from main markets, with Figure 2 depicting the regional distribution of households in Ethiopia and Nigeria.

Selling patterns, as shown in Figure A.1 in the Appendix, indicate a preference for selling large crop amounts outside formal markets, particularly with relatives, friends, and neighbors. Notably, events like the 2011 floods in Ethiopia significantly influenced these trends, with a marked shift in the selling outlets used by farmers.

Figure 3 and 4 categorize crop sales quantities from Figure A.1 by selling position and location, respectively. Specifically, as shown in Figure 3, Ethiopian farmers tend to sell upstream, mainly to agricultural cooperatives and farm-based associations, while Nigerian farmers predominantly sell downstream but also through local markets.

The distribution of sales by location (see Figure 4) shows a majority within or near villages, with a notable portion of Nigerian crops sold outside the region before 2012.

Table 1 presents summary statistics for food and total consumption[2,3], alongside food quantity for sensitivity analysis.

Consumption data in nominal values, adjusted for inflation using the 2010 CPI,[4] shows that food consumption constitutes over 70% of total expenditure for households in both Ethiopia and Nigeria.

Table 2 shows the downstreamness indicator results, indicating that Ethiopian rural households have an average downstreamness score of 0.02, suggesting a predominant upstream positioning within market chains, a trend also observed in Nigeria but with more variability.

These figures indicate that in the Ethiopian sample, the positioning indicator for crop-specific value chains ranges from 0 to 0.7, with rural households having an average downstreamness value of approximately 0.02. In Nigeria, there is greater heterogeneity in downstreamness values, with a maximum of 1 in 2011 and a decrease to 0.45 in 2013. These findings support the transition of food supply chains from local and fragmented to longer and geographically connected ones (IFAD, 2016). Farmers in the market chain predominantly position themselves upstream (Montalbano et al., 2018), and the crops they sell exhibit low price elasticity of demand, as demonstrated by studies from which crop elasticities are taken: World Bank Group (1982), Akinleye & Rahji (2007), Pan et al. (2009), Tafere et al. (2010), Ashagidigbi (2019), Adeniji (2019), and Obayelu et al. (2019) Moreover, analyzing the data while excluding outliers reveals micro-

[1] If households resides in the main market, this measure can be bypassed.

[2] Following the LSMS-ISA documentation on the Ethiopia Socioeconomic Survey, consumption total expenditures include three sources: food, non-food and education expenses for each household.

[3] As specified in the "Basic Information Document" for the LSMS-ISA Nigeria General Household Survey, total consumption is calculated as the sum of all food, education, non-food, and imputed rent expenditures. Expenditures were calculated and aggregated to household level and converted to per capita terms.

[4] Available at http://data.worldbank.org/indicator/FP.CPI.TOTL.

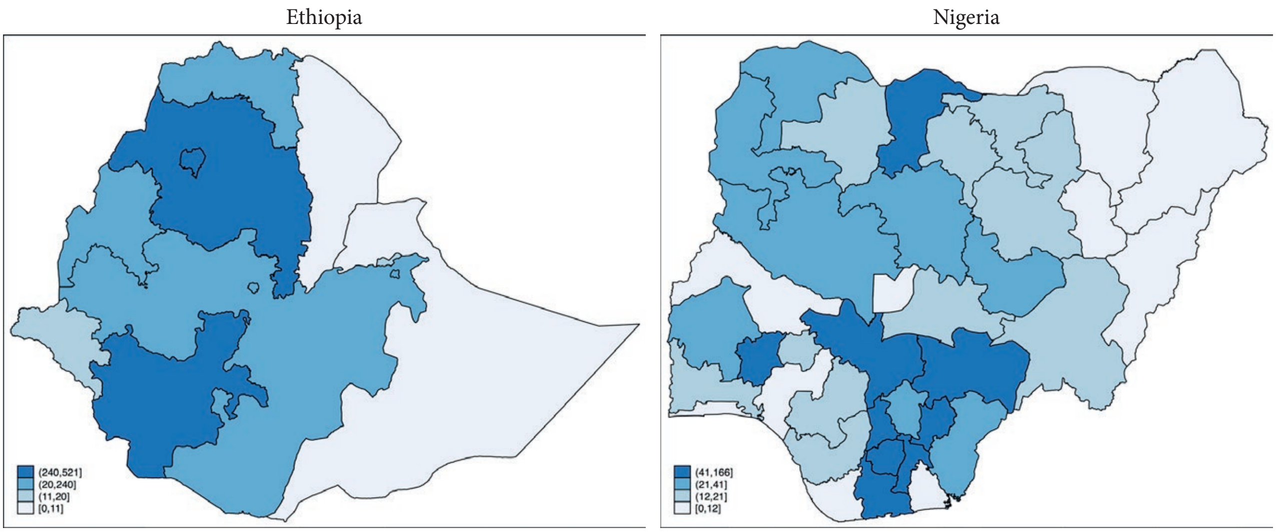

Figure 2. Household Density per Region/State. Source: Author's own elaboration from LSMS-ISA data.

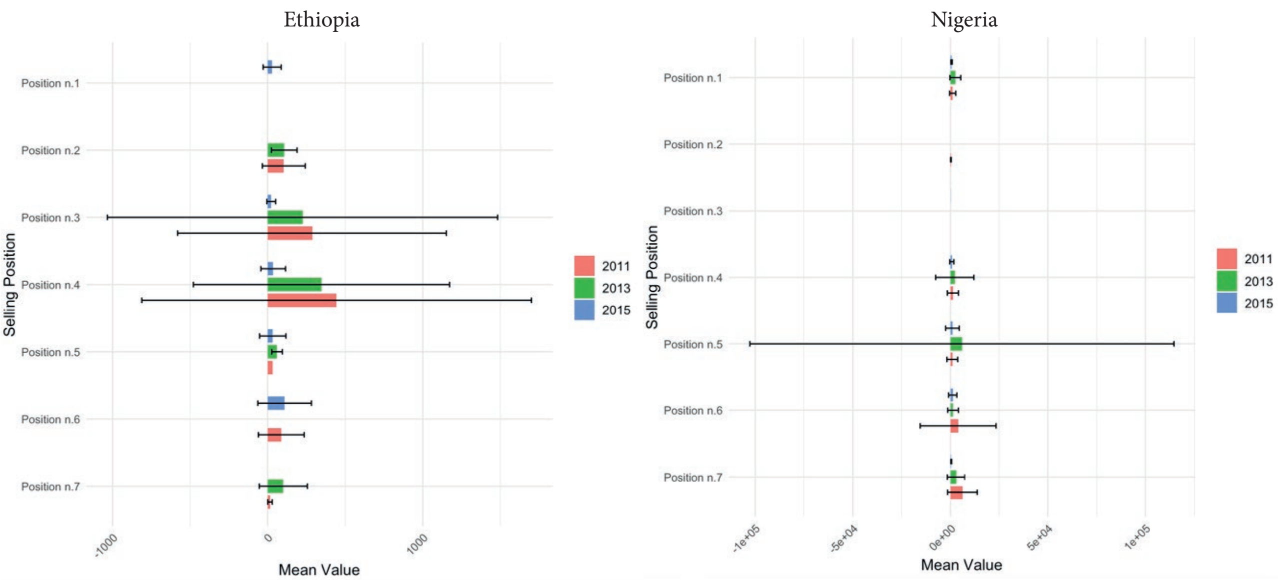

Figure 3. Quantity of Crop Sold (in Kilos) per Position.

trends in market positioning dynamics over the years (Figure A.2, A.3 and A.4 in the Appendix).

6. IDENTIFICATION STRATEGY, RESULTS, AND SENSITIVITY

This section details the identification strategy and results of this study, including analyses of alternative positioning indicators, primary findings for the amended indicator, and subsequent sensitivity and robustness assessments (Subsections 6.1 to 6.3).

6.1. Identification Strategy

The empirical strategy tests the correlation between the amended value-chain positioning indicator and the natural log of food and total household consumption, utilizing a semi-logarithmic econometric model. This approach incorporates household and production char-

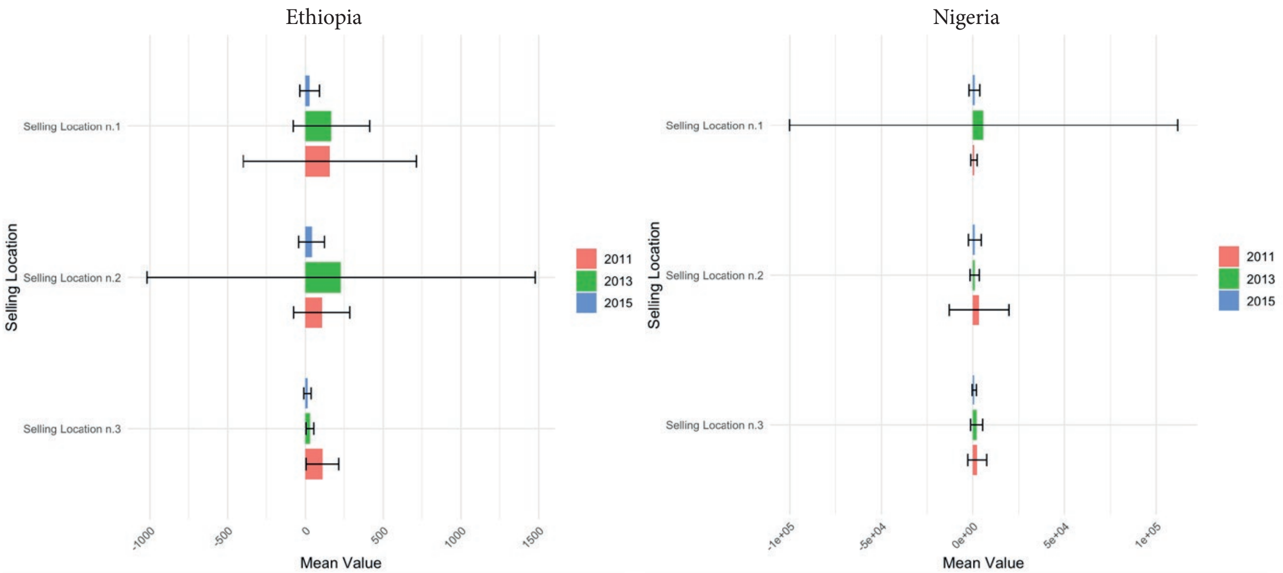

Figure 4. Ethiopia - Quantity of Crop Sold (in Kilos) per Selling Location.

Table 1. Dependent Variables Summary Statistics.

			N. of Observations	Mean	Standard Deviation	Minimum Value	Maximum Value
Ethiopia		Food Consumption *(decimals, ETB)*	1,394	1,666.08	1891.68	156.24	41,616.74
		Total Consumption *(decimals, ETB)*	1,394	2,021.67	1986.22	188.59	42,073.02
	Sens. Test	Food Quantity *(decimals, Kg)*	1,459	7.15	37.77	0.07	1,004.40
Nigeria		Food Consumption *(decimals, NGN)*	1,178	56,075.51	74,259.26	4,751.17	1,672,537
		Total Consumption *(decimals, NGN)*	1,178	78,349.05	88,541.40	9,334.46	1,699,927
	Sens. Test	Food Quantity *(decimals, Kg)*	1,175	32.9454	156.10	0.04	3268.39

Table 2. Downstreamness Indicator Results.

		N. of Obserbations	Mean	Standard Deviation	Minimum Value	Maximum Value
Ethiopia	Downstreamness in 2011 *(decimals)*	521	0.02	0.07	0.00	0.70
	Downstreamness in 2013 *(decimals)*	1,026	0.02	0.07	0.00	0.70
	Downstreamness in 2015 *(decimals)*	883	0.02	0.07	0.00	0.70
Nigeria	Downstreamness in 2011 *(decimals)*	346	0.05	0.12	0.00	1.00
	Downstreamness in 2013 *(decimals)*	757	0.00	0.03	0.00	0.45
	Downstreamness in 2015 *(decimals)*	515	0.03	0.09	0.00	0.86

acteristics to control for heterogeneity, following Dercon (2004), Chaudhuri (2003), and Montalbano et al. (2018). The specification employed is:

$$C_{h,t} = \alpha_h + \beta_t + \phi_1 Down_{h,t} + \delta X_{h,t} + \varepsilon_{h,t}; \quad (4)$$

where $C_{h,t}$ is alternatively the natural log of household per capita[5] of food consumption and total con-

[5] LSMS-ISA household surveys for Nigeria do not provide per adult equivalencies in consumption aggregates. Considering the current debate around the likelihood of incurring in mistakes when self-calculating equivalencies (see, Deaton & Margaret, 1998) and to make estimates across the two samples comparable, the consumption levels for Ethiopia are reported in terms of per capita in line with those for Nigeria.

Table 3. Downstreamness Indicators Comparison – Main Results for Ethiopia.

	Food Consumption				Total Consumption			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Proposed Indicator	(ln) Crop Share	(ln) Distance to Market	Market Outlets	Adjusted Down.	(ln) Crop Share	(ln) Distance to Market	Market Outlets
Downstreamness	42.01***	0.12*	-0.20	0.07	35.96***	0.08	-0.06	0.04
	(12.91)	(0.07)	(1.64)	(0.10)	(11.01)	(0.05)	(1.44)	(0.09)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	6.04***	6.73***	9.25	6.28***	6.66***	7.20***	8.84+	6.86***
	(0.99)	(1.09)	(6.58)	(1.03)	(0.85)	(0.94)	(5.82)	(0.89)
N. of Observations	1,387	1,387	1,381	1,387	1,387	1,387	1,381	1,387
N. of HH_id	1,097	1,097	1,093	1,097	1,097	1,097	1,093	1,097
R-squared Adj.	0.72	0.71	0.64	0.71	0.73	0.72	0.69	0.75
AIC	-1316.97	-1266.77	-1013.52	-1251.08	-1697.19	-1644.86	-1371.93	-1633.08
BIC	-615.49	-565.29	-375.39	-549.61	-995.71	-943.38	-733.80	-931.60

Standard errors, clustered by households id, in parentheses: *** p<0.01, ** p<0.05, * p<0.1, +p<0.15.

sumption, $Down_{h,t}$ represents the value of the proposed downstreamness indicator, and $X_{h,t}$ is the vector of control variables for household heterogeneity and includes observable household and production characteristic. A non-zero ϕ_1 coefficient suggests a significant relationship between market positioning and consumption. The model also accounts for unobserved heterogeneity, time, and location effects, with fixed effects to mitigate time-variant unobserved biases.

The study exclusively considers households engaged in value chains to focus on the impact of market chain positioning.[6] Possible reverse causality between food/total consumption and market positioning is not expected to impact the estimates because proxies for food consumption and commercialization are measured in different time periods. Robustness checks in the Appendix include the Heckman correction for selection bias and the control function method to address self-selection bias, as suggested by Wooldridge (2015).

6.2. Main Empirics

Table 3 contrasts the proposed adjusted «à la Antràs and Chor» (AC) indicator from Equation [3] with common downstreamness indicators like the crop share ratio, the geographical distance to the main market and Montalbano et al. (2018)'s positioning in terms of crop market outlets.

Model comparison using adjusted R-squared, AIC, and BIC coefficients reveals the superior performance of the proposed indicator with respect to traditional market positioning proxies. This finding challenges the commonly used proxies for marketing factors, orientation, and positioning that have been traditionally employed in empirical studies (e.g., *inter alia*, Montalbano et al., 2018; Migose et al., 2018; Mkuna & Wale, 2022).

Table 4 reports the positive impact of downstream positioning on consumption levels in Ethiopia. All estimates were adjusted for household production characteristics to account for additional latent variables that could explain variations in market positioning, effectively reducing potential endogeneity resulting from selectivity bias (Fafchamps & Hill, 2005).

By accounting for time- and geography-related factors, it is observed that Ethiopian farmers positioned downstream in the market experience significantly higher per-capita consumption levels compared to farming households with similar characteristics but lower positioning scores. Specifically, a 0.01 increase in their market positioning boosts per-capita food consumption by over 50% and total consumption by more than 40%, challenging the view that consumption patterns solely depend on food price shifts. Ignoring household and geographic specifics leads to underestimating the "market positioning effect." The impact

[6] Households selling their crop in non-market outlets account for around 7-8% of the final sample for Ethiopia.

Table 4. Main Results for Ethiopia – Panel Fixed Effects Clustered by Household ID.

	Food Consumption			Total Consumption		
	(1)	(2)	(3)	(4)	(5)	(6)
	Wave Fixed Effects	District-Wave Fixed Effects	District-Wave FE HH Trends	Wave Fixed Effects	District-Wave Fixed Effects	District-Wave FE HH Trends
Downstreamness	31.04**	43.11***	42.01***	27.17*	36.13***	35.96***
	(15.03)	(12.74)	(12.91)	(14.31)	(11.03)	(11.01)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE		Yes	Yes		Yes	Yes
Trends			Yes			Yes
Constant	7.65***	5.95***	6.04***	7.99***	6.55***	6.66***
	(0.63)	(0.99)	(0.99)	(0.58)	(0.85)	(0.85)
N. of Observations	1,387	1,387	1,387	1,387	1,387	1,387
N. of HH_id	1,097	1,097	1,097	1,097	1,097	1,097
R-squared Adjusted	0.31	0.72	0.72	0.31	0.73	0.73

Standard errors, clustered by households id, in parentheses: *** p<0.01, ** p<0.05, * p<0.1, $^{+}$ p<0.15.

is consistent across food and total consumption, with accuracy improving when location controls are included. Despite the size of the hypothesized change in positioning score is observed in less than 2% of cases, its significant effect highlights the importance in driving consumption changes among households with varying initial downstream positions.

Similarly, Table 5 presents the Nigerian results, mirroring the Ethiopian findings. A 0.01 enhancement in positioning indicator value corresponds to approximately 40% and 37% increases in per-capita food and total consumption, respectively.

In Nigeria, like Ethiopia, farmers sell through various channels including local markets, cooperatives, and directly to processors, with a crop range extending to non-food items like cotton. The empirical strategy to Nigerian data[7] yields results mirroring Ethiopia's: a 0.01 improvement in market positioning leads to roughly a 40% increase in per-capita food consumption and a 37% increase in total consumption. This confirms that better market positioning, after accounting for variables like district characteristics and time trends, significantly enhances consumption levels for farmers in both countries.

6.3. Sensitivity and Robustness Checks

Table 6 shows the result of the sensitivity analysis for food quantity in both samples. Food quantity is also measured in logarithmic form, just like consumption.

Results in both countries are very similar. Food quantity is positively affected by higher positioning scores for all the specifications provided for both samples. If rural households are able to increase their positioning indicator value by 0.01, on average, and *ceteris paribus*, they are able to more than double their food quantity level both in Ethiopia and Nigeria. Therefore, impact of increased positioning in value chains on food quantity per household is greater, in terms of magnitude, than the impact on food and total consumption levels per capita.

Robustness checks are reported in Table 7 above for Ethiopia and Table 9 for Nigeria.

Table 7 shows the results of Table 4 replicated with population sampling weights.[8] Results are robust and consistent with what was previously obtained. As in Table 4, results for both food and total consumption show the same dynamics: lower significance for the baseline specification and a downward bias if district dummies are not in the control group but only the wave dummies are considered.

Similarly, in Table 8 above, the results for Nigeria (shown in Table 5) are replicated with the provided

[7] The variable "crop code" is not controlled for in the case of Nigeria, given the few changes in labeling across the years that may have altered the panel dataset combined "crop code" variable. Also, interview month is omitted due to several missing observations. Consumption data rely on the postharvest surveying visit. Data on fertilizer use are from the post-planting questionnaire.

[8] Conversely to Nigeria, combined population weights are not reported in the LSMS-ISA Ethiopia Rural Socioeconomic Surveys. To avoid mistakenly corrections, population weights were adjusted across the years by attaching the latest weight to the household's highest surveying wave.

Table 5. Main Results for Nigeria – Panel Fixed Effects Clustered by Household ID.

	Food Consumption			Total Consumption		
	(1)	(2)	(3)	(4)	(5)	(6)
	Wave Fixed Effects	District-Wave Fixed Effects	District-Wave FE HH Trends	Wave Fixed Effects	District-Wave Fixed Effects	District-Wave FE HH Trends
Downstreamness	31.50***	33.39***	33.85***	26.79**	31.56**	31.46**
	(11.94)	(12.16)	(12.50)	(10.75)	(13.97)	(14.19)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE		Yes	Yes		Yes	Yes
Trends			Yes			Yes
Constant	10.75***	11.45***	10.93***	11.08***	11.49***	11.03***
	(0.24)	(0.28)	(0.51)	(0.28)	(0.24)	(0.58)
N. of Observations	1,178	1,178	1,178	1,178	1,178	1,178
N. of HH_id	979	979	979	979	979	979
R-squared Adjusted	0.41	0.82	0.82	0.32	0.74	0.74

Standard errors, clustered by households id, in parentheses: *** p<0.01, ** p<0.05, * p<0.1, +p<0.15.

Table 6. Sensitivity Testing with Food Quantity.

	Food Quantity (Ethiopia)			Food Quantity (Nigeria)		
	(1)	(2)	(3)	(4)	(5)	(6)
	Wave Fixed Effects	District-Wave Fixed Effects	District-Wave FE HH Trends	Wave Fixed Effects	District-Wave Fixed Effects	District-Wave FE HH Trends
Downstreamness	61.86**	70.51*	81.38**	61.07**	82.03***	78.18***
	(26.55)	(36.81)	(36.54)	(25.31)	(26.60)	(28.09)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE		Yes	Yes		Yes	Yes
Trends			Yes			Yes
Constant	-1.09	7.68***	7.76***	2.07***	2.08***	2.89***
	(1.05)	(1.97)	(1.92)	(0.43)	(0.38)	(0.77)
N. of Observations	1,452	1,452	1,452	1,175	1,175	1,175
N. of HH_id	1,121	1,121	1,121	977	977	977
R-squared Adjusted	0.13	0.53	0.54	0.59	0.88	0.88

Standard errors, clustered by households id, in parentheses: *** p<0.01, ** p<0.05, * p<0.1, +p<0.15.

population sampling weights. Coefficient estimates for the proposed amended positioning indicator in Table 7 and 8 are significant for almost all the specifications provided in both samples. Controlling for factors such as time and district fixed effects, including region, district, and village dummies, as well as trends, Ethiopian and Nigerian households who participate and have a better position in the market chain register, on average and *ceteris paribus*, have a per-capita equivalent food and total consumption level around 20% times higher than those farming households with the same characteristics and who have a position-indicator score lower than 0.01 unit.

To address potential selection bias from excluding about 100 households not commercializing their crops within value chains, this study utilizes the *xtheckmanfe* Stata module by Rios-Avila (2020) to account for endogeneity and sample selection. The results, adjusted for time effects and Heckman correction, are in Appen-

Table 7. Main Results with Population Sampling Weights for Ethiopia.

	Food Consumption			Total Consumption		
	(1)	(2)	(3)	(4)	(5)	(6)
	Wave Fixed Effects	District-Wave Fixed Effects	District-Wave FE HH Trends	Wave Fixed Effects	District-Wave Fixed Effects	District-Wave FE HH Trends
Downstreamness	22.68+	21.85+	21.47+	20.08+	21.81*	22.39*
	(15.07)	(14.50)	(14.61)	(13.58)	(13.00)	(12.97)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE		Yes	Yes		Yes	Yes
Trends			Yes			Yes
Constant	7.24***	6.91***	7.05***	7.61***	7.56***	7.68***
	(0.62)	(1.23)	(1.22)	(0.58)	(1.07)	(1.05)
N. of Observations	1,387	1,387	1,387	1,387	1,387	1,387
N. of HH_id	1,097	1,097	1,097	1,097	1,097	1,097
R-squared Adjusted	0.33	0.72	0.73	0.34	0.70	0.71

Standard errors, clustered by households id, in parentheses: *** p<0.01, ** p<0.05, * p<0.1, +p<0.15.

Table 8. Main Results with Population Sampling Weights for Nigeria.

	Food Consumption			Total Consumption		
	(1)	(2)	(3)	(4)	(5)	(6)
	Wave Fixed Effects	District-Wave Fixed Effects	District-Wave FE HH Trends	Wave Fixed Effects	District-Wave Fixed Effects	District-Wave FE HH Trends
Downstreamness	15.96	20.52*	21.58**	11.98	18.26	18.56+
	(12.26)	(10.46)	(10.79)	(10.89)	(13.01)	(13.02)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE		Yes	Yes		Yes	Yes
Trends			Yes			Yes
Constant	10.90***	11.27***	10.38***	11.29***	11.38***	10.52***
	(0.27)	(0.23)	(0.51)	(0.38)	(0.23)	(0.65)
N. of Observations	1,172	1,172	1,172	1,172	1,172	1,172
N. of HH_id	973	973	973	973	973	973
R-squared Adjusted	0.33	0.83	0.83	0.23	0.76	0.77

Standard errors, clustered by households id, in parentheses: *** p<0.01, ** p<0.05, * p<0.1, +p<0.15.

dix Table A.4. Moreover, the issue whether households' participation and positioning in markets could be influenced by characteristics affecting both consumption and market position, is addressed using a control function approach. This approach involves adding the residual of a first-stage regression, which predicts the "Downstreamness Positioning" binary variable, to the main regression as an exclusion restriction. This residual, denoted as ρ, is designed to be uncorrelated with the endogenous variable, thereby providing unbiased estimators in the main equation and mitigating self-selection bias (Wooldridge, 2015). Table A.5 in the Appendix reports the results, showing very consistent outcomes with the previous regressions.

7. DISCUSSION AND CONCLUSIONS

To summarize, the empirical outcomes indicated that changes in market positioning significantly and consistently matters to increasing the consumption levels of Ethiopian farmers selling crops in the market chain. From this perspective, the findings of Montalbano et al. (2018) extend to Ethiopia and Nigeria regarding the positive role of farmers' market participation in Uganda. However, the results contradict the conclusion of Montalbano et al. (2018), arguing instead for the significance of market intermediaries.

Finally, a concern should be sounded concerning the external validity of these findings. Since the focus is on investigating market positioning, the overwhelming majority of farmers who produce crops only for home consumption are excluded from the analysis. This gap hampers the ability of the analysis to derive consistent estimates for the entire population of a crop producer. Nevertheless, results of the parallel test conducted for Nigeria are highly reassuring regarding the proposed amended indicator's external validity.

Historically, the examination of farmers' market decisions traces back to the early 1990s, with seminal works by Fafchamps (1992), von Braun (1995), and Key et al. (2000). Yet, a comprehensive analysis of market structure from the farmers' perspective remains elusive. The motivation behind this work lies on the idea that farmers selling to wholesalers/producers are better off than farmers that sell to the most proximate markets. This work adjusts Antràs and Chor's downstreamness indicator to farming households' selling locations and buyer-market chains. It contributes to the literature by creating a conceptual framework for farmers' market positioning and a replicable setting for assessing the effects of market positioning on both food security and welfare levels.

Utilizing national, representative household surveys from Ethiopia and Nigeria, this paper investigates the relationship between market positioning scores and consumption levels, revealing that farmers positioned further downstream in the value chain experience enhanced food and overall consumption. This study evidences the significant impact of micro-variations in market positioning on rural development and establishes the superiority of the Antràs and Chor-informed indicator over other alternatives for assessing market positioning's welfare effects. The findings, robust across various empirical models and further supported by sensitivity analyses focusing on food quantity, underscore the reliability of the research question addressed.

This work fills a critical void in existing literature by offering a nuanced, well-validated indicator that assesses farmers' value chain positioning with a novel emphasis on market outlet identities and selling locations. By incorporating demand elasticity as a pivotal parameter for vertical integration, as suggested by Antràs and Chor (2013), the indicator not only adheres to but also expands upon the theoretical underpinnings of value chain analysis. Empirical validation from Ethiopia and Nigeria illustrates that slight enhancements in market positioning lead substantial increases in consumption, with 0.01 rise in positioning yielding over a 40% uplift in per-capita consumption levels.

The study also acknowledges the challenges in comparing across countries due to incomplete data in existing datasets, especially regarding the network roster for inputs acquisition. It advocates for a broader data collection strategy encompassing trade flows for all actors in the agricultural chain, aiming to elucidate the value added along a farmer's selling line. This approach promises a more holistic understanding of the agricultural value chain's dynamics and its implications for farmer welfare.

ACKNOWLEDGMENTS

For this paper, I am grateful to my supervisors, Prof. Pierluigi Montalbano and Prof. Marco Letta, for their constant invaluable feedback on this work. I would also like to express my gratitude to the World Bank Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) team for providing the data. Furthermore, I extend my thanks to Prof. Carlo Pietrobelli. Prof. Enrico Marvasi, Prof. Marco Sanfilippo, Prof. Donato Romano, Prof. Fabio Santeremo, Prof. Luca Salvatici, Dr. Sara Savastano and the participants at the 1st DevEconMeet, the Sapienza PhD Meeting 2022, the 12th AIEAA Conference, IFAD & FAO "Working & Networking" Workshop on Climate Change and Food Systems, the 3rd Annual Southern PhD Economics Conference (ASPEC), as well as the 7h Nordic Development Conference (NorDev) for their comments on previous versions of this paper. I am also thankful for the doctoral research support received from Sapienza University of Rome. Finally, I express my sincere gratitude to the Editors and the anonymous referees for their insightful suggestions. Potential errors and views expressed in this paper are those of the author and do not represent those of the institutions with which the author is affiliated. All standard disclaimers apply.

REFERENCES

Adeniji, F. (2019). Consumption function and price elasticity of tobacco demand in Nigeria. *Tobacco Prevention & Cessation*, *5*(December). https://doi.org/10.18332/tpc/114084

African Development Bank, OECD, & United Nations Development Programme. (2014). *African Economic Outlook 2014: Global Value Chains and Africa's Industrialisation*. OECD. https://doi.org/10.1787/aeo-2014-en

Akinleye, S. O., & Rahji, M. A. (2007). Nutrient elasticities among Nigerian households differentiated by income. *Agrekon*, *46*(2), 274–288. https://doi.org/10.1080/03031853.2007.9523772

Antràs, P., & Chor, D. (2013). Organizing the Global Value Chain. *Econometrica*, *81*(6), 2127–2204. https://doi.org/10.3982/ECTA10813

Antràs, P., & Chor, D. (2018). *On the Measurement of Upstreamness and Downstreamness in Global Value Chains* (No. w24185; p. w24185). National Bureau of Economic Research. https://doi.org/10.3386/w24185

Antràs, P., & Chor, D. (2019). On the measurement of upstreamness and downstreamness in global value chains. In *World Trade Evolution: Growth, Productivity and Employment.* (pp. 126–194). Routledge.

Antràs, P., & Chor, D. (2022). Chapter 5 - Global value chains. In *Handbook of International Economics* (Vol. 5, pp. 297–376). Elsevier. https://doi.org/10.1016/bs.hesint.2022.02.005

Ashagidigbi, W. (2019). Analysis of the Demand for Fruits and Vegetables Among Households in Nigeria. *Science Letters*, 7(2), 45-51.

Audet-Bélanger, G., Thijssen, M. H., Gildemacher, P., Subedi, A., De Boef, W. S., & Heemskerk, W. (2013). *Seed Value Chain Analysis* (ISSD Technical Notes Issue no 3.). Centre for Development Innovation, Wageningen University & Research, Wageningen & Royal Tropical Institute, Amsterdam.

Ayele, A., Erchafo, T., Bashe, A., & Tesfayohannes, S. (2021). Value chain analysis of wheat in Duna district, Hadiya zone, Southern Ethiopia. *Heliyon*, *7*(7), e07597. https://doi.org/10.1016/j.heliyon.2021.e07597

Babama'aji, R. A., Shaba, H. A., Adepoju, M. O., Yusuf, M. J., Jantiku, J., Eshiet, R. C. I., Amanabo, U. H., Akinola, O., Haruna, M., Ibrahim, H., Ekwe, D. O., Bako, H., Babankudi, A. S., Dakpanchi, M. A., & Nwodo, N. (2022). Mapping and Comparison of Maize Products Value Chains in Nigeria and Rwanda. *European Journal of Agriculture and Food Sciences*, *4*(3), 57–65. https://doi.org/10.24018/ejfood.2022.4.3.501

Bandiera, O., & Rasul, I. (2006). Social networks and technology adoption in northern Mozambique. The economic journal, 116(514), 869–902. https://doi.org/10.1111/j.1468-0297.2006.01115.x

Barrett, C. B., Bachke, M. E., Bellemare, M. F., Michelson, H. C., Narayanan, S., & Walker, T. F. (2012). Smallholder Participation in Contract Farming: Comparative Evidence from Five Countries. *World Development*, *40*(4), https://doi.org/10.1016/j.worlddev.2011.09.006

Barrett, C. B., Christiaensen, L., Sheahan, M., & Shimeles, A. (2017). On the Structural Transformation of Rural Africa. Journal of African Economies, 26(suppl_1), i11–i35. https://doi.org/10.1093/jae/ejx009

Bellemare, M. F. (2012). As you sow, so shall you reap: The welfare impacts of contract farming. *World Development*, 40(7), 1418-1434. https://doi.org/10.1016/j.worlddev.2011.12.008

Bellemare, M. F., & Novak, L. (2017). Contract Farming and Food Security. *American Journal of Agricultural Economics*, *99*(2), 357–378. https://doi.org/10.1093/ajae/aaw053

Biggeri, M., Burchi, F., Ciani, F., & Herrmann, R. (2018). Linking small-scale farmers to the durum wheat value chain in Ethiopia: Assessing the effects on production and wellbeing. *Food Policy*, *79*, 77–91. https://doi.org/10.1016/j.foodpol.2018.06.001

Carletto, C., Corral, P., & Guelfi, A. (2017). Agricultural commercialization and nutrition revisited: Empirical evidence from three African countries. *Food Policy*, *67*, 106–118. https://doi.org/10.1016/j.foodpol.2016.09.020

Case, A. (1992). Neighborhood influence and technological change. Regional science and urban economics, 22(3), 491–508. https://doi.org/10.1016/0166-0462(92)90041-X

Cattaneo, O., & Miroudot, S. (2013). *From Global Value Chains to Global Development Chains: An Analysis of Recent Changes in Trade Patterns and Development Paradigms, 21st Century Trade Policy: Back to the Past*. Policy Research Working Paper No. 6406, World Bank. https://doi.org/10.1596/1813-9450-6406

Chamberlin, J., & Jayne, T. S. (2013). Unpacking the meaning of 'market access': Evidence from rural Kenya. *World Development*, *41*, 245–264. https://doi.org/10.1016/j.worlddev.2012.06.004

Chaudhuri, S. (2003). *Assessing vulnerability to poverty: Concepts, empirical methods and illustrative examples*.

Davis, D., Kaplinsky, R., & Morris, M. (2018). Rents, Power and Governance in Global Value Chains. *Journal of World-Systems Research*, *24*(1), 43–71. https://doi.org/10.5195/jwsr.2018.662

de Janvry, A., & Sadoulet, E. (2006). Progress in the Modeling of Rural Households' Behavior under Market Failures. In A. de Janvry & R. Kanbur (Eds.), *Poverty, Inequality and Development* (Vol. 1, pp. 155–181). Springer US. https://doi.org/10.1007/0-387-29748-0_9

Deaton, A., & Margaret. (1998). Chapter 17: Consumption. In Designing Household Survey Questionnaires for Developing Countries Lessons from Ten Years of LSMS Experience, Princeton University, Woodrow Wilson School of Public and International Affairs, Research Program in Development Studies.

Deaton, A., & Muellbauer, J. (1980). An Almost Ideal Demand System. American Economic Review, 70(3), 312–326.

Dercon, S. (2004). Insurance against poverty. Oxford Academic. https://doi.org/10.1093/0199276838.001.0001

D'Souza, A., & Jolliffe, D. (2014). Food Insecurity in Vulnerable Populations: Coping with Food Price Shocks in Afghanistan. *American Journal of Agricultural Economics*, *96*(3), 790–812. https://doi.org/10.1093/ajae/aat089

Duncan, A. J., Teufel, N., Mekonnen, K., Singh, V., Bitew, A., & Gebremedhin, B. (2013). Dairy intensification in developing countries: Effects of market quality on farm-level feeding and breeding practices. *Animal*, *7*(12), 2054–2062. https://doi.org/10.1017/S1751731113001602

Fackler, P., & Goodwin, B. (2001). Chapter 17. Spatial price analysis. In B. L. Gardner & G. C. Rausser (Eds.), *Handbook of Agricultural Economics* (Vols. 1, Part B, pp. 971–1024). Elsevier. https://doi.org/10.1016/S1574-0072(01)10025-3

Fafchamps, M. (1992). Cash Crop Production, Food Price Volatility, and Rural Market Integration in the Third World. *American Journal of Agricultural Economics*, *74*(1), 90–99. https://doi.org/10.2307/1242993

Fafchamps, M., & Hill, R. V. (2005). Selling at the Farmgate or Traveling to Market. *American Journal of Agricultural Economics*, *87*(3). https://doi.org/10.1111/j.1467-8276.2005.00758.x

FAO. (2020). *Fruit and vegetables – your dietary essentials*. The International Year of Fruits and Vegetables, 2021, background paper. https://doi.org/10.4060/cb2395en

Feyaerts, H., Van den Broeck, G., & Maertens, M. (2020). Global and local food value chains in Africa: A review. Agricultural Economics, 51(1), 143–157. https://doi.org/10.1111/agec.12546

Gabre-Madhin, E. Z., & Goggin, I. (2006). Does Ethiopia Need a Commodity Exchange? An Integrated Approach to Market Development. *EDRI-ESSP Policy Working Paper No. 4*.

Gashaw, B. A., & Kibret, S. M. (2018). The Role of Ethiopian Commodity Exchange (ECX) in Crop Value Chain Development in Ethiopia. *Research Journal of Finance and Accounting*, *9*(19), 26–33.

Giunta, A., Montalbano, P., & Nenci, S. (2022). Consistency of micro- and macro-level data on global value chains: Evidence from selected European countries. *International Economics*, *171*, 130–142. https://doi.org/10.1016/j.inteco.2022.05.005

IFAD. (2016). Rural Development Report 2016. ISBN 978-92-9072-680-7.

Jensen, R. T. (2010). Information, efficiency, and welfare in agricultural markets: Information, efficiency, and welfare in agricultural markets. Agricultural Economics, *41*(s1), 203–216. https://doi.org/10.1111/j.1574-0862.2010.00501.x

Kaplinsky, R., & Morris, M. (2001). *A Handbook for Value Chain Research* (Vol. 113). IDRC.

Key, N., Sadoulet, E., & Janvry, A. D. (2000). Transactions Costs and Agricultural Household Supply Response. *American Journal of Agricultural Economics*, *82*(2). https://doi.org/10.1111/0002-9092.00022

Mancini, M., Montalbano, P., Nenci, S., & Vurchio, D. (2023). *Positioning in Global Value Chains: World Map and Indicators. A new dataset available for GVC analyses* (Working Papers No. 3/23). Sapienza University of Rome, DISS. https://disse.web.uniroma1.it/sites/default/files/DiSSE_Mancinietal_wp3_2023.pdf

Matuschke, I., & Qaim, M. (2009). The impact of social networks on hybrid seed adoption in India. Agricultural Economics, 40(5), 493–505. https://doi.org/10.1111/j.1574- 0862.2009.00393.x

Migose, S. A., Bebe, B. O., de Boer, I. J. M., & Oosting, S. J. (2018). Influence of distance to urban markets on smallholder dairy farming systems in Kenya. *Tropical Animal Health and Production*, *50*(7), 1417–1426. https://doi.org/10.1007/s11250-018-1575-x

Minten, B., Habte, Y., Tamru, S., & Tesfaye, A. (2018). *Transforming agri-food systems in Ethiopia: Evidence from the dairy sector*, Working Paper 129, International Food Policy Research Institute (IFPRI) and Ethiopian Development Research Institute (EDRI).

Minten, B., Randrianarison, L., & Swinnen, J. (2007). Spillovers from high-value agriculture for exports on land use in developing countries: Evidence from Madagascar. *Agricultural Economics*, *37*(2–3). https://doi.org/10.1111/j.1574-0862.2007.00273.x

Minten, B., Randrianarison, L., & Swinnen, J. (2009). Global Retail Chains and Poor Farmers: Evidence from Madagascar. *World Development*, *37*(11), 1728–1741. https://doi.org/10.1016/j.worlddev.2008.08.024

Mkuna, E., & Wale, E. (2022). Explaining Farmers' Income via Market Orientation and Participation: Evidence from KwaZulu-Natal (South Africa). *Sustainability*, *14*(21), 14197. https://doi.org/10.3390/su142114197

Montalbano, P., & Nenci, S. (2022). Does global value chain participation and positioning in the agriculture and food sectors affect economic performance? A global assessment. *Food Policy*, *108*, 102235. https://doi.org/10.1016/j.foodpol.2022.102235

Montalbano, P., Nenci, S., & Salvatici, L. (2015). *Trade, value chains and food security*. https://doi.org/10.13140/RG.2.2.31952.10249

Montalbano, P., Pietrelli, R., & Salvatici, L. (2018). Participation in the market chain and food security: The case of the Ugandan maize farmers. *Food Policy*, *76*, 81–98. https://doi.org/10.1016/j.foodpol.2018.03.008

Nanyeenya, W., Staal, S., Mugisha, J., Baltenweck, I., Romney, D., & Halberg, N. (2007). Determinants of dairy intensification in Uganda-an integrated analysis of farm resources, location and Gis-derived factors. *African Journal of Livestock Extension*, *5*, 14–20.

Nenci, S. 2020. Mapping global value chain (GVC) participation, positioning and vertical specialization in agriculture and food. *Technical note for The State of Agricultural Commodity Markets – Background paper for The State of Agricultural Commodity Markets (SOCO) 2020*. FAO.

Nenci, S., Fusacchia, I., Giunta, A., Montalbano, P., & Pietrobelli, C. (2022). Mapping global value chain participation and positioning in agriculture and food: Stylised facts, empirical evidence and critical issues. *Bio-Based and Applied Economics*, *11*(2), 93–121. https://doi.org/10.36253/bae-12558

Obayelu, O. A., Ibe, R. B., Adegbite, O., & Oladimeji, A. (2019). Demand for Selected Fruits Among Students of a Tertiary Institution in Southwest Nigeria. *International Journal of Fruit Science*, *19*(1), 45–56. https://doi.org/10.1080/15538362.2018.1533911

Oosting, S. J., Udo, H. M. J., & Viets, T. C. (2014). Development of livestock production in the tropics: Farm and farmers' perspectives. *Animal*, *8*(8), 1238–1248. Cambridge Core. https://doi.org/10.1017/S1751731114000548

Pan, S., Hudson, D., & Ethridge, D. (2009). The Influence of Market Structure on the impacts of Domestic Subsidies on International Cotton Markets. *2009 Conference, August 16-22, 2009, Beijing, China 51196, International Association of Agricultural Economists*. https://doi.org/10.22004/ag.econ.51196

Rashid, S., & Negassa, A. (2013). Policies and performance of Ethiopian cereal markets. In *Food and Agriculture in Ethiopia: Progress and Policy Challenges* (pp. 123–156). ISBN 978-0-8122-4529-5.

Ríos Guayasamín, P., Peixoto, R. T. dos G., Torrico Albino, J. C., & ReYes Hernández, H. (2016). Value chains for organic products in neighboring municipalities of Rio de Janeiro, Brazil. *Agroecology and Sustainable Food Systems*, *40*(4), 352–380. https://doi.org/10.1080/21683565.2015.1137531

Rios-Avila, F. (2020). *XTHECKMANFE: Stata module to fit panel data models in the presence of endogeneity and selection*. Statistical Software Components S458770, Boston College Department of Economic.

Subervie, J., & Vagneron, I. (2013). A Drop of Water in the Indian Ocean? The Impact of GlobalGap Certification on Lychee Farmers in Madagascar. *World Development*, *50*, 57–73. https://doi.org/10.1016/j.worlddev.2013.05.002

Svensson, J., & Yanagizawa, D. (2009). Getting Prices Right: The Impact of the Market Information Service in Uganda. *Journal of the European Economic Association*, *7*(2–3). https://doi.org/10.1162/JEEA.2009.7.2-3.435

Swinnen, J. F. M. (2014). Global Agricultural Value Chains, Standards, and Development. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2434532

Swinnen, J. F. M., & Vandeplas, A. (2014). Price Transmission and Market Power in Modern Agricultural Value Chains. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2400431

Tafere, K., Taffesse, A. S., Tamru, S., Tefera, N., & Paulos, Z. (2010). *Food Demand Elasticities in Ethiopia: Estimates Using Household Income Consumption Expenditure (HICE) Survey Data*. IFPRI.

Timmer, C. P. (1997). Farmers and Markets: The Political Economy of New Paradigms. *American Journal of Agricultural Economics*, *79*(2), 621-627. https://doi.org/10.2307/1244161

Ugonna, C., Jolaoso, M., & Onwualu, A. (2015). Tomato Value Chain in Nigeria: Issues, Challenges and Strategies. *Journal of Scientific Research and Reports*, *7*(7), 501–515. https://doi.org/10.9734/JSRR/2015/16921

USAID. (2017). *Feed the Future Ethiopia Value Chain Activity – Partnering with the Agricultural Growth Program*.

van Asselt, J., & Useche, P. (2022). Agricultural commercialization and nutrition; evidence from smallholder coffee farmers. *World Development*, *159*, 106021. https://doi.org/10.1016/j.worlddev.2022.106021

Veugelers, R., Barbiero, F., & Blanga-Gubbay, M. (2013). Meeting the manufacturing firms involved in GVCs. In *Manufacturing Europe's future* (Bruegel blueprint series, Vol. 21). R. Veugelers.

von Braun, J. (1995). Agricultural commercialization: Impacts on income and nutrition and implications for policy. *Food Policy*, *20*(3), 187–202. https://doi.org/10.1016/0306-9192(95)00013-5

von Braun, J., & Kennedy, E. (1994). *Commercialization of Agriculture, Economic Development and Nutrition*. Baltimore, MD: John Hopkins Press.

von Thünen, J. H. (1966). The isolated state. In *The Economics of Population: Classic Writings* (pp. 211–216). Routledge.

Wegerif, M. C. A., & Martucci, R. (2019). Milk and the city: Raw milk challenging the value claims of value chains. *Agroecology and Sustainable Food Systems*, *43*(10), 1077–1105. https://doi.org/10.1080/21683565.2018.1530716

Wooldridge, J. M. (2015). Control Function Methods in Applied Econometrics. *The Journal of Human Resources*, *50*(2), 420–445. https://doi.org/10.3368/jhr.50.2.420

World Bank Group. (1982). *Cocoa handbook. Commodity Handbook.* World Bank Group, Washington, D.C.

APPENDIX

Table A.1. Variable Definitions and Other Basic Information.

Variable name	Definition	Time period	Source
Gender of the Household Head	Gender of the household head *(binary, 1=female)*	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Age of the Household Head *(decimals)*	Age years of the household head *(decimals)*	2011-2015	World Bank LSMS-ISA Ethiopia only
Number of Household Members in the Labor Force *(decimals)*	Number of household members (*binary, 1=female)*	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Household Size *(decimals)*	Number of people in the household *(decimals)*	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Average Years of Education for Household Adults *(decimals, years of schooling)*	Average education level attained by the household adult members *(values from 0 to 8)*	2011-2015	World Bank LSMS-ISA Ethiopia only
Average Years of Education for Household Head *(decimals, years of schooling)*	Average education level attained by the household head *(values from 0 to 8)*	2011-2015	World Bank LSMS-ISA Ethiopia only
Number of Household Infants *(decimals)*	Number of household members in the infant age range *(decimals)*	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Number of Household Children *(decimals)*	Number of household members in the children age range *(decimals)*	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Household Years of Education *(decimals, years of schooling)*	Average education level attained by all household members *(values from 0 to 8)*	2011-2015	World Bank LSMS-ISA Ethiopia only
Harvest Crop *(decimals, Kg)*	Quantity of crop harvest in the surveying period *(decimals, Kg)*	2011-2015	World Bank LSMS-ISA Ethiopia only
Field Size *(decimals, Ha)*	Average field size in the surveying period *(decimals, Ha)*	2011-2015	World Bank LSMS-ISA Ethiopia only
Free Seed	Event of receiving free seed *(binary, 1=no and 2=Yes)*	2011-2015	World Bank LSMS-ISA Ethiopia only
Seed Purchase	Necessity of purchasing seed *(binary, 1=no and 2=Yes)*	2011-2015	World Bank LSMS-ISA Ethiopia only
Fertilizer Use	Use of fertilizers *(binary, 1=no and 2=Yes)*	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Fertilizer Purchase	Purchase of fertilizers *(binary, 0=no and 1=Yes)*	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Leftover Fertilizer	Presence of leftover fertilizers *(binary, 0=no and 1=Yes)*	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria
Free Fertilizer	Event of receiving free fertilizers *(binary, 0=no and 1=Yes)*	2010-2016	World Bank LSMS-ISA Ethiopia and Nigeria

Table A.2. Households Summary Statistics for Ethiopia.

	N. of observations	Mean	Standard Deviation	Minimum Value	Maximum Value
Gender of the Household Head *(binary, 1=female)*	1,460	0.18	0.39	0	1
Age of the Household Head *(decimals)*	1,460	45.72	14.21	18	97
Number of Household Members in the Labor Force *(decimals)*	1,460	2.69	1.38	0	10
Household Size *(decimals)*	1,460	5.77	2.19	1	14
Average Years of Education for Household Adults *(decimals, years of schooling)*	1,460	1.70	1.83	0	8
Number of Household Infants *(decimals)*	1,460	0.58	0.80	0	5
Number of Household Children *(decimals)*	1,460	2.39	1.68	0	10
Household Years of Education *(decimals, years of schooling)*	1,460	1.70	1.83	0	8
Harvest Crop *(decimals, Kg)*	1,460	914.13	752.98	0	3,249.61
Field Size *(decimals, m^2)*	1,460	9030.31	9370.73	0	38,917.46
Free Seed *(binary, 2=Yes)*	1,459	1.99	0.12	1	2
Seed Purchase *(binary, 2=Yes)*	1,462	1.94	0.24	1	2
Fertilizer Use *(binary, 2=Yes)*	1,462	1.81	0.40	1	2

Table A.3. Households Summary Statistics for Nigeria.

	N. of Observations	Mean	Standard Deviation	Minimum Value	Maximum Value
Gender of the Household Head *(binary, 1=female)*	1,178	0.20	0.40	0	1
Number of Household Members in the Labor Force *(decimals)*	1,178	2.48	2.13	0	13
Household Size *(decimals)*	1,178	6.41	3.27	1	28
Number of Household Infants *(decimals)*	1,178	0.55	0.92	0	6
Number of Household Children *(decimals)*	1,178	1.90	2.22	0	14
Fertilizer Purchase *(binary, 1=Yes))*	1,178	0.33	0.47	0	1
Letfover Fertilizer *(binary, 1=Yes)*	1,178	0.03	0.17	0	1
Free Fertilizer *(binary, 1=Yes)*	1,178	0.01	0.10	0	1
Fertilizer Use *(binary, 1=organic)*	1,178	1.69	0.46	1	2

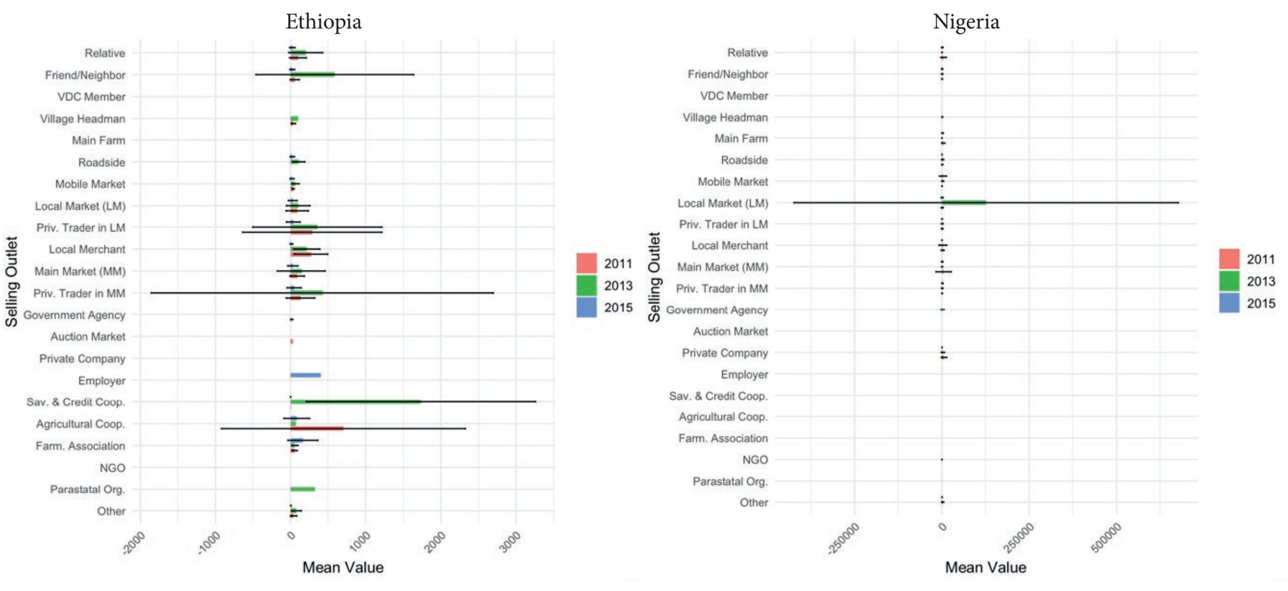

Figure A.1. Quantity of Crop Sold (in Kilos) Mean Values per Selling Outlet.

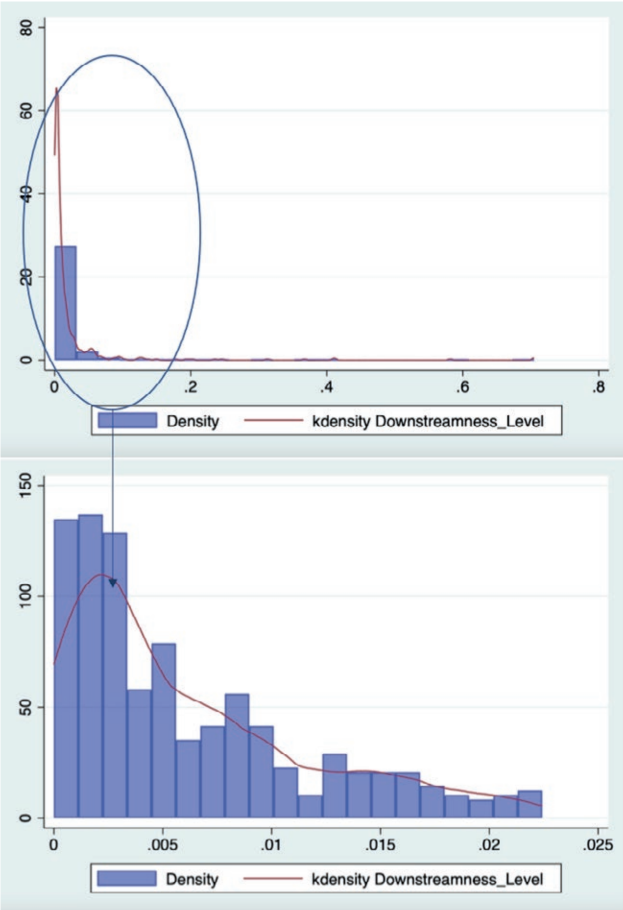

Figure A.2. Kernel Density Downstreamness Positioning Indicator Ethiopia 2011.

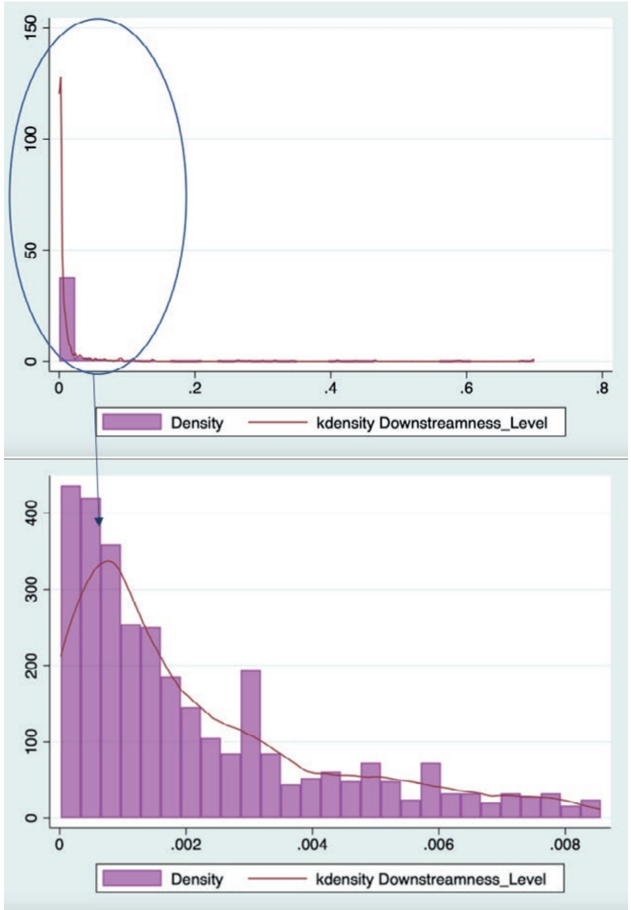

Figure A.3. Kernel Density Downstreamness Positioning Indicator Ethiopia 2013.

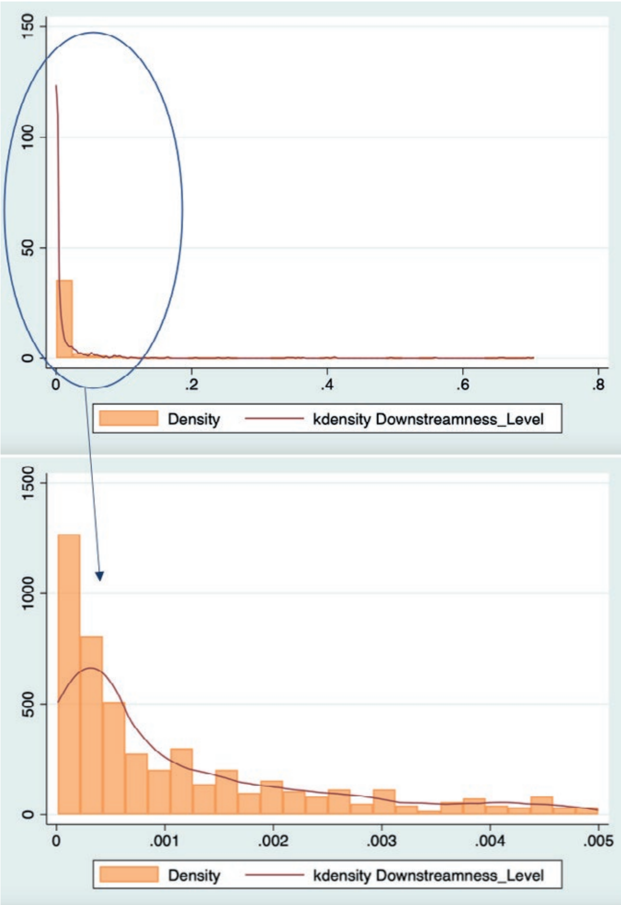

Figure A.4. Kernel Density Downstreamness Positioning Indicator Ethiopia 2015.

Table A.4. Sample Bias – Panel FE with the Heckman Correction.

	Food Consumption		Total Consumption	
	(1)	(2)	(3)	(4)
	Heckman	FE	Heckman	FE
	Wave Fixed Effects	Wave Fixed Effects	Wave Fixed Effects	Wave Fixed Effects
Downstreamness	50.88*	26.41**	48.15+	22.92**
	(30.07)	(12.26)	(30.42)	(11.63)
Controls	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes
Constant	7.57***	7.79***	7.64***	8.15***
	(0.42)	(0.61)	(0.31)	(0.57)
N. of Observations	1,457	1,389	1,457	1,389
N. of HH_id		1,098		1,098
R-squared Adjusted		0.26		0.25

Standard errors, clustered by households id, in parentheses: *** p<0.01, ** p<0.05, * p<0.1, +p<0.15.
Note: Control variables "household average education level" and "crop code" are excluded as their inclusion in the regression models does not allow convergence in the Heckman Fixed Effect computational tools.
Bootstrap replications are set to 50.

Table A.5. Self-Selection Bias – Control Function Method.

	Food Consumption			Total Consumption		
	(1)	(2)	(3)	(4)	(5)	(6)
	Wave Fixed Effects	District-Wave Fixed Effects	District-Wave FE HH Trends	Wave Fixed Effects	District-Wave Fixed Effects	District-Wave FE HH Trends
Downstreamness	27.23*	43.03***	41.03***	24.28+	36.23***	35.86***
	(15.71)	(13.04)	(13.07)	(14.97)	(11.23)	(11.20)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE		Yes	Yes		Yes	Yes
Trends			Yes			Yes
r	0.14	0.01	-0.01	0.10	-0.01	0.01
	(0.09)	(0.10	(0.10)	(0.08)	(0.09)	(0.09)
Constant	7.97***	6.24***	6.25***	8.31***	6.84***	6.95***
	(0.63)	(0.99)	(0.98)	(0.59)	(0.85)	(0.86)
N. of Observations	1,387	1,387	1,387	1,387	1,387	1,387
N. of HH_id	1,097	1,097	1,097	1,097	1,097	1,097
R-squared Adjusted	0.22	0.71	0.69	0.24	0.72	0.72

Standard errors, clustered by households id, in parentheses: *** p<0.01, ** p<0.05, * p<0.1, +p<0.15.

BAE
Bio-based and Applied Economics

AIEAA
ASSOCIAZIONE ITALIANA DI ECONOMIA AGRARIA E APPLICATA

OPEN ACCESS

Citation: Pagliacci, F., & Salpina, D. (2024). Adapting to climate change: what really drives the choices of the producers of Geographical Indications?. *Bio-based and Applied Economics* 13(3): 265-283. doi: 10.36253/bae-15221

Received: October 2, 2023
Accepted: April 9, 2024
Published: October 16, 2024

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Editor: Valentina Raimondi, Luca Salvatici

ORCID
FP: 0000-0002-3667-7115
DS: 0000-0001-9663-2456

Adapting to climate change: what really drives the choices of the producers of Geographical Indications?

Francesco Pagliacci[1], Dana Salpina[1,2,*]

[1] *Department of Land, Environment, Agriculture and Forestry, University of Padua, Via dell'Università 16, 35020 Legnaro (PD) Italy*
[2] *Euro-Mediterranean Center on Climate Change, Porta dell'Innovazione Building - 2nd Floor Via della Libertà 12 , 30175 Venice (VE), Italy*
*Corresponding author. E-mail: dana.salpina@cmcc.it

Abstract. In an era of rapid climate change, there is an increasing call for the efforts directed at detecting best practices of climate change adaptation in agriculture and understanding the factors behind producers' willingness to implement adaptation strategies. Many studies consider solely traditional agriculture and specific sectors (e.g., wine), while little attention has been paid to certified and high-quality products, as a whole. To fill this knowledge gap, in 2022 a questionnaire-based online survey was administered to 137 producers of agri-food Geographical Indications in the Veneto Region (north-eastern Italy). Using a multinomial logit model, this study highlights the factors explaining adaptation strategies distinguishing three cases: (i) farmers who have implemented adaptation strategies; (ii) farmers intending to implement them in the future; (iii) farmers neither having implemented nor willing to do so. Results suggest that socio-demographic characteristics, particularly education, matter, with producers holding a high school degree in agriculture showing a greater willingness to adapt. Also, being full-time farmer couples with higher probability of having already implemented adaptation strategies. Lastly, also a direct observation of climate change in the production area affects farmers' adaptation decisions.

Keywords: climate change, adaptation, PDOs, PGIs, producers' survey.
JEL Codes: Q1, Q15, Q54.

1. INTRODUCTION

One of the major recommendations of the United Nations Climate Change Conference COP27 (in 2022) is the recognition of the importance of sharing best adaptation practices among public and private key stakeholders, while adjusting them to country-specific context (UNFCCC, 2022). In such a setting, national governments have the direct responsibility of detecting best practices, highlighting the main factors behind climate change adaptation.

For the agri-food sector, both incremental and transformational climate change adaptation strategies have a paramount importance (Howden et al.,

Firenze University Press | www.fupress.com/bae

2010; Ingram, 2012; Fedele et al., 2019). Although incremental adaptation strategies alone are commonly considered insufficient to achieve the zero-hunger target of Sustainable Development Goal 2 (SDG2) and address the impacts of climate change (FAO, 2018), they can indeed contribute to national and regional transformative adaptation processes, especially in the case of local level strategies (Rahman et al., 2021).

However, adaptation to climate change for agri-food geographical indication (GI) systems is even more complex process, due to the legislative and institutional framework characterising them. Indeed, for each GI, a Product Specification (hereinafter, PS) defines the delimited area of production as well as production rules (e.g., plant varieties, harvest dates, size and colour). According to the World Trade Organisation (WTO, 1994), GIs are indications aimed at identifying goods as produced in a given geographical area, whose quality and reputation are attributable to the geographical origin itself. In practice, GIs are considered as a sort of social constructions (Belletti et al., 2017), which play a crucial role in fostering endogenous rural development, hence contributing to the preservation of the traditional agri-food systems and related social networks (Vandecandelaere et al., 2010), and thus, to socio-economic and environmental sustainability of the concerned rural areas (Owen et al., 2020). However, to contribute to this goal, GI management must be implemented effectively (Giacomini and Mancini, 2015) and GI regulations put producers under obligation to comply with the respective PS. The complex policy and socio-economic processes on which GIs rely on (Thompson and Scoones, 2009) often makes the modification of their PS complex, even if for the urgent purpose of climate change adaptation. In particular, the introduction of such changes requires an agreement among the involved producers, which can be concerned with long and costly authorisation processes (Belletti et al., 2015; Quiñones-Ruiz et al., 2018) on the one hand, and with the product's quality and reputation at stake, on the other hand. All these reasons explain why agri-food GIs are quite vulnerable to climate change.

In this setting, GIs adaptation to climate change depends on the capacity of agents and institutions to innovate, hence finding new solutions. Information on already-existing adaptation practices and a better understanding of the drivers behind the willingness of GI agents to adapt is crucial in informing public policies. Indeed, policies can foster anticipatory adaptation strategies within the agri-food sector. This is particularly important when self-investment for adaptation is insufficient, also due to the existence of major financial constraints, both in high-income and low-income countries (Ignaciuk, 2015; Deressa et al., 2009).

For the last decade, the studies addressing climate change adaptation of farmers have increased, especially in low-income countries. They have focused either on specific territories, e.g., the "char" islands in Bangladesh (Ahmed et al., 2021), the Amazon basin (Bauer et al., 2022), Laikipia District in Kenya (Ogalleh et al., 2012); or on specific productions, such as tea (Muench et al., 2021), coffee (Bro, 2020), honey (Vercelli, et al. 2021). In fact, only a few studies focused on the nexus of climate change adaptation and GIs in high-income countries. According to Marescotti et al. (2020), safeguarding Protected Designations of Origins (PDOs) and Protected Geographical Indications (PGIs) from the effects of climate change is a rather new topic mostly disregarded by international literature. Some studies addressed climate change perception of wine producers (e.g., Lereboullet, 2013; Lamonaca et al., 2021), while there is paucity of studies focusing on agri-food GIs, specifically. To this regard, a recent study by Henry (2023) suggested the chance for agricultural supply relocation as an option to adapt to climate change, even in the case of GI labels. Although this chance is currently excluded outside of the boundaries of the designed geographical area of production, it is still true that – at least in principle - changes in the geographical area of production are admitted as non-minor amendments by Regulation (EU) No 1151/2012 (Article 53). However, according to an analysis of the amendments in the fruit and vegetable sector in the EU by Marescotti et al. (2020), only one out of 81 non-minor amendments until 2018 affected the area of production, justifying the need to enlarge the production area with climate change. Actually, Henry (2023) also stressed the existence of expected negative impact on quality of products, limiting similar relocations.

This research aims to shed new light on local adaptation strategies in the case of agri-food GIs in the Veneto Region (north-eastern Italy), i.e., one of the regions with the highest climate change risk in Italy (ARPAV, 2017). In particular, its objective is to highlight the main factors influencing the decision of producers to counter climate change impact. The main research questions of this study are: What are the main adaptation practices used by producers of agri-food GIs? And what are the main factors influencing the willingness of agri-food GI producers to adapt?

In order to answer these questions, the study is based on a structured online survey, targeted to agri-food GI producers in the case-study area. With the help of primary data, it highlights the main adaptation practices in place as well as the factors influencing the willingness of farmers to implement them (either currently or in the future). Adaptation revolves around the complex interplay of socio-demographic characteristics (e.g., age, education), management characteristics and networking activity, production type, altitude as well as climate change perception itself. To estimate these factors, a multinomial logit model is used. Findings suggest that despite a generalised awareness of climate change, this has not yet turned into widespread decision to implement adaptation measures. Rather, developing peer-to-peer learning practices among farmers and fostering collaborations among those GI systems that face similar risks is of utmost importance.

The paper is structured as follows. Section 2 provides the theoretical background on adaptation to climate change and on the factors affecting adaptation. Section 3 discusses the materials and methods used, by briefly describing the case study area, the sample, data collection and analysis. Section 4 presents the results of the study, while Section 5 discusses them. Section 6 explores the main policy implications of this study and Section 7 concludes.

2. THEORETICAL BACKGROUND: FACTORS OF CLIMATE CHANGE ADAPTATION

Within climate change literature, adaptation is defined as a process of adjustment to current or future climate and its effects, so as to reduce harm or take advantage of some positive opportunities (IPCC, 2014). In agriculture, there are many climate change adaptation measures (e.g., technological and behavioural, reactive and anticipatory; tactical and strategical) (Ingram, 2012). Adaptation options can be grouped into the following categories: cultivars and breed improvements; changing management practices; switching crops, breeds and farming systems; managing water; diversifying agricultural systems; managing fisheries and supply chain options (FAO, 2018). However, in the case of GIs, adaptation is somehow hindered by the PSs, given that they define bounded production areas and well-codified production rules (Thompson and Scoones, 2009). For example, many GIs include the specifications on crop varieties and breeds (Salpina and Pagliacci, 2022a), hence adaptation requires a modification of the code of practices, turning into long and costly authorisation processes (Belletti et al., 2015; Quiñones-Ruiz et al., 2018). However, despite the extensive literature on GI products, just a few studies provide insights into PSs amendments justified by climate change (e.g., Marescotti et al., 2020; Belletti et al., 2015). Thus, according to Marescotti et al. (2020), compliance with the PSs might be more difficult to attain due to climate change, which would limit adaptation options.

Overall, scholars distinguish between two types of adaptation processes (i.e., incremental and transformational), based on the expected complexity of their implementation, their costs, expected risks, and the number and heterogeneity of the different stakeholders who are engaged (Howden et al., 2010). Incremental adaptation refers to short-term measures implemented at local level based on farmers' knowledge and experience (e.g., introduction of rain covers). Transformational adaptation refers to long-term measures implemented at a larger spatial scale (region, state), suitable when impact intensity is high (e.g., changes in the boundaries of the production area). FAO (2007) also distinguishes between 1) autonomous or on-farm adaptation, i.e., the reaction of a single farmer to climate change; and 2) planned adaptation, as policy options or response strategies, which modify adaptive capacity or ease the introduction of given adaptation strategies. Being GIs "social constructions" (Belletti et al., 2017), both types of adaptation matter, involving both single producers and broader managing authorities. In particular, the understanding of both incremental (autonomous) and transformational (planned) methods of adaptation is crucial for the agri-food sector (Ingram, 2012; Fedele et al., 2019). The transformational or planned adaptation is usually influenced by the socio-economic and political structure of a given country or region. However, at farm level, the factors behind climate change adaptation can vary considerably.

In the case of GIs, these factors can be grouped into four areas: socio-demographic characteristics of producers, farm management and networks; product characteristics; climate change magnitude and its perception.

Socio-demographic characteristics. Studies on climate change adaptation usually claim that a number of socio-demographic variables influence the development and the transmission of innovations at the farm level, including age (Morel and Cartau, 2023), sex (Zamasiya et al., 2017) and education level (Guo et al. 2021). These factors affect the absorptive capacity of farmers towards innovations and the introduction of new agricultural practices, including adaptation to climate change, making easier the acquisition, assimilation, use, and transformation of external knowledge in the decision making process (Asrat and Simane, 2018; Abdala et al., 2022).

Farm management and networks. Besides socio-demographic characteristics of producers, other characteristics of the farm management matter, as well as the networks in which a farm is involved (Below et al. 2012; Khan et al., 2020; Gao et al., 2022). With regard to management practices, the difference between part-time and full-time farmers is important. Although declining in Europe (Shahzad and Fischer, 2022), part-time farming is still present, hence affecting the decisions about climate change adaptation. Full-time farmers are more likely to have more information and knowledge on changes in climatic conditions than part-time farmers, hence the former being more prone to adaptation (Maponya and Mpandeli, 2012). This can also be associated with less time dedicated to farm-related activities by a part-time farmer. Also, the presence of formal and informal networks as a part of social capital (Akahoshi & Binotto, 2016), within and outside each single GI system, can explain diffusion of innovation, hence encouraging agri-food GI producers to innovate (Wang et al., 2021). According to Ingram & Kirwan (2011), informal relationships can facilitate the formation of joint ventures for information exchange and business partnerships, and thus accelerate the adaptation in agriculture.

Product characteristics. Adaptation to climate change can be also affected by some characteristics related to the type of production as well as regulatory issues. Firstly, the effects of climate change – hence, the adaptation practices – differ considerably among, e.g., crop-based or animal-based productions (FAO, 2018). Secondly, and in the case of GIs, type of the certification (i.e., either a PDO or a PGI) may influence adaptation to climate change. Actually, the restrictions imposed by each denomination, particularly in terms of size of production area, provenance of raw materials and production processes, are different, with the former being tighter than the latter.

Magnitude and perception of climate change. When addressing climate change-related risks, several studies have claimed that adaptation decisions can depend both on the (measurable) magnitude of climate change and on individual perceptions. Therefore, in the context of adapting to climate change at the farm level, the effectiveness of adaptation measures can depend both on the overall increase of temperature and on farmers' ability to perceive climate-related hazards, evaluating their impact on production. According to many theories aimed at explaining the risk-reducing behaviour of economic agents against natural hazards, different perception of climate change can emphasise subjective aspect in assessing the risks associated with it. For instance, according to the Protection Motivation Theory (PMT), rooted in the theory of planned behaviour (Fishbein and Ajzen, 1975; Grothmann and Reusswig, 2006), individuals' decisions to engage in a protective response against natural hazards are driven, among others, by threat appraisal (also known as 'risk perception'), which encompasses perceived probability and perceived consequences that an individual associates with a certain hazard (Fishbein and Ajzen, 2010; Fahad et al., 2020; Ahmed et al. 2021; Talanow et al., 2021). Similarly, in the case of climate change adaptation strategies, Guo et al. (2021) claimed that perceived temperature change can have a significant impact on farmer's adaptive behaviour. However, it should also be noticed that farmers' perception of climate change is usually aligned with observed real climatic trends in specific regions (Ogalleh et al. 2012; Alam et al., 2017; Bauer et al., 2022).

3. METHODS AND DATA

3.1. Study area

The Veneto Region is located in the North-East of Italy. It is characterised both by several PDOs and PGIs produced in the area, and by large climate change hazard, making this area perfectly suitable for studying adaptation to climate change and for obtaining insights which might be expanded to agricultural areas in other temperate regions of the EU.

Veneto is among the first Italian regions in terms of the economic impact of food GI, which amounted to € 433m in 2021, including about 800 economic agents. In the region, GIs represent 48% of the total agri-food sector (well above the national average, which is equal to 21%) (ISMEA-Qualivita, 2022). Moreover, in the Veneto Region, 36 different agri-food GIs (18 PDOs and 18 PGIs, respectively) can be produced, according to the PSs that set the boundaries for the production of each GI. Among them, there are some of the GIs with the highest production value in Italy, e.g., Grana Padano cheese, Asiago DOP cheese. Moreover, both crop-based GIs and animal-based GIs are produced. Among crop GIs, there are fruits and berries (e.g., cherries, chestnuts), vegetables (e.g. radicchio chicory, asparagus), and olive oil. Animal-based GIs include processed meats (e.g., ham), cheeses, and honey.

At sub-regional level, the production areas mainly concentrate in the NUTS3 regions (*province*, in Italian) of Treviso, Verona, and Vicenza, where some municipalities are eligible for the production of more than 9 different GIs each (Fig. 1).

In addition to the widespread diffusion of GIs, the Veneto Region is also highly prone to climate change (Pagliacci and Salpina, 2022), having experienced a rapid increase in average temperatures (Regione Veneto, 2021), since the 1990s. In particular, when comparing the decades 1961–1970 and 2009–2018, temperature

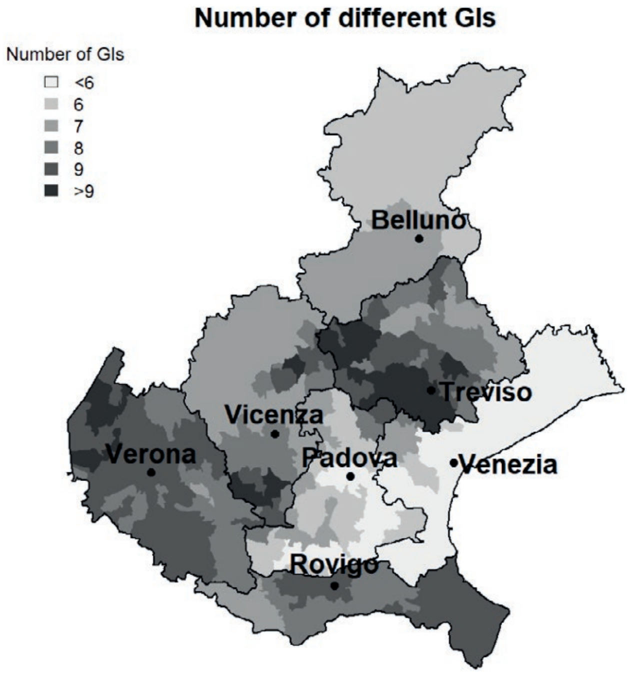

Figure 1. Distribution of the GI production areas across the region.

increase has been large across the entire Veneto region, ranging from a minimum increase of less than +1°C in the plains near the Adriatic Sea to an increase of more than +3°C in some areas of the Alpine region (Pagliacci and Salpina, 2022). In terms of rainfall, there has been a significant change in precipitation patterns. Although the region's annual total precipitation has not changed widely, there has been an increase in both the maximum annual values of short-term rainfall, on the one hand (Sofia et al., 2017), and in the frequency, length, and severity of droughts and related heat spells, on the other (Bonzanigo et al., 2016). In general terms, it can be observed that climate variability has increased, with a large number of extreme events (e.g., heavy rainfall, strong winds, hailstorms…) observed in almost every municipality of the region, in the decade 2010–2020. Given these characteristics, climate change hazard can be considered high across the whole region, with almost all agri-food sectors being largely affected (Pagliacci and Salpina, 2022).

3.2. Data collection

To answer the research questions, primary data was collected using a questionnaire-based online survey administered to agri-food GI producers in the study area.

Consortia or Producer Organisation (POs) helped in identifying respondents. As not all of them agreed upon providing a full list of producers, due to privacy reasons, they were asked to send the questionnaire directly to their members/producers, or alternatively information available online were considered. After a pilot phase (December 2021), the entire survey was administered between January and August 2022. Comprehensively, 183 responses were collected, with 46 of them being discarded after the first data cleaning. Thus, the final database includes data from 137 producers that answered all the questions necessary for the analysis.

Among the respondents, 29 producers of animal-based GIs[1] and 108 producers of crop-based GIs participated in the survey. It is approximately 18% of the overall population of GI producers located in the region[2], excluding the producers of the raw materials. The sample size – ranging from 5 to 15% – can be considered as adequate for a household survey (Bartlett et al., 2001; Alam et al., 2017).

All agri-food GIs factually produced in the region were considered in this study. To further classify them, the current analysis refers to the clusters of agri-food GIs of the Veneto Region identified by Salpina and Pagliacci (2022a) on a broad set of variables (i.e., type of GI, category, total revenue, decade of registration, share of production occurring in the region). Their classification returned six clusters of GIs. Three of them include PDOs only, distinguished according to revenue, territorial concentration at the local level and decade of registration ("Little revenue PDOs"; "Large-scale PDO cheeses"; "Second-generation PDOs"). The remaining clusters include PGIs (the "Unexploited opportunities", namely GIs for which the production in Veneto is actually nil; "First-generation crop PGIs", i.e., early PGIs, with higher revenue; "Second-generation crop PGIs with little revenue", i.e., PGIs with little turnover, more territorially concentrated, and registered more recently) (Salpina and Pagliacci, 2022a). In the current analysis, all the clusters were considered, with the only exception of the 'unexploited opportunities', given that the four meat-based PGIs included are not produced in Veneto. Actually, the focus on clusters, rather than on single products, enables us to provide information that can be useful for GI products

[1] In the case of animal-based GIs, producers of the final products (e.g., cheesemakers) were surveyed, asking them to report also details about their suppliers. Except for a few large dairy companies, often cheesemakers were also milk-producers, hence able to provide first-hand information. Moreover, the answers of a few cheesemakers producing 2 GIs were duplicated.

[2] The total number of producers for all GIs is not available. According to the authors' estimations based on data of Qualivita and numbers provided by Consortia, there are approximately 800 producers of agri-food GIs in the region (around 700 in the case of crop-based, and around 100 for animal-based GIs), excluding the producers of raw materials, i.e., only milk or meat producers.

with similar characteristics (e.g., size of production area, total turnover).

With regard to the contents of the survey, the questionnaire addressed a broad series of topics: farm management and networks, GI production, perception about climate change, implementation of adaptation measures, barriers to adaptation, additional socio-demographic information of the respondents. Some of those questions were used to retrieve some core variables for the econometric model (see the following section 3.3). This includes the questions on socio-demographic characteristics, farm management and network, product characteristics, and climate change perception and adaptation decisions (i.e., those mentioned in the theoretical background section). Additional questions included in the survey were instead used as ancillary variables to enhance the primary findings of the study, through some additional descriptive statistics. Among others, they include the questions on the impact of extreme weather events on agri-food GIs, on adaptation measures implemented or planned to be implemented by producers and on cost-effectiveness evaluation of these measures, as well as on barriers to adaptation.

In particular, the adaptation practices proposed in the questionnaire are based on the results of Salpina and Pagliacci (2022b), who had used semi-structured interviews and focus-group discussions involving managers of Consortia and POs in the same study area to understand how agents involved in agri-food GIs production are adapting to climate change.

3.3. The econometric model

Firstly, preliminary descriptive statistics are analysed, considering: observations on climate change, extreme events and adaptation practices, distinguishing between crop and animal-based GIs.

Secondly, the main drivers of adaptation of GIs producers to climate change are analysed through econometric models. As a dependent variable, the analysis considers the implementation of adaptation strategies by GI producers. In particular, three alternative situations are distinguished: (i) the one in which producers have already implemented adaptation strategies at the farm level; (ii) the one in which producers are willing to implement them in the next future; (iii) the one in which producers neither have implemented them in the past nor are willing to do so in the future.

A set of covariates is considered to analyse the occurrence of the different situations (Table 1). The table bases on the theoretical background presented in Section 2, thus distinguishing the core variables in terms of socio-demographic characteristics of the producers, farm management and networks, production characteristics, magnitude and perception of climate change. Lastly, a control variable (altitude) is considered as well, by distinguishing farms in the lowlands, hills, and mountains.

All these factors affect farmers' decision to implement adaptation strategies. To test this hypothesis, a comprehensive multinomial model is used. In particular, we estimate five different models:

$$Y = \beta_p P + \beta_a A + \varepsilon \quad (1)$$

$$Y = \beta_f F + \beta_a A + \varepsilon \quad (2)$$

$$Y = \beta_d D + \beta_a A + \varepsilon \quad (3)$$

$$Y = \beta_c C + \beta_a A + \varepsilon \quad (4)$$

$$Y = \beta_p P + \beta_f F + \beta_d D_e + \beta_c C + \beta_a A + \varepsilon \quad (5)$$

Where:

- **Y** is the (*n x 3*) matrix, where n = 137 respondents, indicating the alternatives decisions about adaptation (No, Yes, Yes in the future), and assuming the unwillingness to implement any adaptation strategies (both in the past and in the future) as the reference baseline.
- **P** is the (*n x 3*) matrix of the proxies of the socio-demographic characteristics of producers (including age range, sex and education level) and is the (*3 x 1*) vector of respective unknown parameters.
- **F** is the (*n x 2*) matrix of the proxies for farm management (i.e., full-time/part-time activity) and the number of farm adhesions, or networks the farm is involved in, such as POs and associations (e.g., CIA – Confagri) and is the (*2 x 1*) vector of respective unknown parameters.
- **D** is the (*n x 3*) matrix of the proxies for the product characteristics (type of certifications, clusters, and type of product) and is the (*3 x 1*) vector of respective unknown parameters.
- **C** is the (*n x 3*) matrix of the proxies for climate change variables, encompassing both variations in mean temperature between 2009-2018 and 1961-1970, and producer perception of climate change and extreme events in the production area. Additionally, is the (*3 x 1*) vector of respective unknown parameters.
- **A** is the (*n x 1*) vector of control variables about altitude and is the (1 x 1) unknown parameter.
- **ε** is the (n x 1) vector of error terms.

Table 1. Classification of the core variables considered for the analysis of the factors of adaptation.

Factor	Label	Levels (when categorical)
Socio-demographic characteristics	Age	0 = Less than 35
		1 = 35-44
		2 = 45-54
		3 = 55-64
		4 = more than 64
	Sex[a]	1 = Male
	Education level	0 = Elementary school
		1 = Middle school
		2 = High school (agrarian)
		3 = High school (non-agrarian)
		4 = University degree (agrarian)
		5 = University degree (non-agrarian)
Farm management and networks	Farm management	1 = Part-time
	Nr. of adhesions (memberships to different networks)	Continuous
Product characteristics	Cluster, according to Salpina and Pagliacci (2022a)	0 = Custer "Little revenue PDOs"
		1 = Custer "Large-scale PDO cheeses"
		2 = Custer "Second-generation PDOs"
		3 = Custer "First-generation crop PGIs"
		4 = Custer "Second-generation crop PGIs with little revenue"
	Certification type (PDO vs. PGI)	1 = PGI
	Type of the product	1= Crop-based
Climate change	Climate change observation in the production area	1 = Yes
	Observation of extreme events in the production area	1 = Yes
	Long-term temperature change (Difference in °C of the mean temperature of the period 2009-2018 and the mean temperature of the period 1961-1970)[b]	Continuous
Control factor	Altitude	0 = Mountains 1 = Hills 2 = Lowlands

[a] The research uses a binary sex categorisation (male/female), as a set of biological attributes associated with physical and physiological features.
[b] Data refers to the municipality where the producer is located. Data retrieved and adapted by https://climatechange.europeandatajournalism.eu/en/about (see Ferrari and Gjergji, 2020, for further methodological details).

The implementation of the models was performed by using the software R (R Core Team, 2021).

4. RESULTS

4.1. Characteristics of respondents

All the statistics about the socio-demographic characteristics of the producers, farm management, and product type characteristics under consideration in this study are shown in Table 2 and commented in this subsection. The following subsection 4.2 will focus on magnitude and perception of climate change.

With regard to the geographical distribution of the respondents, most of them are from the NUTS-3 regions of Treviso (30%), Verona (23%), and Vicenza (19%) which also host the largest number of agri-food GIs in the region (Fig. 2).

In terms of socio-demographic characteristics of the producers, most of the respondents are young producers. The rate of female respondents (23%) is low, but somehow similar to the share of women who are agricultural holders in the Veneto Region (26% of the total, according to Istat, 2022). The largest share of respondents has a diploma of non-agrarian high school, followed by those with a university degree in non-agricultural field.

With regard to farm management and networks, respondents are mostly full-time farmers, with only 38 out of 137 being part-time farmers. They are small-size farms, 50% of the total cases being family-run. Moreo-

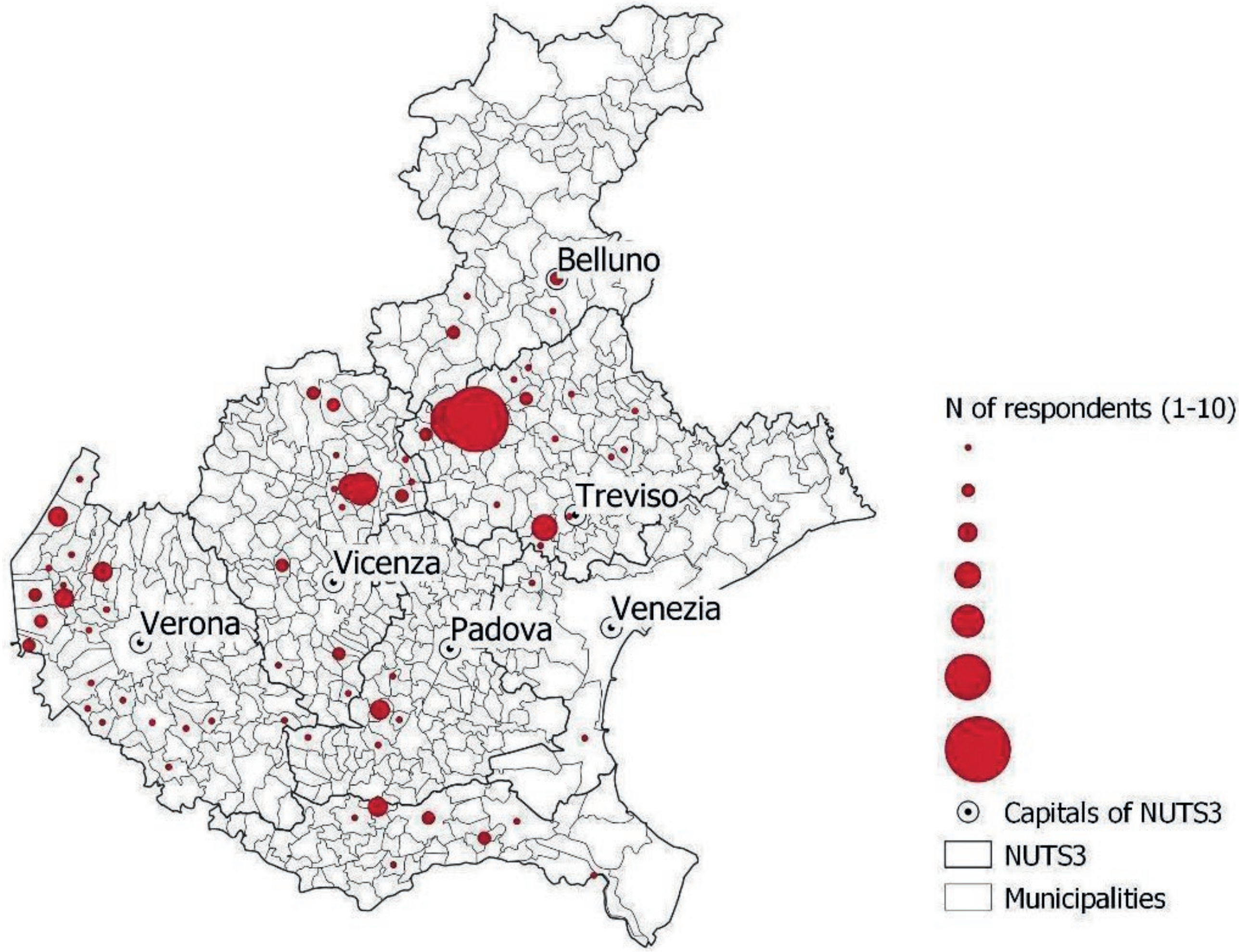

Figure 2. Geographical distribution of the sample.

ver, they are also members of only 1.66 networks on average.

When considering the characteristics of the produced GIs, most respondents are crop-based GI producers (108 out of 137), and PGI producers (63 out of 137). With regard to the 6 GI cluster classification by Salpina and Pagliacci (2022a), most of the respondents belong to the cluster of "Second-generation crop PGIs", "Little revenue PDOs", and "Second-generation PDOs", which include the largest number of agri-food GIs.

4.2. Climate change magnitude and perception and adaptation practices

With regard to climate change, data on long-term temperature change provided by Ferrari and Gjergji (2020) and some of the ancillary variables collected in the survey help to better characterise the sample. On average, the set of the municipality in which the respondents are located have experienced an increase of +2.7 °C, when comparing the period 1961-1970 and the period 2009-2018. Thus, 95% of the respondents producing crop-based GIs and 86% of the respondents producing animal-based GIs had direct experience of climate change in the production area. The main concern for both groups is an increased irregularity of precipitation (80%, on average), followed by temperature increase (72%, on average) (Fig 3). In terms of extreme weather events, 73% of the respondents have directly observed them in their production areas, over the last decade. On average, the impact of the extreme events under consideration in this research is evaluated as medium, except for frost, which seem to have the lowest effect among the respondents. Producers of animal-based GIs reported also a high impact of drought (Table 3).

Table 2. Producer, farm, and production characteristics of the respondents (137 total respondents).

Factor	Label	Levels (when categorical)	Value	Missing values
Socio-demographic characteristics	Age	0 = Less than 35	17	24
		1 = 35-44	25	
		2 = 45-54	30	
		3 = 55-64	19	
		4 = more than 64	22	
	Sex	1 = Male	81	25
	Education level	0 = Elementary school	1	24
		1 = Middle school	20	
		2 = High school (agrarian)	11	
		3 = High school (non-agrarian)	43	
		4 = University degree (agrarian)	10	
		5 = University degree (non-agrarian)	29	
Farm management and networks	Farm management	1 = Part-time	38	38
	Nr. of adhesions (memberships to different networks)	Average number (std. Dev.)	1.66 (1.15)	0
Product characteristics	Cluster, according to Salpina and Pagliacci (2022a)	0 = Custer "Little revenue PDOs"	29	0
		1 = Custer "Large-scale PDO cheeses"	18	
		2 = Custer "Second-generation PDOs"	27	
		3 = Custer "First-generation crop PGIs"	16	
		4 = Custer "Second-generation crop PGIs with little revenue"	48	
	Certification type (PDO vs. PGI)	1 = PGI	63	0
	Type of the product	1= Crop-based	108	0

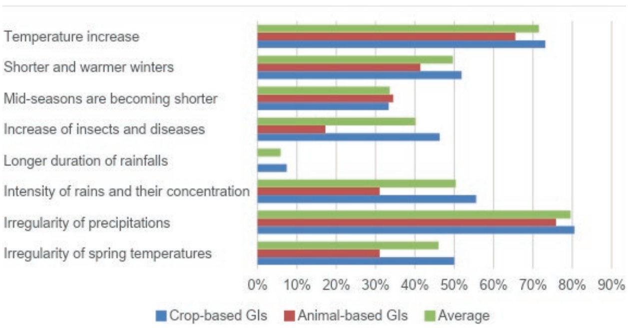

Figure 3. Observations on climate change.

More specifically, among the effects of climate change on crop-based GIs, respondents pointed out the effect on the volume of production and water availability. Conversely, the perceived effect on soil quality is relatively lower. Among animal-based GI producers, the major concern is heat stress, affecting cattle and milk production during summer, with negative consequences in terms of both product quality and quantities produced.

Despite the large and direct experience of climate change, only 24% of the respondents have already adopted some types of adaptation measures to cope with climate change. Moreover, 33% of them are planning to adopt them in the next future.

Among the managerial measures, which are implemented by both crop-based GI producers and animal-based GI producers, insurances (45%) are the most popular anticipatory measures of adaptation, followed by the use of advisory services and training. Among more technical measures (namely, those specific to either crop-based GIs or animal-based GIs), introduction of new crop varieties (49%), followed by increased efficiency of pests (46%), irrigation (45%) and crop rotation (45%) are the ones most mentioned by crop-based GI respondents. As for the producers of animal-based GIs, they mostly opt for barn cooling systems to deal with heat stress of animals (34%), followed by importing forage from outside the production area (21%) (Fig. 4).

In terms of costs and effectiveness of adaptation measures, the ranking for managerial and technical adaptation measures of crop-based GIs is quite heterogeneous. For crop-based GIs, introduction of new irrigation systems and increased efficiency of pesticides were attributed the highest scores in terms of cost/effectiveness ratio (3.6/5.0), whereas pest increase received the lowest score (2.1/5.0). For animal-based GIs, the lowest

Table 3. Average impact of extreme weather events on agri-food GIs (as evaluated by producers, scale from 1 to 5)

	Impact (Yes)	Drought	Frost	Hailstorm	Heavy rainfall/ Flood	Insects/ diseases outbreaks
Crop-based GIs	84/108	3.1	2.6	3.3	3.0	3.4
Animal-based GIs	16/29	3.7	2.3	3.5	3.1	3.3
Average	100/137	3.2	2.5	3.3	3.0	3.4

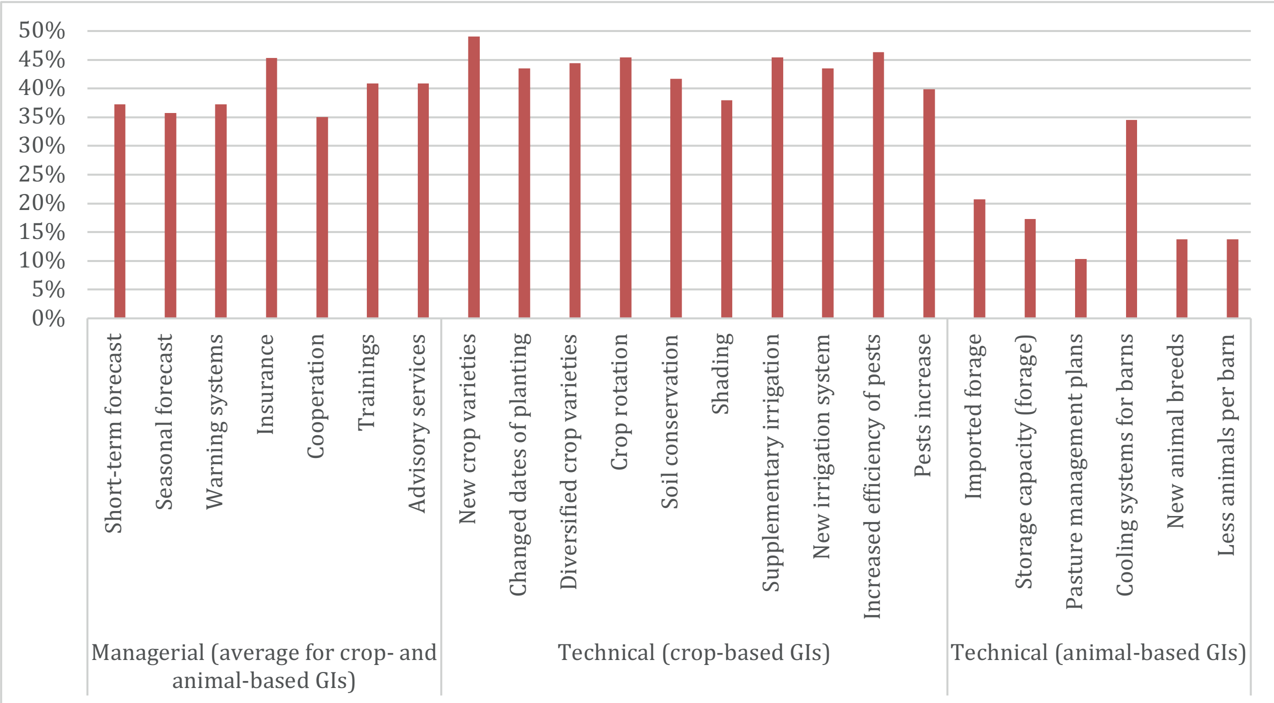

Figure 4. Adaptation methods implemented or planned to be implemented by producers of agri-food GIs.

score is for pasture management plans (1.0/5.0), while the highest one is for barn cooling systems (3.8/5.0) (Table 4).

4.3. Drivers affecting climate change adaptation

The factors influencing farmer willingness to implement adaptation measures are analysed under models (1)-(5) admitted in this study. Table 5 returns the results of these models.

In (1), which includes sociodemographic variables, education plays an important role. As expected, the respondents with a high school degree in agriculture show a greater willingness to adapt (either in terms of already-implemented adaptation strategies or in terms of future adaptation). Conversely, age is never significant. In (2), part-time management negatively affects adaptation decisions, while larger number of adhesions to associations and other sectoral networks couples with a higher probability of having already introduced some forms of adaptation practices. When considering production features, in (3), no covariates are significant. In (4), direct perception of the effects of climate change plays a major role in driving adaptation decisions, while, as an unexpected result, an increase in average temperature in the production areas shows a negative coefficient. Lastly, when considering all covariates jointly, in (5), education level remains the main factor influencing on-farm adaptation to climate change. In particular, education in agrarian field is positively associated with adaptation strategies. It is also confirmed that part-time farmers are less willing to undertake adaptation measures. As for GI products, "large-scale PDO cheeses" (Cluster 2) show negative coefficients, in

Table 4. Average score of adaptation measures (as evaluated by producers, scale from 1 to 5).

Managerial methods of adaptation (average)	
Short-term forecast	3.0
Seasonal forecast	2.7
Warning systems	2.9
Insurance	3.2
Cooperation	2.7
Trainings	3.4
Advisory services	3.0
Involvement of external actors	2.7
Adaptation measures for crop-based GIs	
New crop varieties	2.8
Changed dates of planting	2.6
Diversified crop varieties	3.5
Crop rotation	3.5
Soil conservation	2.8
Shading	2.5
Supplementary irrigation	3.6
New irrigation system	3.6
Increased efficiency of pests	3.6
Pests increase	2.1
Adaptation measures for animal-based GIs	
Imported forage	2.3
Storage capacity (forage)	2.2
Pasture management plans	1.0
Cooling systems for barns	3.8
New animal breeds	2.8
Less animals per barn	2.0

terms of both current and future adaptation to climate change. Similarly, when considering the type of GIs, producers of crop-based GIs are less willing to adapt than those of animal-based GIs, both when considering already existing adaptation strategies and future ones. Nevertheless, adaptation to climate change remains significant among producers that do observe climate change in their production areas. In addition, altitude of the production areas only shows a small effect, suggesting a negative relation between flatland locations and adaptation strategies.

Table 5 also shows the results of the McFadden test (Hausman and McFadden, 1984), the Akaike Information Criterion (Sakamoto et al., 1986), and the Bayesian information criterion (Schwarz, 1978), computed for each model. Although the computed tests do not point to the full model (5), however it is the one with the largest accuracy ratio.

5. DISCUSSION

This study offered important insights into the extent of adaptation to climate change in the case of the high quality agri-food GIs of the Veneto Region (Italy). The results show that agri-food GI producers are highly aware of climate change, having experienced both its direct and indirect impacts. In the case of animal-based GI productions, mainly indirect impacts of climate change are observed (e.g., alteration in fodder quality and quantity). In the case of crop-based products, the spectrum of direct impacts seems to be larger. However, although producers are perfectly aware of climate change and of its effects on GI production, adaptation has not reached its full potential among them. Only 50% of the respondents have already adapted to climate change or are expressing their willingness to do so in the next future. In particular, their decisions seem to be driven by a large number of factors.

All the different types of admitted drivers (i.e., socio-demographic characteristics of producers, farm management, type of product, climate change observation) matter in predicting adaptation measures at the farm level. Producers with an educational degree related to agriculture, who adhere to sectoral networks, and who perceive more directly climate change in their production area tend to be more willing to adapt to climate change. These findings are consistent with previous studies that claim the critical role played by risk perceptions (Fishbein and Ajzen, 2010; Grothmann and Reusswig, 2006; Menapace et al., 2015; Hasan and Kumar, 2019; Zagaria et al., 2021), involvement in social networks (Bairagi et al., 2021; Bazzana et al., 2022) and education (Muench et al., 2021; Guo et al. 2021), when explaining adaptation attitudes. The counterintuitive negative relationship between magnitude of climate change and willingness to implement adaptation strategies (as observed in just one of the selected models) might be explained with the intuition that further decreases in economic profitability, due to global warming, could make any adaptation investments too costly compared to any potential future benefits.

However, among the most interesting findings, rigidity of the PS deserves specific attention. Indeed, it can be observed that some of the adaptation practices implemented by conventional farmers, either in Italy (Bonzanigo et al., 2016) or elsewhere (Song et al., 2019; Antwi-Agyei et al., 2021; Nor Diana et al., 2022), are also adopted by some of the producers of agri-food GIs in the Veneto Region. This is the case, for example, of some varietal improvements as well as by the introduction of barn cooling systems. The main difference in adap-

Table 5. Results of the models.

	(1)		(2)		(3)		(4)		(5)	
	Yes	Future	Yes	Future	Yes	Future	Yes	Future	Yes	Future
Sex (Male)	0.890	0.246							1.731	0.649
	(0.633)	(0.575)							(1.097)	(0.861)
Age (35-44)	-0.155	0.872							1.468	1.491
	(0.938)	(0.969)							(1.375)	(1.230)
Age (45-54)	0.245	1.592							0.803	1.900
	(0.956)	(0.983)							(1.393)	(1.262)
Age (55-64)	-0.118	0.768							1.302	0.782
	(0.983)	(1.023)							(1.608)	(1.443)
Age (over64)	-0.493	-0.156							0.034	0.055
	(0.893)	(1.023)							(1.494)	(1.232)
Education (Middle)	15.073***	12.502***							-	-
	(0.678)	(0.653)								
Education (High non-agrarian)	16.046***	13.403***							2.403*	1.792
	(0.456)	(0.458)							(1.417)	(1.172)
Education (High agrarian)	50.949***	49.297***							41.679***	42.209***
	(0.361)	(0.361)							(0.652)	(0.652)
Education (University non-agrarian)	14.830***	12.654***							1.021	2.380*
	(0.543)	(0.503)							(1.601)	(1.328)
Education6 (University agrarian)	17.094***	14.883***							1.840	2.804
	(0.976)	(0.966)							(1.841)	(1.726)
Farm management (Part-time)			-2.598***	-1.677***					-3.724***	-2.400**
			(0.755)	(0.643)					(1.173)	(1.033)
Nr. of adhesions			0.564*	0.244					0.514	-0.030
			(0.301)	(0.283)					(0.384)	(0.375)
Clusters CL2					0.994	1.316			-13.671***	-12.405***
					(1.164)	(1.230)			(1.588)	(1.543)
Clusters CL3					0.220	0.191			-0.611	1.232
					(0.750)	(0.748)			(1.580)	(1.491)
Clusters CL5					0.190	0.362			-1.094	-0.452
					(0.609)	(0.561)			(0.870)	(0.855)
Clusters CL6					-0.597	-0.444			0.211	0.419
					(0.458)	(0.412)			(0.739)	(0.673)
Certification type (PGI)					-0.408	-0.082			-0.883	-0.033
					(0.468)	(0.437)			(0.760)	(0.660)

(Continued)

Table 5. (Continued).

	(1)		(2)		(3)		(4)		(5)	
	Yes	Future	Yes	Future	Yes	Future	Yes	Future	Yes	Future
Type (crop)					0.950	1.431			-10.467***	-10.939***
					(0.868)	(0.950)			(1.419)	(1.416)
Climate change observation (Yes)							1.889*	0.731	7.088***	4.506***
							(1.047)	(1.002)	(1.675)	(1.519)
Observation of extreme events (Yes)							-0.007	0.767	-0.062	1.334
							(0.709)	-0.783	(1.355)	(1.326)
Long-term temperature change							-1.471**	-0.624	-1.494	0.146
							(0.735)	(0.695)	(1.238)	(1.106)
Altitude (hills)	-0.312	-0.121	-1.136	-1.006	-0.463	-0.399	0.278	-0.266	-1.277	-1.545
	(0.856)	(0.801)	(0.937)	(0.820)	(0.860)	(0.820)	(0.870)	(0.771)	(1.462)	(1.342)
Altitude (lowlands)	-0.094	-0.093	-1.746*	-1.445	0.276	0.015	0.061	-0.351	-2.572*	-1.920
	(0.880)	(0.829)	(1.020)	(0.917)	(0.840)	(0.804)	(0.840)	(0.758)	(1.388)	(1.280)
Constant	-16.063***	-13.910***	1.382	1.814*	-0.606	-0.872	1.889*	0.731	7.088***	4.506***
	(1.033)	(1.012)	(1.109)	(1.021)	(1.085)	(1.137)	(1.047)	(1.002)	(1.675)	(1.519)
Obs.	106		93		115		99		86	
AIC	253.56		196.86		273.61		229.16		218.17	
BIC	322.81		222.18		317.53		255.11		321.25	
McFadden	0.13		0.13		0.04		0.04		0.29	
Accuracy	53.77		49.46		49.57		42.42		63.95	

Notes: statistically significant *p<0.1; **p<0.05; ***p<0.01.

tation strategies between agri-food GI producers and conventional ones is the existence of regulative barriers imposed by PSs. However, the fact that the certification type (i.e., producing either a PDO or a PGI) is never significant might suggest that rigidity of code of practices (i.e., more stringent PSs in the case of PDOs than in the case of PGIs) is not a big issue in climate change adaptation for GI producers. This finding seems to be supported also by the analysis of the main barriers, according to the respondents' perspectives (Table 6). Indeed, the restriction imposed by PSs is one of the least perceived concerns by producers, who are worried much more by the lack of financial resources or by difficulties in having access to public funds (e.g., those of the Rural Development Policy). Moreover, information issues seem to play a key role in the adaptation process.

Similarly, to what is observed across Europe (Simonet and Leseur, 2019) or elsewhere (Alam et al., 2017; Belay et al., 2022), the economic aspect of adaptation is proved to matter, as on-farm adaptation mostly relies on producers' own resources. On top of that, there is an issue of uncertainty, associated with the high cost of investments, and with the uncertain long-term benefits. In other words, uncertain future costs of climate risks compared to the certain and immediate costs of adaptation measures together with uncertain expected returns on investment represent one of the major barriers to climate change adaptation (Lefebvre et al., 2014), also in the case of agri-food GI producers.

Table 6. Barriers to climate change adaptation, as perceived by producers of agri-food GIs (as evaluated by producers, scale from 1 to 5).

Barriers (Number of respondents)	Adaptation			
	No (40)	Yes (33)	Yes_ future (45)	Total (118)
Lack of financial resources	3.6	3.1	3.9	3.6
High cost of investments and long-term benefits	3.9	3.2	3.5	3.5
Accession to RDP funds	3.6	3.9	3.8	3.7
Long waiting time for the accession RDP funds	3.8	3.5	3.9	3.7
Lack of technical assistance	3.4	3.0	3.4	3.3
Lack of information on effectiveness of certain adaptation measures	3.8	3.5	3.8	3.7
Restriction imposed by PSs	3.5	3.1	3.2	3.3
Land property	2.8	2.4	2.8	2.6
Lack of local and production networks	2.1	2.8	2.5	2.5
Lack of producers' representation in the decision-making process	3.3	3.3	3.3	3.3

The barriers discussed above couple with external factors, mainly involving policy and governance issues: observed complexity in having access to public funds, a lack of technical assistance in obtaining such help, market dynamics and the current geo-political conditions. In this context, climate change adaptation, which is of utmost importance given the impacts already affecting GI farmers and producers, seems to require specific policy interventions.

6. POLICY IMPLICATIONS

The results of this study represent an important contribution, not only to inform policymakers at regional level (i.e., in the Veneto Region), but also for national and EU policymakers and stakeholders. Indeed, the results of this study are highly generalizable in terms of suggested approach and adopted empirical strategy. In particular, the suggested strategy, distinguishing three alternative situations (farmers who have implemented adaptation strategies; farmers intending to implement them in the future; and farmers neither having implemented nor willing to do so in the future) holds promise for delivering a relatively elevated degree of accuracy and interpretability, also when implemented in other case studies.

Moreover, the results suggest that the main policy instruments for high-quality agri-food products might be largely improved across the EU. Firstly, a more targeted support within the new Common Agricultural Policy (2023–2027) will largely help. This is true also in a region such as Veneto, where in the 2014-2020 programming period just 1.5% of the total funds of the Rural Development Programme was earmarked to the measure aimed at supporting quality schemes (i.e., measure 03).

Besides a larger public fund allocation, in this context, reliability of new technologies and clear information regarding their effectiveness might help. This will provide new incentives to the producers of agri-food GI, when considering their options of investing in new adaptation measures to climate change. Moreover, it could also be helpful developing peer-to-peer learning practices among producers together with fostering further collaborations among GI systems that face similar risks. Indeed, the role of public policies is not limited to allocation of financial resources to prevent the financial barriers of adaptation, but it can also ease knowledge transfer (Ignaciuk, 2015), fostering collaborations between farms and Consortia, and across sectors (e.g., public and private). To this regard, the framework of Agricultural Knowledge and Innovation Systems (AKIS) could be strengthened, in terms of a multi-stakeholder process (Cruz Maceín et al., 2023). Analogously, also the functions of Consortia and POs could be strengthened to better facilitate the coordination among the stakeholders for the implementation of adaptation strategies at GI level. These entities, which frequently offer advisory support, can serve as innovation intermediaries, cooperating with research organisations (Salpina and Pagliacci, 2022b) and facilitating horizontal and vertical diffusion of information. Thus, Consortia and POs can play a pivotal role in sustaining adaptation efforts, and guide farmers in investing in new adaptation measures. Lastly, the findings of this empirical study hold the potential to contribute significantly to international discourse surrounding food policy, by providing an in-depth examination of climate change adaptation practices within the GI agri-food sector, the policy area that has thus far received limited attention within academic circles.

7. CONCLUSION

This study aimed at analysing climate change adaptation strategies in the case of high-quality agri-food sector, shedding light on the main factors influencing the decision of producers to adapt. In the past, this topic was largely neglected in the literature. Actually, to the authors' best knowledge, only a few other studies have already focused on the topic of climate change adaptation, taking agri-food GIs into consideration. The key findings of the research suggest that despite a generalised (and high) awareness of climate change among GI farmers and producers, this has not yet turned into widespread adoption of adaptation measures. The main factors influencing the willingness of producers are confirmed to revolve around the complex interplay of socio-demographic characteristics (e.g., age, education), farm management and networks, and production characteristics, in addition to the perception of climate change.

Despite the potential limitations of any online surveys (e.g., some bias in respondents' characteristics, in favour of younger and more educated ones), further studies could eventually replicate the questionnaire-based survey in other countries and regions, making use of the same methods proposed here. Moreover, it should be noticed that this study encompassed the certified agri-food sector in general. Thus, future works, focusing on a specific sector (e.g., only cheese products), would allow for a more targeted examination of key variables affecting climate change adaptation. One additional limitation of this study is the absence of a comparison between farmers operating within GI schemes and the ones operating outside such schemes. However, such a limitation was due to the complexity of such a comparison and mostly to the data collection process, which was primarily done through Consortia and POs. Future research will eventually address this gap, providing valuable insights into this phenomenon. Moreover, future lines of research will also involve the analysis of the drivers contributing to the adoption of specific adaptation measures and will consider additional and more sophisticated proxies for climate change perception.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the financial support from the project "What if the terroir moves under our feet? Addressing the effects of climate change on the use of geographical indications for agri-food products in Veneto, Italy" (PAGL_BIRD20_05 - BIRD 3 2020/2022 research grant). Project financed with BIRD 2020 funds, Department TESAF, University of Padova - Italy. The authors thank the editor and the anonymous referees for their precious suggestions that have led to a great improvement in the overall quality of the paper.

REFERENCES

Abdala, R.G., Binotto, E., Borges, J.A.R. (2022). Family farm succession: evidence from absorptive capacity, social capital and socioeconomic aspects. *Revista de Economia e Sociologia* Rural, 60(4), E235777. https://doi.org/10.1590/1806-9479.2021.235777

Ahmed, Z., Guha, G.S., Shew, A.M., Alam, G.M. (2021). Climate change risk perceptions and agricultural adaptation strategies in vulnerable riverine char islands of Bangladesh. *Land Use Policy* 103, 105295. https://doi.org/10.1016/j.landusepol.2021.105295.

Akahoshi, W.B., Binotto, E. (2016). Cooperativas e capital social: caso da Copasul, Mato Grosso do Sul. *Gestão & Produção* 23(1), 104-117. https://doi.org/10.1590/0104-530X532-13.

Alam, G.M.M., Alam, K., Mushtaq, S. (2017). Climate change perceptions and local adaptation strategies of hazard-prone rural households in Bangladesh. *Climate Risk Management* 17, 52-63. https://doi.org/10.1016/j.crm.2017.06.006.

Antwi-Agyei, P., Nyantakyi-Frimpong, H. (2021). Evidence of Climate Change Coping and Adaptation Practices by Smallholder Farmers in Northern Ghana. *Sustainability* 13, 1308. https://doi.org/10.3390/su13031308.

ARPAV (2017). A proposito di cambiamenti climatici (seconda edizione). Available at: https://www.arpa.veneto.it/arpavinforma/pubblicazioni/a-proposito-di-.-cambiamenti-climatici-seconda-edizione (last accessed on 18th December 2022).

Asrat, P., Simane, B. (2018). Farmers' Perception of Climate Change and Adaptation Strategies in the Dabus Watershed, North-West Ethiopia. *Ecological Processes* 7, 7. https://doi.org/10.1186/s13717-018-0118-8.

Bairagi, S., Bhandari, H., Das, S.K., Mohanty, S. (2021). Flood-tolerant rice improves climate resilience, profitability, and household consumption in Bangladesh. *Food Policy*, 105, 102183. https://doi.org/10.1016/j.foodpol.2021.102183

Bartlett, J.E., Kotrlik, J.W., Higgins, C.C. (2001). Organizational research: determining appropriate sample size in survey research. *Information Technology, Learning, and Performance Journal* 19(1), 43–50.

Bauer, T.N., De Jong, W., Ingram. V. (2022). Perception matters: An Indigenous perspective on climate change and its effects on forest-based livelihoods in the Amazon. *Ecology and Society* 27(1), 17. https://doi.org/10.5751/ES-12837-270117.

Bazzana, D., Foltz, J.D., Zhang, Y. (2022). Impact of climate smart agriculture on food security: An agent-based analysis. *Food Policy*, 111, 102304. https://doi.org/10.1016/j.foodpol.2022.102304

Belay, A., Oludhe, C., Mirzabaev, A., Recha, J.W., Berhane, Z., Osano, P.M., Demissie, T., Olaka, L.A., Solomon, D. (2022). Knowledge of climate change and adaptation by smallholder farmers: evidence from southern Ethiopia, *Heliyon*, 8(12), e12089. https://doi.org/10.1016/j.heliyon.2022.e12089.

Belletti, G., Marescotti, A., Brazzini, A. (2017). Old World Case Study: The Role of Protected Geographical Indications to Foster Rural Development Dynamics: The Case of Sorana Bean PGI. In: van Caenegem, W., Cleary, J. (Eds.) "The Importance of Place: Geographical Indications as a Tool for Local and Regional Development", 253–276. Springer International Publishing AG

Belletti, G., Marescotti, A., Sanz-Cañada, J., Vakoufaris, H. (2015). Linking protection of geographical indications to the environment: Evidence from the European Union olive-oil sector. *Land Use Policy* 48, 94–106. https://doi.org/10.1016/j.landusepol.2015.05.003.

Below, T.B., Mutabazi, K.D., Kirschke, D., Franke, C., Sieber, S., Siebert, R., Tscherning, K. (2012). Can farmers' adaptation to climate change be explained by socio-economic household-level variables? *Global Environmental Change* 22, 223–235. https://doi.org/10.1016/j.gloenvcha.2011.11.012.

Bonzanigo, L., Bojovic, D., Maziotis, A., Giupponi, C. (2016). Agricultural policy informed by farmers' adaptation experience to climate change in Veneto, Italy. *Regional Environmental Change* 16, 245–258. https://doi.org/10.1007/s10113-014-0750-5.

Bro, A.S. (2020). Climate Change Adaptation, Food Security, and Attitudes toward Risk among Smallholder Coffee Farmers in Nicaragua. *Sustainability* 12, 6946. https://doi.org/10.3390/su12176946.

Cruz Maceín, J.L., Gonzalez-Fernandez, I., Barrutieta, A. et al. (2023) Adaptation strategies for dealing with global atmospheric change in Mediterranean agriculture: a triple helix approach to the Spanish case study. Regional Environmental Change 23, 142. https://doi.org/10.1007/s10113-023-02131-1

Deressa, T.T., Hassan, R.M., Ringler, C., Alemu, T., Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change*, 19(2), 248-255. https://doi.org/10.1016/j.gloenvcha.2009.01.002.

Fahad, S., Inayat, T., Wang, J., Dong, L., Hu, G., Khan, S., Khan, A. (2020). Farmers' awareness level and their perceptions of climate change: A case of Khyber Pakhtunkhwa province, Pakistan. *Land Use Policy* 96, 104669. https://doi.org/10.1016/j.landusepol.2020.104669.

FAO (2007). Adaptation to climate change in agriculture, forestry and fisheries: Perspective, framework and priorities, Rome. https://www.fao.org/3/au030e/au030e.pdf (last accessed on 18th December 2022).

FAO (2018). Climate Smart Agriculture Sourcebook, CSA E-Learning modules. FAO. https://www.fao.org/climate-smart-agriculture-sourcebook/production-resources/en/ (last accessed on 18th December 2022).

Fedele, G., Donatti, C.I., Harvey, C.A., Hannah, L., Hole, D.G. (2019). Transformative adaptation to climate change for sustainable social-ecological systems. *Environmental Science & Policy* 101, 116–125. https://doi.org/10.1016/j.envsci.2019.07.001.

Ferrari, L., Gjergji, O. (2020). Il riscaldamento climatico in Europa, comune per comune. In: European Data Journalism Network. Available at: https://www.europeandatajournalism.eu/ita/Notizie/Data-news/Il-riscaldamento-climatico-in-Europa-comune-per-comune (last accessed on 19th December 2022).

Fishbein, M., Ajzen I. (1975). *Beliefs, attitude, intention and behaviour*. Addison-Wesley: Reading, MA.

Fishbein, M., Ajzen, I. (2010). *Predicting and Changing Behavior: The Reasoned Action Approach*. Psychology Press: New York, NY, USA. https://doi.org/0.4324/9780203838020.

Gao, J., Shahid, R., Ji, X., Li, S. (2022). Climate change resilience and sustainable tropical agriculture: Farmers' perceptions, reactive adaptations and determinants of reactive adaptations in Hainan, China. *Atmosphere* 2022 13, 955. https://doi.org/10.3390/atmos13060955.

Giacomini, C., Mancini, M.C. (2015). Organisation as a key factor in Localised Agri-Food Systems (LAFS). *Bio-Based and Applied Economics* 4(1), 17-32. https://doi.org/10.13128/BAE-15088.

Grothmann, T. and Reusswig, F. (2006). People at Risk of Flooding: Why Some Residents Take Precautionary Action While Others do not. Natural Hazards, 38: 101–120. DOI 10.1007/s11069-005-8604-6

Guo, R., Li, Y., Shang, L., Feng, C., Wang, X. (2021). Local farmer's perception and adaptive behavior toward climate change. *Journal of Cleaner Production* 287, 125332. https://doi.org/10.1016/j.jclepro.2020.125332.

Hausman, J.A., McFadden, D. (1984). A Specification Test for the Multinomial Logit Model, *Econometrica* 52, 1219–1240.

Hasan, M. K., Kumar, L. (2019). Comparison between meteorological data and farmer perceptions of climate change and vulnerability in relation to adaptation, *Journal of Environmental Management*, 237, 54-62. https://doi.org/10.1016/j.jenvman.2019.02.028.

Henry, L. (2023). Adapting the designated area of geographical indications to climate change. *American Journal of Agricultural Economics* 105, 1088-1115. https://doi.org/10.1111/ajae.12358.

Howden, S., Crimp, S., Nelson, R. (2010). Australian agriculture in a climate of change. In Proceedings of Greenhouse 2009 Conference, Perth, Australia, 23–26 March 2009, CSIRO Publishing, Collingwood, Australia, 101–111.

Ignaciuk, A. (2015). Adapting Agriculture to Climate Change: A Role for Public Policies, OECD Food, Agriculture and Fisheries Papers, No. 85, OECD Publishing, Paris. https://doi.org/10.1787/5js08hwvfnr4-en.

Ingram, J. (2012). Agricultural adaptation to climate change: New approaches to knowledge and learning. In Climate change Impact and Adaptation in Agricultural Systems. Wallingford (UK): CAB International, 253–270.

Ingram, J., Kirwan, J. (2011). Matching new entrants and retiring farmers through farm joint ventures: Insights from the Fresh Start Initiative in Cornwall, UK. *Land Use Policy* 28(4), 917-927. https://doi.org/10.1016/j.landusepol.2011.04.001.

IPCC (2014). Annex II: Glossary. IPCC: Geneva (CH). https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf (last accessed on 20th December 2022).

Ismea-Qualivita (2022). Rapporto sulle produzioni agroalimentari e vitivinicole italiane DOP IGP STG. Fondazione Qualivita, Siena, Italia. https://www.qualivita.it/osservatorio/rapporto-ismea-qualivita/#toggle-id-1 (last accessed on 18th December 2022).

Istat (2022). 7° Censimento generale dell'agricoltura: Integrazione dei primi risultati: https://www.istat.it/it/archivio/273753.

Khan, I., Lei, H., Shah, I.A., Ali, I., Khan, I., Muhammad, I., Huo, X., Javed, T. (2020). Farm households' risk perception, attitude and adaptation strategies in dealing with climate change: Promise and perils from rural Pakistan. *Land Use Policy* 91, 104395. https://doi.org/10.1016/j.landusepol.2019.104395.

Lamonaca, E., Santeramo, F. G., & Seccia, A. (2021). Climate changes and new productive dynamics in the global wine sector. Bio-Based and Applied Economics, 10(2), 123–135. https://doi.org/10.36253/bae-9676

Lefebvre, M., De Cuyper, K., Loix, E., Viaggi, D., Gomez, Y., Paloma, S. (2014). European farmers` intentions to invest in 2014-2020: survey results. EUR 26672. Luxembourg: Publications Office of the European Union, JRC90441. https://doi.org/10.2791/82963.

Lereboullet, A-L. (2013). How do Geographical Indications interact with the adaptive capacity and resilience of viticultural systems facing global change? [Conference Short Paper] 25th ESRS Congress. 29 July – 1 August 2013, Florence, Italy, 331-332

Maponya, P., Mpandeli, S. (2012). Climate Change and Agricultural Production in South Africa: Impacts and Adaptation options. *Journal of Agricultural Science* 4(10), 48-60. https://doi.org/10.5539/jas.v4n10p48.

Marescotti, A., Quiñones-Ruiz, X.F., Edelmann, H., Belletti, G., Broscha, K., Altenbuchner, C., Penker, M., Scaramuzzi, S. (2020). Are Protected Geographical Indications Evolving Due to Environmentally Related Justifications? An Analysis of Amendments in the Fruit and Vegetable Sector in the European Union. *Sustainability* 12(9), 3571. https://doi.org/10.3390/su12093571.

Menapace, L., Colson, G., Raffaelli, R. (2015). Climate change beliefs and perceptions of agricultural risks: An application of the exchangeability method. *Global Environmental Change* 35, 70-81. https://doi.org/10.1016/j.gloenvcha.2015.07.005.

Mitter, H., Larcher, M., Schönhart, M., Schmid, E. (2019). Exploring Farmers' Climate Change Perceptions and Adaptation Intentions: Empirical Evidence from Austria. *Environmental Management* 63, 804–821. https://doi.org/10.1007/s00267-019-01158-7.

Morel, K., Cartau, K. (2023). Adaptation of organic vegetable farmers to climate change: An exploratory study in the Paris region. *Agricultural Systems*, 210. 103703. https://doi.org/10.1016/j.agsy.2023.103703

Muench, S., Bavorova, M., Pradhan, P. (2021). Climate Change Adaptation by Smallholder Tea Farmers: A Case Study of Nepal. *Environmental Science & Policy* 116, 136-146. https://doi.org/10.1016/j.envsci.2020.10.012.

Nor Diana, M.I., Zulkepli, N.A., Siwar, C., Zainol, M.R. (2022). Farmers' Adaptation Strategies to Climate Change in Southeast Asia: A Systematic Literature Review. *Sustainability* 14, 3639. https://doi.org/10.3390/su14063639.

Ogalleh, S.A., Vogl, C.R., Eitzinger, J., Hauser, M. (2012). Local Perceptions and Responses to Climate Change and Variability: The Case of Laikipia District, Kenya. *Sustainability* 4(12), 3302-3325. https://doi.org/10.3390/su4123302.

Owen, L., Udall, D., Franklin, A., Kneafsey, M. (2020). Place-Based Pathways to Sustainability: Exploring Alignment between Geographical Indications and the Concept of Agroecology Territories in Wales. *Sustainability* 12, 4890. https://doi.org/10.3390/su12124890

Pagliacci, F., Salpina D. (2022). Territorial hotspots of exposure to climate disaster risk. The case of agri- food geographical indications in the Veneto Region. *Land Use Policy* 123, 106404. https://doi.org/10.1016/j.landusepol.2022.106404.

Quiñones-Ruiz, X., Edelmann, H., Penker, M., Belletti, G., Marescotti, A., Scaramuzzi, S., Broscha, K., Braito, M., Altenbuchner, C. (2018). How are food Geographical Indications evolving? – An analysis of EU GI amendments. *British Food Journal* 120, 1876–1887. https://doi.org/10.1108/BFJ-02-2018-0087.

Rahman, T.H.M., Albizua, A., Soubry, B., Tourangeau, W. (2021). A framework for using autonomous adaptation as a leverage point in sustainable climate adaptation. *Climate Risk Management* 34, 100376. https://doi.org/10.1016/j.crm.2021.100376.

Regione Veneto (SISTAR) (2021). I cambiamenti climatici ormai tangibili. Statistiche Flash. https://statistica.regione.veneto.it/Pubblicazioni/StatisticheFlash/statistiche_flash_ottobre_2021.pdf (last accessed on 20 June 2022).

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Sakamoto, Y., Ishiguro, M., and Kitagawa, G. (1986). Akaike Information Criterion Statistics. D. Reidel Publishing Company.

Salpina, D., Pagliacci, F. (2022a). Contextual vulnerability to climate change of heterogeneous agri-food geographical indications: A case study of the Veneto region (Italy). *Environmental Science & Policy*, 136: 103–113. https://doi.org/10.1016/j.envsci.2022.06.005.

Salpina, D., Pagliacci, F. (2022b). Are We Adapting to Climate Change? Evidence from the High-Quality Agri-Food Sector in the Veneto Region. *Sustainability* 14(18), 11482. https://doi.org/10.3390/su141811482.

Schwarz, G. (1978). Estimating the Dimension of a Model. *The Annals of Statistics* 6(2), 461-464.

Shahzad, M. A., Fischer, C. (2022). The decline of part-time farming in Europe: an empirical analysis of trends and determinants based on Eurostat panel data. *Applied Economics* 54(42), 4812-4824. https://doi.org/10.1080/00036846.2022.2036687.

Simonet, G., Leseur, A. (2019). Barriers and drivers to adaptation to climate change – a field study of ten French local authorities. *Climatic Change* 155, 621–637. https://doi.org/10.1007/s10584-019-02484-9.

Sofia, G., Roder, G., Dalla Fontana, G., Tarolli, P. (2017). Flood dynamics in urbanised landscapes: 100 years of climate and humans' interaction. *Scientific Reports* 7, 40527. https://doi.org/10.1038/srep40527.

Song, C.-X., Liu, R.-F., Les Oxley, Ma, H.-Y. (2019). Do farmers care about climate change? Evidence from five major grain producing areas of China. *Journal of Integrative Agriculture* 18, 1402–1414. https://doi.org/10.1016/S2095-3119(19)62687-0.

Talanow, K., Topp, E.N., Loos, J. Martín-López, B. (2021). Farmers' perceptions of climate change and adaptation strategies in South Africa's Western Cape. *Journal of Rural Studies* 81, 203-219. https://doi.org/10.1016/j.jrurstud.2020.10.026.

Thompson, J., Scoones, I. (2009). Addressing the dynamics of agri-food systems: an emerging agenda for social science research. *Environmental Science & Policy* 12(4), 386–397. https://doi.org/10.1016/j.envsci.2009.03.001.

UNFCCC (2022). Joint work on implementation of climate action on agriculture and food security. Decision -/CP.27, the United Nations Climate Change Conference COP27, Sharm el-Sheikh, 18 Nov 2022 https://unfccc.int/documents/624317 (last accessed on 16th December 2022).

Vandecandelaere, E., Arfini, F., Belletti, G., Marescotti, A. (2010). Linking people, places and products. A guide for promoting quality linked to geographical origin and sustainable Geographical Indications. 2nd edition. FAO, Rome. https://www.fao.org/documents/card/en/c/debded43-9d99-5c74-a440-e8db347941ac (last accessed on 20th December 2022).

Vercelli, M., Novelli, S., Ferrazzi, P., Lentini, G., Ferracini, C. A. (2021). Qualitative Analysis of Beekeepers' Perceptions and Farm Management Adaptations to the Impact of Climate Change on Honey Bees. *Insects* 12, 228. https://doi.org/10.3390/insects12030228.

Wang, W., Zhao, X., Li, H., Zhang, Q. (2021). Will social capital affect farmers' choices of climate change adaptation strategies? Evidences from rural households in the Qinghai-Tibetan Plateau, China. *Journal of Rural Studies* 83, 127-137. https://doi.org/10.1016/j.jrurstud.2021.02.006.

WTO (1994). Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement). https://www.wto.org/english/docs_e/legal_e/27-trips_01_e.htm (last accessed on 20th November 2022).

Zagaria, C., Schulp, C.J.E., Zavalloni, M., Viaggi, D., Verburg, P.H. (2021). Modelling transformational adaptation to climate change among crop farming systems in Romagna, Italy. *Agricultural Systems,* 188. 103024. https://doi.org/10.1016/j.agsy.2020.103024.

Zamasiya, B., Nyikahadzoi, K., Mukamuri, B.B. (2017). Factors influencing smallholder farmers' behavioural intention towards adaptation to climate change in transitional climatic zones: A case study of Hwedza District in Zimbabwe. *Journal of Environmental Management*, 198 (1), 233-239, https://doi.org/10.1016/j.jenvman.2017.04.073.

BAE
Bio-based and Applied Economics

AIEAA
ASSOCIAZIONE ITALIANA DI ECONOMIA AGRARIA E APPLICATA

Citation: Ciliberti, S., Frascarelli, A., Martino, G., & Marchini, A. (2024). Exploring preferences for contractual terms in a scenario of ecological transition for the agri-food sector: a latent class approach. *Bio-based and Applied Economics* 13(3): 285-299. doi: 10.36253/bae-15374

Received: November 20, 2023
Accepted: May 22, 2024
Published: October 16, 2024

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Editor: Francesco Pagliacci, Valentina Raimondi, Luca Salvatici

ORCID
SC: 0000-0001-7833-9547
AF: 0000-0002-8910-7044
GM: 0000-0001-6827-3185
AM: 0000-0001-7358-9133

Exploring preferences for contractual terms in a scenario of ecological transition for the agri-food sector: a latent class approach

Stefano Ciliberti, Angelo Frascarelli*, Gaetano Martino, Andrea Marchini

Department of Agricultural, Food an Environmental Sciences, University of Perugia, Italy
*Corresponding author. E-mail: angelo.frascarelli@unipg.it

Abstract. Governance mechanisms along the agri-food supply chains are increasingly important in a scenario of ecological transition. Under the conceptual and analytical lens of the Transaction Cost Economics, we explored farmers' preferences towards a variety of clauses usually adopted in production contracts. To this purpose, a discrete choice experiment among 190 durum wheat producers in Italy was conducted. Results from a latent class model showed that producers were mainly interested in fixed prices formula and to join shared rules of production but revealed little or no interest for compelling sustainable cultivation techniques and the provision of technical assistance. However, these preferences are heterogeneous across farmers and vary depending on their level of education and previous use of contractual arrangements, with relevant implications for contract design and management.

Keywords: contracts, transition, NIE, latent class analysis, cereals.
JEL Codes: Q13, D23, L14.

INTRODUCTION

There is consensus that the global food system is not delivering as needed on several key metrics, including addressing excessively high rates of hunger and malnutrition, agriculture-driven environmental footprint, unequal distribution of welfare along supply chains, among others (McGreevy et al., 2022). A more recent movement has called attention to the fact that such problems may be better addressed when implementing an ecological transition in food system to respond to shocks and crises stemming from conventional food systems. Cholez et al. (2017) posit that an examination of contractual frameworks is pivotal during this transition, as they can adeptly navigate uncertainties and simultaneously provide clear demarcations of property and decision rights in emerging supply chains. Taken as a whole, this literature highlights the importance of governance considerations for the agro-ecological transition.

Over the last decade production contracts have become increasingly important to enhance coordination along the agri-food supply chain (Mac-

Firenze University Press | www.fupress.com/bae

Donald 2015; Vassalos et al., 2016). They can connect farmers with buyers, reduce uncertainty in prices and demand, provide risk sharing against natural disasters and climate related shocks, and in some cases, provide access to inputs technical assistance (FAO, 2017). However, there are at least two main different types of contracts at stake (marketing and production contracts) which differ for several reasons (Dubbert et al., 2021). While in marketing contracts farmers control their assets and production inputs independently by usually determining price, quantity and delivery conditions to secure sales on market (Soullier and Moustier, 2018), production contracts entail the provision of resources – such as production input supply (e.g. seedlings and fertilizer), credit, and other support like extension services or transport of harvest – and quite often they impose a particular production method or input regime to farmers (Otsuka et al., 2016).

Production contracts represent an organizational solution which has been extensively discussed regarding its potential to resolve market limits. They allow farmers to be integrated into modern agricultural value chains by reducing transaction costs and being provided with inputs, technical assistance and assured against price fluctuations (Schipmann & Qaim, 2011; Swinnen and Maertens, 2007).

This type of contracts increasingly aims to engage farmers in delivering high quality products and contributing to environmental sustainability by reducing the use of chemical fertilisers and pesticides. However, in many situations, farmers are hesitant to use written contracts, likely due the fact that existing informal contracts are deeply rooted in traditional social norms (Jäckering et al., 2021). Moreover, farmers may be reluctant because of the high enforcing costs, especially when formal institutions are not well developed (Michler and Wu, 2020).

To sum up, participating in a contract entails tradeoff between incentives and costs (Bogetoft and Olesen, 2002). For this reason, if the contract design does not include price incentives and provision of inputs, farmers may be discouraged from participating in the arrangements because they must comply with quality and sustainability requirements and other costly specifications (Abebe et al., 2013; Pancino et al., 2019). Moreover, producers may have different views on and experiences with the advantages and disadvantages related to contracts (Widadie et al., 2020). Consequently, two research questions arise: which contractual terms can lead farmers to adopt production contracts in a scenario of ecological transition? Do farms and farmers' characteristic affect acceptance of contractual terms?

In this background, the first aim of this study is to investigate farmers' preferences towards a wide variety of contractual terms usually adopted in production contracts in the context of the Italian durum wheat sector. The second aim is to determine which and whether farmers and farms characteristics affect the probability of accepting the above-mentioned clauses. In doing so, our paper contributes to filling a knowledge gap on the role of heterogeneous farmers' preferences in affecting contract design, offering insights on the potential acceptance of contractual terms in a scenario of ecological transition. This latter imposes a reduction of chemical inputs and a gradual shift from fossil fuels to cut net greenhouse gas emissions in agriculture.

Accordingly, we first elaborate a conceptual and analytical framework about the effects and the potential acceptance for specific clauses in the agri-food context. Material and methods are then described in detail, mainly revolving around a discrete choice experiment carried out among Italian farmers. Lastly, results from latent class logit estimations are presented and discussed in the lights of the existing literature before final remarks and policy recommendations are delivered.

2. STUDY CONTEXT

We focus on a staple food crop of strategic importance for Italy and for many countries bordering the Mediterranean, such as durum wheat. Italy produces half of the durum wheat grown in the EU-28 (UK included) and it is leader both in the per capita consumption of pasta and in its production (Bux et al., 2022).

Durum wheat represents the main cereal crop in Italy covering about 44% of the total cereal area. Cultivation is widespread in Southern Italy, in marginal areas at risk of abandonment, characterized by few employment alternatives in other economic sectors and in which it is difficult to find an alternative crop. In 2020, 1.2 million hectares (about 10% of the total utilized agricultural area) were sown to durum wheat in Italy for a total production of about 4 million tons. Apulia, with a production of about 760,000 tons, is still Italy's main producer overtaking Sicily, Marche, and Emilia-Romagna (Ismea, 2022). Durum wheat is at the base of a national supply chain of considerable importance, with first and second processing industries generating a turnover of about 5.6% of total Italian agribusiness (Ismea, 2023). Italy is the undisputed leader in the pasta industry, accounting for more than 73% of the EU turnover, with an average production of around 5.3 million tons per year which is a quarter of the total world production (Ismea, 2023). In terms of market outlets, semolina pasta is one of the most important components of Italian agrifood exports (4.6%), which have grown steadily in recent years and contribute positively to the EU's agri-food trade balance (Crea, 2022).

The Italian supply chain of pasta has evolved over the last decade thanks to the growth in demand for "100% Italian" and high-quality pasta, in order to add value to the national production pasta. As far as quality is concerned, the protein content is traditionally considered the main quality parameter. As for the origin of pasta, despite the increase in the cultivation of national durum wheat, the annual requirement of the Italian milling and pasta making industries is around 6 million tons, against a national production of 4 million tons (Istat, 2024; Italmopa, 2023). Being far away from self-sufficiency, the supply chain is persistently dependent on import (especially from non-EU countries) as a consequence. In order to improve the degree of self-sufficiency and the quality of the provision of durum wheat, a national Fund (named "*Fondo grano duro*") has been established since 2017 incentivizing farmers to sign long-term production contracts with pasta makers (Ciliberti et al., 2019).

Last but not least, in order to contain emissions and increase the environmental sustainability of pasta, both processors and pasta companies promote the adoption of environmental-friendly cultivation techniques, practices and methods (Bux et al., 2022; Stanco et al., 2020). In this regard, the share of utilised agricultural area dedicated to organic durum wheat is particularly high in Southern Italy, with Basilicata at the first place (22.8%), followed by Molise (13.5%), Apulia (13.5%) and Sicily (9.6%). Lastly, Marche (6.4%) is the first region in Center-North Italy (Sinab, 2023). Because of the increasing request for high quality and sustainable productions and due also to public interventions, the number of contractual arrangements between main semolina and pasta producers and farmers (or their organizations) has widely increased all over the country in the last years (Rossi et al., 2023).

3. CONCEPTUAL FRAMEWORK

Recent advancements in Transaction Cost Economics have revealed that hybrid governance mechanisms are largely widespread, with contracts being their primary form (Ménard, 2004). These latter play a pivotal role in fostering ecological transition, aiming to coordinate the actions of a diverse set of actors and integrate different dimensions of sustainability, as noted by Cholez and Magrini (2023). Contractual frameworks are crucial for this transition path, since they can have direct consequences on the use of input and dedicated investments to achieve certain environmental threshold in agri-food systems.

Under the lens offered by TCE, a flourishing literature has analysed contracts as governance structures affected by transactional attributes such as asset specificity and uncertainty (Anh et al., 2019; Cai and Ma, 2015; Key and Runsten, 1999; Mao et al. 2022; Minten et al., 2009; Ochieng et al., 2017; Ola and Menapace, 2020; Permadi et al., 2017; Widadie et al., 2020). Evidence reveals that, on the one hand, some contractual requirements can be associated with high transaction costs, therefore representing a major obstacle for choosing contracts. On the other hand, these latter flourish in presence of collective actions, transparent conditions and trust which help farmers to reduce transaction costs.

Ménard (2018) underscored the importance of assessing contracts based on the allocation of rights between transacting parties as a negotiation process. This refreshed viewpoint facilitates an analysis emphasizing how contracts can help alleviate sources of uncertainty and asset specificity surrounding novel technologies and knowledge and distinctly delineate the rights and responsibilities regarding the benefits stemming from the ecological transition. Consequently, contracts raise crucial questions about the collective strategies that go beyond individual interests and include varied modes of organization, besides market forces. In other words, implementing effective governance is contingent upon the alignment of individual interests with these collective strategies, expanding beyond market-driven relations and incorporating diversified organizational modes, where hybrid coordination and the role of contracts are key (Ménard, 2004).

Such a governance perspective examines the logic behind the adoption of coordination mechanisms to support the relationships among a multitude of agents involved in the ecological transition along the agri-food supply chain. In this paper, we follow previous works dealing with production contracts (Abebe et al., 2013; Polinori and Martino, 2019; Oliveira et al., 2021) matching the econometric rationale of choice experiments, where individuals derive utility from the different characteristics a good possesses, with aspect of contract design. In this approach, contractual terms affect the value (utility) each farmer gain from the choice, which is the difference between revenues and costs (i.e. the profit).

Moreover, according to the discriminating alignment principle of Williamson (1991), each contractual term is expected to affect not only production costs but also transaction costs related to transactional attributes (mainly asset specificity and uncertainty) associated with contractual conditions chosen. To better capture this effect, we therefore explicitly decompose the value (utility) associated to contractual choices in two components: a positive (i.e. revenue) and a negative one (i.e. production and transaction costs).

As a consequence, we see this expected value as the profit for the farmer i (i = 1, 2, 3 . . .N) from each contractual terms t (t = 1, 2, 3. . .), which we decompose as follows:

$$\pi_{it} = R_{it} - (C_{it} + T_{it}) \quad (1)$$

with π_{it} being the profit, R_{it} the revenue the farmers get from each contractual terms, while C_{it} and T_{it} respectively represent related production and transaction costs.

It follows that since each contractual term brings its own revenues as well as production and transaction costs, alternative combinations of different contractual terms lead to different expected profit configurations. Consequently, all other things being equal, insertion/removal of a contractual term affects both revenues and costs involved, as follows:

$$\Sigma_j^J \beta Z_{ijk} W_i = W_i R_{ijt} - W_i(C_{ijt} + T_{ijt}) \quad (2)$$

where Z_{ijk} is an index for the alternative j from a choice situation k of contractual terms which are chosen in a contract from an i_{th} farmer, whose individual (and farms') characteristics are represented by a vector W, while β expresses the magnitude of the acceptance of each term. Reasonably, a farmer asked to choose among alternatives is willing to accept a contract including combinations of contractual terms which maximizes his/her expected profit.

3.1. Contractual terms, individual characteristics and farmers' preferences

Henceforth, inspired by previous studies in this field for similar (Soullier and Moustier, 2018) or identical crops (Biggeri et al., 2018; Carillo et al., 2017; Ciliberti et al., 2019; 2022; 2023; Oliveira et al., 2021; Pancino et al., 2019; Rossi et al., 2023; Viganò et l., 2022; Weituschat et al., 2023), we conceptualize both the role of selected but highly relevant contractual terms (related to production techniques, technical assistance, quality requirements and payment solutions) and confounding variables referred to individual (farms and farmers') characteristics. Accordingly, we elaborate research hypotheses to be tested.

Rules for sustainable production

The fact that a farmer chooses a production contract implies the willingness to commit resources to comply with certain production rules (Ciliberti et al., 2019). This seems to contradict basic behavioural assumptions, but in some cases farmers may want to demonstrate their commitment and may prefer a trader that values such an individual effort (given the fact that buyers are able to measure individual commitments, at least after the transaction occurred). Another driver is that farmers' engagement and reputation could lead to higher price premium (Carriquiry and Babcock, 2007; McCluskey and Loureiro, 2005). Moreover, farmers may also believe that opting for a less strict buyer will lead some of them to take opportunistic actions; such an occurrence in turn could contribute to damaging potential common benefits of building a collective reputation (Stanco et al., 2020). In this work, we propose farmers three contractual terms generically referred to production rules: shared and agreed rules, imposed rules or no rules of production. Based on previous literature we elaborate a following research hypothesis (RH 1):

> Durum wheat producers prefer to commit on contractual terms introducing production rules.

Moreover, in a scenario of ecological transition there is increasing evidence that some contractual terms require farmers for the adoption of environmental-friendly practices (Pancino et al., 2019; Rossi et al., 2023). However, adoptions of sustainable cultivation techniques imposing strict restrictions on pesticides, fertiliser or natural resources uses can represent a disincentive for farmers to enter a contract, since this would lead to lower yields and higher unit costs of production (Weituschat et al., 2023). Here, we focus on three specific sustainability requirements related to the durum wheat production cycle: a fractioned supply of nitrogen (that is the most important fertilizer for cereals), the adoption of a cultivation technique that promotes minimum soil disturbance (i.e. no-tillage), and lastly a joined combination of these two practices. Based on previous evidence, we elaborate a research hypothesis (RH 2), as follows:

> Durum wheat producers prefer contractual terms establishing mild sustainable cultivation techniques, rather than strict and costly commitments.

Provision of technical support

The need to access information and assistance on technology, production rules and quality requirements may motivate farmers toward production contract (Oliveira et al., 2021). In this paper we explore preferences towards three specific contractual clauses on this subject: no technical assistance, the provision of direct technical support thanks to advisors, the provision of remote support by means of a remote decision support system (DSS). The buyer could provide all the required technical assistance so that farmers can benefit of updated and timely research-based information (Rossi et al., 2010). In a scenario of ecological transition, forms of technical assistance provided by buyers can help farmers to understand the reasoning for limiting pesticide and fertilizers use and the benefits of applying a more precise dosage, therefore fostering the adoption of sustainable production techniques (Ciliberti et al., 2022; Šūmane et al., 2018). Therefore, we formulate a research hypothesis (RH 3) related to this type of clause:

> Durum wheat producers prefer contractual terms establishing the provision of technical assistance.

Quality requirements

Maintaining and improving the quality production and ensuring compliance with food safety requirements is crucial in modern agricultural settings. Such an issue is associated with the ability to comply with formal or informal quality standards for farmers (Biggeri et al., 2018; Carillo et al., 2017; Soullier and Moustier, 2018). However, quality remains the main challenge in situations where the agri-food markets do not incentivize it, as farmers may be reluctant to invest their time and energy to improve quality. It follows that related requirements are a major source of uncertainty in agri-food transactions for buyers (Frascarelli et al., 2021). Usually, farmers may choose between low quality requirements, with small incentive to improve quality but low risk of product rejection, and a high-quality option, with higher incentive but larger risk of product rejection. Farmers therefore tend to prefer contract with low quality requirements, all other things being equal , given the uncertainty of farmers about meeting quality standards and due to the lower risk of product rejection (Oliveira et al., 2021). Here we want to test farmers' preferences for different and increasingly demanding quality requirements referred to various thresholds of protein content in durum wheat: in more details, a lower level (>12.5%), a medium-high level (13.5%), and a very high level (14.5%) of proteins. Based on the existing literature a research hypothesis (RH 4) is elaborated as follows:

> Durum wheat producers prefer contractual terms setting in advance lower quality standards and requirements.

Price and payment formulas

The general assumption in the literature is that farmers' motivation to participate in contractual arrangements is primarily to manage market uncertainty with pre-established price formula. These latter refer to the payment conditions farmers agree with, in exchange for delivering an agreed product quality and quantity. Since the mid-2000s price volatility has been a typical feature of prices of grain commodity, driven by several factors as a consequence of increasing linkages among food, energy, and financial markets (Ott, 2014; Santeramo e Lamonaca, 2019; Tadesse et al., 2014). To this regard, the adhesion to properly designed contracts is expected to reduce sources of market uncertainty (Oliveira et al., 2021). This governance solution applies also to the durum wheat supply chain, characterised by strong price instability and asymmetric price transmission along the value chain, which mainly penalise farmers (Viganò et al., 2022). In this paper we want to test farmers' preferences for three different price formulas: fixed, variable (that is, market) and a mixed price option (50% fixed and 50% market price). Thus, based on previous evidence, a research hypothesis (RH 5) is elaborated, as follows:

> Durum wheat producers prefer contractual terms establishing price formula alternative to variable market price.

As for payment modality, fearing opportunistic behaviours, farmers do not like delays and want to avoid issues with payments since they increase uncertainty, particularly when buyers are not trusted (Ciliberti et al., 2023). Moreover, farmers prefer immediate payment over delayed payment to address market uncertainty, also because they need money for purchasing inputs for the next production cycle (Oliveira et al., 2021). In this paper we test farmers' preferences for three different clauses related to payment modality: payment on delivery, deferred payment, and payments in instalments on a monthly basis. Accordingly, another research hypothesis (RH 6) comes out:

> Durum wheat producers prefer contractual terms setting immediate payment.

Lastly, the relationship between contractual terms and farmers' utility and preferences can be affected by some characteristics we intended to control for. The emerging literature on the determinants of farmers' preferences towards contractual terms in the durum wheat sector suggests several of those individual characteristics which must be checked for (Frascarelli et al., 2020; Rossi

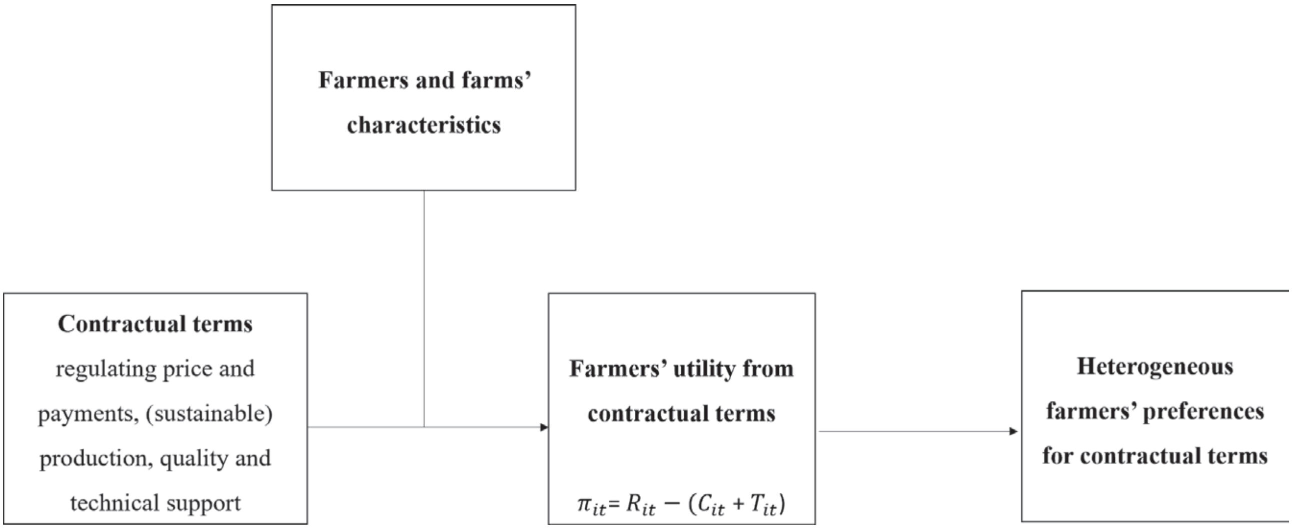

Figure 1. The causal pathway between contractual terms and farmers' preferences.

et al., 2023; Weituschat et al., 2023a;2023b). We decided to select some of the most representative and relevant, focusing on age, education, experience, size, participation in cooperative, and previous use of contracts.

All that said and considered, figure 1 graphically illustrates and resumes the hypothesized causal relationship we conceptualized between specific contractual terms and farmers' utility and preferences, which can be affected by confounding variables related to individual farms and farmers' characteristics.

4. MATERIALS AND METHODS

4.1. Experimental design, sampling strategy and data collection

Discrete choice experiments are frequently performed in economic literature in order to establish individual preferences across items, such as good, services or in our case, contracts (Hensher et al., 2005; Louviere et al., 2010). The experimental design for a choice experiment relies on the identification of a set of relevant characteristics (attributes), which in our case relate to different type of contractual terms and their corresponding levels.

To this purpose, after analysing real production contracts adopted in the durum wheat supply chain over the last years (see Ciliberti et al., 2022 for more details), we also conducted a focus group discussion with key stakeholders to gain a better understanding of which clauses are more relevant for durum wheat producers[1]. These activities helped us to evaluate the relevance of some contractual terms for farmers, so as to decide which attributes and levels to include in our discrete choice experiment. Therefore, based on this evidence, we selected six attributes with three levels each, which are reported in Table 1.

Afterwards, we decided to adopt an efficient design using the software Stata so that contractual attributes and their levels were randomly distributed into 18 choice sets, containing three contracts with six attributes each. Then, choice sets were arranged into 6 blocks and each respondent was submitted to one block with three choice sets only, so as to reduce the number of contracts to evaluate. In detail, for each choice set, each farmer was allowed to specify his preference towards one out of three contracts plus an opt-out option (i.e. "none of the previous contract").

A structured questionnaire (including the choice experiment and an additional section with general information on farmers and farms' characteristics) was then realized to investigate farmers' preferences over contractual terms (see Supplementary material). It was pretested and validated across a small sample of almost two dozens of randomly selected durum wheat producers. As a final step, in order to collect data and information from our study population, consisting of farmers producing durum wheat in Italy, we adopted a purposive sampling strategy. To this aim, trained interviewers

[1] The focus group included 8 participants among representatives of durum wheat producers, input providers, buyers (processors, manufacturers) and experts (agronomists and technical advisors). The aim was to discuss the following questions: which are the main contractual terms included in production contracts? How are they negotiated between producers and buyers? What are the main (emerging) clauses related to environmental sustainability, if any?

Table 1. Attributes and related levels selected for the discrete choice experiment.

Attributes	Levels
Production rules	Not established
	Arranged with the buyer
	Compelled by the buyer
Sustainability requirements	Fractioned use of nitrogen (FUN)
	Minimum soil disturbance (MSD)
	Joined adoption of FUN and MSD
Technical support	Not provided
	Provided by technical advisors
	Remotely provided thanks to a DSS software
Quality requirements	Medium grain protein content (> 12.5%)
	Medium-high grain protein content (> 13.5%)
	High grain protein content (> 14.5%)
Price formula	Fixed price
	Market price
	Mixed (50% market – 50% fixed) price
Payment modality	On delivery
	Deferred payment
	Monthly payments

directly submitted the survey among farmers attending several technical workshops and seminars in Central and Southern Italy (where durum wheat production is mostly located), between late 2018 and early 2020 (until national authorities imposed the lockdown due to the Covid-19 pandemics). As a consequence, the composition of the sample mainly depended on farmers' attendance to these workshops and their willing and ability to correctly fill out the questionnaire in all its sections. Results are based on a sample of 190 completed questionnaires collected among durum wheat producers. No protests from respondents were observed and reported. Table A in the Appendix reports detailed descriptive statistics related to respondents' characteristics. Comparing information with those available for the reference population (Ismea, 2023b; Istat 2024), it comes out that the average size of the sampled farms is way larger than the national one in 2021 (that was 11.1 hectares). However, apart from some respondents located in Central and Northern Italy (Marche and Emilia-Romagna), about 75% of the interviewed farmers came from Southern Italy (with a large share from Apulia, followed by Basilicata), where most of the production (76%) and cultivated areas for durum wheat (69%) were located in 2020 (Ismea, 2023b). Lastly, farmers with less than 45 years represents 13% of the total at national level. Only one out of ten has a degree, whereas almost 60% own a secondary school diploma (Istat, 2024).

4.2. Econometric analysis

In this paper, we follow Pacifico and Yoo (2013) and Yoo (2020) to run a latent-class conditional logit (LCL), which extends the conditional logit by incorporating a discrete representation of unobserved preference heterogeneity across decision makers. Specifically, LCL assumes that there are C distinct types, or "classes" of decision makers and that each class c makes choices consistent with its own conditional logit model with utility coefficient vector β_c. Suppose that the probability that decision maker i belongs to class c is given by a fractional multinomial logit specification:

$$\pi_{nc}(\boldsymbol{\Theta}) = \frac{\exp(z_i\theta_c)}{1+\sum_{l=1}^{C-1}\exp(z_i\theta_l)} \tag{2}$$

where z_i is a row vector of decision maker n's characteristics and the usual constant regressor (that is, 1); θ_c is a conformable column vector of membership model coefficients for class c, with θ_C normalized to **0** for identification; and $\boldsymbol{\Theta} = (\theta_1, \theta_2,\ldots, \theta_{C-1})$ denotes a collection of the $C-1$ identified membership coefficient vectors.

Under LCL, the joint likelihood of decision maker n's choices is given by

$$L_n(B,\boldsymbol{\Theta}) = \sum_{c=1}^{C}\pi_{nc}(\boldsymbol{\Theta})P_n(\beta_c) \tag{3}$$

where $B = (\beta_1, \beta_2,\ldots, \beta_C)$ denotes a collection of the C utility coefficient vectors and each $P_n(\beta_c)$ is obtained by evaluating $\beta = \beta_c$.

In more detail, the model is estimated using an Expectation-Maximization (EM)-Algorithm (Bhat, 1997). Such a model simultaneously estimates preference coefficients for different classes and the probability of an individual to belong to a class based on choice patterns and individual covariates. It therefore extends the previous analysis by incorporating a discrete representation of unobserved preference heterogeneity. As a result, we are able to further check for preference heterogeneity among farmers, since latent class model identifies unobserved groups of individuals with homogenous preferences by using a discrete mixing distribution (Swait, 1994). Lastly, econometric analyses were run using the software Stata 14.2 implementing usual optimization methods for maximum likelihood estimation.

5. RESULTS AND DISCUSSION

Latent class analyses were performed in order to identify classes of durum wheat producers with similar

Table 2. Individual characteristics for each class (mean and standard deviations) and differences.

Main characteristics	Class 1	Class 2	Difference
age (n.)	47.03 (14.22)	48.34 (11.83)	-1.31*
exp_y (n.)	26.63 (14.51)	27.28 (12.38)	-0.65
educ_h (%)	81.50 (38.83)	93.02 (25.50)	-11.52***
coop_m (%)	40.42 (49.08)	39.02 (48.83)	1.40
contr_p (%)	63.88 (48.04)	48.83 (50.03)	15.05***
size (ha)	121.97 (217.27)	305.64 (715.99)	-183,67

***, **, * Denote that mean values of class 1 farmers are significantly different from class 2 farmers at $p < .01$, $p < .05$, and $p < .10$, respectively.

preferences towards contractual attributes. We computed different models with 2 and 3 classes and used information criteria measures to test goodness-of-fit (Yang, 2006). The number of classes was chosen with regard to the Akaike information criterion (AIC), the consistent AIC (CAIC) and the Bayesian information criterion (BIC). We opted for a latent model with 2 classes which minimizes most criteria, in our case CAIC (1207.79 vs 1250.97) and BIC (1174.79 vs 1197.97), revealing the best goodness-of-fit. Table 2 reports the differences of durum wheat producers and their farms across the 2 classes, focusing on relevant control variables referred to individual characteristics.

Looking at Table 2 we are able to identify main differences among members of the two classes of respondents. On the one hand, class 1 group less experienced farmers with lower education and smaller cultivated areas, but with a higher attitude to join collective arrangement and sign contracts to sell durum wheat. On the other hand, class 2 encompasses durum wheat producers with opposite features, therefore more experienced and educated, less collaborative and with bigger farms. However, by using a nonparametric Mann-Whitney U test for continuous data and a chi-square test for dummy variables, statistically significant differences between the two classes emerged for age, high level of education and the use of production contracts.

Looking at the results of the latent class analysis, the majority of contractual terms show significant coefficients in both classes, highlighting relevant preferences towards attributes (Table 3), even if some interesting differences among classes.

First and foremost, we focus on the "no-choice" variable, which was selected in 123 out of 570 "no-choice" situations faced by the respondents[2]. Results reveal a significant but contrasting interest for production contracts across classes. In class 1, the negative coefficient (-1.310) suggests that farmers were significantly keen to reject the "no-choice" option in favour of one of the production contracts they were proposed. This latter was therefore considered more beneficial and reliable than the status quo in order to overcome spot market imperfections and reduce transaction costs, in line with Van den Broeck et al. (2017). On the other hand, the positive coefficient in class 2 (+6.528) shows a significant preference for the "no-choice" option and so against the proposed contractual solutions as a whole, in accordance with previous findings from Schipmann and Qaim (2011) and Blandon et al. (2010).

With regard to production rules, positive and significant coefficients for both terms highlight that farmers in both classes are highly reluctant to rules unilaterally imposed by the processing industry (i.e., the reference variable), but with some interesting differences. Always taking as reference the base level, farmers in the first class prefer shared rules (+0.476) more than no rules at all (+0.369), while in the second class the opposite is true with producers largely preferring a free production process (+2.581) over rules agreed with buyers (+1.950). With all that said, the first research hypothesis is partially confirmed, in line with earlier evidence from Gelaw et al. (2016), showing that farmers usually choose to join contracts since they are willing to commit resources in order to comply with certain production rules and gain reputation. However, at the same time, farmers tend to refuse contractual terms unilaterally imposing techniques and production rules, since they are traditionally concerned and suspicious of any attempt of limiting their decisional autonomy (Ciliberti et al., 2023; Vaissiere et al., 2018).

When asked to reveal preferences towards specific contractual terms setting rules for a more environmental-friendly and sustainable production, farmers reveal heterogeneous preferences across the two classes. While in the first class clauses are not significant, vis à vis a combined use of no-tillage and a fractioned supply of nitrogen (the reference level), farmers in class 2 show a clear and significant preference for a minimum mechanical soil disturbance (+1.256), but also a noteworthy and larger aversion to a lower use of nitrogen as fertilizer (-2.076). This is a signal that, in absence of specific incentives, farmers still look at this type of clauses with low enthusiasm and a certain suspect. They only accept to reduce soil disturbance since – compared to a

[2] In detail, the "no-choice" variable was selected at least in one choice set out of three by 21 respondents, in two choice sets out of three by 15 respondents and in all the three choice sets by 24 respondents, for a total of 60 respondents out of 190 (31.6%) which selected the "no-choice" option at least once.

Table 3. Parameter estimates for the latent class model

Attribute	Level	Class 1			Class 2		
		Coeff.	P>|z|	SE	Coeff.	P>|z|	SE
Production rules	Arranged	0.476	**	0.154	1.950	**	0.968
	None	0.369	**	0.157	2.581	**	1.003
Sustainability requirements	MSD	0.027		0.149	1.256	*	0.671
	FUN	0.049		0.148	-2.076	*	1.199
Technical support	Advisors	0.270	*	0.151	1.090		0.676
	DSS	0.250		0.153	0.004		0.738
Quality requirements	Protein > 12.5%	0.290	*	0.150	1.366	**	0.642
	Protein > 13.5%	0.210		0.154	-1.231		0.797
Price formula	Fixed price	0.680	***	0.160	2.269	**	0.796
	Mixed price	0.419	**	0.166	0.397		0.962
Payment modality	On delivery	0.083		0.153	0.031		0.745
	Deferred payments	0.131		0.153	0.650		0.633
No-choice	:	-1.310	***	0.486	6.528	***	1.601
Class share			0.723			0.277	
Log likelihood			-504.833				
AIC			1075.667				
BIC			1256.799				

Control variables (reference: class 2)

Variables	Coeff.	P>|z|	SE			
age	0.018		0.032	:	:	:
contr_p	0.923	**	0.454	:	:	:
coop_m	0.019		0.473	:	:	:
educ_h	-2.771	**	1.133	:	:	:
exp_y	-0.034		0.032	:	:	:
size	-0.001		0.000	:	:	:

Significance levels: *** 1% ** 5% * 10%

fractioned use of fertilizers – it can ensure a reduction of costs, but with a limited impact on yields and production. As a consequence, the second hypothesis can be confirmed, substantiating the fact that farmers' commitment in environmentally sustainable production is still partial, as it is perceived as a source of disadvantage when compared with farmers' returns from conventional agricultural production (Chèz et al., 2020). The primary reason is that the cost of environmentally sustainable production is considerably higher and that the yield is relatively lower than that of conventional agriculture (Wang et al., 2019).

As far as technical support is concerned, it is interesting to observe that only durum wheat producers in class 1 showed a slightly significant and positive interest (+0.270) for a contractual term introducing such a service (against the reference level "no technical support"), provided that it is offered on field by buyers' trusted technicians and advisors. No significant preferences occurred in class 2 instead. Therefore, even with some caveats, the third hypothesis can be confirmed in the light of the evidence on the acceptance of technical assistance. This result contributes to confirming farmers' interest for support services aimed to foster both innovation uptake and compliance with contractual requirements (Cholez et al., 2023; Martino et al., 2017). In the durum wheat sector, these ancillary services are usually provided when signing a contract, so that farmers can get support from expert agronomists in order to improve grain quality, production yields and profitability (Viganò et al., 2022). Our results confirm that relational contracting fosters process innovation in agri-food chains (Martino et al., 2017). However, a possible interpretation of the results could be that frequent on farm visits or solutions for remote assistance could be seen, by the most dynamic and independent farmers, as a subtle attempt of controlling their activities and performances, therefore limiting the acceptance of this type of clauses.

Looking at clauses related to quality requirements, results clearly allow to confirm the fourth hypothesis highlighting significant and positive preference for these terms in both classes, but only to a limited extent. It is not by chance that farmers in class 1 and 2 prefer terms imposing the lowest possible qualitative threshold (of protein content) for their product (coefficients are respectively +0.290 and +1.366) vis à vis the most compelling one (that is, protein more than 14.5%). These results are fully in line with previous indications highlighting that these clauses are accepted by farmers because deemed able to reduce source of behavioural and technological uncertainty for farmers, since buyers' requirement are known in advance. However, as expected, farmers tend to opt for less stringent clauses confirming previous indication from Blandon et al. (2010), Oliveira et al., 2021).

When clauses related to price formula are considered, farmers' preference reveal a strong and significant interest in both classes for clauses offering fixed instead of market price. Taking into account this latter option as reference level, in class 2 there is a stronger interest for a guaranteed minimum price than in class 1 (coefficients are respectively +2.269 and +0.680). Moreover, in class 1 durum wheat producers are also significantly attracted by mixed price (+0.419) compared to the base level. That said, empirical evidence corroborates the fifth research hypothesis in accordance with previous empirical studies which highlighted that, all other things being equal, farmers prefer a fixed price option over a variable one (Miyata et al., 2009). Price stability is therefore confirmed to be a major driver of participating in contracts, since it can shield farmers against the volatility which has largely affected cereals since the mid-2000s due to the several circumstances (Maertens and Vande Velde, 2017; Santeramo e Lamonaca, 2019). However, contradicting the common credence that farmers are risk averse, Wang et al. (2011) also showed that based on their characteristics, farmers may have different risk preferences and entrepreneurial attitude, so that a mixed pricing strategy based on certain performance criteria can be sometime preferred to a minimum guaranteed price.

Very interestingly, farmers reveal no significant preference to any type of payment modality compared to the reference level (fractioned monthly payment). Therefore, they make no distinction between payment on delivery and other solutions establishing payments in instalments or delayed. So, the sixth hypothesis must be rejected, in line with the work of Oliveira et al. (2021), but against earlier evidence revealing negative preference for delayed payment (Cai and Ma, 2015).

Lastly, results reveal that only a few control variables can explain differences among the two groups of respondents and their preferences towards contractual terms. In line with previous works, they refer to previous use of contracts and the level of education. On the one hand, earlier experiences with production contracts make farmers more likely to belong to class 1, so more confident and relying on production contracts, as already demonstrated by Van den Broeck et al. (2017). On the other hand, higher level of education (i.e., high school diploma or higher qualification) increase the likelihood of going into class 2, with a significant but negative effect on contract participation in contrast with Widadie et al. (2020) but perfectly in line with findings of Ren et al. (2021) and Miyata et al. (2009).

6. CONCLUSIONS

Implementing innovative and effective governance mechanisms along the agri-food supply chain is of key importance in a scenario of ecological transition, so as to better coordinate actions of a multitude of economic actors in an uncertain context. Adopting the conceptual lens of the Transaction Cost Economics, the present work contributed to the burgeoning literature in this field, investigating whether and how production contracts may play a key role in fostering a better alignment of individual interests with broader collective goals and strategies, integrating also social and environmental dimensions. Focusing on a highly strategic agri-food production in the Italian context, such as durum wheat, we conducted a discrete choice experiment to analyse farmers' preferences for a selected and relevant number of contractual terms, which differently affect source of production and transaction costs. Moreover, applying a latent class analysis we also detected the role played by some individual characteristics questioning the homogeneity of these preferences.

Findings indicated that the path towards the use of contracts able to match both private and public goals is still long for at least two reasons. First, farmers show a strong interest for clauses protecting against market and behavioural uncertainty (fixed price and shared rules of production) but are still hesitant in joining compelling quality and environmental requirements if not properly incentivized or supported. Moreover, technical support provided by the buyer is sometimes seen as a form of control and therefore unwelcome. Second, results are not homogenous across respondents, revealing that there is need to better take into account the heterogeneity of preferences, overcoming one-size fits all approach to contract design and implementation. To this regard, attention must be paid to the fact that respondents sometimes preferred to not make a choice. This fact signals the existence of a not negligible share of farmers who have different opinions and preferences from other producers as well as different expectations and needs which shall be somehow addressed by stakeholders.

As a consequence, interesting policy and managerial implications follow. In line with the approach of this paper, the importance of implementing an evidence-based and more participatory approach to contract design, negotiation and adoption is noteworthy. Such an action could allow to better tailor contractual terms on producers' characteristics and to reduce their suspicion over such a governance solution, which is often seen as a subtle form of exploitation promoted by buyers to reduce their decisional autonomy over land. Empirical evidence also reveals that another key and central point in a context of ecological transition is to identify and define types of (monetary or non-monetary) incentives to promote the adoption of terms related to sustainable cultivation practices and the adoption of environmental certification.

Even if they still play a limited role in the Italian cereal sector, cooperatives, Producers' Organizations, and Interbranch Organizations can also play a decisive role along this path, reducing transaction costs related to the negotiation and the enforcement of production. Lastly, technical support provided by contract should be better promoted across durum wheat producers, highlighting the strategic role of knowledge and innovation transfer for improving both quality and sustainability of production.

All that said, it must be also considered that this work has some limitation. First, since results were based on a purposive and biased sample of a few hundred durum wheat producers they cannot be generalized, if not with some caution. In this regard, investigating farmers' preferences for contractual terms in a given period of time for a specific production in a certain context at least allowed to reduce potential sources of exogenous heterogeneity. Moreover, another caveat is related to the fact that the empirical analysis relied on a discrete choice model approach, so on stated rather than on observed preferences. Lastly, experimental design imposed to select only a limited number of contractual terms to be analysed, leaving room for future research in this area to evaluate further and different clauses.

FUNDING SOURCES

This work was supported by the National Operational Programme on Research and Innovation 2014-2020 (FSE REACT-EU - Action IV.6 "Green") of the Italian Ministry of University and Research (MD 1062/2021). The content of this article does not reflect the official opinion of the funding Institutions. The views expressed in this paper are solely those of the authors.

ACKNOWLEDGEMENTS

The authors wish to thank the participants to the 2023 AIEAA conference held in Milan for their valuable feedback and insights.

REFERENCES

Anh, N.H., Bokelmann, W., Thi Thuan, N., Thi Nga, D., and Van Minh, N. (2019). Smallholders' Preferences for Different Contract Farming Models: Empirical Evidence from Sustainable Certified Coffee Production in Vietnam. Sustainability, 11: 3799. https://doi.org/10.3390/su11143799

Berdegué, J.A., Balsevich, F., Flores, L. and Reardon, T. (2005). Central America Supermarkets' Private standards of quality and safety in procurement of fresh fruits and vegetables. Food Policy, 30: 254–269. https://doi.org/10.1016/j.foodpol.2005.05.003

Bhat, C. R. (1997). An endogenous segmentation mode choice model with an application to intercity travel. Transportation Science, 31: 34–48. https://doi.org/10.1287/trsc.31.1.34

Biggeri, M., Burchi, F., Ciani, F. and Herrmann, R. (2018). Linking small-scale farmers to the durum wheat value chain in Ethiopia: Assessing the effects on production and wellbeing. Food Policy, 79, 77–91. https://doi.org/10.1016/j.foodpol.2018.06.001

Blandon, J., Henson, S., and Islam, T. (2010). The Importance of Assessing Marketing Preferences of Small-scale Farmers: A Latent Segment Approach. European Journal of Development Research, 22: 494–509. https://doi.org/10.1057/ejdr.2010.26

Bogetoft, P., and Olesen, H. B. (2002). Ten rules of thumb in contract design: lessons from Danish agriculture. Eur. Rev. Agric. Econ., 29: 185–204. https://doi.org/10.1093/eurrag/29.2.185

Bux, C., Lombardi, M. Varese, E. and Amicarelli, V. (2022). Economic and Environmental Assessment of Conventional versus Organic Durum Wheat Production in Southern Italy. Sustainability, 14: 9143. https://doi.org/10.3390/su14159143

Cai, R. and Ma, W. (2015). Trust, transaction costs, and contract enforcement: evidence from apple farmers in China. British Food Journal, 117: 2598-2608. https://doi.org/10.1108/BFJ-10-2014-0335

Carillo, F., Caracciolo, F. and Cembalo, L. (2017). Do durum wheat producers benefit of vertical coordination? Agric. Food Econ: 5, 19. DOI 10.1186/s40100-017-0088-7

Carriquiry, M. and Babcock, B.A. (2007). Reputations, market structure, and the choice of quality assurance systems in the food industry. American Journal of Agricultural Economics, 89 (1): 12–23. https://doi.org/10.1111/j.1467-8276.2007.00959.x

Chèze, B. David, M. and Martinet V. (2020). Understanding farmers' reluctance to reduce pesticide use: a choice experiment. Ecological Economics, 167: 106349. 10.1016/j.ecolecon.2019.06.004

Cholez, C. and Magrini, M.B. (2023). Knowledge and network resources in innovation system: How production contracts support strategic system building. Environmental Innovation and Societal Transitions, 47: 100712. https://doi.org/10.1016/j.eist.2023.100712

Cholez, C., Magrini, M. B. and Galliano, D. (2017). Field crop production contracts. Incentives and coordination under technical uncertainty in French cooperatives. Économie rurale, 360(4): 65-83.

Cholez, C., Magrini, M.B., and Galliano, D. (2020). Exploring inter-firm knowledge through contractual governance: A case study of production contracts for faba-bean procurement in France. Journal of Rural Studies, 73: 135–146. doi.org/10.1016/j.jrurstud.2019.10.040

Ciliberti S., Martino G., Frascarelli A. and Chiodini, G. (2019), Contractual arrangements in the Italian durum wheat supply chain: the impacts of the "Fondo grano duro". Food Economy, 21(2): 51-69. https://doi.org/10.3280/ECAG2019-002004.

Ciliberti, S., Frascarelli, A., and Martino, G. (2023). Matching ecological transition and food security in the cereal sector: the role of farmers' preferences on production contracts. Frontiers in Sustainable Food Systems, 7:1114590. https://doi.org/10.3389/fsufs.2023.1114590

Ciliberti, S., Stanco, M., Frascarelli, A., Marotta, G., Martino, G., and Nazzaro, C. (2022). Sustainability Strategies and Contractual Arrangements in the Italian Pasta Supply Chain: An Analysis under the Neo Institutional Economics Lens. Sustainability, 14: 8542. https://doi.org/10.3390/su14148542

Crea (2022). Annuario dell'agricoltura italiana 2022. Available at: https://www.crea.gov.it/documents/68457/0/Annuario_CREA_2022_Volume_LXXVI+%281%29.pdf/d3ba7ca4-cc94-e292-f85c-be3121447d8c?t=1704909583689 (Last accessed: February 2024)

Dubbert, C., Awudu, A. and Sadick, M. (2021). Contract farming and the adoption of sustainable farm practices: Empirical evidence from cashew farmers in Ghana. Applied Economic Perspectives and Policy, 45: 1–23. https://doi.org/10.1002/aepp.13212

FAO (2017). Legal Aspects of Contract Farming Agreements, Rome. Available at: https://www.fao.org/3/i6711e/i6711e.pdf (Accessed September, 2023).

Frascarelli, A., Ciliberti, S., Magalhães de Oliveira, G., Chiodini, G. and Martino, G. (2021). Production Contracts and Food Quality: A Transaction Cost Analysis for the Italian Durum Wheat Sector. Sustainability, 2021: 13(5). https://doi.org/10.3390/su13052921

Gelaw, F., Speelman, S. and Van Huylenbroeck, G. (2016). Farmers' marketing preferences in local coffee markets: Evidence from a choice experiment in Ethiopia. Food Policy, 61: 92-102. https://doi.org/10.1016/j.foodpol.2016.02.006.

Hensher, D., Rose, J. and Greene, W. (2005). Applied choice analysis: A primer. Cambridge, UK. Cambridge University Press.

Ismea (2022). Scheda di settore cereali – frumento duro. Available at: https://www.ismeamercati.it/seminativi/cereali (Last accessed : September 2023)

Ismea (2023a). Rapporto sull'agroalimentare italiano. Available at: https://www.ismeamercati.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/12802 (Last accessed : February 2024)

Ismea (2023b). Scheda di settore: frumento duro. Available at: https://www.ismeamercati.it/seminativi/cereali (Last accessed : February 2024)

Istat (2024). Statistiche Istat - Datawarehouse I.stat. Available at: http://dati.istat.it/Index.aspx?QueryId=33702 (Last accessed: February 2024)

Italmopa (2023). L'industria molitaria italiana nel 2022. Available at: https://www.italmopa.com/landamento-economico-del-settore/ (Last accessed: February 2024)

Jäckering, L. Meemken, E. Sellare, J. and Qaim, M. (2021). Promoting written employment contracts: evidence from a randomised awareness campaign. European Review of Agricultural Economics, 48(4): 1007–1030. https://doi.org/10.1093/erae/jbaa035

Key, N. and Runsten, D., (1999). Contract farming, smallholders, and rural development in Latin America: the organization of agroprocessing firms and the scale of outgrower production. World Development, 27: 381–401. https://doi.org/10.1016/S0305-750X(98)00144-2

Louviere, J.J., Flynn, T.N. and Carson, R.T. (2010). Discrete Choice Experiments Are Not Conjoint Analysis. Journal of Choice Modelling, 3(3): 57-72. https://doi.org/10.1016/S1755-5345(13)70014-9.

Mao, H., Fu, Y., Cao, G. et al. (2022). Contract farming, social trust, and cleaner production behavior: field evidence from broiler farmers in China. Environmental Science Pollution Researc, 29: 4690–4709. https://doi.org/10.1007/s11356-021-15934-8

MacDonald, J. M. (2015). Trends in Agricultural Contracts. Choices, 30(3): 1-6. http://www.jstor.org/stable/choices.30.3.02.

Maertens, M. and Vande Velde, K. (2017). Contract-farming in staple food chains: the case of rice in Benin. World Development, 95: 73-87. https://doi.org/10.1016/j.worlddev.2017.02.011

Martino, G. and Polinori, P. (2019). An analysis of the farmers' contractual preferences in process innovation implementation. *British Food J*ournal,121: 426–440. https://doi.org/10.1108/BFJ-12-2017-0697

Martino, G., Rossetti, E., Marchini, A. and Frascarelli, A. (2017). Process innovation in milling stage in olive oil sector: Evidence from an empirical analysis in Umbria (Italy). British Food Journal, 119(8): 1748-1765. https://doi.org/10.1108/BFJ-12-2016-0585

McCluskey, J.J. and Loureiro, M.L. (2005). Reputation and production standards. Journal of Agricultural and Resource Economics, 30 (1): 1–11.

McGreevy, S.R., Rupprecht, C.D., Niles, D., Wiek, A., Carolan, M., Kallis, G., Tachikawa, M. et al. (2022). Sustainable agrifood systems for a post-growth world. Nature sustainability, 5(12): 1011-1017. https://doi.org/10.1038/s41893-022-00933-5

Ménard, C. (2004). The economics of hybrid organizations. Journal of Institutional and Theoretical Economics (JITE)/Zeitschrift für die gesamte Staatswissenschaft, 160: 345-376. https://www.jstor.org/stable/40752467

Ménard, C. (2018). Research frontiers of new institutional economics. RAUSP Management Journal, 53: 3-10. https://doi.org/10.1016/j.rauspm.2017.12.002

Michler, J. D. and Wu, S. Y. (2020). Relational contracts in agriculture: theory and evidence. Annual Review of Resource Economics, 12: 111–127. https://doi.org/10.1146/annurev-resource-101719-034514

Minten, B., Randrianarison, L. and Swinnen, J.F.M. (2009). Global retail chains and poor farmers: evidence from Madagascar. World Development, 37: 1728-1741. https://doi.org/10.1016/j.worlddev.2008.08.024

Miyata, S., Minot, N. and Hu, D. (2009). Impact of contract farming on income: linking small farmers, packers, and supermarkets in China. World Development, 37: 1781-1790. https://doi.org/10.1016/j.worlddev.2008.08.025

Ochieng, D.O., Veettil, P.C. and Qaim, M. (2017). Farmers' preferences for supermarket contracts in Kenya. Food Policy, 68:100–111. https://doi.org/10.1016/j.foodpol.2017.01.008

Ola, O. and Menapace, L. (2020). Smallholders' perceptions and preferences for market attributes promoting sustained participation in modern agricultural value chains. Food Policy, 97: 101962. https://doi.org/10.1016/j.foodpol.2020.101962

Oliveira, G.M.d., Martino, G., Ciliberti, S., Frascarelli, A. and Chiodini, G. (2021). Farmer preferences regarding durum wheat contracts in Italy: a discrete choice experiment. British Food Journal, 123(12): 4017-4029. https://doi.org/10.1108/BFJ-09-2020-0876

Otsuka, K., Nakano, Y. and Takahashi, K. (2016). Contract Farming in Developed and Developing Countries. Annual Review of Resource Economics, 8: 353–76. https://doi.org/10.1146/annurev-resource-100815-095459

Ott, H. (2014). Volatility in cereal prices: intra-versus inter-annual volatility. Journal of Agricultural Economics, 65(3): 557-578. https://doi.org/10.1111/1477-9552.12073

Pacifico, D. and Yoo, H. (2013). Lclogit: A Stata Command for Fitting Latent-Class Conditional Logit Models via the Expectation-Maximization Algorithm. The Stata Journal, 13(3): 625–639. https://doi.org/10.1177/1536867X1301300312

Pancino, B., Blasi, E., Rappoldt, A., Pascucci, S., Ruini, L., and Ronchi, C. (2019). Partnering for sustainability in Agri-food supply chains: the case of Barilla sustainable farming in the Po Valley. Agric. Food Econ, 7: 1–10. https://doi.org/10.1186/s40100-019-0133-9

Permadi, D.B., Burton, M., Pandit, R., Walker, I. and Race D. (2017). Which smallholders are willing to adopt Acacia mangium under long-term contracts? Evidence from a choice experiment study in Indonesia. Land Use Policy, 65: 211-223. 10.1016/j.landusepol.2017.04.015.

Ren, Y.J., Peng, Y., Campos, B.C. and Houjian, L. (2021). The effect of contract farming on the environmentally sustainable production of rice in China. Sustainable Production and Consumption, 28: 1381-1395. https://doi.org/10.1016/j.spc.2021.08.011

Rossi, E.S., Materia, V.C., Caracciolo, F., Blasi, E. and Pascucci, S. (2023). Farmers in the transition toward sustainability: what is the role of their entrepreneurial identity?. Frontiers in Sustainable Food Systems, 7:1196824. https://doi.org/10.3389/fsufs.2023.1196824

Rossi, V., Meriggi, P., Caffi, T., Giosué, S. and Bettati, T. (2010). A web-based decision support system for managing durum wheat crops. Devlin, G and Muyeen, SM (eds), Decision Support System. Rijeka, Croatia. Intech.

Santeramo, F.G. and Lamonaca, E. (2019). On the drivers of global grain price volatility: an empirical investigation. Agricultural Economics, 65(1): 31-42. https://doi.org/10.17221/76/2018-AGRICECON

Schipmann, C. and Qaim, M. (2011). Supply chain differentiation, contract agriculture, and farmers' marketing preferences: The case of sweet pepper in Thailand. Food Policy, 36: 667–677. https://doi.org/10.1016/j.foodpol.2011.07.004

Sinab (2023). Bio-statistiche, Available at: https://www.sinab.it/content/bio-statistiche (Last accessed: February 2024)

Singh, S. (2002). Contracting out solutions: political economy of contract farming in the Indian Punjab. World Development, 30: 1621–1638. https://doi.org/10.1016/S0305-750X(02)00059-1

Soullier, G., and Moustier, P. (2018). Impacts of Contract Farming in Domestic Grain Chains on Farmer Income and Food Insecurity. Contrasted Evidence from Senegal. Food Policy, 79: 179–98. https://doi.org/10.1016/j.foodpol.2018.07.004

Stanco, M., Nazzaro, C., Lerro, M. and Marotta, G. (2020). Sustainable Collective Innovation in the Agri-Food Value Chain: The Case of the "Aureo" Wheat Supply Chain. Sustainability, 12, 5642. https://doi.org/10.3390/su12145642.

Šūmane, S., Kunda, I., Knickel, K., et al. (2018). Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture. Journal of Rural Studies, 59: 232-241. https://doi.org/10.1016/j.jrurstud.2017.01.020

Swait, J. (1994). A structural equation model of latent segmentation and product choice for cross-sectional revealed preference choice data. Journal of Retailing and Consumer Services, 1 (2): 77-89. https://doi.org/10.1016/0969-6989(94)90002-7

Swinnen, J. F. M. and Maertens, M. (2007). Globalization, Privatization, and Vertical Coordination in Food Value Chains in Developing and Transition Countries. Agricultural Economics, 37: 89–102. https://doi.org/10.1111/j.1574-0862.2007.00237.x

Tadesse, G. B., Algieri, M., Kalkuhl and Von Braun, J. (2014). Drivers and triggers of international food price spikes and volatility. Food Policy, 47: 117-128. https://doi.org/10.1016/j.foodpol.2013.08.014

Vaissiere, A. C., Tardieu, L., Quetier, F., and Roussel, S. (2018). Preferences for biodiversity offset contracts on arable land: a choice experiment study with farmers. Eur. Rev. Agric. Econ. 45: 553–582. https://doi.org/10.1093/erae/jby006

Van den Broeck, G., Vlaeminck, P., Raymaekers, K., Velde, K.V., Vranken, L. and Maertens, M. (2017). Rice farmers' preferences for fairtrade contracting in Benin: evidence from a discrete choice experiment. Journal of Cleaner Production, 165: 846–854. https://doi.org/10.1016/j.jclepro.2017.07.128

Vassalos, M., Hu, T., Woods, W., Schieffer, J. and Dillon, C. (2016). Risk preferences, transaction costs, and choice of marketing contracts: Evidence from a choice experiment with fresh vegetable producers. Agribusiness, 32 (3): 379-396. https://doi.org/10.1002/agr.21450

Viganò, E., Maccaroni, M. and Righi, S. (2022). Finding the right price: supply chain contracts as a tool to guarantee sustainable economic viability of organic farms. Int. Food Agribus. Manag. Rev., 25(3): 1-16. https://doi.org/10.22434/ifamr2021.0103

Wang, H.H., Zhang, Y. and Wu, L. (2011). Is contract farming a risk management instrument for Chinese farmers? Evidence from a survey of vegetable farmers in Shandong. China Agricultural Economic Review, 3: 489–505. https://doi.org/10.1108/17561371111192347

Wang, Y., Liang, J., Yang, J., Ma, X., Li, X., Wu, J., Yang, G., Ren, G. and Feng, Y. (2019) Analysis of the environmental behavior of farmers for non-point source pollution control and management: an integration of the theory of planned behavior and the protection motivation theory. Journal of Environmental Management, 237: 15–23. https://doi.org/10.1016/j.jenvman.2019.02.070

Weituschat, C. S., Pascucci, S., Materia, V. C., and Caracciolo, F. (2023). Can contract farming support sustainable intensification in Agri-food value chains?. Ecological Economic, 211: 107876. https://doi.org/10.1016/j.ecolecon.2023.107876

Widadie, F., Bijman, J. and Trienekens, J. (2020). Farmer preferences in contracting with modern retail in Indonesia: A choice experiment. Agribusiness, 37(2): 371-392. https://doi.org/10.1002/agr.21652

Williamson, O. E. (1991). Comparative economic organization: The analysis of discrete structural alternatives. Administrative science quarterly, 36: 269-296. https://doi.org/10.2307/2393356

Wolf, S., Hueth, B. and Ligon, E. (2001). Policing Mechanisms in Agricultural Contracts. Rural Sociology, 66: 359–381. https://doi.org/10.1111/j.1549-0831.2001.tb00072.x

Yang, C. (2006). Evaluating latent class analysis models in qualitative phenotype identification. Computational

Statistics & Data Analysis, 50: 1090-1104. https://doi.org/10.1016/j.csda.2004.11.004
Yoo, H. I. (2020). lclogit2: An enhanced command to fit latent class conditional logit models. The Stata Journal, 20(2): 405–425. https://doi.org/10.1177/1536867X20931003

APPENDIX A

Table A. Characteristics of the sampled durum wheat producers and their farms (n=190).

Variable name	Variable description	Mean	sd	Min	Max
age	years of the farmers (n.)	47.24	13.70	18	85
contr_p	use of production contract (y/n)	0.62	0.48	0	1
coop_m	member of a cooperative (y/n)	0.40	0.49	0	1
educ_h	high school or higher qualification (y/n)	0.83	0.36	0	1
exp_y	years of experience as farmers (n.)	26.84	14.01	2	60
size	hectares of farming areas (n.)	164.87	399.82	2.56	3680

BAE
Bio-based and Applied Economics

AIEAA
ASSOCIAZIONE ITALIANA DI ECONOMIA AGRARIA E APPLICATA

OPEN ACCESS

Citation: Sogari, G., Wongprawmas, R., Andreani, G., Lefebvre, M., Pellegrini, N., Gómez, M.I., Mora, C., & Menozzi, D. (2024). Intention and behavior toward eating whole grain pasta on a college dining campus: Theory of Planned Behavior and message framing. *Bio-based and Applied Economics* 13(3): 301-316. doi: 10.36253/bae-15456

Received: November 28, 2023
Accepted: March 15, 2024
Published: October 16, 2024

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Editor: Francesco Pagliacci, Valentina Raimondi, Luca Salvatici

ORCID
GS: 0000-0002-2561-571X
RW: 0000-0002-4897-7414
GA: 0000-0001-8660-7732
NP: 0000-0002-9178-5274
MIG: 0000-0002-3591-5249
CM: 0000-0003-3180-5496
DM: 0000-0002-5241-1587

Intention and behavior toward eating whole grain pasta on a college dining campus: Theory of Planned Behavior and message framing

Giovanni Sogari[1], Rungsaran Wongprawmas[1], Giulia Andreani[1], Michele Lefebvre[2], Nicoletta Pellegrini[3], Miguel I. Gómez[4], Cristina Mora[1], Davide Menozzi[1,*]

[1] *Department of Food and Drug, University of Parma, Parco Area delle Scienze 47/A, 43124 Parma, Italy*
[2] *Director, Nutrition Management, Cornell University, Ithaca, NY 14850, USA*
[3] *Department of Agricultural, Food, Environmental and Animal Sciences, University of Udine, Via Sondrio 9 2/A, 33100 Udine, Italy*
[4] *Charles H. Dyson School of Applied Economics and Management, Cornell University, Ithaca, NY 14850, USA*
* Corresponding author. E-mail: davide.menozzi@unipr.it

Abstract. The consumption of whole grains has several health benefits, however, most US consumers – including young adults – do not meet the recommended consumption intake. To understand the underlying factors affecting the intention and consumption of whole grain pasta, a survey based on the Theory of Planned Behavior (TPB) was developed and administered to US college students. For four weeks, participants (n = 325) either did not receive any information (control) or received weekly messages on the health benefits of whole grain pasta (e.g., high fiber and niacin contents) in the forms of gain- (treatment 1) or loss-framed (treatment 2) information. Variables of the TPB model and consumers' perceptions were investigated both at Time 1, when the first message was received (week 0), and at Time 2, one month after the intervention (week 4). Results from the two moments were compared. We found that the TPB measures and perceived usefulness were not influenced by the treatment group; however, the gain-framed message engendered greater message engagement than the loss-framed one. Finally, results from the structural equation model showed that attitude, subjective norms, and perceived behavioral control were positively associated with the intention to consume whole grain pasta, and the intention was a strong determinant of participants' behavior. Based on our results, implications and suggestions for future studies are discussed.

Keywords: dietary fiber, message framing, gain-framed, loss-framed, message engagement.
JEL Codes: I12, D91, D83.

1. INTRODUCTION

Substantial socio-environmental changes from adolescence to college can be challenging for many young adults (Christoph, Ellison, & Meador, 2016).

In a situation in which young adults are now faced with making their own dietary choices, this transition is often associated with unhealthy eating habits (Quick, Wall, Larson, Haines, & Neumark-Sztainer, 2013; Stok, Renner, Clarys, & Deliens, 2018), which can contribute to overweight and obesity and other diet-related diseases (Kann et al., 2018; World Health Organization, 2014). Therefore, campus dining programs are working to change the perception of nutrition and healthy eating within their food eateries (Franchini, Biasini, Rosi, & Scazzina, 2023). From new and innovative design strategies and different approaches to healthy menus to the inclusion of more produce, many campus dining programs have tested and used health principles and guidelines to nudge customers' decisions (Andreani, Sogari, Wongprawmas, Menozzi, & Mora, 2023). One example comes from the US-based Menus of Change program. Menus of Change, founded in 2012 by the CIA and Harvard School of Public Health, is an initiative to achieve healthy and sustainable menus, with the tagline "The Business of Healthy, Sustainable, and Delicious Food Choices". Menus of Change University Research Collaborative (MCURC) was established with working groups of scholars and campus dining leaders interested in using college and university dining as a platform to establish and accelerate efforts to move campus diners towards healthy menus.

Healthy eating habits should include high consumption of food considered to be healthy, such as fruit, vegetables, and other high-fiber options, such as whole grains [1] and legumes (U.S. Department of Health and Human Services and U.S. Department of Agriculture & US Department of Agriculture, 2015). Among healthy food choices, whole grain intake is a pivotal aspect to be considered in weight management and overall health of young adulthood, which helps in overweight and obesity prevention (Quick et al., 2013).

Grains, including whole grains, are staple foods in many countries of the world (European Commission, 2019) and can be consumed as single foods (e.g., rice, oatmeal), or included as an ingredient in many food products (e.g., breads, cereals, crackers, and pasta) (U.S. Department of Health and Human Services and U.S. Department of Agriculture & US Department of Agriculture, 2015). Evidence showed that higher consumption of whole grains and dietary fiber is inversely associated with the risk of obesity and weight gain (Maki et al., 2019; Slavin, 2005), type 2 diabetes mellitus and cardiovascular disease (Ye, Chacko, Chou, Kugizaki, & Liu, 2012). Because of the health benefits linked to dietary fiber (see Jones & Engleson, 2010 for a more comprehensive review), governmental institutions and nutritional experts have developed nutrition education and health promotion campaigns to recommend the inclusion of whole grains in the diet (Jones & Engleson, 2010; Marquart, Wiemer, Jones, & Jacob, 2003; Shepherd et al., 2012). For instance, the 2015–2020 Dietary Guidelines for Americans suggests that a healthy eating pattern should include grains, at least half of which should be from whole grains (U.S. Department of Health and Human Services and U.S. Department of Agriculture & US Department of Agriculture, 2015).

Previous reserach (e.g., Wongprawmas et al., 2021) indicates that the availability of whole grain options at comparable prices to conventional ones could be beneficial for students since it may mitigate consumption barriers such as availability and price (Meynier, Chanson-Rollé, & Riou, 2020). Moreover, another barrier to consuming whole grain products is consumers' negative perceptions of their sensory attributes (i.e., taste and texture) (Bisanz & Krogstrand, 2007; Dammann, Hauge, Rosen, Schroeder, & Marquart, 2013).

Despite the relevance whole grains have in a healthy diet, limited research (Ugunesh, Siau, Mohd Sanip, & Koo, 2023; Weingarten & Hartmann, 2023) has investigated the links between consumer attitudes, intention, and behavior to consume whole grain foods, especially among young adults. Therefore, we tested the Theory of Planned Behavior (TPB) (Ajzen, 1991) – which is an expectancy-value model of behavior change – to measure the variables influencing the consumption of whole grain pasta. The TPB model postulates that behavioral intention is the central determinant of behavior. Previous systematic reviews have demonstrated that the TPB and similar psycho-social theories (e.g. the Theory of Reasoned Action, TRA) can serve as reliable tools for predicting sustainable (e.g., Biasini et al., 2021) and health-promoting behaviours (e.g., McEachan, Conner, Taylor, & Lawton, 2011), including healthy eating behaviours (e.g., McDermott et al., 2015). These reviews have shown that, in general, attitude towards the behaviour is the most significant predictor of intention, and intention is the most significant predictor of behaviour (McDermott et al., 2015; Biasini et al., 2021). Biasini et al. (2021) observed a wide range of explained variance in intention (7–87%) and/or behaviour (3–81%) across different applied models and study designs. As suggested by these authors, longitudinal studies can provide a prospective

[1] "Grains and grain products made from the entire grain seed, usually called the kernel, which consists of the bran, germ, and endosperm. If the kernel has been cracked, crushed, or flaked, it must retain the same relative proportions of bran, germ, and endosperm as the original grain in order to be called whole grain. Many, but not all, whole grains are also sources of dietary fiber." (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015, pag. 96).

prediction analysing the causal relationship between dependent and independent variables, which would be otherwise precluded in cross-sectional investigations (McEachan et al., 2011; Biasini et al., 2021).

Based on these considerations, first, the model we tested hypothesizes that the intention to include whole grain pasta in the diet is influenced by the attitude (a person's favorable or unfavorable evaluation of the behavior), the subjective norms (what other people think one should do), and the perceived behavioral control (the perceived ease or difficulty of performing the behavior). Second, we hypothesized that the prospective behavior (actually eating whole grain pasta), measured after four weeks (Time 2), is determined by the intention and perceived behavioral control. Figure 1 shows the theoretical framework. In addition, past studies suggest that whole grain food consumption could be promoted by using positive information about its health benefits presented at the point of consumption. One study by Sogari et al. (2019) found that a psychological health benefit (i.e., vitamin benefits reduce fatigue) related to whole grain foods significantly increased the number of individuals preferring whole grain vs. regular pasta. Another study by Weingarten and Hartmann (2023) showed that repeated exposure to positive information about the health benefits of whole grain increased attitudes and led to higher intentions to consume such products. Therefore, the use of health claims and messages to encourage the consumption of whole grain pasta over regular pasta is one communication strategy that could support the shift toward a healthy eating pattern. Based on this evidence, it is relevant to understand the effectiveness of different communication strategies on the attitude towards whole grain options in terms of the framing effect, i.e. decisions are influenced by the way the outcomes are presented (Dolgopolova, Li, Pirhonen, & Roosen, 2022). Meta-analysis results have recently indicated that product attributes framed as gains have a higher effect on attitudes and intentions than product attributes framed as losses (Dolgopolova et al., 2022). Other researches have indicated that encouraging positive behaviors by evoking loss aversion is not necessarily a guiding principle when it comes to health benefits (e.g., Gallagher & Updegraff, 2012). Dolgopolova et al. (2022) have suggested that loss-framed messages are mainly effective when it comes to decisions involving significant risk, and that food choices are not associated with an immediate high level of risk. Thus, a secondary aim of our study is to understand whether providing information on the health benefits of whole grains, under two different framing conditions (gain vs. loss-framed), would influence the TPB measures as well as other variables (e.g., perceived usefulness of eating whole grain pasta).

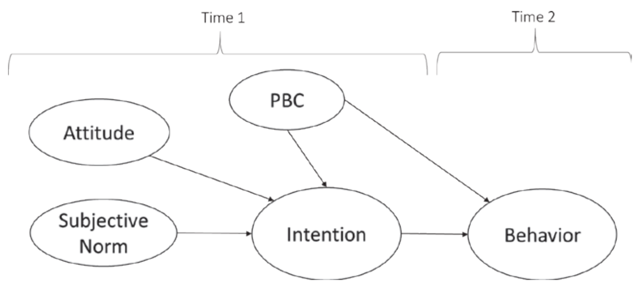

Figure 1. Theoretical framework of the Theory of Planned Behavior (TPB) in Time 1 (main survey in week 0) and Time 2 (follow-up survey after 4 weeks).

2. METHODS

2.1. Data Collection and the Sample

Data collection was carried out across several dining halls at Cornell University, Ithaca, NY, US in spring 2019. An online questionnaire was distributed using the Qualtrics LLC platform (Provo, US), and included attitudinal and motivational items derived from the TPB framework, as well as questions on overall eating habits. Some survey sections, including the message frames, were revised to improve the clarity of their meaning and reduce the total survey length to approximately 12 minutes. The entire survey was pre-tested with 50 students and Faculty staff members. The data collection took place during dinner time in front of the pasta station in a dining setting (Time 1). A final sample of 499 college students (female 53.6%, mean age 18.8y), all pasta consumers, participated in this study. Participants mostly had a healthy weight range (Body Mass Index between 18.5 and 24.9), were mainly omnivores with a slightly high proportion of flexitarian and vegan or vegetarian, and only 10% had dietary or healthy restrictions. Table 1 shows the full set of socio-demographics of the participants.

One month after Time 1 (Time 2), a follow-up questionnaire was sent via email to all the participants in order to evaluate whether any changes in their attitudinal variables occurred and to assess the reported consumption behavior of eating whole grain pasta over the last month. Most of the participants returned the electronic questionnaire on the day they received it, and few of them completed it in the following days. A final sample of 325 respondents returned the questionnaire. The full survey flow (Time 1 and Time 2) is shown in Figure A1 in the Appendix. The two surveys at the two time points were linked through the student ID number. Following the completion of the study, participants received a monetary compensation of $5. The study was approved by the Institutional Review Board (IRB) of the Office of Research Integrity and Assurance of Cornell University (Protocol Number: 1810008359).

2.2. Measures

The main survey (Time 1) consisted of three sections. The first section included the message or framing treatment (control, gain-framed, and loss-framed messages) – details are reported in section 2.3. In the two treatment groups, the participants were asked to carefully read the information provided. The second section was structured to measure the various components of the TPB (Ajzen, 1991) and other factors in relation to the participant's behavior of including whole grain pasta in the diet over the next month (for details see Table A1). The TPB survey items and the health claims were based on a review of the existing literature (Fishbein & Ajzen, 2011) followed by a revision by two nutrition experts as well as three experts in social sciences. Finally, the third section of the survey included socio-demographic data (i.e., participants' age, gender, and Body Mass Index[2]), self-perception of overall health, physical exercise, eating behavior, and dietary/healthy restrictions.

For the TPB section, all measures were assessed using a 7-point scale, from strongly disagree (1) to strongly agree (7). Two items measured the Perceived Behavioral Control (PBC), which is related to the control of performing the behavior. Three items assessed the Subjective Norms (SN), which is an individual's perception of social pressure on the way a person should or should not demonstrate a specific behavior. Attitude towards the behavior (ATT), which represent the degree of a favorable or unfavorable evaluation of a specific behavior, was based on two items about the likelihood that consuming whole grain pasta would result in personal beliefs (i.e., tasty, easy). Behavioral Intention (INT) is the willingness of an individual to perform a specific behavior and it was measured using three items.

The factors of the TPB model have prior determinants: ATT is guided by behavioral beliefs about the likely consequences of performing the behavior, SN is driven by the normative beliefs about the opinions/expectations of important others, and PBC is influenced by the control beliefs about barriers and facilitators to perform that behavior (Fishbein & Ajzen, 2011). All these beliefs (n=12) were measured using a 7-point Likert scale from strongly disagree (1) to strongly agree (7).

In addition, we asked about the perceived usefulness of whole grain pasta, which measured subjects' perceptions of performance and effectiveness gains from eating whole grain pasta (e.g., stay in shape, improve work performance) by using three 7-point Likert scaled items.

Two factors were also used to evaluate the quality of the messages provided in the two information conditions. The first factor was the consumer evaluation of the message (Hung & Verbeke, 2019), which was based on five items with a 7-point Likert scale, to measure several characteristics of the health claim, including familiarity, understandability, credibility, interest, and importance. The second factor was the argument quality of the message (Bhattacherjee & Sanford, 2006), which was used to measure whether the information provided was helpful, valuable, informative, and persuasive, by using four 7-point Likert scaled items.

Four weeks after the initial survey (Time 2), participants' behavior was also assessed by using two measures of reported behavior using a 7-point scale (Fishbein & Ajzen, 2011). In the first item, respondents were asked to indicate how frequently they consume whole grain pasta, on average, ranging from 'never' to 'almost every day'. In the second item, participants were asked whether they had included whole grain pasta in their diet at least once over the past month. In addition, attitude, intention, and perceived usefulness were measured again in Time 2 using the same items as in Time 1. Note that all canteens on the Campus offer whole grain dishes daily; therefore, product availability is not a barrier for the participants.

2.3. Intervention with health messages

At the beginning of the study, participants were randomly assigned to either a no-information group (control, n=100) or one of the two treatment groups, namely gain-framed (n=202) or loss-framed (n=197) messages. Students in the gain or loss-framed treatment received four messages about whole grain pasta health benefits. The health benefits were adapted by authorized health claims.

In the US, a food-related health claim[3] must be approved by public authorities (i.e. the Food and Drug

[2] The body mass index, abbreviated as BMI, is a measure of a person's weight relative to height that correlates well with body fat (Eurostat, 2017). A person is considered underweight if they have a BMI below 18.5, normal weight between 18.5-24.9, and overweight if they have a BMI greater than or equal to 25.

[3] "Health claim means any claim made on the label or in labeling of a food, including a dietary supplement, that expressly or by implication, including "third party" references, written statements (e.g., a brand name including a term such as "heart"), symbols (e.g., a heart symbol), or vignettes, characterizes the relationship of any substance to a disease or health-related condition." (Food and Drug Administration, 2023).

Table 1. Socio-demographic characteristics, lifestyle variables, and health-related factors reported for the total sample and by the groups at Time 1.

Variables	All	Information treatments			*p*-value
		Control	Gained-frame	Loss-frame	
N	499	100	202	197	
%	100	20.0	40.5	39.5	
Age[1] (mean, sd)	18.8 (1.16)	18.6 (1.13)	18.9 (1.16)	18.8 (1.17)	0.267
Gender[2]					0.451
Male	44.4	41.0	47.5	42.9	
Female	53.6	59.0	49.5	55.1	
Others or prefer not to answer	2.0	0.0	3.0	2.0	
BMI[1]	22.9 (5.79)	22.0 (5.00)	23.1 (5.77)	23.1 (6.16)	0.267
Eating behavior[2]					0.357
Omnivore	80.1	79.0	83.2	77.6	
Vegetarian	6.6	6.0	4.0	9.7	
Vegan	3.2	3.0	3.0	3.6	
Flexitarian	8.8	11.0	7.9	8.7	
Others	1.2	1.0	2.0	0.5	
Dietary/Healthy restrictions[2]					0.461
Yes	10.4	10.0	8.9	12.2	
No	87.8	90.0	88.6	85.7	
Prefer not to answer	1.8	0.0	2.5	2.0	
Self-perception of overall health[3]	5.0 (4.0-6.0)	6.0 (4.2-6.0)	5.0 (4.0-6.0)	5.0 (4.0-6.0)	0.145
Physical excercise[3]	4.0 (3.0-5.0)	4.0 (3.0-5.0)	4.0 (3.0-5.0)	4.0 (3.0-5.0)	0.255

Note: Data are presented as the mean (SDs) for continuous variables, as number (%) for nominal variables, and as the median (IQRs) for categorical variables. SDs = standard deviations. IQRs = Interquartile ranges. BMI: Body Mass Index. N = 498 for age, gender, eating behavior, dietary/healthy restrictions, self-perception of overall health; N=481 for BMI; and N=495 for physical exercise. [1]ANOVA. [2]Pearson chi-square. [3]Kruskal–Wallis Test.
Self-perception of overall health: How healthy do you consider yourself? (from very bad = 1 to very well= 7)
Physical exercise: How often do you usually engage in physical exercise (30 minutes of exercise)? (from never = 1 to more than 3 times per week = 5. They can choose "I do not want to answer").

Administration, FDA) and must be supported by a significant body of research showing the relationship between the food/constituent and a health effect in humans. Based on this context, four specific health claims related to whole grains were considered (Table A2). Moreover, following previous works (see Deliens et al., 2016 for a systematic review) a media-based approach was used to communicate such expected healthy benefits. In our study, we decided to use health claims in the form of messages considering both general benefits of whole grain foods (e.g., fibers have positive effects on weight management) and more specific ones (e.g., the relationship between fibers and gut health or bowel function) (EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA), 2010).

For the two treatment groups, we decided to convey identical information but differently framed in terms of gains or losses associated with an expected outcome (Dolgopolova et al., 2022). A gain-framed message might take the form of ''If you perform the advocated action, desirable outcome X will be obtained'', whereas a loss-framed message might be "If you do not perform the advocated action, desirable outcome X will be avoided" (O'Keefe & Jensen, 2008). The rationale is that one type of framing may be more effective than another at promoting health behavioral change (Gallagher & Updegraff, 2012). Participants in the treatment groups read a similar health message that differentiated for details of either the benefits of including whole grain pasta (gain-framed), or the health dangers of not including whole grain pasta (loss-framed).

In addition, participants in the two treatment groups received four emails (one per week) that included a different health claim message, still considering the same framework group (gain-framed or loss-framed) and were blinded to the other intervention.

Thanks to the online platform used to send out personalized emails (mailchimp.com), we were able to electronically assess whether the recipient opened the email with the health claim message. For those who did not open it, a reminder was sent the following day. However, we cannot be sure whether the participants actually read the text incorporated in the email. The information sent via email was different every week to avoid the boredom of reading the same message and the risk of dropping out of the study. The messages were sent to participants in a random order. In this way, the subjects were exposed to all four types of claims (see Table A2) in order to have a broader knowledge of the several beneficial roles of eating whole grain food.

2.4. Data Analysis

Descriptive statistics were used to report the percentages, median, means, and standard deviations. One-way ANOVA, Pearson Chi-square, and Kruskal-Wallis tests for independent samples were performed in order to determine the existence of significant differences between the control and treatment groups regarding the socio-demographic data, lifestyle variables, and health-related factors.

The internal consistency, validity, and reliability of ATT, SN, PBC, INT, and Perceived Usefulness (PU) factors were tested using Cronbach's alpha, factor loadings (λ), and composite reliability (CR), respectively, and considering all participants at each time point (Time 1 and Time 2). Discriminant validity was tested by comparing the square root of the AVE of each construct with the inter-construct correlation (Bagozzi & Yi, 2012). Then, the internal consistency was assessed for each factor at each time point in all groups. Almost all of Cronbach's alphas of each factor at each time point were above the acceptable threshold ($\alpha > .60$) (van Griethuijsen et al., 2015). Eleven composite variables were created by averaging the items within each factor (Table 2). Details of the internal consistency of each factor of the TPB model and other variables in Time 1 and Time 2 are presented in Table A3.

One-way ANOVA tests were used to analyze the impacts of different health claim messages as well as the effects of providing information under two different framing scenarios (gain vs. loss-framed) on the TPB measures.

Repeated measures ANOVA was used to examine the interaction of time and information treatments on attitude, intentions, and perceived usefulness at baseline (week 0) and week 4. The results indicated that there were no different effects between the control and the framings nor differences among health claim messages.

Therefore, the following Structural Equation Modelling (SEM) model analysis was performed on the total sample without separating groups according to the framings. A SEM approach was used to test the theoretical framework presented in Figure 1. SEM allows the specification of a model with both latent (e.g., attitude towards including whole grain pasta in the diet) and observed variables (e.g., the questionnaire items) (Kline, 2016). The latent variables, namely the abstract phenomena that cannot be directly measured by the researcher, have been analyzed using confirmatory factor analysis (Byrne, 2010). Confirmatory Factor Analysis (CFA), often referred to as the measurement model, is used when the researcher has some knowledge of the underlying latent variable structure or wishes to evaluate a priori hypotheses driven by theory. In our case, to improve the overall goodness-of-fit of the model, we decided to apply the latent variable structure for all TPB variables but PBC, for which we used the observed averaged variable. The goodness-of-fit of the models was assessed using χ^2 and their degrees of freedom (df), Tucker-Lewis Index (TLI), comparative fit index (CFI), root mean square error of approximation (RMSEA) with a 90% confidence interval, and the standardized root mean square residual (SRMR). Statistical analysis was performed using SPSS v.28.0 and AMOS v.27.0 statistical software (IBM Corporation, Armonk, NY, USA).

3. RESULTS

3.1. Descriptive statistics

Table 2 shows the descriptive statistics of the latent and observable variables: the factor loadings of the variables items (λ) above 0.50, CR values above 0.70, Cronbach's α above 0.70 with the only exception of PBC (0.62), and AVE values above 0.50 show strong reliability, and convergent validity of all factors in the measurement model. The results demonstrate a moderately positive consumer attitude toward including whole grain pasta in their diet (mean score: 4.75). Nevertheless, subjective norms did not show to greatly influence consumers (3.57) whereas they reported relatively strong control over the behavior (5.49). Again, consumers exhibited a moderately positive intention to include whole grain pasta in their diet (4.23). In general, participants reported consuming whole grain pasta occasionally (4.63).

As shown in Table 3, the squared root of the AVE of each construct was greater than the Spearman's rank-order correlation (ρ) between the constructs, which also indicates the discriminant validity of the model.

We also tested the effects of information (gain vs. loss-framed) on the TPB constructs and other variables in Time 1 and Time 2 (see details in Appendix Table

Table 2. Mean values (standard deviation, SD) of single items and TPB constructs, factor loadings (λ), composite reliability (CR), average variance extracted (AVE) and Cronbach's α of the total sample (N=499) and follow-up (N=325).

	N	Mean (SD)	λ	CR	AVE	α
Time 1						
Attitude (Including whole grain pasta in my diet over the next month will be)	499	4.75 (1.48)		0.74	0.59	0.70
Difficult/Easy	499	4.98 (1.67)	0.59			
Not tasty/Tasty	499	4.51 (1.72)	0.92			
Subjective norm	499	3.57 (1.41)		0.92	0.79	0.90
Most people who are important to me think that I should include whole grain pasta in my diet over the next month	499	3.69 (1.54)	0.95			
Most people who influence my decisions think that I should include whole grain pasta in my diet over the next month	499	3.61 (1.45)	0.93			
It is expected that I should include whole grain pasta in my diet over the next month	499	3.41 (1.65)	0.78			
Perceived behavioral control	499	5.49 (1.13)		0.84	0.72	0.62
I believe that including whole grain pasta in my diet over the next month is possible	499	5.43 (1.33)	0.85			
The decision to include whole grain pasta in my diet over the next month will be only up to me	499	5.56 (1.34)	0.85			
Intention	499	4.23 (1.55)		0.91	0.77	0.91
I intend to include whole grain pasta in my diet over the next month	499	4.40 (1.64)	0.89			
I will try in anyway to include whole grain pasta in my diet over the next month	499	4.25 (1.68)	0.84			
I will definitely include whole grain pasta in my diet over the next month	499	4.03 (1.74)	0.89			
Follow Up (Time 2)						
Behavior	325	4.63 (1.71)		0.77	0.62	0.76
In the past month, how often have you included a meal with whole grain pasta in your diet?	325	3.84 (1.70)	0.83			
I have included whole grain pasta in my diet at least once in the past month	325	5.42 (2.10)	0.75			

Table 3. Spearman's rank-order correlations (ρ) between the TPB constructs including the squared root of the AVE of each construct (reported in bold).

	ATT	SN	PBC	INT	BEH
ATT	**0.77**	0.22***	0.30***	0.45***	0.32***
SN		**0.89**	n.s.	0.58***	0.31***
PBC			**0.85**	0.25***	0.16**
INT				**0.88**	0.55***
BEH					**0.79**

Note: ATT = attitudes; SN = subjective norms; PBC = perceived behavioral control; INT = Intentions; BEH = behavior; *** indicates significance at p<0.001, ** significant at p<0.01, ns=not significant

A3). No significant differences between control, gain- and loss-framed groups were found for the TPB measures and PU, neither in Time 1 nor Time 2. Regarding how participants evaluate the type of message and the quality of the argument, significant differences were found between the gain- and loss-framed condition. The gain-framed message was found to slightly but significantly engender greater message engagement in terms of overall evaluation (M= 4.86) and quality of the message (M=4.77) than the loss-framed message (overall evaluation: M=4.16, and quality of the message: M = 3.96).

Interestingly, the results of repeated measures ANOVA (Table 4) suggested that time (Time 1 vs. Time 2) had a positive impact on perceived usefulness ($p < 0.001$), intention ($p < 0.001$) and attitude ($p = 0.006$). Nevertheless, there was no significant effect of the interaction of time and treatments (framing) for perceived usefulness (Wilks lambda = 0.99, F =2.41, $p = 0.092$), intention (Wilks lambda = 0.99, F =1.10, $p = 0.334$) and attitude (Wilks lambda = 0.99, F =0.42, $p = 0.659$). The explanation for this finding could be that the request to fill out a follow-up questionnaire in the control group might have positively affected the perceived usefulness of and intention to consume whole grain pasta in Time 2.

3.2. Effect of beliefs

The correlations (ρ) between behavioral, normative, and control beliefs with their relative constructs (attitudes, subjective norms, and PBC, respectively), intention to eat whole grain pasta over the next month, and behavior are reported in Table 5.

Intermediate correlation levels (ρ = 0.40–0.70) are reported for the association of normative beliefs with subjective norms and behavioral beliefs with attitude to

Table 4. Results of repeated measures ANOVA.

Variables	Times				Wilks lambda	F	Partial eta squared	*p*-value
	Time 1		Time 2					
	M	SD	M	SD				
ATT (N = 325)	5.20	1.46	5.52	1.34	0.95	7.73	0.05	0.006
PU (N = 325)	4.35	1.10	4.84	1.12	0.86	51.99	0.14	<0.001
INT (N = 325)	4.18	1.55	4.41	1.49	0.96	13.70	0.04	<0.001

Note: ATT = Attitude; PU = Perceived usefulness; INT = Intentions; M = Means; SD = Standard Deviation.

Table 5. Spearman's rank order correlations (ρ) between beliefs and their respective direct measure (attitude, subjective norm, and perceived behavioral control – PBC), intention, and behavior.

Beliefs	ρ	Sig.	ρ	Sig.	ρ	Sig.
Control beliefs	PBC		Intention		Behavior	
ConBel1	0.11	**	0.11	**	0.03	ns
ConBel2	-0.28	***	0.08	*	-0.03	ns
ConBel3	-0.28	***	0.20	***	0.06	ns
ConBel4	-0.09	**	0.08	*	0.06	ns
Behavioral beliefs	Attitude		Intention		Behavior	
BehBel1	0.40	***	0.40	***	0.24	***
BehBel2	0.43	***	0.38	***	0.18	**
BehBel3	0.45	***	0.42	***	0.22	***
Normative beliefs	Subjective norms		Intention		Behavior	
NorBel1	0.62	***	0.41	***	0.14	**
NorBel2	0.66	***	0.41	***	0.18	**
NorBel3	0.45	***	0.32	***	0.08	ns
NorBel4	0.51	***	0.35	***	0.09	*
NorBel5	0.54	***	0.33	***	0.17	**

eating whole grain pasta (ρ = 0.40). In particular, parents' and friends'/partners' opinions are the two normative beliefs that primarily affect subjective norms and intention. Regarding behavioral beliefs, the two most relevant beliefs associated with eating whole grain pasta are a long-term investment for the individual and less diet-related diseases. Control beliefs are negatively associated with PBC, in particular, for the higher costs of whole grain pasta and the perceived lack of availability in the dining halls. These represent the main barriers that decrease the perceived ability of respondents to perform the behavior. Finally, the link between control beliefs and intention has positive values, although it is almost non-significant.

The effect of the beliefs on behavior is less relevant (ρ ≤ 0.30) and significant only for normative and behavioral beliefs.

3.3. Structural equation model results

The results of the SEM analysis with standardized path coefficients and R^2 are reported in Figure 2, while the unstandardized coefficients and standard errors are reported in Table A4. The SEM analysis was performed on the entire sample because framing had no effect on the TPB measures. The results show that there is a satisfactory fit between the hypothesized model and the data (χ^2 (df) = 112.61 (37); CFI = 0.975; TLI = 0.955; RMSEA (90% C.I.) = 0.064 (0.051–0.078)). Overall, the TPB model explains 53.2% of the variance for the intention to consume whole grain pasta over the next month (measured in Time 1), and 44.5% of the variance in the self-reported behavior measured in Time 2. Attitude, subjective norms, and perceived behavioral control are significant predictors of the intention to consume whole grain pasta over the coming month. Specifically, subjective norms (β = 0.50, p < 0.001) and attitude (β = 0.36, p < 0.001) have a greater influence on the intention than the PBC (β = 0.16, p < 0.001). The intention is also a strong determinant of the behavior to consume whole grain pasta (β = 0.68, p < 0.001), measured after four weeks (self-reported behavior).

4. DISCUSSION AND CONCLUSIONS

Understanding how the behavior towards the inclusion of whole grain products is formed becomes a crucial stage to develop efficient healthy food choice strategies. In our study, the TPB model provides a significant explanation for the variance of the intention to consume whole grain pasta over the next month (R^2=0.53), as well as the (self-reported) prospective behavior (R^2=0.45). Thus, our results of the TPB model show that when individuals have strong attitudes, subjective norms, and perceived behavioral control toward eating whole grain pasta, their intention to eat this product increases, and this higher motivation would be strongly associated with

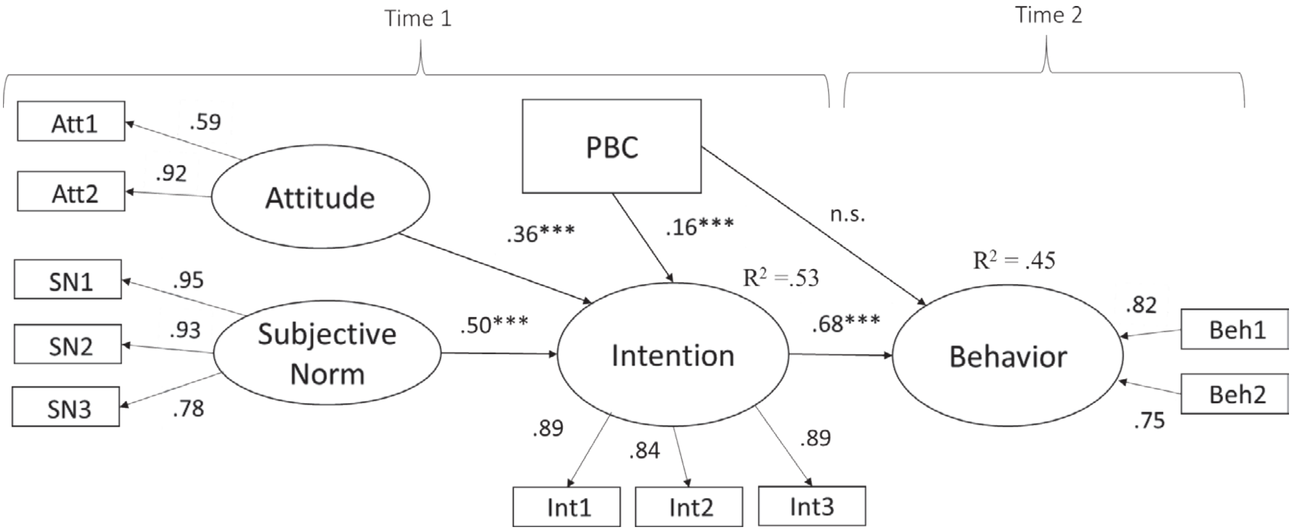

Figure 2. Results of the TPB model in Time 1 (n=499) and in Time 2 (n=325). Notes: *** indicates a significant difference at $p < 0.001$, n.s. = not significant. Goodness-of-fit statistics: χ^2 (df) = 112.61 (37); CFI = 0.975; TLI = 0.955, RMSEA (90% C.I.) = 0.064 (0.051-0.078).

the actual behavior. Similar results were found in other studies with regard to healthy dieting; for instance, in studies conducted by Hagger et al. (2006), the applied models explained 69% (Hagger & Chatzisarantis, 2006) and 56% (Hagger, Chatzisarantis, & Harris, 2006) of the intention, with relatively high variability in the explained behavior (66% and 32%, respectively). In line with previous studies (Biasini, Rosi, Scazzina, & Menozzi, 2023; Sogari et al., 2022), the intention well predicts young adults' behavior. In particular, subjective norms (i.e., the perceived social influence) affected the intention more than the attitude and PBC (Li, Long, Laubayeva, Cai, & Zhu, 2020). Usually, adolescents or young adults are more influenced by social and peers than other age groups, and this may explain why subjective norms have a stronger influence on intention in the TPB model (Barberis, Gugliandolo, Costa, & Cannavò, 2022; Friedman et al., 2022). In our case, the effect of behaviors of other students in the canteen (the social context) might affect the participant's motivation to comply.

Providing health messages at the point of consumption could, however, steer consumer decisions and be an effective method of delivering strategies to increase healthy eating. A message can be framed either to promote the advantages of consuming a particular food (gain-framed) or to stress the negative outcomes of not consuming that particular food (loss-framed) (Gallagher & Updegraff, 2012). The success of various message-framing strategies is usually assessed by measuring consumer behaviors, intentions, or attitudes (Dolgopolova et al., 2022).

Our findings show no effect of frame condition on the TPB measures in Time 1. This is in line with a review by Gallagher & Updegraff (2012) that showed no significant effect of framing on attitudes and intentions. Moreover, our results align with recent findings by Weingarten and Hartmann (Weingarten & Hartmann, 2023), who found that participants did not change their behavior toward whole grain consumption directly after receiving the first messages on the health benefits. Ottersen et al., (2022) conducted a study with Norwegian consumers to test whether daily mobile phone text message reminders about animal welfare, and the environmental and health consequences of meat would reduce people's meat consumption. They showed that meat consumption did not change. Therefore, simply reminding consumers about these issues may not be enough without further interventions, as eating and dietary habits are strongly entrenched behaviors that are primarily controlled by autonomic processes.

Our study is one of the few to assess the self-reported prospective behavior change (after four weeks of intervention) as a measure of message framing persuasiveness (Gallagher & Updegraff, 2012). As suggested by Meynier et al., (2020) information provision will more likely lead to a behavioral change if the information is provided on more than one occasion. For instance, Weingarten and Hartmann (2023) found that providing information over time about the health benefits of whole grain consumption contributed to increasing the positive attitude and behavioral intentions to consume such products. However, in Time 2, we found no impact of the informative message (health information) on attitude, intention, and the reported behavior of eating whole grain pasta. This could be also due to the weekly information treatment (once per week), rather than a more intense exposure (daily messages for 14 days, as in the case of Weingarten and Hartmann (2023)). Another possible reason could be that information messages might have a short-lived effect on participants rather than other types of messages. For instance, Carfora et al., (2019) showed that participants exposed to emotional messages experienced a more enduring and long-lasting effect than information-type messages.

The specific characteristics of the sample (young adults with a healthy status) may be one reason why the health claim message did not have an impact in changing the perception towards whole grain. Past studies (e.g., Rothman & Updegraff, 2011) suggest that gain-framed and loss-framed messages may be amplified when the message is of high personal relevance, which might not be our case. Another possible reason for the lack of impact from the message is that it did not specifically target consumers' relevant beliefs (Fishbein & Ajzen, 2011; Weingarten & Hartmann, 2023). In our study, we found that the opinions of important others (e.g., parents, friends, and partners) were the strongest normative beliefs influencing the subjective norms (de Leeuw, Valois, Ajzen, & Schmidt, 2015); whereas the two most important behavioral beliefs relating to eating whole grain pasta were a personal long-term investment and the possibility of having fewer diet-related illnesses. Hence, the messages and interventions should target changing these key beliefs in order to lead to the desired changes.

However, gain-framed messages were evaluated in terms of "Consumer evaluation" and "Argument quality" better than loss-framed ones. The positive message about the health consequences associated with eating whole grain pasta was considered to be more appropriate, helpful, valuable, and persuasive. Thus, in line with the literature (Dolgopolova et al., 2022; Gallagher & Updegraff, 2012; Rothman, Bartels, Wlaschin, & Salovey, 2006), our results confirm the higher appropriateness of gain-framed health messages when encouraging behavior with 'little risk' compared to loss-framed messages (more persuasive with a 'significant risky' behavior to perform).

Several limitations of our study occur. The first limitation is that we collected data only from a single University in the US, with a limited targeted population. Therefore, based also on the characteristics of this convenience sample (students enrolled in a US college), generalization of the findings to the broader population may be limited. Second, this study used self-report measures about the behavior of eating whole grain pasta which may be subject to response biases or limited memory. Third, although we focused our analysis on the individuals who actually opened the emailed messages, we cannot be sure whether the messages were truly read by the participants. Despite these limitations, we believe that our work will serve as a stimulus for further investigation on how to better develop communication strategies for the health benefits of whole grain products. Future research could explore different types of messages in terms of content and formats, as well as evaluate the results after a longer exposure. If concentrating on young adults, further studies could also consider testing the information across multiple dining halls to evaluate whether results are consistent across different cities. Finally, partnerships between nutrition, social scientists, and culinary professionals could support the development of relevant and useful information materials about whole grains consumption benefits.

FUNDING

This study is part of a wider project called "CONSUMEHealth. Using consumer science to improve healthy eating habits" and has received funding from the European Union's Horizon 2020 research and Innovation programme under the Marie Sklodowska-Curie grant agreement No 749514.

ACKNOWLEDGEMENTS

The authors are grateful to all the staff of the Cornell Dining venues for their collaboration and help in carrying out this study. Additionally, we want to express our gratitude to the students Mary Gaffney, Martina Cirelli, and Andrew Peterson who helped us in the data collection.

REFERENCES

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Andreani, G., Sogari, G., Wongprawmas, R., Menozzi, D., & Mora, C. (2023). Indulgent or informative logos? Effects on university students' intention to purchase healthy and sustainable food. *International Journal of Gastronomy and Food Science*, *33*, 100774. https://doi.org/https://doi.org/10.1016/j.ijgfs.2023.100774

Bagozzi, R. P., & Yi, Y. (2012). Specification, evaluation, and interpretation of structural equation models. *Journal of the Academy of Marketing Science*, *40*, 8–34. https://doi.org/10.1007/s11747-011-0278-x

Barberis, N., Gugliandolo, M. C., Costa, S., & Cannavò, M. (2022). Healthy and binge eating behaviours: the motivational processes underlying peer pressure. *Psychology, Health & Medicine*, *27*(5), 1144–1153. https://doi.org/10.1080/13548506.2021.1903054

Bhattacherjee, A., & Sanford, C. (2006). Influence Processes for Information Technology Acceptance: An Elaboration Likelihood Model. *MIS Quarterly*, *30*(4), 805–825. https://doi.org/10.2307/25148755

Biasini, B., Rosi, A., Giopp, F., Turgut, R., Scazzina, F., & Menozzi, D. (2021). Understanding, promoting and predicting sustainable diets: A systematic review. *Trends in Food Science & Technology*, *111*, 191–207. https://doi.org/https://doi.org/10.1016/j.tifs.2021.02.062

Biasini, B., Rosi, A., Scazzina, F., & Menozzi, D. (2023). Predicting the Adoption of a Sustainable Diet in Adults: A Cross-Sectional Study in Italy. *Nutrients*, Vol. 15. https://doi.org/10.3390/nu15122784

Bisanz, K. J., & Krogstrand, K. L. S. (2007). *Consumption & Attitudes about Whole Grain Foods of UNL Students Who Dine in a Campus Cafeteria*. Retrieved from https://api.semanticscholar.org/CorpusID:70589297

Byrne, B. M. (2010). *Structural equation modeling with AMOS: Basic concepts, applications and programming* (2nd ed.). New York, US: Routledge/Taylor & Francis Group.

Carfora, V., Bertolotti, M., & Catellani, P. (2019). Informational and emotional daily messages to reduce red and processed meat consumption. *Appetite*, *141*, 104331. https://doi.org/10.1016/j.appet.2019.104331

Christoph, M. J., Ellison, B. D., & Meador, E. N. (2016). The Influence of Nutrition Label Placement on Awareness and Use among College Students in a Dining Hall Setting. *Journal of the Academy of Nutrition and Dietetics*, *116*(9), 1395–1405. https://doi.org/10.1016/j.jand.2016.05.003

Dammann, K. W., Hauge, D., Rosen, R. A., Schroeder, N., & Marquart, L. (2013). 6 - Consumption and consumer challenges of wholegrain foods. In J. A. Delcour & K. B. T.-F.-R. and W. F. Poutanen (Eds.), *Woodhead Publishing Series in Food Science, Technology and Nutrition* (pp. 120–149). https://doi.org/https://doi.org/10.1533/9780857095787.1.120

de Leeuw, A., Valois, P., Ajzen, I., & Schmidt, P. (2015). Using the theory of planned behavior to identify key beliefs underlying pro-environmental behavior in high-school students: Implications for educational interventions. *Journal of Environmental Psychology*, *42*, 128–138. https://doi.org/https://doi.org/10.1016/j.jenvp.2015.03.005

Deliens, T., Van Crombruggen, R., Verbruggen, S., De Bourdeaudhuij, I., Deforche, B., & Clarys, P. (2016). Dietary interventions among university students: A systematic review. *Appetite*, *105*, 14–26. https://doi.org/10.1016/j.appet.2016.05.003

Dolgopolova, I., Li, B., Pirhonen, H., & Roosen, J. (2022). The effect of attribute framing on consumers' attitudes and intentions toward food: A Meta-analysis. *Bio-Based and Applied Economics*, *10*(4), 253–264. https://doi.org/10.36253/bae-11511

EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). (2010). Scientific Opinion on Dietary Reference Values for carbohydrates and dietary fibre. *EFSA Journal*, *8*(3), 1462. https://doi.org/10.2903/j.efsa.2010.1462

European Commission. (2019). Whole grain. Retrieved from Health Promotion and Disease Prevention website: https://ec.europa.eu/jrc/en/health-knowledge-gateway/promotion-prevention/nutrition/whole-grain

Fishbein, M., & Ajzen, I. (2011). Predicting and changing behavior: The reasoned action approach. In *Predicting and Changing Behavior: The Reasoned Action Approach*. https://doi.org/10.4324/9780203838020

Food and Drug Administration. *21CFR101.14.* , (2023).

Franchini, C., Biasini, B., Rosi, A., & Scazzina, F. (2023). Best practices for making the university campus a supportive environment for healthy and sustainable diets. *Current Opinion in Environmental Science & Health*, *32*, 100436. https://doi.org/https://doi.org/10.1016/j.coesh.2022.100436

Friedman, V. J., Wright, C. J. C., Molenaar, A., McCaffrey, T., Brennan, L., & Lim, M. S. C. (2022). The Use of Social Media as a Persuasive Platform to Facilitate Nutrition and Health Behavior Change in Young Adults: Web-Based Conversation Study. *Journal of Medical Internet Research*, *24*(5), e28063. https://doi.org/10.2196/28063

Gallagher, K. M., & Updegraff, J. A. (2012). Health message framing effects on attitudes, intentions, and behavior: a meta-analytic review. *Annals of Behavioral Medicine : A Publication of the Society of Behavioral Medicine*, *43*(1), 101–116. https://doi.org/10.1007/s12160-011-9308-7

Hagger, M. S., & Chatzisarantis, N. L. D. (2006). Self-identity and the theory of planned behaviour: Between- and within-participants analyses. *British Journal of Social Psychology*, *45*(4), 731–757. https://doi.org/https://doi.org/10.1348/014466605X85654

Hagger, M. S., Chatzisarantis, N. L. D., & Harris, J. (2006). The Process by Which Relative Autonomous

Motivation Affects Intentional Behavior: Comparing Effects Across Dieting and Exercise Behaviors. *Motivation and Emotion*, *30*(4), 306–320. https://doi.org/10.1007/s11031-006-9046-5

Hung, Y., & Verbeke, W. (2019). Consumer evaluation, use and health relevance of health claims in the European Union. *Food Quality and Preference*, *74*, 88–99. https://doi.org/10.1016/J.FOODQUAL.2019.01.002

Jones, J. M., & Engleson, J. (2010). Whole Grains: Benefits and Challenges. *Annual Review of Food Science and Technology*, *1*(1), 19–40. https://doi.org/10.1146/annurev.food.112408.132746

Kann, L., McManu, T., Harris, W. A., Shanklin, S. L., Flint, K. H., Queen, B., … Ethier, K. A. (2018). *Youth Risk Behavior Surveillance – United States, 2017 MMWR Surveill Summ 2018;67(No. SS-8):* https://doi.org/http://dx.doi.org/10.15585/mmwr.ss6708a1

Kline, R. B. (2016). Principles and practice of structural equation modeling, 4th ed. In *Principles and practice of structural equation modeling, 4th ed.* New York, NY, US: Guilford Press.

Li, L., Long, X., Laubayeva, A., Cai, X., & Zhu, B. (2020). Behavioral intention of environmentally friendly agricultural food: the role of policy, perceived value, subjective norm. *Environmental Science and Pollution Research*, *27*(15), 18949–18961. https://doi.org/10.1007/s11356-020-08261-x

Maki, C. K., Palacios, M. O., Koecher, K., Sawicki, M. C., Livingston, A. K., Bell, M., … McKeown, M. N. (2019). The Relationship between Whole Grain Intake and Body Weight: Results of Meta-Analyses of Observational Studies and Randomized Controlled Trials. *Nutrients* , Vol. 11. https://doi.org/10.3390/nu11061245

Marquart, L., Wiemer, K. L., Jones, J. M., & Jacob, B. (2003). Whole grain health claims in the USA and other efforts to increase whole-grain consumption. *Proceedings of the Nutrition Society*, *62*(1), 151–160. https://doi.org/DOI: 10.1079/PNS2003242

McDermott, M. S., Oliver, M., Simnadis, T., Beck, E. J., Coltman, T., Iverson, D., … Sharma, R. (2015). The Theory of Planned Behaviour and dietary patterns: A systematic review and meta-analysis. *Preventive Medicine*, *81*, 150–156. https://doi.org/10.1016/j.ypmed.2015.08.020

McEachan, R. R. C., Conner, M., Taylor, N. J., & Lawton, R. J. (2011). Prospective prediction of health-related behaviours with the Theory of Planned Behaviour: a meta-analysis. *Health Psychology Review*, *5*(2), 97–144. https://doi.org/10.1080/17437199.2010.521684

Meynier, A., Chanson-Rollé, A., & Riou, E. (2020). Main Factors Influencing Whole Grain Consumption in Children and Adults – A Narrative Review. *Nutrients*, *12*(8), 2217. https://doi.org/10.3390/nu12082217

O'Keefe, D. J., & Jensen, J. D. (2008). Do Loss-Framed Persuasive Messages Engender Greater Message Processing Than Do Gain-Framed Messages? A Meta-Analytic Review. *Communication Studies*, *59*(1), 51–67. https://doi.org/10.1080/10510970701849388

Ottersen, I. S., Benningstad, N. C. G., & Kunst, J. R. (2022). Daily reminders about the animal-welfare, environmental and health consequences of meat and their main and moderated effects on meat consumption. *Cleaner and Responsible Consumption*, *5*, 100068. https://doi.org/https://doi.org/10.1016/j.clrc.2022.100068

Quick, V., Wall, M., Larson, N., Haines, J., & Neumark-Sztainer, D. (2013). Personal, behavioral and socio-environmental predictors of overweight incidence in young adults: 10-yr longitudinal findings. *International Journal of Behavioral Nutrition and Physical Activity*, *10*(1), 37. https://doi.org/10.1186/1479-5868-10-37

Rothman, A. J., Bartels, R. D., Wlaschin, J., & Salovey, P. (2006). The Strategic Use of Gain- and Loss-Framed Messages to Promote Healthy Behavior: How Theory Can Inform Practice. *Journal of Communication*, *56*(s1), S202–S220. https://doi.org/https://doi.org/10.1111/j.1460-2466.2006.00290.x

Rothman, A. J., & Updegraff, J. A. (2011). Specifying when and how gain-and loss-framed messages motivate healthy behavior: an integrated approach. In G. Keren (Ed.), *Perspectives on framing*. Psychology Press.

Shepherd, R., Dean, M., Lampila, P., Arvola, A., Saba, A., Vassallo, M., … Lähteenmäki, L. (2012). Communicating the benefits of wholegrain and functional grain products to European consumers. *Trends in Food Science & Technology*, *25*(2), 63–69. https://doi.org/https://doi.org/10.1016/j.tifs.2012.01.002

Slavin, J. L. (2005). Dietary fiber and body weight. *Nutrition (Burbank, Los Angeles County, Calif.)*, *21*(3), 411–418. https://doi.org/10.1016/j.nut.2004.08.018

Sogari, G., Li, J., Lefebvre, M., Menozzi, D., Pellegrini, N., Cirelli, M., … Mora, C. (2019). The influence of health messages in nudging consumption of whole grain pasta. *Nutrients*, *11*(12). https://doi.org/10.3390/nu11122993

Sogari, G., Li, J., Wang, Q., Lefebvre, M., Huang, S., Mora, C., & Gómez, M. I. (2022). Toward a reduced meat diet: University North American students' acceptance of a blended meat-mushroom burger. *Meat Science*, *187*, 108745. https://doi.org/https://doi.org/10.1016/j.meatsci.2022.108745

Stok, F. M., Renner, B., Clarys, P., & Deliens, T. (2018). Understanding Eating Behavior during the Transition from Adolescence to Young Adulthood : A Literature.

Nutrients, *10*(667), 1–16. https://doi.org/10.3390/nu10060667
U.S. Department of Health and Human Services and U.S. Department of Agriculture, & US Department of Agriculture. (2015). 2015–2020 Dietary Guidelines for Americans. Retrieved April 4, 2019, from http://health.gov/dietaryguidelines/2015/guidelines/
Ugunesh, D., Siau, C. S., Mohd Sanip, M. N. A. Bin, & Koo, H. C. (2023). Perceived barriers towards whole grain consumption among the Malaysian adult population: findings from a theory-based qualitative study. *British Food Journal*, *125*(3), 1130–1147. https://doi.org/10.1108/BFJ-10-2021-1152
van Griethuijsen, R. A. L. F., van Eijck, M. W., Haste, H., den Brok, P. J., Skinner, N. C., Mansour, N., … Bou-Jaoude, S. (2015). Global Patterns in Students' Views of Science and Interest in Science. *Research in Science Education*, *45*(4), 581–603. https://doi.org/10.1007/s11165-014-9438-6
Weingarten, N., & Hartmann, M. (2023). Fifty shades of grain – Increasing whole grain consumption through daily messages. *Appetite*, *187*, 106608. https://doi.org/https://doi.org/10.1016/j.appet.2023.106608
Wongprawmas, R., Sogari, G., Menozzi, D., Pellegrini, N., Lefebvre, M., Gómez, M. I., & Mora, C. (2021). Determinants of US University Students' Willingness to Include Whole Grain Pasta in Their Diet. *International Journal of Environmental Research and Public Health*, *18*(6). https://doi.org/10.3390/ijerph18063173
World Health Organization. (2014). Adolescents: health risks and solutions. Retrieved from Fact sheet N°345 website: http://www.searo.who.int/thailand/factsheets/fs0027/en/
Ye, E. Q., Chacko, S. A., Chou, E. L., Kugizaki, M., & Liu, S. (2012). Greater whole-grain intake is associated with lower risk of type 2 diabetes, cardiovascular disease, and weight gain. *Journal of Nutrition*, *142*(7), 1304–1313. https://doi.org/10.3945/jn.111.155325

APPENDICES

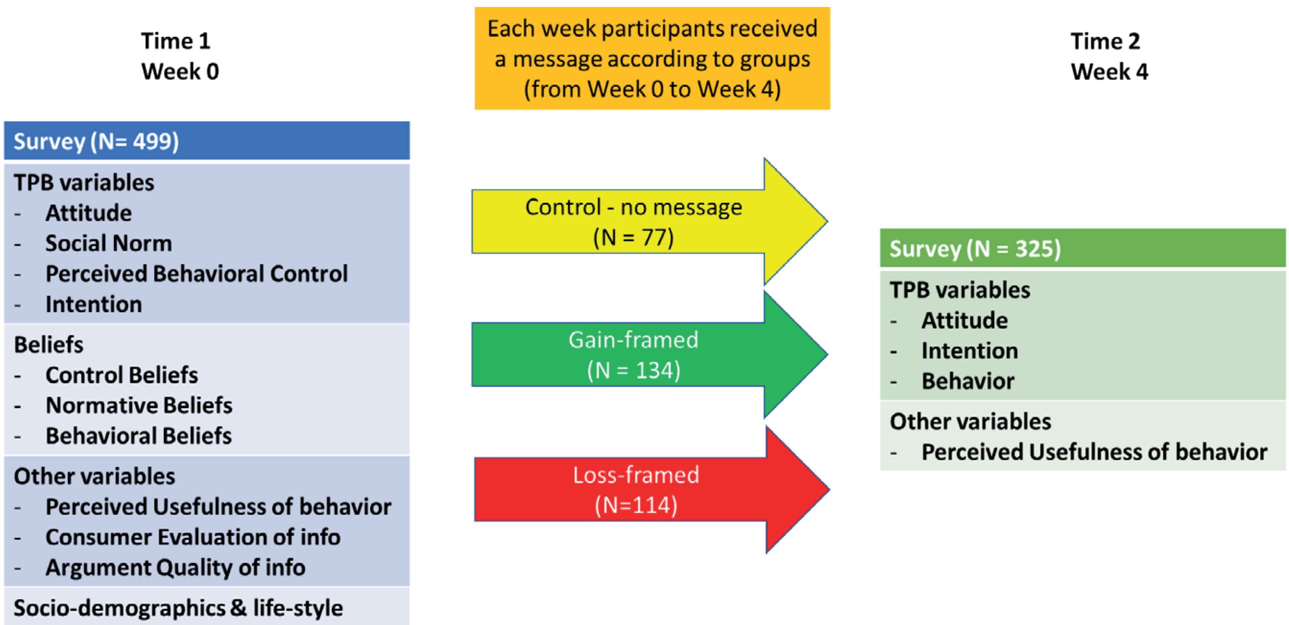

Figure A1. Survey flow.

Table A1. Constructs and Items.

Codes	Constructs and items
	Behavioral beliefs (1 = strongly disagree; 7 = strongly agree) (time 1)
BehBel1	If I include whole grain pasta in my diet over the next month I believe I will live a better quality of life in my old age
BehBel2	If I include whole grain pasta in my diet over the next month I believe I will have made a long-term investment for myself
BehBel3	If I include whole grain pasta in my diet over the next month I believe I will have less diet-related diseases in my life
	Normative beliefs (1 = strongly disagree; 7 = strongly agree) (time 1)
NorBel1	My parents think I should include whole grain pasta in my diet over the next month
NorBel2	My friends/partner think I should include whole grain pasta in my diet over the next month
NorBel3	Nutritionists think I should include whole grain pasta in my diet over the next month
NorBel4	My doctor thinks I should include whole grain pasta in my diet over the next month
NorBel5	Chefs think I should include whole grain pasta in my diet over the next month
	Control beliefs (1 = strongly disagree; 7 = strongly agree) (time 1)
ConBel1	The limited advertising from the dining halls/restaurants I usually go does not encourage me to include whole grain pasta in my diet over the next month
ConBel2	The higher costs of whole grain pasta stops me from including this product in my diet over the next month
ConBel3	The lack of availability in the dining halls I usually go stops me from including whole grain pasta in my diet over the next month
ConBel4	The limited information from public authorities about whole grain benefits does not encourage me to include whole grain pasta in my diet over the next month
	Attitude towards the behavior (time 1 and time 2)
	For me, including whole grain pasta in my diet over the next month (7-point scale)
ATT1	Difficult - Easy
ATT2	Not tasty - Tasty
	Subjective norm (1 = strongly disagree; 7 = strongly agree) (time 1)
SN1	Most people who are important to me think that I should include whole grain pasta in my diet over the next month
SN2	Most people who influence my decisions think that I should include whole grain pasta in my diet over the next month
SN3	It is expected that I should include whole grain pasta in my diet over the next month
	Perceived behavioral control (1 = strongly disagree; 7 = strongly agree) (time 1)
PBC1	I believe that including whole grain pasta in my diet over the next month is possible
PBC2	The decision to include whole grain pasta in my diet over the next month will be only up to me
	Behavioral Intention (1 = strongly disagree; 7 = strongly agree) *(time 1 and time 2)*
INT1	I intend to include whole grain pasta in my diet over the next month
INT2	I will try in anyway to include whole grain pasta in my diet over the next month
INT3	I will definitely include whole grain pasta in my diet over the next month
	Behavior (after one month) (7-point scale) (time 2)
Beh1	In the past month, how often have you included a meal with whole grain pasta in your diet? Never - Almost always
Beh2	I have included whole grain pasta in my diet at least once in the past month. False-True
	Consumer evaluation of the claim (1 = strongly disagree; 7 = strongly agree) (time 1)
ConsEval1	I am familiar with the health claim I just read
ConsEval2	I understand this health claim
ConsEval3	This health claim is credible
ConsEval4	This health claim is interesting
ConsEval5	This health claim is important
	Argument quality (1 = strongly disagree; 7 = strongly agree) (time 1)
ArgQua1	The information provided about whole grain pasta is informative
ArgQua2	The information provided about whole grain pasta is helpful
ArgQua3	The information provided about whole grain pasta is valuable
ArgQua4	The information provided about whole grain pasta is persuasive

(Continued)

Table A1. (Continued).

Codes	Constructs and items
	Perceived Usefulness (1 = strongly disagree; 7 = strongly agree) (time 1 and time 2)
PercUse1	Including whole grain pasta in my diet will help me to stay in shape (e.g., maintaining my body weight).
PercUse2	Including whole grain pasta in my diet will improve my work performance (e.g., make my working/studying life more productive).
PercUse3	Including whole grain pasta in my diet will make my diet more balanced and healthy (e.g., right amount of fiber intake).

Table A2. In italic the messages shown to participants.

Message	Health benefits of eating whole grain	Gain framed message (Gfm)	Loss-framed message (Lfm)
1	Better chance of success in maintaining your body weight (BW)	*If you include whole grain pasta in your diet, you might have a better chance of success in maintaining your body weight.*	*If you do not include whole grain pasta in your diet, you might not have a better chance of success in maintaining your body weight.*
2	Its fiber content will contribute to your normal bowel function (BF)	*If you include whole grain pasta in your diet, its fiber content will contribute to your normal bowel function.*	*If you do not include whole grain pasta in your diet, a lack of fiber content will not contribute to normal bowel function.*
3	Niacin content (vitamin B3) will contribute to the reduction of tiredness and fatigue (T&F)	*If you include whole grain pasta in your diet, its niacin content (vitamin B3) will contribute to the reduction of tiredness and fatigue.*	*If you do not include whole grain pasta in your diet, a lack of niacin (Vitamin B3) will not contribute to the reduction of tiredness and fatigue.*
4	Its fiber content will promote your healthy gut (HG)	*If you include whole grain pasta in your diet, its fiber content will promote your healthy gut.*	*If you do not include whole grain pasta in your diet, a lack of fiber content will not promote your gut health.*

Four different types of health messages were developed, based on the latest scientific opinion on the substantiation of health claims related to (1) whole grain (EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA), 2010), (2) wheat bran fibre and increase in faecal bulk (EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA), 2010a), and (3) niacin and reduction of tiredness and fatigue (EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA), 2010a).

Table A3. Internal consistency of TPB constructs and other variables in Time 1 and Time 2.

Variable	N. of Items	Control				Gain Frame				Loss Frame				*p*-value [a]
		N	Cronbach's alpha	M	SD	N	Cronbach's alpha	M	SD	N	Cronbach's alpha	M	SD	
Time 1 ATT	2	100	0.628	4.750	1.319	202	0.717	4.849	1.566	197	0.702	4.655	1.473	0.426
Time 2 ATT	2	77	0.598	4.773	1.344	134	0.748	4.787	1.516	114	0.756	4.956	1.351	0.572
Time 1 PU	3	100	0.762	4.443	1.062	202	0.825	4.315	1.141	197	0.847	4.201	1.221	0.225
Time 2 PU	3	77	0.837	4.714	1.016	134	0.861	4.925	1.157	114	0.824	4.818	1.140	0.408
Time 1 SN	3	100	0.857	3.443	1.311	202	0.905	3.705	1.370	197	0.897	3.504	1.497	0.216
Time 1 PBC	2	100	0.559	5.505	1.067	202	0.616	5.505	1.116	197	0.643	5.472	1.185	0.951
Time 1 INT	3	100	0.902	4.120	1.496	202	0.918	4.297	1.611	197	0.897	4.191	1.517	0.613
Time 2 INT	3	77	0.933	4.416	1.369	134	0.931	4.368	1.572	114	0.907	4.450	1.479	0.910
Time 2 Bahavior	2	77	0.732	4.727	1.572	134	0.760	4.493	1.746	114	0.768	4.676	1.803	0.566
Time 1 ConsEval	5	-	-	-	-	202	0.622	4.857	0.886	197	0.742	4.154	1.127	<0.001
Time 1 ArgQua	4	-	-	-	-	202	0.859	4.774	1.132	197	0.908	3.956	1.415	<0.001

Note: TPB = Theory of Planned Behavior; ATT = Attitude; PU = Perceived usefulness; SN = Subjective Norms; PBC = Perceived Behavioral Control; INT = Intention; ConsEval = Consumer evaluation of the claim; ArgQua = Argument Quality. M = Means; SD = Standard Deviation. [a] Comparison between groups using ANOVA tests.

Table A4. TPB Model: unstandardized beta coefficients, standard errors (S.E.), p-values, in Time 1 (n=499) and in Time 2 (n=325).

	Path coefficients		
Predictors	*Beta*	*S.E.*	*p*
Predictors of Behavioral Intention (in Time 1)			
ATT	0.565	0.076	<0.001
PBC	0.220	0.051	<0.001
SN	0.604	0.055	<0.001
Predictors of Behavior (in Time 2)			
INT	0.612	0.057	<0.001
PBC	0.077	0.067	0.250

Note: ATT: attitude towards the behavior; SN: subjective norms; PBC: perceived behavioral control; INT: behavioral intention.

Finito di stampare da
Logo s.r.l. – Borgoricco (PD) – Italia

Bio-based and Applied Economics Focus and Scope

The journal *Bio-based and Applied Economics* (*BAE*) provides a forum for presentation and discussion of applied research in the field of bio-based sectors and related policies, informing evidence-based decision-making and policy-making. It intends to provide a scholarly source of theoretical and applied studies while remaining widely accessible for non-researchers.

BAE seeks applied contributions on the economics of bio-based industries, such as agriculture, forestry, fishery and food, dealing with any related disciplines, such as resource and environmental economics, consumer studies, regional economics, innovation and development economics. Beside well-established fields of research related to these sectors, *BAE* aims in particular to explore cross-sectoral, recent and emerging themes characterizing the integrated management of biological resources, bio-based industries and sustainable development of rural areas. A special attention is also paid to the linkages between local and international dimensions. *BAE*'s objectives are:

- to stimulate cross-fertilization between the above mentioned research fields;
- to synthesize and integrate lessons learned from current strands of literature in economics;
- to provide a forum for well-established scholars as well as promising young researchers;
- to increase the knowledge about assessment, design and evaluation of public policies;
- to promote the debate on issues relating to the economics profession and its consultancy activities;
- to discuss future research pathways on the above issues.

***BAE* publishes high quality research and review papers, after a timely and rigorous double blind peer review process. *BAE* also publishes book reviews.**

BAE
Bio-based and Applied Economics

Full Research Articles

218 Francesco Pagliacci, Valentina Raimondi, Luca Salvatici, *Editorial. Guns, Germs and Climate: Food Security and Food Systems in a Risky World*

224 Amsalu Woldie Yalew, Victor Nechifor, Emanuele Ferrari, *The implications of the Russian invasion of Ukraine for African economies: A CGE analysis for Ethiopia*

244 Tulia Gattone, *Participation of farmers in market value chains: A tailored Antràs and Chor positioning indicator*

264 Francesco Pagliacci, Dana Salpina, *Adapting to climate change: what really drives the choices of the producers of Geographical Indications?*

284 Stefano Ciliberti, Angelo Frascarelli, Gaetano Martino, Andrea Marchini, *Exploring preferences for contractual terms in a scenario of ecological transition for the agri-food sector: a latent class approach*

300 Giovanni Sogari, Rungsaran Wongprawmas, Giulia Andreani, Michele Lefebvre, Nicoletta Pellegrini, Miguel I. Gómez, Cristina Mora, Davide Menozzi, *Intention and behavior toward eating whole grain pasta on a college dining campus: Theory of Planned Behavior and message framing*