SOCIETÀ ITALIANA
DI ECONOMIA
AGRO-ALIMENTARE

ECONOMIA AGRO-ALIMENTARE *FOOD ECONOMY*

An International Journal on Agricultural and Food Systems

2022, Vol. 24, Issue 1

FrancoAngeli
OPEN ACCESS

SIEA
SOCIETÀ ITALIANA DI
ECONOMIA AGRO-ALIMENTARE

ECONOMIA AGRO-ALIMENTARE
Food Economy

(Rivista fondata da Fausto Cantarelli)

FrancoAngeli

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Amministrazione: v.le Monza 106 - 20127 Milano - Tel. 02/2837141 - Fax abbonamenti 02/26141958 - e-mail: riviste@francoangeli.it

Registrazione del Tribunale di Reggio Emilia n. 932 del 6 novembre 1996 - Direttore Responsabile: dr. Stefano Angeli - Quadrimestrale.
 Stampa: Logo srl, sede legale: Via Marco Polo 8, 35010 Borgoricco (Pd).

I quadrimestre 2022

Economia agro-alimentare
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2022, Vol. 24, Issue 1

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Economia agro-alimentare /
Food Economy
An International Journal on Agricultural and Food Systems
Vol. 24, Iss. 1, Art. 9, pp. 1-5 - ISSN 1126-1668 - ISSNe 1972-4802
DOI: 10.3280/ecag2022oa13875

Editorial

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Volume 24, Issue 1, of *Economia agro-alimentare / Food Economy*, features seven regular Articles and one Note, all written in English. The topics cover several important issues: food product value-enhancement, dietary habits, farming profitability, efficiency and trade, price transmission and innovation analysis. The range of the analysis goes from local to global and covers geographical areas in Italy, Indonesia, Nigeria, Guatemala, Kazakhstan, and Switzerland.

The authors are affiliated with Institutions based in Italy, Indonesia, Nigeria, Guatemala, the USA, Kazakhstan, the Republic of Korea, Switzerland, and Morocco.

Fabio Gaetano Santeramo, Roberto Manno, Marco Tappi, and Emilia Lamonaca authored the article "Trademarks and Territorial Marketing: Retrospective and Prospective Analyses of the trademark *Prodotti di Qualità*". Through a multidisciplinary approach, they investigate the potential role of Trademarks as territorial marketing tools to help the economic growth of regions. The analysis deals with the case of the Apulian "Prodotti di Qualità" (PQ) quality label, a territorial marketing initiative of the Apulia Region (Italy). The study was carried out through both a prospective

analysis of marketing issues and a prospective analysis of the legal issues, emphasising the importance of communication and promotion campaigns to exploit the potential of quality schemes. In fact, as a result of their analysis, authors argue that consumers' greater awareness can provide larger benefits for producers and rural communities, such as higher prices, preservation of traditional practices in the agri-food sector, and job opportunities throughout the supply chain, among others.

Kiki Yuliati, Ruth Samantha Hamzah, Basuni Hamzah authored the article "Feasibility study on indigenous confectionery business – the case of gulo puan industries". This paper examines the financial feasibility of a value-added product named gulo puan, a value derivative of swamp buffalo milk in rural sub-district Pampangan in Indonesia. The justification is that rural lower-middle income countries need artisanal food industry in local communities to extend perishable farm commodity shelf life, product diversification and income generation. However, a financial analysis must be done to assess the probability of success to have a successful product. This study shows that the product's return under different cost scenarios is financially sound. The contribution of this manuscript is a case study analysing the returns of developing a unique, value-added farm commodity in a lower-middle-income country using Cost-Benefit Analysis.

Kehinde Paul Adeosun, Kabir Kayode Salman, Nnaemeka Andegbe Chukwuone, Chukwuma Otum Ume, Chiamaka Adaobi Chukwuone, Cynthia Njideka Ezema contributed with the article "Factors Influencing Fruits And Vegetables Consumption among Pregnant Women: Evidence from Enugu State, Nigeria". The article contributes to the knowledge of fruit and vegetable consumption in Nigeria through a survey of a sample of 100 pregnant women from ten selected hospitals/health centres in the Nsukka local government area of Enugu State. The objective is to measure the amount and frequency of fruit and vegetable consumption among pregnant women. Using multiple and quantile regression, the authors also determine the socio-demographic factors and maternal conditions affecting fruit and vegetable consumption and these factors' influence on the expenditure levels. The results indicate that socioeconomic factors, such as income, occupation, education and distance from home to market affect the consumption of fruits and vegetables in pregnant women. Among the personal (maternal) conditions, the main predictors are the stage of pregnancy and the receipt of nutritional advice.

Rupananda Widanage, Catherine Chan, Yin-Phan Tsang, Brent Sipes, Haddish Melakeberhan, Amílcar Sanchez-Perez, Alfredo Mejía-Coroy

authored the article "Enhancing Technical Efficiency and Economic Welfare: A Case Study of Smallholder Potato Farming in the Western Highlands of Guatemala". Efficiency is nowadays part of any business. Unfortunately, the productivity of smallholder farmers in the Western Highlands of Guatemala is currently 29% lower than the world average. It is important to correct this inefficiency because the country relies highly on farming. This paper examines the criteria to improve smallholder potato farming and increase productivity with a stochastic production frontier analysis. It has been found that higher elevation, smaller farm size, and location of the farms are the main factors that need an improvement to have a better potatoes production.

In the article "Productive efficiency and trade opportunities for Kazakhstan dairy farms", Sang Woo Han, Song Soo Lim, and Aida Balkibayeva provide an interesting forecast of the Kazakhstan dairy sector for export via "The Belt and Road Initiative (BRI)". A survey is carried out on a sample of 23 dairy farms across nine regions in Kazakhstan. Then, the authors use a DEA approach to assess the efficiency of dairy farm production and estimate Kazakhstan's exportation potential. Findings from the study show the heterogeneous farming conditions dairy farms face and their dichotomous productive efficiency. The authors discuss feasible strategies to update and adapt Kazakhstan's dairy industry in order to boost its potential for export efficiently.

In the article "The Short-Term Impact of a Zero Concentrate Supplementation on Organic Dairy Production", Daniel Hoop and Fredy Schori from Agroscope, investigate the short-term economic impact of a zero-concentrate supplementation in organic dairy production systems. Based on a field trial conducted in Switzerland, the research also aimed to understand how a cut in concentrates influences the main drivers determining the economic performance of the production system. Authors provide evidence on how the culling rate, milk price and price of concentrates are crucial for the economic success of a zero-concentrate supplementation. As a result, a short-term trade-off between profitability and zero-concentrate supplementation is highlighted in the specific setting analysed.

The article "Asymmetric Price Transmission in the Cocoa Supply Chain in Indonesia" written by Ahmad Ridha, Raja Masbar, Aliasuddin Aliasuddin, Vivi Silvia investigates the asymmetric price transmission of global cocoa beans and cocoa pasta prices to farm prices in Indonesia. They take the monthly price series for January 2007 to December 2020 from Statistics Indonesia, the International Cocoa Organization, and the International Trade Center. In addition, they use the export tax policy of cocoa beans as a

dummy variable to observe the price fluctuations of cocoa beans at the farm level before and after the performance. Using a nonlinear autoregressive distributed lag model, the authors show that negative price shocks in global markets and cocoa pasta are more rapidly transmitted to farmer prices than positive price shocks. The authors relate these findings, which mostly confirm existing literature, with some structural characteristics of the Indonesian market, i.e. the presence of many intermediary agents, the ineffectiveness of Indonesia's farm cooperatives and the existing Indonesian export policy. The authors call for government interventions aimed at reducing the loss of farmers' welfare.

Finally, in the Note by Youssef Beni Houd, Mohamed El Amrani titled "Social Network Analysis: A useful tool for studying Innovation diffusion processes" the authors propose a review of the use of Social Network Analysis in the analysis of innovation diffusion in the agricultural sector. They first observe that the studies reviewed are mainly from developing countries. Then they point out that while in some research, the authors only described the network using sna indicators, other methods and theoretical frameworks were used together with SNA in most studies. The authors argue that SNA is useful for interpreting innovation diffusion mechanisms, partly because it can be applied in many situations. The description of the networks of relationships between actors that can foster or block innovation allows one to obtain relevant information on how they are shared and evaluate the different roles and importance of the actors involved.

We have some updates regarding the journal's indexing and abstracting. *Economia Agro-alimentare* is now indexed in the World Journal Clout Index (WJCI) Report of Scientific and Tecnological Periodicals, an initiative developed by the China Academic Journals Electronic Publishing House Co., Ltd. and commissioned by the China Association for Science and Technology. The index incorporates an evaluation of Web attention in the International and Chinese scientific audiences. The journal details for the 2021 edition are available at this link: https://wjci.cnki.net/UserIndex/JournalOverseaDetails?filename=ISSN1972-4802&Year=2020.

With this issue, we welcome 13 new members of the Scientific Advisory Board (SAB) for the current year, who have replaced 10 SAB members. We thank the colleagues Themis Altintzoglou, Gervasio Antonelli, Susan Cholette, Francesco Di Iacovo, Phoebe Koundouri, Inmaculada Martinez-Zarzoso, Robert Richardson, Mara Thiene, Stefania Troiano, and Ellen van Loo, for their invaluable service in the last years. Altogether, the SAB now counts 48 members, including scholars from institutions based in Italy (14),

the USA (7), the UK (4), Germany (4), Greece (2), Brasil (2), France (2), Switzerland (1), Republic of Korea (1), Portugal (1), Belgium (1), Sweden (1), Hungary (1), Albania (1), Austria (1), Norway (1), Poland (1), plus 3 international institutions. The updated full list of SAB members is available in the journal front matter and on the website www.economiaagroalimentare.it. The Editor-in-Chief and the Editorial Board look forward to working with our new Scientific Advisory Board.

Economia agro-alimentare /
Food Economy
An International Journal on Agricultural and Food Systems
Vol. 24, Iss. 1, Art. 5, pp. 1-37 - ISSN 1126-1668 - ISSNe 1972-4802
DOI: 10.3280/ecag2022oa12860

Trademarks and Territorial Marketing: Retrospective and Prospective Analyses of the trademark *Prodotti di Qualità*

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Abstract

Trademarks are useful territorial marketing policies contributing to the economic growth of a certain region. However, the complexity of these strategies from a marketing and legal perspective requires a deeper understanding of the functioning of trademarks. We investigate these dynamics for the trademark "Prodotti di Qualità" (PQ), a territorial marketing initiative of Apulia Region (Italy) aiming at enhancing agri-food products with regulated high-quality standards, raising awareness among consumers and promoting marketing and sales of such products. We adopt a multidisciplinary approach to conduct a prospective analysis of marketing issues and a perspective analysis on legal issues. We conclude that, in face of some benefits for users in terms of reduced asymmetric information between consumers and producers, a stronger communication and promotion campaign would increase consumers' awareness and producers' confidence, also contributing to avoid the overlap of the PQ trademarks with other legal forms of labelling, such as geographical indications and certification trademarks. Policy interventions in this direction would be beneficial for the future development of the Apulian territorial marketing.

Article info

Type:
Article
Submitted:
02/11/2021
Accepted:
28/02/2022
Available online:
31/03/2022

JEL codes:
M38, Q13, R58, K11

Keywords:
Brand
Geographical Indication
Intellectual Property
Public Policy
Quality Scheme
Region

Managing Editor:
Alessio Cavicchi

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Introduction

The ability of a region to distinguish its products and services from competitors is a relevant economic driver for that region (Simeon and Buonincontri, 2011). Public policies of territorial marketing may contribute to the economic development of a region, by enhancing its image with respect to its competitors and attracting resources and investments (Zbuchea, 2014). A fruitful initiative of territorial marketing is the regional promotion of high-quality agri-food products or services through regional trademarks, given the growing interest that consumers attach to the quality of products or services evoked by the origin and the traditionality of production methods and processes (Bryla, 2015).

Trademarks are advertising and promotional tools helping firms to signal the quality of their products and services, distinguish them from competitors (Simonson, 1994), protect their identity, and increase their competitiveness and revenues (Howard, Kerin, and Gengler, 2000). Trademarks are intellectual property (IP) rights that include words, phrases, symbols, designs, colours, smell, sound, or combination thereof used to identify and distinguish one's products and services from those of others (Graham *et al.*, 2013; Crass, Czarnitzki and Toole, 2019). The benefits of trademarks are for both consumers and owners or licensees. Consumers may identify specific quality attributes of products and services boasting a trademark reducing occasions of confusion and economising on their search costs (Moschini, Menapace and Pick, 2008). Owners or licensees of a trademark may obtain benefits in terms of reputation (Ramello, 2006). Trademarks may be owned by individual or legal entities representing a group of operators (Charlier and Ngo, 2012): this feature confers to trademark the nature of private goods[1] (Drivas and Iliopoulos, 2016).

Issues related to the use of IP rights are highly debated among academics and policymakers. The IP rights may help in solving market failures

1. The nature of private goods differentiates trademarks from geographical indications (GIs), an IP rights with the characteristics of a public good. Recognised in 1994 with the signing of the Trade-Related Intellectual Property Rights (TRIPS) agreement of the World Trade Organisation (WTO), GIs are indicative of the quality, reputation, and other characteristics of products attributable to their geographical origin (i.e., defined area, territory, or locality) or to specific production method (Moschini, Menapace and Pick, 2008; Menapace *et al.*, 2011; Drivas and Iliopoulos, 2016). GIs provide to producers an opportunity to differentiate the genuineness of their products, leading a premium price (Deselnicu *et al.*, 2013) and contributing to generate positive externalities on natural resources, cultural heritage, and socio-economic spillover at the territorial level (Arfini *et al.*, 2019). GIs may also lead to an increase of farmers' income fostering rural development (Cei *et al.*, 2018). Trademarks also differ from brands: the former identify a product; the latter identify a business strategy (Desai, 2012).

associated with the asymmetric information existing between consumers and producers (e.g., Aprile, Caputo and Nayga, 2012; Menapace and Moschini, 2012; Cei *et al.*, 2018). However, some scholars discuss on the trademark genericide which occurs when the consumers use the brand name to describe a generic category (e.g., Taylor and Walsh, 2002). Others focus on the trademark infringement due to confusion and genericness: visual, acoustic, and semantic affinity among trademarks, similarity of marketing channels, low degree of buyer care are just some of factors determining the trademark infringement which occurs if the owner of a senior mark is damaged when consumers choose a product with a junior mark confused with the senior mark (e.g., Simonson, 1994; Howard, 2000). One of the most important principles in the European Union (EU) trademark law relates to the "risk of association" in the mind of consumers, which takes place when the senior mark enjoys high reputation. The art 8(5) of the EU Trademark Regulation no. 2017/1001 clarifies that a trademark "shall not be registered where it is identical with, or similar to, an earlier trade mark, irrespective of whether the goods or services for which it is applied are identical with, similar to or not similar to those for which the earlier trade mark is registered, where, in the case of an earlier EU trade mark, the trade mark has a reputation in the Union or, in the case of an earlier national trade mark, the trade mark has a reputation in the Member State concerned, and where the use without due cause of the trade mark applied for would take unfair advantage of, or be detrimental to, the distinctive character or the repute of the earlier trade mark". The European Commission launched in November 2020 an important conference[2] aiming, *inter alia*, to address potential overlap between essential functions of trademarks and other IP rights, such as GIs. In this regard, the Court of Justice of the European Communities has condemned the use of national quality signs to indicate territory of origin, as an alternative to the GIs, considering it a protectionist policy contradicting the free movement of goods in the EU market (Charlier and Ngo, 2012). Indeed, the EU has recently restricted the use of trademarks to guarantee the geographical origin of products or services (Song, 2018). The introduction in the EU of the Certification Trademarks in 2017 has reserved to these trademarks the (essential) function of guarantee for specific characteristics of the products "with the exception of their geographical origin" (art. 83(1) Regulation no. 2017/1001).

The described context highlights the complexity of territorial marketing policies from marketing and legal perspectives. We investigate these dynamics, conducting a retrospective and prospective analysis on the

2. More details at ec.europa.eu.

trademark "Prodotti di Qualità" (PQ) owned by the Apulia Region (Italy) following with a multidisciplinary approach.

The reminder of the article is organised as follows. The next section provides examples of public policies of territorial marketing in Italy with a focus on Apulian initiatives and the PQ trademark. Section 2 deepens on marketing issues related to quality schemes in general, and to the PQ trademark in particular. We explored marketing issues from different perspectives with different methods: a survey has been conducted to obtain consumers' opinions on quality schemes (e.g., willingness to pay, frequency of purchasing); focus groups discussions have been conducted to detect factors affecting producers' decisions to adhere to quality schemes (e.g., costs and benefits, distribution channels); a Fuzzy Cognitive Map approach has been used for development scenarios and policy analysis related to quality schemes; evidence are provided for the PQ trademark. We adopted a desk analysis approach to deepen on legal issues related to the PQ trademark and its evolution overtime, discussed in Section 3. The last section concludes providing improvement proposals.

1. Public policies of territorial marketing

The impulse given by the Commission Communication (2010/C 341/04)[3], the Regulation (EU) no. 1152/2012, and the procedure under art. 16 of the Regulation (EU) no. 1305/2013 led to the proliferation of initiatives of territorial marketing with the introduction of Regional Quality Schemes. The main objective of Regional Quality Schemes is to enhance agri-food products with regulated high-quality standards, raise awareness among consumers of the high-quality levels of agri-food products, promote and support marketing and sales of such products. Several strategies are adopted by stakeholders to support Regional Quality Schemes. An example is Strenght2Food, an EU-funded project whose aim is to "*assesses the impacts, exchanges knowledge, and informs policy making on sustainable food chains*"[4], through the identification and implementation of strategies for upscaling, that are the creation of new markets for high- quality agri-food products and the expansion of the existing ones. Through the development of an 'economy of quality', these strategies contribute to support stakeholders and policymakers in enhancing the efficacy of public policies on quality schemes and to stimulate the development of new quality markets in regional agri-food

3. EU best practice guidelines for voluntary certification schemes for agricultural products and foodstuffs.

4. More details at www.strength2food.eu.

supply chains through pilot initiatives and innovative actions. These efforts contribute to understand how public policies of territorial marketing (e.g., trademarks) may be further exploited to positively affect rural development: as emerged from the first Stength2Food forum, stakeholders agree on the primarily touristic and local identity importance of Regional Quality Schemes. From the producers' perspective, it is recommended to increase the innovation in the agri-food sector, improve the cooperation among stakeholders, implement innovative marketing strategies, explore consumers' preferences to develop effective and sustainable local agri-food supply chains. From the policymakers' perspective, it is recommended to facilitate multi-stakeholders' connections, promote public policies of territorial marketing for regional products, establish quality and safety standard control systems (Csillag *et al*., 2021). As for the establishment of quality and safety standard control systems, in Italy, Regional Quality Schemes are managed by CCPB, a limited company specialised in certification services (i.e., inspection, control, and certification activities related to quality-controlled products) and in quality assessment of agri-food products. The CCPB has been authorised by several Italian Regions to perform inspection and control activities related to their quality-controlled products. It supervises the *Quality Controlled* collective trademark of Emilia Romagna Region (Regional Law no. 28/99), the *Verified Quality* regional trademark of Veneto Region (Regional Law no. 12/2001), the *Guaranteed quality* regional trademark from Marche Region (Regional Law no. 23/2003), the *Patata Felix* collective trademark of Campania Region (Regional Council Deliberation no. 6291/2002). Other examples of territorial marketing initiatives in Italy include *Agriqualità*, a trademark registered by Tuscany Region (Regulation no. 47/2004) to identify and promote agri-food products obtained with integrated pest management techniques; *AQUA*, a collective and voluntary Quality Brand of Friuli Venezia Giulia Region (Regional Law no. 21/2002) managed by the regional Agency for the rural development (ERSA); *Guaranteed Safe Quality*, a trademark of Sicily Region (Regional Law no. 1/2005) enhancing agri-food products with a high-quality standard and promoting their diffusion according to specific production standards. In some cases, Regional Quality Schemes tend to set more stringent quality standards. For instance, the *Quality Controlled* collective trademark of Emilia Romagna Region establishes mandatory requirements for the production of mussels: i.e., limits are defined for total aerobic count (less than 5×10^5 CFU/g) and *Escherichia coli* (200 MPN/100 g), and requirements for the total absence of the algal toxin type Paralytic Shellfish Poison (Vernocchi *et al*., 2007).

A strategy of territorial marketing has been developed also in Apulia Region, ranked seventh in numbers and tenth in economic impacts (about 30 million EUR) of high-quality agri-food products in Italy (Qualivita,

2018). The Region owns an EU collective trademark "Prodotti di Qualità" (i.e., Quality Products, hereinafter PQ trademark) whose aim is to improve the value of products with a high controlled quality standard, to inform consumers on the quality of products adhering to the Regional Quality Scheme identified by the PQ trademark, to promote the regional quality scheme. The PQ trademark has changed overtime to comply with changing regulations at the EU level[5]. Previously granted only to the EU producers for agri-food products under European (i.e., Protected Designation of Origin – PDO –, Protected Geographical Indication – PGI–) and Italian (i.e., Denomination of Controlled Origin – DCO –, Typical Geographical Indication – TGI–, Denomination of Controlled and Guaranteed Origin – DCGO –) quality schemes, now the Apulia Region licenses use the PQ trademark to the EU producers for the agri-food products (other than PDO and PGI) adhering to the Regional Quality Scheme "Prodotti di Qualità". Producers of labelled agri-food products were able to directly require the license of the PQ trademark, which use was conditional to the compatibility with the labelling rules of previous quality schemes[6]. Differently, non PDO or PGI producers may obtain the license for the PQ trademark if their agri-food products are characterised by high qualitative standards in terms of public health, animal welfare, environmental protection, specific characteristics of production process, or belong to the category of Traditional Agri-food Products (TAP)[7]. The user licence is conditional to obtaining the certification by third parties. The licensees are subject to control systems of inspection bodies recognised by the Apulia Region[8].

In 2018, licensees of the PQ trademark were 201, most of which wine producers (57%) and mainly located in Bari (38%) and Taranto (18%) provinces (Figure 1).

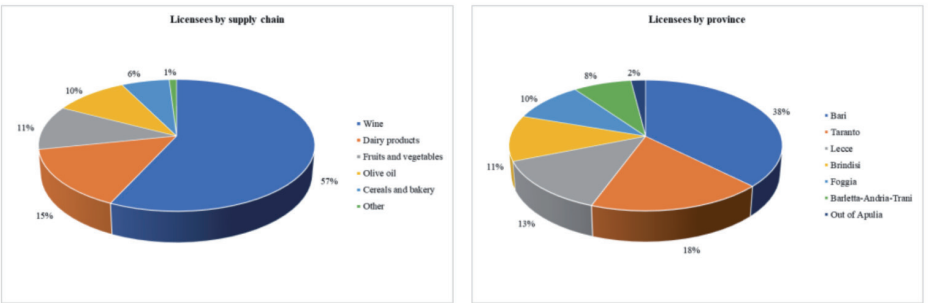
5. See section 3.2 for more details.

6. Control systems of inspection bodies designated and monitored by the Italian Ministry of Agriculture to the respect of European or Italian quality schemes were valid also for the PQ trademark.

7. The TAP is a quality schemes already defined by the Apulia Region more limiting than other Regional Quality Schemes.

8. Producers (i.e., individual farms producing, processing and marketing products, agri-food processing and marketing firms with supply chain agreements) may apply to obtain the user license of the PQ trademark through digitised systems, by requesting submission to one of the control bodies recognised by the Apulia region.

Figure 1 - Licensees of the PQ trademark



Participating to Regional Quality Schemes may contribute to improve market access and increase market outlets for high-quality agri-food products. It also allows producers to obtain financial supports provided by the measure 3 of the Regional Development Programme (RDP) 2014-2020 to improve competitiveness of producers through the protection of quality schemes, and promotion of high-quality products in local, national, and international markets.

Other examples of public policies of territorial marketing are trademarks created by local authorities at different levels (e.g., Municipalities, Provinces, Mountain communities, Park Authorities, etc.) to valorise local high-quality agri-food products. Among these, in Italy, the activity of Chambers of commerce (CCIAA) seems to stand out: "Bergamo, città dei Mille… sapori" of CCIAA Bergamo, "Tradizione e sapori di Modena" of CCIAA Modena, "Denominazione di Cucina Ambrosiana" of CCIAA Milano, "I Prodotti della Campagna Romana" of CCIAA Roma are only a few initiatives (Giacomini, 2007). Beyond the municipal or regional boundaries, some initiatives contribute to promote the quality of agri-food product, such as the "Legambiente per l'Agricoltura Italiana di Qualità" (LAIQ), a collective trademark for agri-food products under quality schemes set by the Italian environmental association Legambiente, "Demeter", an international trademark to safeguard biodynamic agri-food supply chain (Giacomini, 2007), "Presidio Slow Food", a trademark including agri-food products that meet environmental and social sustainability[9].

9. It represents an opportunity for small farms to enhance and valorise their local products. Although "Slow Food" is not evocative of the territory, it protects and promote local and sustainable systems of ecology, agronomy, and gastronomy by building viable local markets (Chrzan, 2004).

2. Retrospective analysis: marketing issues related to the PQ trademark

Consumers' perspective

An online survey allowed us to investigate consumers' opinion on the EU quality schemes[10] and the PQ trademark.

We collected data through a questionnaire consisting of six sections. The first section investigates the frequency of consumption of products with EU quality schemes. The quality schemes under investigation are PDO, PGI, Traditional Speciality Guaranteed (TSG), DCO, TGI, DCGO. The second and third sections analyse the spending habits of consumers. Respondents are asked to quantify, in percentage terms, the premium price they are willing to pay for products with quality schemes with respect to conventional products (i.e., products without quality schemes). Information on the frequency of purchasing in selected distribution channels and the expensiveness (i.e., premium price) of products bought in those channels. The distribution channels investigated are producers (e.g., olive oil mils, winemakers, cheese factories), retailers (e.g., minimarkets, greengrocers, butcher shops, fish shops, bakery), and large retailers (e.g., supermarkets, superstores). The expensiveness of products with quality schemes is measured using a 7-point Likert scale, where 1 is an extremely affordable and 7 is extremely expensive. The fourth section aims at understanding why consumers choose products with quality schemes. Respondents are asked to indicate on a 7-point agree/disagree Likert scale if products with quality schemes support local economies, ensure the origin of products, a quality higher than conventional products, a guarantee higher than products with industrial brands. The fifth section focuses on the PQ trademark and examines the level of knowledge of the trademark and the frequency of consumption of products adhering to the Regional Quality Scheme "Prodotti di Qualità". The last section allows for some socio-demographic information.

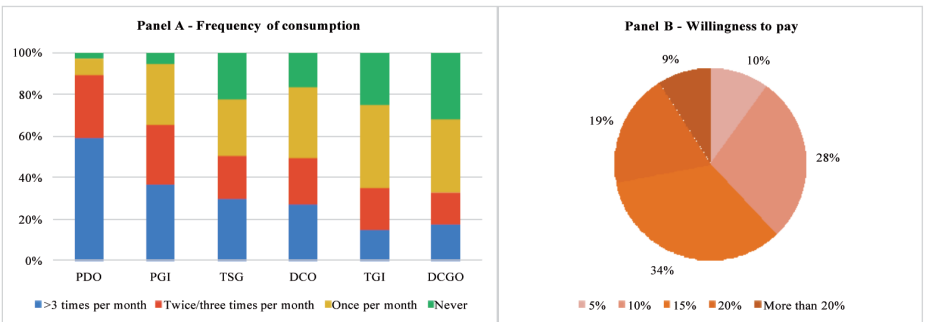
The questionnaire, preliminary tested among selected respondents, was available from July to December 2020 on Google Form and shared via social networks (e.g., Facebook, LinkedIn, Twitter) and e-mail lists (e.g., professional associations, producers' groups, consumers' groups[11]).

10. As clarified by the European Commission (2021), "EU quality policy aims to protect the names of specific products to promote their unique characteristics, linked to their geographical origin as well as traditional know-how. Product names can be granted a 'geographical indication' (GI) if they have a specific link to the place where they are made". More details at: ec.europa.eu.

11. Members of consumers association or professional associations may be more informed than the average consumer. This is a limit of a snowball sampling recruitment. However, we used consumers or professional associations only as 'distribution channels' of the

Adopting a snowball sampling recruitment allowed us to take advantage of interpersonal relations and connections among respondents (McCullough 1998). The final sample consists of 115 respondents. Our typical respondent is a mature woman (36 years old on average) with a Bachelor or Master's degree and an average yearly income ranging between 20,000 EUR and 45,000 EUR, living in the Apulia region. The results show that PDO products are the most consumed: 96% of respondents declare to consume PDO products at least twice or three times per month. Differently, the frequency of consumption of DCO, TGI, or DCGO products tend to be low: more than one-third of respondents consume them only once per month (Figure 2, panel A). The result is not surprising considering that DCO, TGI, or DCGO products, such as wines, tend to be consumed (e.g., special occasions) with a frequency lower than mass-market products such as *Prosciutto di Parma* PDO, *Grana Padano* PDO, *Parmigiano Reggiano* DOP.

Figure 2 - Frequency of consumption and willingness to pay for EU quality schemes



Note: Acronyms are PDO (Protected Designation of Origin), PGI (Protected Geographical Indication), TSG (Traditional Speciality Guaranteed), DCO (Denomination of Controlled Origin), TGI (Typical Geographical Indication), DCGO (Denomination of Controlled and Guaranteed Origin).

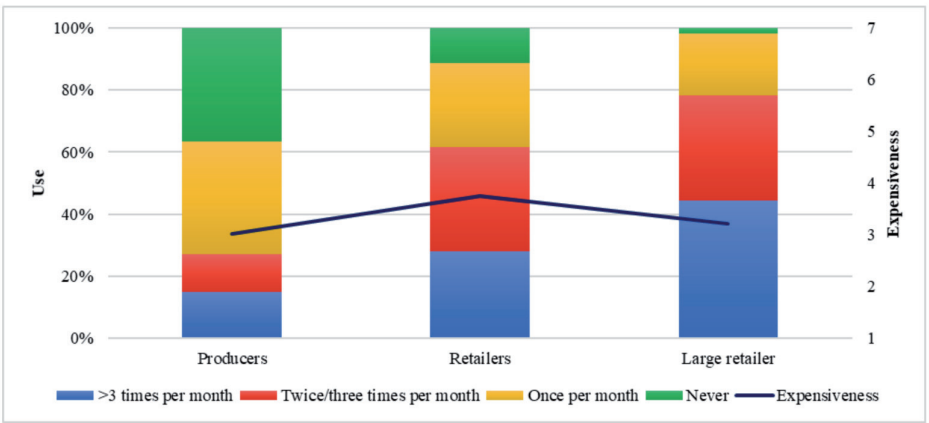
The EU quality schemes are a source of information for consumers and consumers tend to be willing to pay a premium for products with quality schemes (Mérel and Sexton, 2012). A state-owned mark triggers a positive willingness to pay (Wongprawmas and Canavari, 2017). Our results show that more than two-third of respondents are willing to pay 10-

questionnaire. Indeed, the associations shared the questionnaire with their personal (and not only professional) network: in this way we took advantage of interpersonal relations and connections among respondents (e.g., McCullough, 1998).

15% more for products with quality schemes (Figure 2, panel B). Findings are consistent with previous studies: a recent meta-analysis shows that consumers are willing to pay, on average, 11.5% more for products with trademarks (i.e., 13.6% for PDO products and 6.2% for PGI products) (Leufkens, 2018). The results are also consistent with market trends: according to the ISMEA data[12], *Prosciutto di Parma* PDO has a price 17% higher than conventional ham, whereas TGI wine has a price 25% higher than conventional wine.

The large retail is the distribution channel where consumers frequently buy products with quality schemes, whereas producers cover only niche segment markets. Two-third of consumers frequently buy products with quality schemes from retailers although, on average, prices are perceived as more expensive than prices applied to products with quality schemes by producers and large retailers (Figure 3).

Figure 3 - Use of distribution channels for products with EU quality schemes and average premium price



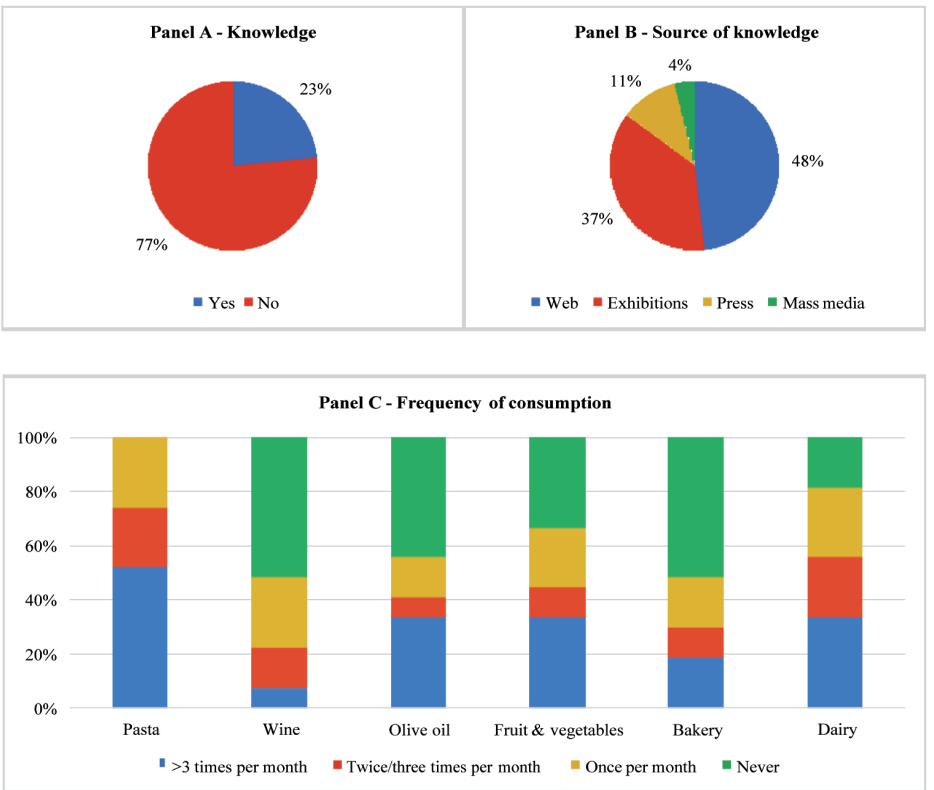
Note: Expensiveness (i.e., premium price) ranges from extremely affordable (1) to extremely expensive (7) and refers to prices applied in each distribution channel.

The half of respondents declare to consume products with quality schemes because they are considered a support for local economies and a guarantee of the origin of products (in terms of safety and traceability) and of quality levels higher than conventional products or products with industrial brands.

12. ISMEA is an Italian institute for agricultural and food marketing services.

As suggested in van Ittersum *et al.* (2007), consumers tend to prefer and consume products with quality schemes because they provide guarantee on their quality and support the local economies. Quality schemes attract consumers (Resano, Sanjuán, and Albisu, 2012) and affect their preferences for regional products (van der Lans *et al.*, 2001; Santeramo *et al.*, 2020). The benefits should be greater for products adhering to the Regional Quality Scheme, but the results show that the EU collective trademark of the Apulian Region is well-known only to a low percentage of respondents (23%) who find information on the PQ trademark mostly on the web or participating to exhibitions in Italy or abroad (Figure 4, panels A and B). The most consumed products with the PQ trademark are pasta, olive oil, and dairy products (Figure 4, panel C).

Figure 4 - Knowledge and frequency of consumption of products with the collective EU trademark Prodotti di Qualità



The large percentage of Apulian respondents in the sample opens a reflection on the limited knowledge of the PQ trademark and highlights the need to plan a vivid promotion and communication of the collective trademark of the Apulia Region. An effective promotion and communication activity would improve the value of products characterised by high and controlled quality standards, expand consumers knowledge and communicate them quality levels and characteristics of products with the PQ trademark, foster the marketing of products adhering to the Regional Quality Scheme (Santeramo and Lamonaca, 2020).

Producers' perspective

We carried out focus groups discussions to investigate technical and economic factors affecting the decision of agri-food producers to adhere to quality schemes.

Schemes under investigation were alternatively the EU quality schemes (e.g., PDO, PGI, TSG, DCO, TGI, DCGO) and the PQ trademark. The focus group discussions were opened to small and medium producers, representative of the Apulian producers and of the major agri-food supply chains. Participants were selected based on well-established criteria according to which producers tend to adopt quality schemes based on their size and supply chain (EU-DG JRC/IPTS 2006; Bouamra-Mechemache and Chaaban, 2010). The sample of producers adopting European and Italian quality schemes is heterogeneous in terms of quality schemes (75% PDO, 25% PGI), supply chains (50% olive and olive oil, 17% horticultural products, 17% wine, 8% dairy produce, 8% cereal and bakery products), whereas the sample of producers adopting the PQ trademark includes different supply chains (29% cereal and bakery products, 29% horticultural products, 29% wine, 13% olive and olive oil).

Following Morgan (1998), the research protocol is based on a set of semi-structured and open-ended questions from a literature review on the issue, included in six sections, synthesised in Table 1. Questions are related to the type and magnitude of costs and benefits related to quality schemes, the type of distribution channels and related profit margins, the strategies adopted to communicate and promote quality schemes, the reasons related to the participation to Regional support for quality schemes, the adoption and use of the PQ trademark.

Table 1 - Research protocol for focus group discussions

Section	Description
Introduction	Warming up questions to introduce participants
Costs and benefits	Costs and benefits related to quality schemes
Distribution channels	Distribution channels and profit margins achievable for quality schemes
Communication andpromotion	Communication and promotion strategies for quality schemes
Regional budget	Reasons to (not) adhere to Regional budget for quality schemes
Regional trademark	Adoption, use, procedures

From the focus group discussions, it emerges that the PQ trademark is beneficial for producers of agri-food products other than PDO and PGI adhering to the Regional Quality Scheme "Prodotti di Qualità", whereas it does not lead value added to producers adopting European and Italian quality schemes.

Licensees of the trademark that already adopt the PDO or PGI labels tend to not display the PQ trademark in their labels because of insufficient benefits. Licensees associate insufficient benefits with limited reputation and incisiveness of the PQ trademark both at the national and international level. Some technical issues concern the use of the PQ trademark: sometimes the use of the trademark is incompatible with the labelling rules of EU quality schemes. For instance, the product specification of a PDO olive oil bans the use of extolling wording, such as "quality", in labels.

Licensees of the trademark that do not adopt the PDO or PGI labels declare to obtain benefits due to the evocative capacity of the sound "Made in Puglia".

Overall, it emerges the need to improve communication and promotion of the PQ trademark, both at individual (single producers) and collective (institutions) level. Although communication and promotion activities of the trademark should be a basic entrepreneurial strategy, institutions should guide producers in the growth pathway of the trademark to achieve national and international exposure (Santeramo *et al.* 2021a,b). It is worth noting the need to express agri-food excellences of Apulia region through a brand evocative of the Apulian heritage (e.g., Apulian farmhouses). According to producers' opinions, an Apulian brand would enhance the regional agri-food sector.

From the sample of producers adopting the PQ trademark, it emerges that the accession procedure to the trademark is simple, differently from the renewal procedure of the license. For producers of agri-food products other than PDO and PGI adhering to the Regional Quality Scheme "Prodotti di Qualità", main issues are related to the switch from the previous license – *Prodotti di Qualità Puglia* – to the new one – *Prodotti di Qualità – Qualità garantita dalla Regione Puglia* –[13].

Preliminary and direct costs related to the Regional Quality Scheme are frequent, although negligible. More impacting, but less frequent, are indirect costs (e.g., promotional costs, costs related to other quality schemes). As a result of the Regional Quality Scheme, producers collect a variety of different benefits (e.g., higher sale prices, access to niche market segments), quantifiable in monetary terms in an increase of about one-tenth as compared to products without quality schemes. The direct sale and the large-scale distribution are the main driver of products under the Regional Quality Scheme; they serve as first outlet and ensure higher profit margins than the retail. Although the balance between costs and benefits of the quality scheme is positive, the overall impression is that much of the price premium for products under the quality scheme is eaten away by higher production and processing costs.

As for communication and promotion strategies, most producers have an active profile at least on one of the most popular social networks or manage a company website. Producers mainly attend in trade fairs and events both in Italy or abroad or promote their products through press advertising. The sponsorship and mass communication advertising are less adopted. This is in line with trends observed at the national level (Qualivita, 2018). As argued in Canavari *et al.* (2010, p. 321), communication "brought companies in front of an excellent opportunity to facilitate and improve their business processes or even to build completely new business models".

The vast majority producers did not adhere to the financial support in favour of products under quality schemes, provided by the Apulia Region through the measures 3.1 and 3.2 of the Rural Development Programme (RDP) 2014-2020. The low rates of adherence are mainly related to the lack of knowledge and skill in selecting regional calls. Other issues are related to the limited efficiency of associations a mandatory requirement to adhere to the financial support provided by the measure 3.2.

13. See section 3 for a description of changes in the version of the PQ trademark granted by the ApuliaRegion.

Development scenarios and policy analyses

The Fuzzy Cognitive Map approach, first developed by Kosko (1986), allowed us to obtain information on interactions among technical and economic factors affecting the decision of agri-food producers to adopt regional trademarks. A Cognitive Map is a qualitative model based on stakeholders' knowledge that describes the functioning of a system and consists of variables and of causal relationships between them. According to Kosko (1986), knowledge is specification of classifications and causes that tend to be uncertain, random, fuzzy: this fuzziness passes into knowledge. The Fuzzy Cognitive Mapping approach allows to model complex systems involving many stakeholders, whose behaviours and actions potentially affect the systems, and to compare the perceptions of different stakeholders. This modelling method is thus able to incorporate stakeholders' opinions about a system, contributing to support management and policy decisions. We use the Fuzzy Cognitive Map approach to obtain the opinions of producers on the opportunity to enhance agri-food products with regulated high-quality standards. The aim is to determine what the most important goals are for the different producers (i.e., higher revenues or margins, development of existing markets, coverage of niche markets) and which (combination of) policies (e.g., Regional support measures, communication and promotion strategies) would increase the benefits of producers. This would enable agri-food producers to support and participate in the activities of the management and policy plan.

We applied the protocol detailed in Özesm and Özesmi (2004) to build and analyse a Fuzzy Cognitive Map. First, we identified the system boundaries and relevant variables starting from evidence retrieved by focus group discussions. Relevant variables pertain to a set of macro-themes: i.e., costs and benefits of trademarks, distribution channels used for trademarks, communication and promotion of trademarks, regional budget in support of trademarks, characteristics of the regional trademark. The Table 2 lists the system variables and associates them to a univocal label used hereafter. The variables pertain to three categories according to their role within the system: i.e., policy objective, policy driver, context variable. The policy objectives are retrieved from the Regulations governing use of the PQ trademark[14]. Policy drivers include variables susceptible of being used as instruments to achieve the policy objectives. Context variables are factors having impacts on the functioning of the system.

14. Art. 1 indicates that the PQ trademark aims at enhancing agri-food products with regulated high-quality standards, raising awareness among consumers of high-quality levels of agri-food products, promoting and supporting marketing and sales of high-quality agri-food products.

Table 2 - Description of system variables

ID	Variable	Label	Category
1	Higher revenues or margins	REV	Policy objective
2	Development of existing markets	EXS	Policy objective
3	Coverage of niche markets	NIH	Policy objective
4	Direct costs (e.g., certification, inspection)	DIR	Policy driver
5	Indirect costs (e.g., structural adjustments, operational changes)	IND	Policy driver
6	Regional support measures for products under qualityschemes	REG	Policy driver
7	Communication strategies (e.g., web, events)	COM	Policy driver
8	Promotion strategies (e.g., sponsor)	PRO	Policy driver
9	Access to distribution channels (e.g., large retailers)	CHA	Context variable
10	Producer groups and organisations	PGO	Context variable
11	Reputation of firms already using trademarks (e.g., privatelabels)	REP	Context variable
12	Products adopting other quality schemes (e.g., PDO, PGI,Organic)	PQS	Context variable
13	Recognisability of the brand “Puglia”	REC	Context variable

In a second phase, we identified the relationships among relevant variables as perceived by involved stakeholders (i.e., small and medium producers adopting the PQ trademark). The stakeholders were identified and recruited via email from the research institution in charge of the research. Each stakeholder was asked to recognise the relationships (i.e., positive, null, negative effects) among relevant variables identified in the first phase. Each stakeholder was endowed with a matrix allowing qualitative comparisons between variables (see Figure A.1 in the Appendix). In other terms, for each couple of variables in the system (i.e., variable in row with respect to variable in column[15], for instance the relationship between “Higher revenues or margins” – REV – and “Development of existing markets” – EXS – or the opposite relationship between EXS and REV), a stakeholder establishes whether, according to its knowledge, a variable (in row, say REV) affects the state of another variable (in columns, say EXS), and whether this effect is

15. Higher revenues or margins (REV) with respect to each of the other variables listed in Table 2; Development of existing markets (EXS) with respect to each of the other variables listed in Table 2; andso on and so forth.

positive (e.g., the status of EXS augments the operation of REV), null (e.g., the status of EXS does not affect the operation of REV), negative (e.g., the status of EXS diminishes the operation of REV). The individual evaluations of the relationships among relevant variables were translated into numerical form (i.e., 1 for positive effect, 0 for null effect, –1 for negative effect) and then combined to obtain the social adjacency matrix: if the positive (negative) effect prevails the elements of the matrix are greater (lower) than zero, whereas null elements of the matrix may be associated either to a non-existing relationship between variables (i.e., all the stakeholders attributed 0 to a certain couple of variables) or to a mixed effect of a variable with respect to another one (e.g., half of stakeholders attributed –1 and the remaining attributed 1). The social adjacency matrix was then normalised (i.e., each element of the matrix has been divided by the total number of respondents) so to have elements ranging between –1 and 1 (Lopolito *et al.*, 2020, p. 6). Each element of the normalised social adjacency matrix (Figure 5) represents the weight of the relationships between variables based on the perception of the stakeholders. All but two elements (i.e., Products adopting other quality schemes – CHA and Recognisability of the brand "Puglia" – IND) of the matrix are non-negative. Different policy objectives are correlated: for instance, higher revenues or margins may be associated with the development of existing markets or with the coverage of niche markets, and vice-versa. Exception made for costs (both direct and indirect), policy drivers tend to have a positive effect on policy objectives (i.e., higher revenues or margins, development of existing markets, coverage of niche markets), with communication strategies exerting the greater influence. Policy objective in their turn positively affect policy drivers: for instance, the higher the revenues or margins are, the greater the adoption of communication and promotion strategies. Policy drivers are interconnected, particularly communication and promotion strategies. Also, context variables such as the access to distribution channels or the membership in producer groups and organisations play a role.

The dynamics of the system have been analysed through the artificial neural network approach[16] (i.e., fuzzy inference) to inform on the importance of the variables of the system and on the potentiality of policy intervention. The modelling of policy interventions is based on two steps: i.e., a natural dynamic simulation and a policy intervention simulation. The artificial neural network calculations have been applied to the variables forming the system (see Table 2) and the set of relationships connecting them (see Figure 5). The steady state value of system variables, reported in Table 3, reflects their

16. The artificial neural network approach allows to represent the typical causative loops and feedbacks interconnecting the variables of a Fuzzy Cognitive Map by means of its back-forward logic. For a detailed description of the approach see Lopolito *et al.* (2020).

Figure 5 - The normalised social adjacency matrix

			Policy objective			Policy driver					Context variable				
		ID	1	2	3	4	5	6	7	8	9	10	11	12	13
	ID	Variables	REV	EXS	NIH	DIR	IND	REG	COM	PRO	CHA	PGO	REP	PQS	REC
Policy objective	1	Higher revenues or margins		0.11	0.19	0.07	0.07	0.11	0.19	0.22	0.19	0.07	0.11	0.11	0.19
	2	Development of existing markets	0.11		0.07	0.07	0.07	0.07	0.15	0.15	0.07	0.00	0.07	0.04	0.22
	3	Coverage of niche markets	0.11	0.11		0.04	0.00	0.04	0.11	0.04	0.11	0.04	0.07	0.04	0.11
Policy driver	4	Direct costs (e.g. certification, inspection)	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5	Indirect costs (e.g. structural adjustments, operational changes)	0.04	0.00	0.00	0.00		0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.04
	6	Regional support measures for products under quality schemes	0.15	0.19	0.07	0.07	0.07		0.26	0.19	0.11	0.15	0.04	0.07	0.22
	7	Communication strategies (e.g. web, events)	0.37	0.41	0.26	0.04	0.04	0.26		0.33	0.37	0.04	0.26	0.22	0.37
	8	Promotion strategies (e.g. sponsor)	0.11	0.11	0.07	0.07	0.00	0.11	0.11		0.07	0.00	0.15	0.04	0.15
Context variable	9	Access to distribution channels (e.g. large retailers)	0.26	0.26	0.22	0.00	0.11	0.22	0.26	0.26		0.07	0.15	0.19	0.26
	10	Producer groups and organisations	0.11	0.15	0.04	0.04	0.04	0.19	0.15	0.07	0.04		0.07	0.04	0.19
	11	Reputation of firms already using trademarks (e.g. private labels)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00
	12	Products adopting other quality schemes (e.g. PDO, PGI, Organic)	0.04	0.00	0.00	0.00	0.04	0.07	0.04	0.04	-0.04	0.00	0.04		0.04
	13	Recognisability of the brand *Puglia*	0.19	0.33	0.26	0.07	-0.07	0.30	0.37	0.33	0.15	0.19	0.15	0.30	

Notes: Acronyms are Higher revenues or margins (REV), Development of existing markets (EXS), Coverage of niche markets (NIH), Direct costs (DIR), Indirect costs (IND), Regional support measures for products under quality schemes (REG), Communication strategies (COM), Promotion strategies (PRO), Access to distribution channels (CHA), Producer groups and organisations (PGO), Reputation of firms already using trademarks (REP), Products adopting other quality schemes (PQS), Recognisability of the brand "Puglia" (REC).

importance within the system according to stakeholders' knowledge (without external influence such as policy intervention) and provides an idea of the evolution of the system in an autarchic context (i.e., first step: natural dynamic simulation). It emerges that all the variables have a positive effect: the most important is the development of existing markets and the recognisability of the brand "Puglia". Other potential favourable effects are the adoption of strategies for the communication and promotion of the quality scheme and the Regional support measures for products under quality schemes. The variables with a relatively low steady state are the direct and indirect costs associated with quality schemes and the producers' groups and organisations.

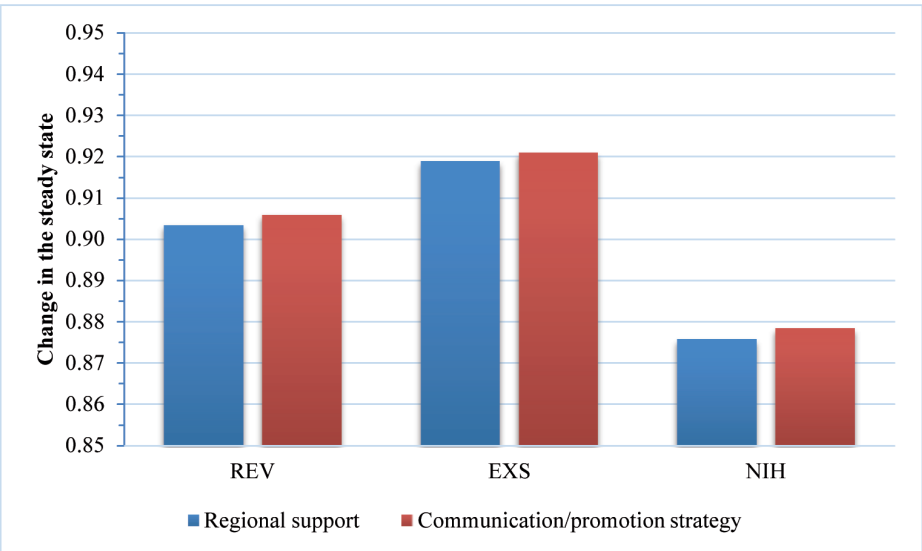
Table 3 - The steady state of system variables

Variable	**Label**	**Steady state**
Higher revenues or margins	REV	0.90
Development of existing markets	EXS	0.92
Coverage of niche markets	NIH	0.87
Direct costs (e.g., certification, inspection)	DIR	0.77
Indirect costs (e.g., structural adjustments, operational changes)	IND	0.74
Regional support measures for products under quality schemes	REG	0.89
Communication strategies (e.g., web, events)	COM	0.91
Promotion strategies (e.g., sponsor)	PRO	0.91
Access to distribution channels (e.g., large retailers)	CHA	0.87
Producer groups and organisations	PGO	0.78
Reputation of firms already using trademarks (e.g., private labels)	REP	0.87
Products adopting other quality schemes (e.g., PDO, PGI, Organic)	PQS	0.86
Recognisability of the brand "Puglia"	REC	0.92

To simulate how the system would evolve if subject to external influences, we analysed how two different type of policy interventions impact on the system (i.e., second step: policy intervention simulation). This second step requires the selection of variables that are likely to be used as policy drivers. We assumed as policy drivers a stronger effect of the Regional support for quality scheme in the first scenario, and the adoption of more effective communication and promotion strategies for products under quality schemes in the second scenario. The comparison between the steady state of

variables measuring the policy objectives (i.e., higher revenues or margins, development of existing markets, coverage of niche markets) with and without the policy intervention gives a measure of the effect of a policy intervention. The simulated effects of the activation of different policy interventions are summarised in Figure 6.

Figure 6 - The effects of policy interventions



Notes: Acronyms are Higher revenues or margins (REV), Development of existing markets (EXS), Coverage of niche markets (NIH).

The results reveal that both policy interventions would have a positive and increasing impact on the policy objective related to the PQ trademark (i.e., achievement of higher revenues or margins, development of existing markets, coverage of niche markets). A policy intervention aiming at enhancing the communication and promotion strategies for products under quality schemes would have greater benefits than a stronger Regional support in favour of quality schemes. The greater gain would be in terms of coverage of niche markets.

3. Prospective analysis: legal issues related to the PQ trademark

The use of the "Puglia" denomination, as a clear indication of origin[17], is likely to call into question the quite complex legal framework introduced in EU Trademark law regulating the interplay between individual, collective and certification trademarks, as well as the public rules governing GIs not only under the apical PDO and PGI (a *sui generis* type of Intellectual Property), but also under the EU/Regional Quality Schemes. Trademarks are constructed around their very "essential functions", which are distinguishing the goods/service provided by the proprietor or under its consent (i.e., individual trademark), allowing the goods/services fulfil the defined and reasonable set of characters as certified by a third party (i.e., certification trademark), ascertaining the goods/services are produced/provided by a member of a collective body according to the relevant disciplinary (i.e., collective trademarks). Traditionally, GIs are able to convey by themselves information and characters of the goods, playing a more informative function ("what you are") than identifying the goods from those of other competitors ("who you are"): it is therefore essential that the conditions for a GI to be part of an individual, certification or collective trademark (especially in the case of "geographical" collective trademarks) must be clearly defined to avoid dilution and confusion. Incoherence with the specific "essential functions" of any particular type of trademark is sanctioned by the EU Trademark Regulation with specific grounds for revocation and cancellation.

The PQ trademark is an EU collective trademark, protecting agri-food products and services of licensees of the trademark – the only ones entitled to use it – and, according to art. 74 of the EU Trademark Regulation (EUTMR, Regulation (EU) 2017/1001), distinguishing them from products and services of licensees of other trademarks (i.e., essential function of trademarks, Simonson 1994). The distinctive feature of EU collective trademarks is the membership[18]: the PQ collective trademark is owned by the Apulia Region (art. 3(1) Regulations of Use – RoU) which may grant the use of the trademark to producers and providers of services in the agri-food sector that

17. "Puglia" is also a registered GI for wines and olive oils.

18. The EUIPO Guidelines define the essential function of a collective trademark: i.e., distinguish the goods and services of the members of the association that owns the mark from those of other companies that do not belong to that association (20/09/2017, C-673/15 P & C-674/15 P & C-675/15 P & C-676/15 P, DARJEELING (fig.) / DARJEELING *et al.*, EU:C:2017:702, § 63; 12/12/2019, C-143/19 P, EIN KREIS MIT ZWEI PFEILEN (fig.), EU:C:2019:1076, § 26, 57, 58). Therefore, the EU collective trademark indicates the commercial origin of certain goods and services by informing the consumer that the producer of the goods or the service provider belong to a certain association and have the right to use the mark (EUIPO Giudelines, Part B, Section 4, Chapter 15, Point 1.2).

meet required standards[19]. The collective PQ trademark has been registered at the European Union Intellectual Property Office (EUIPO) n. 010953875 on November 15, 2012, in accordance with the Regulation (EC) no. 207/2009. It consists of a graphical element (i.e., a "Q", enclosed in rays of sunshine, containing a bud-like "p") and a wording (i.e., "Prodotti di Qualità Puglia") (Figure 7, logo A). The refence to the graphical and verbal components of the trademark is important due to the general obligation that any trademark shall be used coherently with the elements resulting from the graphical representation displayed at the time of filing according to Articles 4, 31, 41, 49(2) of the EUTMR.

A first legal issue concerns the role of the wording "Puglia" (Table 4). While it appears as an essential component of the PQ collective trademark (whose full title is "Prodotti di Qualità Puglia" according to the RoU), effectively it is a changing element. Indeed, the â symbol applies only to the graphical element and to the wording "Prodotti di Qualità" but the art. 2(2) of the RoU states that the geographical indication should change according to the region of origin of each product or service boasting the PQ collective trademark[20]. For instance, if the Apulia Region grants the PQ trademark to two agri-food products, one originating in Apulia and the other in Tuscany, the PQ trademark should report the wording "Prodotti di Qualità Puglia" for the product originating in Apulia and the wording "Prodotti di Qualità Toscana" for the product originating in Tuscany. It is not clear, therefore, if the "Puglia" element – which is, of course, a clear indication of origin – is a component of the EU collective trademark PQ (as claimed) or if the claimed verbal components consist only in "Prodotti di Qualità". Nevertheless, it is important to verify whether "Puglia" is an essential part of the collective trademark (as claimed): indeed, according to EUTMR, an indication of origin (as certainly is "Puglia") may be part of a collective trademark. But to eliminate any risk of competition or dilution/misappropriation with the GIs, the article 74(2) EUTMR requires that the proprietor cannot "prohibit[s] a third party from using in the course of trade such signs or indications, provided that he uses them in accordance with honest practices in industrial or commercial matters; in particular, such a mark shall not be invoked against a third party who is entitled to use a geographical name". What constitutes "honest practices" is often problematic and may be open to

19. The fact that the EUTMR allows ownership of collective trademarks to "legal persons governed by public law" has been interpreted so far as referring to bodies governed by public bodies such as "consejos reguladores" or "colegios profesionales" under Spanish law, whereas in the case of the trademark PQ the owner of the collective trademark is the same public body itself.

20. Recall that agri-food products and services originating in any region of the EU may therefore obtain the PQ collective trademark.

Figure 7 - The EU collective trademark Prodotti di Qualità

Notes: EUIPO stands for the European Union Intellectual Property Office.

controversy. This point emerged during several orders by the Italian Constitutional Court[21], which annulled regional quality trademarks due the risk, even merely potential or indirect, to influence the consumers' choice on the trademarked goods with restrictive effects on the free movement of goods[22].

Table 4 - Legal issues related to the PQ trademark

Issue	Description	Status
1	Role of the wording "Puglia"	Resolved (removal of logos A and B)
2	Use of multiple PQ logos	Resolved (removal of logos A and B)
3	Effective and purported use of the PQ trademark	Resolved (removal of logos A and B)
4	Overlap between collective and certification trademarks	Partially resolved (logo C not officially registered at the EUIPO; no provisions for Regional Quality Scheme in Regulation governing use of PQ)
5	Overlap between EU quality scheme and Regional Quality Scheme	Potential (e.g., strategic behaviour of producers)

Notes: EUIPO stands for the European Union Intellectual Property Office.

It is worth noting that the "logo A" version of the PQ collective trademark is granted only to PDO or PGI agri-food products. This may create potential misunderstanding in the use of the geographical origin (i.e., "Puglia") as it may overlap with the specific regime of GIs. Notwithstanding the coherent and legitimate use of the "Puglia" geographical indication according to art. 2(2) of the RuO and artt. 74(2) and 75(2) EUTMR, the risk exists that the public may attach the PQ collective trademark the function certifying the geographical origin of products/services to which the logo A is applied. This, however, is in contrast with the distintictive feature of the collective trademark (i.e., "Puglia" should refer to the owner of the PQ collective

21. Court Orders n. 86/2012 of 12 April 2012; n. 191/2012 of 19 July 2012; n. 260/2014. The collective geographical trademark introduced by the Emilia Romagna Region has been accepted by the EU Commission on the basis that it was open to any producer in the EU insofar the goods respect the regional quality standards, so that the Trademark distinguishes the specific methods of production and not the geographical origin (Germanò, 2016, p. 222).

22. See section 3.1 of Commission Communication – EU best practice guidelines for voluntary certification schemes for agricultural products and foodstuffs, n. 2010/C 341/04.

trademark that is the Apulia Region) and with art. 76(2) EUTRM which states that an EU collective trademark shall "be refused if the public is liable to be misled as regards the character or the significance of the mark, in particular if it is likely to be taken to be something other than a collective mark". In other words, the wording "Puglia" together with the expression "Prodotti di Qualità" clearly suggest a "quality certification" function of the collective trademark for products originating in the Apulia region[23].

Three years after the registration of the PQ collective trademark at the EUIPO, the Apulian Region approved the Regional Quality Scheme "Prodotti di Qualità" (Regional Determination n. 2210/2015[24]), referred to more than 180 agri-food products grouped in 9 agri-food chains[25]. The Regional Quality Scheme complies with the Regulation (EU) no. 1305/2013 (art. 16(1b)) notified to the European Community under the Directive 98/34/CE no. 2015/0045. Since December 9, 2015, the PQ collective trademark has been granted in a two-fold version: (i) the logos reporting the geographical origin of products to which the trademark refers (i.e., "Puglia" or any other region in the EU) automatically granted to PDO or PGI agri-food products (Figure 7, logos A and B), and (ii) the logo with the wording "Qualità garantita dalla Regione Puglia" granted to other agri-food products than PDO and PGI under the Regional Quality Scheme (Figure 7, logo C). The "blanket" element in the logo B has been introduced to comply with art. 2(2) of the RoU of PQ. In the logo C, the ® symbol applies to the graphical element and to the wording "Prodotti di Qualità", whereas the wording "Puglia" is no longer used as an indication of geographical origin but as a guarantee of the quality of agri-food products adhering to the Regional Quality Scheme.

With changes introduced in 2015, the first legal issue (i.e., the role of the wording "Puglia") remains and, *de facto*, is strengthened. The wording "Puglia" is not uniformly represented and holds different (and contrasting) roles: i.e., essential element in the logo A, changing element in the logo B, guarantee element in the logo C. It is indeed evident that the further wording "Qualità garantita dalla Regione Puglia" is indicating that the goods passed some quality

23. New rules introduced in the EU trademark regulations with respect to "certification trademarks" discipline the signs performing the essential function of guaranteeing consumers about certain characters of the products, which are certified by the trademark proprietor. These characters may be material, mode of manufacture of goods or performance of services, quality, accuracy or other characteristics, with the exception of geographical origin, so to not overlap with PDO and PGI. Furtherexceptions and limitations relate to the "duty of neutrality" of the owners of the certification trademarks.

24. More details at rqr.iamb.it.

25. The 9 chains are cereals and bakery, nursery products, fishery, dairy, fruit and vegetables, processed fruit and vegetables, meat-based products, animal-based products, animal husbandry for meat.

certification made by the Apulia Region, and this is clearly a function reserved to certification trademarks, not to the collective (even geographical) trademarks. Rules governing certification trademarks introduced in the EU on October 1st, 2017, include the prohibition to certify the geographical origin of goods and services (a prohibition applying to sign, the regulations governing use and the list of goods and services). The slight differences between the logos are therefore able to invest their very essential functions so to cause confusion and dilution with the reserved functions of GIs[26].

Further concerns, related to the first legal issue, is the use of multiple PQ logos (second legal issue) and the effective and purported use of the PQ collective trademark (third legal issue) (Table 4). The three logos used for the PQ collective trademark share many of their essential elements (i.e., the graphical elements "Q" and "p", and the wording "Prodotti di Qualità"), which is sufficient to establish potential confusion in the users[27]. The confusion arises from the mismatch between the aim of the PQ collective trademark that, according to art. 1 of the RoU of the trademark, is to enhance high-quality agri-food products and the misleading association of the wording "Puglia" with the geographical origin of agri-food products (logo A) rather than with the ownership of the trademark. This kind of confusion seems buffered by the introduction of the logo C, but it is worth noting that only the logo A is the official logo registered the the EUIPO[28].

The three logos are graphically similar, but formally and substantially different: their effective and purported use is an issue. While the logos A and B may be granted to any PDO or PGI products, the logo C may be granted only to non-PDO or PGI agri-food products and services complying with product specifications approved under the Regional Quality Scheme "Prodotti di Qualità"[29]. As a result, the "dilution" of geographical indication

26. The origin of the term dilution dates back to 1926 when Frank Schechter first advocated the idea that trademark law protects against "the gradual whittling away or dispersion of the identity" (Schechter, 1926). In other words, the junior user, or second user of the trademark, lessens the value of the senior trademark, which subsequently constitutes an injustice and wrong against the senior user's good reputation and property. The possibility, rather than the actuality, of consumer confusion is held to be the relevant element in modem trademark decisions incorporating the dilution doctrine. MILLER & DAVIS.

27. Consistent with the EUTMR, in case of reputation, the confusion may occur if "a company uses the same or a similar sign as a trade name in such a way that a link is established between the company bearing the name and the goods or services coming from that company".

28. "The likelihood of confusion is conceived as 'the risk that the public might believe that the goods or services in question come from the same undertaking or, as the case may be, from economically-linked undertaking" Case C-39/97 Canon Kabushiki Kaisha v. Metro Goldwyn- Mayre Inc EC:C:1998:442, (29-30).

29. Recall that, as explained below in the section, today the only version of the PQ collective trademarkgranted is the logo C.

may occur among producers. Consider as an example the *Pane di Altamura*, a prestigious PDO granted to the Apulian bread produced in Altamura and responding to specific protocols as recognised by the EU Commission (Regulation (EC) no. 1291/2003). An Altamura bread producer not adhering or fulfilling the standards entitling the use of the *Pane di Altamura* PDO, may still have full title to use bread (commercial denomination) and Altamura (place of origin) information in the labelling of its products, with the exclusion of the official *Pane di Altamura* PDO. This phenomenon is not rare and many "famous" PDO may decide to speculate (or even cannibalise) the important market acknowledgment of their own denomination, increasing the quantity of the productions/sales to the detriment and dilution of the "quality uniformity" which made the historical success of the same PDO and which should be expected by customers (e.g., the drying process of the *Pasta di Gragnano* PDO – one of the most important and characterising phase of its production – may vary "from 4 to 60 hours"). Differently, it appears that the essential function of the logo C falls under the "certification" function as it deals with the fulfillemt of a particular characteristic (i.e., quality). If a producer is entitled to pass the Regional Quality Scheme (which are much broader than the PDO or PGI rules), this could amount to a sort of "intra-GI" competition, to the detriment of consumers and possible dilution of the efforts put by the virtuous PDO and PGI to safeguard their products' quality.

The certification function of the PQ collective trademark in the version granted for products adhering to the Regional Quality Scheme associates it with EU certification trademarks (Table 4). The distinctive feature of EU certification trademarks are the neutrality commitment (i.e., the owner shall certify products and services of the licensees, but shall notit cannot be owned by a person carrying out a business involving the supply of the goods and services of the kind certified)[30] and the exclusion of grographical origin (i.e., the trademark shall not certify the grographical origin of products and services)[31]. While the the PQ trademark granted in the logo C version fullfills all the requirements of EU certification trademarks, it is defined as an EU collective trademark (although not officially registered in this version at the EUIPO). Thus, the fourth legal issue is related to the conflict with the artt. 76(2) and

30. "Any natural or legal person, including institutions, authorities and bodies governed by public law, may apply for EU certification marks provided that such person does not carry on a business involving the supply of goods or services of the kind certified" (art. 82(3) EUTMR).

31. "An EU certification mark shall be an EU trade mark which is described as such when the mark is applied for and is capable of distinguishing goods or services which are certified by the proprietor of the mark in respect of material, mode of manufacture of goods or performance of services, quality, accuracy or other characteristics, with the exception of geographical origin, from goods and services which are not so certified" (art. 82(1) EUTMR).

85(2) EUTMR, according to wich EU collective and certification trademarks shall be refused if they are likely to be confused with something other than a collective and a certification mark, respectively (Song, 2018). At the national level, collective trademarks performing the "essential functions" reserved by the law to the newly introduced certification trademarks needed to decide between collective or certification trademarks within December 31, 2020. The Apulia Region opted for the removal of the logos with the geographical indication and the remaining version of the PQ trademark (logo C) seems having the characteristics attributed to EU collective trademarks (Figure 7). However, it seems that the PQ regime still lacks coherence and needs to find a balance between the various aspects of its trademarks and establish a system which is not conflicting with itself. Currently the system performs functions such as certification function, representation of GI and the Quality scheme which is legally contradictory because of the issues discussed above.

The last concern is the potential overlap between the EU quality scheme (PDO or PGI) and the Regional Quality Scheme "Prodotti di Qualità" (Table 4). After the last changes introduced in 2020, the PDO or PGI products are left outside any PQ labelling and continue to benefit only of the strong protection ensured by PDO or PGI labels, to avoid potential conflicts between the PQ trademark and both the EU collective and certification trademarks. However, if a certain product is eligible to obtain both the EU quality scheme and the Regional Quality Scheme "Prodotti di Qualità", producers not adhering to the EU quality scheme may still result compliant to the Regional Quality Schemes. In such cases, especially in the long run, the PQ trademark – which seems to focus prominently in the "made in Puglia" concept, with narrow quality prescriptions – may potentially erode and/or compete with the stronger, commercially acknowledged EU quality schemes.

To sum up, the first three legal issues (i.e., the role of the wording "Puglia", the use of multiple PQ logos, the effective and purported use of the PQ trademark) have been definitively resolved with changes introduced in 2020, resulting in the removal of logos A and B[32]. Since December 31, 2020, the

32. Legal issues raised around the use of the PQ trademark have directly affected the owner of the trademark (i.e., the Apulia Region). Other stakeholders, such as the producers (i.e., licensees of the PQ trademark), are only indirectly affected by legal issues: they have simply introduced changes proposed by the owners to cope with potential issues. For instance, a concern relates to the use of multiple PQ logos. The three logos used for the PQ trademark by different producers (i.e., producers under EU quality schemes, producers under the Regional quality scheme of the Apulia Region, producers under the Regional quality scheme of other Regions), sharing many of their essential elements, may induce potential confusion in the users (i.e., consumers). Anyway, neither producers nor consumers have sufficient information to be able to affect the evolution of legal issues. Indeed, the issues have been definitively resolved by the owner with changes introduced in 2020, resulting in the removal of two out of three logos for the PQ trademarks.

PQ trademark is no longer associated with any PDO or PGI product, but only to agri-food products and services complying with product specifications approved under the Regional Quality Scheme "Prodotti di Qualità". Whether this change encompasses the requirements and conditions to ensure the coherence between the essential functions played by the sign and the relevant legal regimes (especially with regards to the specific conditions relating the certification trademark, its ownership and the "duty of neutrality") is questionable. Same doubts persists also with regards to the fourth legal issue (i.e., overlap between collective and certification trademarks): the remaining PQ trademark (logo C) still performs a mixed function of quality scheme and certification function carrying over the diluted reputation of the "Puglia" wording (either as a GI and as part of the trademark "Prodotti di Qualita Puglia"), which could lead to possible confusion on the mind of consumers. The occurrence of the fifth legal issue (i.e., Overlap between EU quality scheme and Regional Quality Scheme "Prodotti di Qualità") cannot be excluded in the next future, if potential benefits (e.g., higher margins, niche markets, recognisability of the "Made in Puglia") will induce producers to adopt strategic behaviours to obtain the PQ trademark rather than the PDO or PGI labels due to less bureaucracy.

4. Conclusions and improvement proposals

The promotion of agri-food products through territorial marketing policies, such as trademarks, is a fruitful opportunity to improve the visibility and competitiveness of a region (Zbuchea, 2014). However, the success of these policies depends on the efficacy of marketing communications and the compliance of these initiatives with regulations for the IP rights (Simonson, 1994). We conducted retrospective and prospective analyses on the trademark "Prodotti di Qualità" (PQ) owned by the Apulia Region (Italy) to identify both marketing and legal issues related to the use of this label. The retrospective analysis on marketing issues related to quality schemes revealed that the PQ trademark offers several benefits to both consumers and producers reducing the asymmetric information between them. Enhancing the quality of agri-food products, the PQ trademark increases the awareness of consumers and their willing to pay a premium price for labelled products. This improves producers' revenues and margins and allows them to further develop existing markets and cover niche markets. However, the results highlight the need to strengthen strategies of communication and promotion of the PQ trademark: policy interventions in this area appear to be a potential solution. The prospective analysis on legal issues was related to the use of the PQ trademark and to its evolution overtime. The PQ trademark is evocative

of the "Made in Puglia" concept, but as an EU collective trademark it does not indicate the geographical origin of labelled products and services, according to recent changes in the EU trademark regulation. As argued in Trestini and Stiletto (2020, p. 16), "there is a real difference between the declaration of "made in" and the origin of agricultural products used to produce foods". A potential legal issue is the overlap of the Regional Quality Scheme "Prodotti di Qualità" and the EU quality schemes with the geographical indication. Again, a stronger communication and promotion campaign implemented by regional policymakers would be beneficial.

The analysis highlights that quality is a relevant attribute for consumers in the choice of products and for producers as well in the negotiation of prices of their products. Accordingly, policymakers both at the international level (e.g., European Commission) and at the local level (e.g., Regions) should encourage the adoption of quality schemes in order to protect products with distinctive quality characteristics. Quality is associated to products with certain desirable attributes, such as place of origin and traditional know-how. A major challenge for policymakers is to inform consumers on the relevance of quality schemes and on what a quality scheme represents: i.e., the linkage between quality and a specific production area or method. A greater awareness of consumers is likely to translate into larger benefits for producers and rural communities, such as higher prices for quality products, preservation of traditional practices in the agri-food sector, creation of job opportunities throughout the supply chain. Quality is also associated to products without any defects and adulterations[33]. Safety and traceability issues figure among the objectives of Regional quality schemes and also of the PQ trademark. These objectives are indeed at the basis of any quality labels which are the expression of traditional systems consisting in setting quality standard conditions (e.g., ingredients, processing methods, origin), seals (e.g., collective/certification trademarks), and controls. In the EU, the Department of Central Inspectorate for the protection of quality and anti-fraud of agri-food products works daily to prevent and repress frauds in the trade of agri-food products, supervise registered quality productions, contrast the irregular marketing of agri-food products and the fraudulent phenomena[34]. Several practices have been developed to avoid fraudulent

33. Details at: knowledge4policy.ec.europa.eu.

34. Frauds are unfortunately common in the agri-food sector, and they are not limited to domestic market but often involve the international arena, where the counterfeit of agri-food production is quite sensitive. Fraudulent malpractices may create unfair competition and lead to market distortions (Ulberth, 2020). In 2014, the infringement of quality schemes totalled approximately 4.3 billion EUR, corresponding to 9% of the total market for quality schemes (EUIPO, 2016). If, in general, the falsification of agri-food products aims at achieving economic benefits and profit margins without affecting human health (Ulberth, 2020),

behaviours and strengthen the power of trademarks. For instance, agri-food identities may be defined at a molecular DNA basis[35]. It is important to consider the achievements made in terms of biodiversity and genetic classification[36]: an example in this direction is the "Born in Sicily" project[37] whose aim is to safeguard and promote genetic resources 'Born in Sicily' for the agri-food sector. A further method used to cover safety and traceability issues of agri-food products is the use of the blockchain technology[38] that has been successfully applied in a series of project in the Italian agri-food sector, such as the "Wine Blockchain" project[39] that builds trust and transparency between the producer and the final consumer, by controlling the wine production chain from the origin of grapes to the transformation into the bottle. Consistent with the EU "From Farm to Fork" strategy, the blockchain technology allows to trace the path of products throughout every stage of the supply chain. The use of a QR code to instantly check the correspondent information stored in the blockchain allows to satisfy the demand for traceability and to control for the compliance of products with protocols of quality and source of origin. Policymakers should take inspiration from these successful initiatives and encourage their adoption in different agri-food supply chains. Stronger actions against frauds and adulterations have a key role in enhancing trust of producers and consumers in quality schemes.

potential adverse effects cannot be excluded: a few examples are the cases of milk with melamine in China (Pei *et al*., 2011) and spirit with methanol in Czech Republic (Mika, Weissmannova-Dolezalova, and Fiserova, 2014).

35. Genotype and phenotype are a strong link between any living plant or material to a particular territory. Several methods based on chemometrics (e.g., elemental, microbial, and metabolomic fingerprinting, stable isotope ratio analyses, spectroscopies, separation techniques, mass spectrometry, DNA-PCR methods to identify species/varieties of agri-food products) have been proposed for food authentication and geographical origin determination (Danezis *et al*., 2016; Camin *et al*., 2017; Galvez, Mejuto and Simal-Gandara, 2018).

36. Provided that this would be the scope of a Quality scheme in the agri-food sector.

37. Details at: www.iusetnorma.it.

38. Strongly required by consumers, the blockchain technology is an encrypted digital dataset where all transactions (e.g., records as farm origination details, production batch, factory and processing data, shipping details) are registered and shared by all participants (e.g., farmers, processors, distributors, grocers) without any manipulation risk, also ensuring end-to-end traceability across the agri-food chains and allowing consumers to know the story of agri-food products through their smartphones (Galvez, Mejuto and Simal-Gandara, 2018).

39. Details at: www.ezlab.it.

Acknowledgements

The authors gratefully acknowledge support from the Regione Puglia. The authors thank Nicola Laricchia, Luigi Trotta, and Gianluca Nardone for their technical support, and Antonio Lopolito and the participants at the XLII AISRe Annual Conference for their comments and suggestions on earlier drafts.

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Appendix

Figure A.1 - Fuzzy Cognitive Map

			Policy objective			Policy driver					Context variable				
		ID	1	2	3	4	5	6	7	8	9	10	11	12	13
	ID	Variables	REV	EXS	NIH	DIR	IND	REG	COM	PRO	CHA	PGO	REP	PQS	REC
Policy objective	1	Higher revenues or margins													
	2	Development of existing markets													
	3	Coverage of niche markets													
Policy driver	4	Direct costs (e.g. certification, inspection)													
	5	Indirect costs (e.g. structural adjustments, operational changes)													
	6	Regional support measures for products under quality schemes													
	7	Communication strategies (e.g. web, events)													
	8	Promotion strategies (e.g. sponsor)													
Context variable	9	Access to distribution channels (e.g. large retailers)													
	10	Producer groups and organisations													
	11	Reputation of firms already using trademarks (e.g. private labels)													
	12	Products adopting other quality schemes (e.g. PDO, PGI, Organic)													
	13	Recognisability of the brand *Puglia*													

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Economia agro-alimentare /
Food Economy
An International Journal on Agricultural and Food Systems
Vol. 24, Iss. 1, Art. 7, pp. 1-30 - ISSN 1126-1668 - ISSNe 1972-4802
DOI: 10.3280/ecag2022oa12375

Feasibility study on indigenous confectionery business – the case of gulo puan industries

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Abstract

Agricultural and dairy products can be processed into a more diverse range of products that can attract wider consumers, particularly the burgeoning urban middle-class. However, studies on such an industry, particularly those in the low and lower-middle income countries, are disproportionately sparse in the literature. Therefore, this study examines the financial viability of product diversification of swamp buffalo milk-based artisanal confectionery product named *gulo puan*, which is exclusively produced in Pampangan sub-district, Ogan Komering Ilir regency, South Sumatra, Indonesia. To improve its marketability, the diversification of gulo puan into chocolate bar-like products was proposed. Financial feasibility analyses Cost-Benefit Analysis which includes Net Present Value (NPV), Net Benefit Cost Ratio (Net B/C), Internal Rate of Return (IRR) and Payback Period were conducted to examine the financial feasibility of *gulo puan* chocolate bar. Furthermore, sensitivity analysis was carried out to account for uncertainty of data. The results represent by the value of NPV (IDR 210,519,017 equals to USD 14,493.56 and IDR 185,050,910 equals to USD 12,740.16), Net B/C (1.7 and 1.6), IRR (35%) and payback period (43 months), respectively. Sensitivity analysis shows positive NPV value despite an increase in raw material costs in 6% under more pessimistic assumption. Thus, it is concluded that the proposed implementation is viable, robust,

Article info

Type:
Article
Submitted:
14/08/2021
Accepted:
26/03/2022
Available online:
29/04/2022

JEL codes:
G17, Q13, Q14

Keywords:
Traditional food
Dairy product
Financial analysis
Cost-benefit analysis
Product diversification

Managing Editor:
Catherine Chan

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and realistic. Hence, the government should play a key role to provide sufficient access to capital, upgrading skill and knowledge in order to improve the competitive edge of artisanal food industries. In addition, the diversification of *gulo puan* into chocolate bar-like products was proposed to improve marketability of the products.

Introduction

Indonesia is a developing country with a low-middle income level (LMIC, low-midlle income country), those low-middle income levels are mainly spread in rural areas (Hussain *et al*., 2007; Liu *et al*., 2019; Mastromarco *et al*., 2014; Mkondiwa *et al*., 2013). The majority of rural communities depend on agricultural products for their livelihood. Some of them process the produce into processed local food, with simple knowledge, skills and tools (Kpossilande *et al*., 2020). Therefore, the artisanal food industry (AFI) has been an important and often indispensable to the local economy. AFIs are able to contribute to local community income by distributing local food at affordable prices to the urban poor (Honfoga *et al*., 2018). In addition, AFI helps food availability by directly processing the raw products of livestock production, thereby reducing the amount of redundant production due to spoilage and extending the shelf life of these products.

Despite its importance, AFI faces constrains such as lack of or nonexistent professional staff, very low capital base, and poor food hygiene (Dossou *et al*., 2017). On the other hand, AFI is often underappreciated and even ignored in policy making in many countries particularly in LMIC. These artisanal industries are rarely recognized due to its informal nature, and hence it is not included in regional policies (Honfoga *et al*., 2018; Lybbert & Elabed, 2013). Due to lack of attention and unsystematic promotion to the growing middle-class masses in these countries, these products are often considered outdated, irrelevant, and out-of-fashion (Cirne *et al*., 2019). Moreover, there are differences in the consumption habits of urban and rural communities in LMIC (Popkin, 2014). Urban communities are closer to processed food compared to traditional foods counterparts. The changes in market preference of urbanians resulted in traditional food being abandoned, they prefer to consume modern-popular foods, which are mostly adapted versions of that from abroad (Honfoga *et al*., 2018).

In this study, industries of *gulo puan*, a dairy-based traditional food, was studied with a focus on its financial potentials. We explore a value added option by diversifying the *gulo puan* product into chocolate *gulo puan*

to increase its attractiveness to potential consumers. Snack food products have the same impact as agricultural products and marketing on business operations in food processing because their existence attracts consumers (Ahmed *et al*., 2020; Lybbert & Elabed, 2013). It is for this reason that we chose chocolate bar as a diversified product from this artisanal confectionery product. *Gulo puan*, with relatively high sugar content, is suitable to be processed into *gulo puan*-chocolate bar (GPCB). A specially-crafted *gulo puan* with some chocolate bar characteristics could potentially increase the attractiveness of *gulo puan*. The financial potentials of this diversification were examined through cost-benefit analysis (CBA), namely net present value (NPV), net benefit and cost ratio (Net B/C), internal rate of return (IRR), payback period, and sensitivity analysis.

The average annual income of *gulo puan* producers in 2013 in the Pampangan District was an average of IDR[1] 10.1 million or USD 711.88 (Aprilyanti & Sobri, 2018). As comparison, the regional minimum wage of workers in South Sumatra Province in the year of 2020 is IDR 36.5 million per year or USD 2,595.18 (Indonesian Central Bureau of Statistics, 2020b). Based on this data, the annual income of *gulo puan* business is apprehensive to provide financial benefits regardless of its promising potential. On the other side, there are several examples of successful practice and promotion of traditional food-derived value-added product in the literature, mostly in more advanced economies (e.g., in Parmigiano Reggiano region of Italy (Roest & Menghi, 2000), Brazil (Medeiros *et al*., 2017), West Australia (Azavedo & Walsh, 2018), United Kingdom (Blundel, 2010), and Japan (Hashimoto & Telfer, 2008)). A few examples in LMIC exist at limited quantity in the literature (Elisabeth, 2015; Kpossilande *et al*., 2020), which is far smaller than the rest of the world. Kpossilande *et al*. (2020) examined the potential of AFIs in West Africa using an economic potentials approach. Further, a study by Elisabeth (2015) uses a value-added approach to AFI products. In addition, the study of Honfoga *et al*. (2018), using a market integration approach and found that traditional food still dominates compared to popular food in rural areas in one of the LMIC countries in Africa. It indicates that traditional food remains engaged to the local community. On the other hand, product diversification could potentially extend the consumer base of the product in question towards urbanites.

With the rationale above, we propose an evaluation of diversification feasibility of *gulo puan* AFI, which was examined during the five years period. To the best of our knowledge, there are no studies examining the feasibility of AFI in LMIC using the CBA approach, we bridge this literature

1. IDR is Indonesian Rupiah; USD 1 equals to IDR 14.525.

gap. Despite the specific scope of the study, this study is aimed to provide a perspective of financial potentials of the industry, particularly on less-represented LMIC context. In addition, that necessary information provides policy makers to formulate policies for increasing financial viability of AFI products.

Considering the above issues, the paper was organized as follows. In section 1, we elaborate upon the background which consist of the explanation of the main product and challenges faced by AFIs. Section 2 describes the materials and methods as well as the theoretical framework of the research hypothesis. The empirical results and discussions are presented in section 3. Finally, conclusions and policy implications of the study are given in section 4.

1. Background

Gulo puan

Presently, *gulo puan* is produced almost exclusively in Pampangan, South Sumatra province, Indonesia (see Figure 1). In its original form, it consists of the basic ingredients of brown sugar and swamp buffalo milk. The local community, using relatively simple and manual processing tools, processes the buffalo milk into *puan gulo* with intention to prolong the milk shelf life. The process of making *gulo puan* is basically similar to that of caramel production. The difference is that caramel uses white sugar while *gulo puan* uses brown sugar. *Gulo puan* texture is soft, gritty, with a brownish color. It tastes sweet and slightly salty, which is akin to combination of caramel and cheese. The way to make it is by mixing five liters of swamp buffalo milk and a kilogram of brown sugar, then cook over low heat. The dough is then stirred for about five hours by gently and continuously to prevent lumping. It is noted that one of the reasons of the localized production of *gulo puan* is attributed to its specific ingredient, that is the swamp buffalo milk. Replacing it with other milk may change its texture and taste, particularly the umami level of the end product, which is its key characteristic.

Challenges of gulo puan AFI

Most small-scale dairy processing enterprises in LMICs tend to have challenging technical problems, e.g. sanitation quality, and poor economy-of-scale. The situation is changing gradually, though the capacity of utilization remains low (Dominguez-Salas *et al*., 2019). Further, dairy-based traditional

food, let alone confectionary, is relatively rare in tropical countries. Tropical countries with warm and humid weather present challenges in the process of making traditional dairy-based food. Therefore, the production of *gulo puan* in Pampangan district is merely traditional and not necessarily economical, which keeps the industry confined to the region itself.

Challenges faced by the *gulo puan* artisanal industry are similar to that in other typical LMIC counterparts. Those are the informal status of such business, poor transportation infrastructure, geographical isolation which lead to limited market coverage, inadequate knowledge and technology access, and limited labor skill. The popularity of *gulo puan* has been in steady decline, since a significant portion of its customers base are uninterested or aging. Potential younger customers are not interested to consume *gulo puan* as it is perceived as an old-fashioned food. The price of *gulo puan* is IDR 50,000 to IDR 60,000 (±USD 3.56 to 4.23) per kilograms. Currently, only few communities are still consuming the *gulo puan* on a regular basis, especially those from the Pampangan area. Outside its consumer base, the acceptance tends to be low or even repulsive due to the unusual aroma that comes from swamp buffalo milk. It should be noted that despite its relatively close distance to provincial capital of Palembang, there is only one minor road leading into the vicinity. The transportation access usually become worse during the rainy season where the road becomes slippery and muddy, complicating the marketing distribution process for AFIs. The challenges are not addressed properly since the AFIs are often overlooked by policy makers.

Despite efforts from the government to encourage the added value of local produce, in practice it has not been equally implemented, particularly in rural areas. Most income sources of the rural community derived from farming, such as selling crop products to the city. The revenue from the artisanal food industry is not even ranked within top ten of income contributors to the community in Pampangan district (Ogan Komering Ilir Regency, 2020). In addition to inadequate equipment, infrastructure, and technology, limited capital is also a basic obstacle in developing *gulo puan* AFIs. As local community turns to add other crops as their source of income, livestock can be more resilient to climate change than the existing crops, yet they can suffer adverse impacts such as heat or drought stress, increase of diseases, and ultimately animal losses, particularly in grazing systems in arid and semi-arid areas at low latitudes (HPLE, 2016). Furthermore, mechanization of agricultural activities in the area has proven to render the buffaloes as idle assets, potentially decreasing the scale of production (Aprilyanti & Sobri, 2018; Muhakka *et al*., 2013). Without government intervention, this problem cannot be solved independently by the community therefore, all of these challenges need to be addressed by policy makers to improve the standard of living of *gulo puan* producers.

CBA on Investment of AFI

The essence of CBA follows the assumptions of Pareto's theory (1896-1897) which says a project is said to be efficient only if at least one person gets better and no one is harmed. Furthermore, a project is said to have improvement if the total benefit is greater than the total cost. Hence, the benefits obtained can compensate the costs. If there is improvement, then the project is said to be efficient. CBA is often used in financial and political circles in terms of budget or financial analysis. However, there is no specific guidelines for conducting CBA, only that the analytical framework should be based on sequential steps. Similar to mathematical proofs, its integrity depends on following a consistent line of argument, starting with policy goals, alternative means of achieving goals, and taking into account any legal, physical, or institutional constraints (Dobes, 2019).

The CBA method is considered more practical to be applied to small-scale projects (Dobes, 2019). In addition, this method is one of the investment feasibility analysis that relies on economic rationality, the calculations are relatively minimalist but financially robust and valid. From a domestic viewpoint, the financial aspect of private enterprises is more conclusive than public-owned enterprises, for policy makers (Meyer *et al*., 2021). By this justification, the results obtained can influence interested parties, in particular the policy makers. In regard to this proposed project, AFIs is assumed as a small-scale private business. In despite of small business, if the project is successfully implemented, it will make a significant contribution on society (Friedman, 2005). The main priority in this study is to present financial calculations that can be achieved by the transformation of local products into popular products through product diversification. Thus, investors can access information that it is possible to improve local businesses based on local product. Furthermore, attention from the government in the form of policies becomes very important (Szeto & Kim, 2018). We therefore employed CBA as the method to examine the financial viability of *gulo puan* AFIs and proposed a hypothesis as follows:

H1: The diversification of local product (*gulo puan*) into popular product (GPCB) is financially viable

2. Materials and methods

Profile of the Study Area

Pampangan is a sub-district in Ogan Komering Ilir Regency with a distance of approximately 42 kilometers and 67.3 kilometers from the regency (Kayu Agung) and province (Palembang) capitals, respectively. This

sub-district is located in the northeast of the capital city of Komering Ilir Regency, namely Kayu Agung. It is located at an altitude of ±10 meters above sea level, with an area of 824.40 kilometers square and a population of 28,962 people (Indonesian Central Bureau of Statistics, 2020b).

Figure 1 - Maps of Pampangan sub-district within Ogan Ilir Regency and South Sumatra Province

Source: Ogan Komering Ilir Regency (2020).

Data collection

There are several stages in obtaining the data of this study. Firstly, small-scale laboratory experiments were carried out to determine the exact amount of material to transform *gulo puan* into GPCB. This data is further used to calculate the expected revenue and expenses of the proposed project. From the laboratory experiment it is found that the ingredients of GPCB is presented in Table 1.

Table 1 - The ingredients of making one kilogram of Gulo Puan *Chocolate Bar*

Item	**Quantity**
Gulo Puan	1,000 g
Cocoa Powder	375 g
Milk Powder (Full Cream)	90 g
Additional Flavor	30 g
Cocoa Butter	15 g

Source: Primary data collected in 2020.

Secondly, interviews were conducted at the study area to determine the influence of the existence of the *gulo puan* artisanal industries on social, economic, cultural and environmental conditions. There were 10 respondents who were randomly selected from 15 AFIs which were active workers and owners of AFIs. The interview consisted of semi-structured questions using the discussion group method. The questions consist of demographic questions, e.g., age and gender, and detailed questions related to social, economic, cultural and environmental conditions. The statistical data shows the respondents consist of 70% of female and 30% of male. The average annual income of *gulo* puan AFI is IDR 9.96 million equals to USD 685.71. Furthermore, we found that 100% *of gulo puan* producers attain skill and knowledge in processing *gulo puan* from their ancestors. It implies that they do not use modern skill nor upgraded knowledge (Table 2).

Table 2 - Descriptive statistics of respondents and related questions

Demographics		**Detailed Questions Responses**	**Result**
Female	70%	The average income from *gulo puan* AFI (yearly; Million IDR)	Average: IDR 9.96 million (USD 685.71)
Male	30%	The average of total income (yearly; Million IDR)	Mean: IDR 18.36 million (USD 1,264.02)
Age	Mean: 49.5	The origin of skill and knowledge in processing the *gulo puan* (passing down through generations=1; novel/ modern skill and knowledge=2)	1=100%; 2=0%
		Tools used (simple=1; sophisticated=2)	1=100%; 2=0%
		Infrastructure and transportation (good=1; poor=2)	1=20%; 2=80%

Source: Primary data collected in 2020.

The last stage was the collection of the secondary data. The secondary data was obtained from a literature study from Indonesian Central Bureau of Statistics. We used the Indonesian Central Bureau of Statistics website to examine the price and cost of each item (Indonesian Central Bureau of Statistics, 2020a).

Data analysis

The data was examined using qualitative and quantitative analysis. The result of laboratory experiment for ingredient of GBPC and interviews were classified as primary data which is used for qualitative analysis. Whilst quantitative analysis was carried out using secondary data which is collected from Indonesian Central Bureau of Statistics (2020a). After the data was collected, the initial balance sheet was designed. The financial statement consists of a classification of accounts in the accounting formula, namely assets, liabilities and equity. Furthermore, cash flow estimates for five years and an interest rate was employed to calculate the NPV, IRR, Net B/C, and payback period as well as sensitivity analysis. This study uses two scenarios. The first scenario uses a loan interest rate of 9%. For the second scenario, we use an interest rate of 11%, assuming the loan interest rate is the maximum MSME interest rate based on historical data in Indonesia.

By displaying comprehensive calculation results, interested parties can see the value of NPV, IRR, net B/C, PP[2], respectively. Technically, one calculation of viable result will be followed by the other calculation. However, in this study, we decided to display all the calculation results with the consideration that the more complete the information provided will explain better. Likewise for sensitivity analysis, we can predict how far the results of this calculation are sensitive to changes in significant factors, such as raw materials.

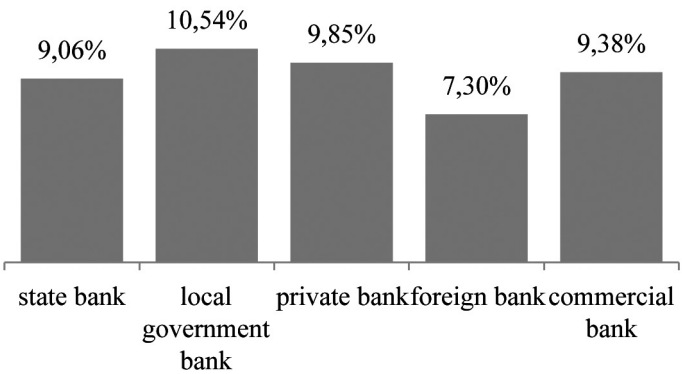
3. Results

At the time of the study, there were fifteen *gulo puan* AFIs in Pampangan. In this study, *gulo puan* AFIs are aggregated into one legal entity for a five-year period (2020 to 2024). Cost increase was calculated based on the inflation rate of Indonesia. The inflation rates of Indonesia is at 4% per year. Furthermore, the cost of establishing and installing electricity comes from personal capital, whilst additional capital is obtained from loan (bank debt) in the amount of IDR 150,000,000 or around USD 1,500. The average Micro Small Medium Enterprise (MSME) annual loan interest rate is 9.23%, while the lowest and highest interest is at the point of 7.3% and 10.54%, respectively (see Figure 2).

2. We use four measurements in term of CBA, comprises of NPV, IRR. Net B/C and Pavback Period. The formulation of each measurement is as follows: NPV=$\sum_{t=1}^{n}\frac{Bt}{(1+i)^t}-\sum_{t=1}^{n}\frac{Ct}{(1+i)^t}=\sum_{t=1}^{n}\frac{Bt-Ct}{(1+i)^t}$; IRR=$\frac{NPV}{NPV\ -NPV'}\ (i'-i)$; Net B/C=$\sum_{t=0/1}^{n}\frac{\frac{B_t-C_t}{(1+i)^t}}{\frac{B_t-C_t}{(1+i)^t}}$; Payback Period=$\frac{I}{A_b}$.

The areas of interest in this study are cost and revenue. The costs are classified into several categories, namely investment costs, production costs and operating costs. Meanwhile, revenue is estimated from sales of chocolate bars price multiply by estimated number of bars of aggregated entity.

Figure 2 - Average Loan Interest Rates



Source: Bank of Indonesia (2020).

Cost breakdown

Total costs include investment, production and operating costs. Investment costs are obtained from personal capital consisting of establishment costs and electrical installation costs which occur once at the time of establishment. The cost of acquisition of fixed assets is obtained by loan capital. The rest of capital loan is saved in the form of cash or cash equivalents. Establishment cost is required to establish the legal aspect of new company, which consists of notary fees, business license and registration fees of IDR 5,000,000 or USD 344.23. In addition, the company has to register a corporate taxpayer identification number which is free of charge. Electricity for MSME business scale is at the cost of IDR 454 (USD 0.032) per Volt Ampere (VA)[3]. Thus, the cost of installing electricity power by the State electricity company in Indonesia is IDR 13,274,960[4] equals to USD 913.93. Electricity installation

3. Electricity for MSME business scale is classified between 14.1 VA to 200 kVA, where VA is the abbreviation of volt ampere. Volt ampere is the unit of apparent power in electrical circuit and kVA is the kilo volt ampere. 1 kVA equals to 1,000 VA.

4. The calculation of installing cost defines as the multiplication of 29.24kVA x IDR 454 x 1,000 VA. 29.24 kVA is denoted for the electrical power needed of the project.

service costs consist of electric transformer (IDR 6,000,000 or USD 413.08) and installation fees (IDR 5,000,000 or USD 344.23). Furniture, fixture, machine, vehicle and other assets that are used more than a year are classified as fixed assets.

The cost of fixed assets are the acquisition costs which have been capitalized by shipping, installation, testing fees up to ready-to-use assets. The vehicle used is assumed to be a modified motorcycle to meet the transportation challenge due to poor transportation infrastructure from the *gulo puan* AFIs location to the production center of GBPC. Production center is in Palembang, the capital of the province. The rationale of choosing modified motorcycle is that the road access is rough, bumpy and mostly consists of only non-all weather one lane, thus presenting difficulties for traversing heavy vehicles.

Furthermore, during the rainy season the road terrain is much worse due to mud and soil. Lastly, the cost of packaging, stickers, and leaflets design for promotion purposes was specified at IDR 1,500,000 (USD 103.27). The total investment costs for the GPCB at the time of business establishment are shown at Table 3.

Table 3 - Estimated total investment costs

Item	**Investment Cost (IDR)**
Business establishment	5,000,000
Electrical installation	24,274,960
Fixed assets	85,800,000
Equipment[5]	18,350,000
Miscellaneous	1,500,000
Total	**134,924,960**

Source: Indonesian Central Bureau of Statistics (2020a).

Gulo puan is the main raw material in producing GPCB bars. Based on a small-scale laboratory test, each kilogram of *gulo puan* is estimated to bring out 1.5 kilograms of chocolate bar. Other food ingredients (Table 4) are added to improve and to vary the flavor of chocolate bar. In this case, we added nuts, dried fruits and honey.

5. Equipment is classified into current assets. The list is shown at Table A1 in appendix.

Table 4 - Total cost for 1.5 kilogram of GPCB

Item	Quantity	Price/g (IDR)	Total cost (IDR)
Gulo Puan	1,000 g	60	60,000
Cocoa Powder	375 g	225	84,375
Milk Powder (Full Cream)	90 g	75	6,750
Additional Flavor	30 g	200	6,000
Cocoa Butter	15 g	250	3,750
Total			**160,875**

Source: Indonesian Central Bureau of Statistics (2020a); Primary data collected (2020).

As seen at Table 4, the total cost of raw materials to produce 1.5 kilograms of chocolate bars is IDR 160,875 (USD 11.07) or IDR 103.2 (USD 0.0072) per gram of *gulo puan*. The GPCB is assumed to be marketed in several sizes, at the size of 30 grams, 60 grams, and 100 grams. Several package sizes are available to give costumers more flexible options. A study conducted by Thaichon *et al*. (2018) revealed that most consumers chose to buy a smaller size product because it is more handy and easier to carry. Moreover, smaller size will be more affordable for those with lower income. The targeted sales of this project are thus on the smaller size (i.e., 30 grams). The annual sales targets for this project are represented in Table A7. The total cost of raw materials in the first year is IDR 366,566,400 or USD 25,236.92 (3,552,000 grams multiply by IDR 103.2/gram or USD 0.0072/ gram).

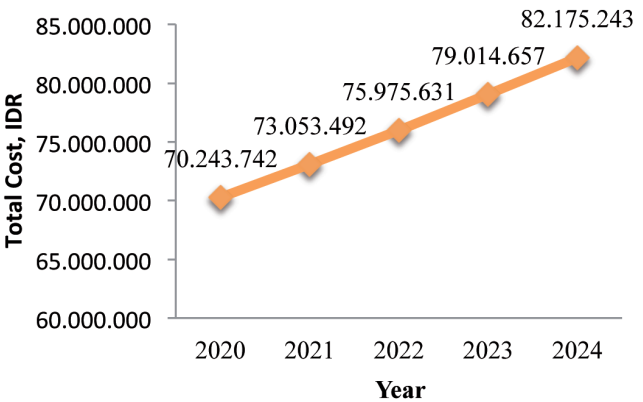
The cost of production equipment yearly was assumed to be 20% of the equipment costs provided for investment in business establishment. Therefore, the amount is 20% multiply by IDR 18,350,000 (USD 1,263.33) which equals to IDR 3,670,000 (USD 252.66). Furthermore, the estimated total production cost during period of project (2020 to 2024) is given in Table 5. It includes the cost of raw material, quality control and packaging, equipment and labor cost.

The operational cost is consist of administration, maintenance, electricity, water subscription, internet subscription, transport cost, miscellaneous cost, depreciation, rental cost of place of business as well as rental cost of several equipments such as brookfield texture analyzer, muffle furnace, spectrophotometer to ensure the quality of each production.

Table 5 - Estimated production cost for five-year project. Total production cost consists of production material, quality control & packaging, production equipment, labor cost. It is assumed to increase by 4% a year

Production Cost	**2020**	**2021**	**2022**	**2023**	**2024**
Raw material	366,566,400	381,229,056	396,478,218	412,337,347	428,830,841
Quality control and packaging	33,000,000	34,320,000	35,692,800	37,120,512	38,605,332
Equipment	3,670,000	3,816,800	3,969,472	4,128,251	4,293,381
Labor cost	72,000,000	74,880,000	77,875,200	80,990,208	84,229,816
Total	**475,236,400**	**494,245,856**	**514,015,690**	**534,576,318**	**555,959,371**

Figure 3 - Estimated operational cost for five-year project. Total operational cost consists of all operational related activities, including depreciation. It is assumed to increase by 4% a year

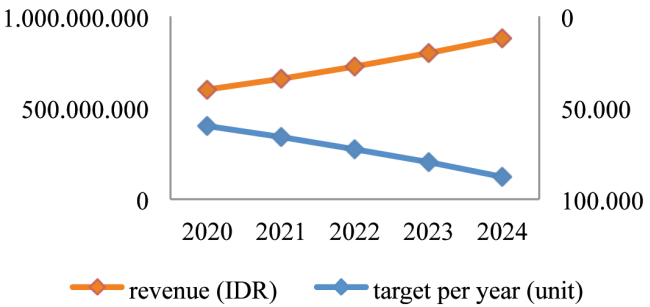


Revenues

Revenue of this project is calculated by multiplying sales targets and the price of each size of GBPC. The price is determined by aggregated the costs and comparing the price of similar products. The sales target per year for each size are shown in Table A9. The GPCB products are assumed to be sold in three different sizes, listed as small (30 grams), medium (60 grams), and large (100 grams). Sales target per day is 250 packs consisting of 70 pieces of big size, 80 pieces of medium size and 100 pieces of small size. The operational working days of business were assumed to be 240 days (5 working days a week). Sales target increases by 10% per

year, assuming *ceteris paribus* from the data published by the International Cocoa Organization (ICCO) Consultative Board (2010) which revealed that consumption of chocolate confectionery products increased by 11% between 2000 to 2008 corresponding to an average of annual growth rate of Indonesia is at 5.1%. Meanwhile, the average of annual growth rate of Indonesia for the past 10 years is 5.4% (Indonesian Central Bureau of Statistics, 2020b).

Figure 4 - Estimated chocolate bar selling revenue for five-year project



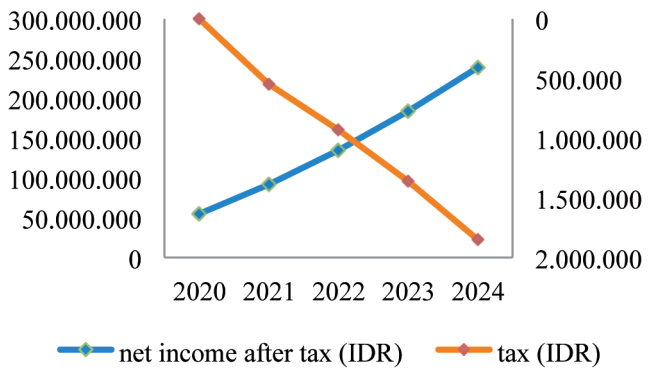
Source: Indonesian Central Bureau of Statistics (2020a); Primary data collected (2020).

The GPCB production per year is estimated at 60,000 packages, which equals to 3,552 kg of *gulo puan* per year in total. It implies that *gulo puan* AFIs at Pampangan should be produced at least 9.7 to 10 kg per day (3,552 divided by 365 days) to meet the minimum production quantity to transform into GBPC. The solution is by increasing the female buffalo population, and/or boosting the milk productivity per buffalo. The former can be achieved by providing incentives to farmers, while the latter can be achieved by improving nutrition feed intake (Naveed-ul-Haque *et al.*, 2018) and educating the farmers to adhere to good milk-producing buffalo rearing practice (Deb *et al.*, 2016; Sweers *et al.*, 2014). Moreover, based on the above data, it is necessary to calculate net income and cash flow in determining the result of investment criteria analysis.

The profit generated from the project shows the amount of IDR 54,519,858 (USD 3,753.51), IDR 92,155,454 (USD 6,344.60), IDR 135,081,672 (USD 9,299.94), IDR 183,648,939 (USD 12,643.64), and IDR 238,475,296 (USD 16,418.26) in the first, second, third, fourth, and fifth year, respectively (Figure 5). Based on Indonesian Government Regulation Number 46 in the year of 2013, corporate taxpayers with a gross turnover not more than IDR 4.8 billion (± USD 334.809) in a year will be charged a tariff of 1%. Gross turnover is the net income for the following year thus, the implementation of

the tariff is for the following tax period. Therefore, in the first year of project the income tax is zero, meanwhile in the further period the amount of tax is IDR 545,199 (USD 37.53), IDR 927,007 (USD 63.82), IDR 1,360,087 (USD 93,63), and IDR 1,850,000 (USD 127.36).

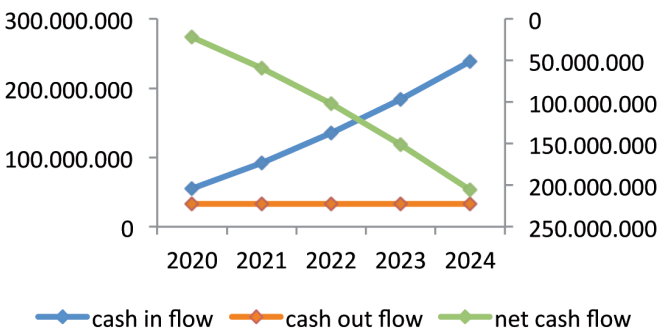
Figure 5 - Estimated Net Income for Five-year Project



Source: Indonesian Central Bureau of Statistics (2020a); Primary data collected (2020).

Figure 6 shows net cash flow data of GPCB based artisanal confectionery product project for five years period. Cash inflow is obtained from net income plus depreciation expense, while cash outflow represents payments from bank loans. The amount of net cash flow is obtain from the deduction between cash in flow and cash out flow. We calculated the amount of net cash flow in every period are IDR 21,819,858, IDR 59,455,454, IDR 102,381,672, IDR 150,948,939, IDR 205,775,296, respectively.

Figure 6 - Estimated Cash Flow for Five-year Project



Source: Indonesian Central Bureau of Statistics (2020a); Primary data collected (2020).

Feasibility analysis

The decision to invest in a project is difficult (Dué, 1991). Therefore, financial analysis is needed prior to deciding on an investment. Financial analysis is what needs to be done first to ensure that the project is economically feasible. If the financial feasibility is met, it means that there is added economic value that provides benefits from the proposed project (Dué, 1991). Financial feasibility uses a market price approach. Whilst, the calculation of economic feasibility uses social price (shadow price), which in the scope of this study, it is complicated to determine the accurate social price. Market prices are generally available and accessible, besides that the results of financial feasibility using CBA calculations are relatively accurate, especially if used on small and private projects. Which in turn the objective of this study is to increase the added value of local products to deliver economic and social impact. In the end, it can be taken into account by policy makers to develop competitiveness of AFI, one of which is through diversification of local food products.

NPV is employed to measure the opportunities and financial viability of the project assuming that there are changes in cost or productivity which impart effect to the cash flow of a company. The interest rate used in NPV calculation is 9% which is the prevailing bank loan interest rate (Indonesian Central Bureau of Statistics, 2020a).

NPV shows positive value of IDR 185,050,910 (USD 12,740.16) and IDR 210,519,017 (USD 14,493.56). It indicates that the proposed investment in the next five years will receive positive net benefits. In addition, net B/C ratio of 1.6 or 1.7 is a comparison of the total present value of net cash flows. An

Table 6 - Investment criteria result of CBA analysis

Criteria	Result	Explanation
NPV	Debt ratio 9%: IDR 210,519,017 (USD 14,493.56) Debt ratio 11%: IDR 185,050,910 (USD 12,740.16)	NPV > 0 = feasible
Net B/C	9%: 1.7 11%: 1.6	Net B/C > 1 = feasible
IRR	35%	IRR > debt ratio (i.e., 9%, max 11%) = feasible
Payback Period	Personal capital: 16 months Total capital: 43 months	PP < project period (5 years) = feasible

IRR of 35% indicates that this business projection can return the investment capital up to a loan interest rate of 35% per year. It is noted that the IRR is considerably larger than the loan interest rate (i.e., 9%). Furthermore, the repayment periods for the business are shorter than the proposed project, which are 16 months and 43 months. It is concluded that the proposed project is feasible.

Sensitivity Analysis

Lastly, sensitivity analysis was conducted to examine the effect of changes in production parameters on performance of the production system in generating profits. Sensitivity analysis looks at what might happen if a certain change occurs in a variable. For example, how will the results change if the expected price changes. The results obtained will provide an indication of the resilience of a project to unexpected exogenous shocks. Since the economic assumptions on which the analysis is based are not expected to remain the same, the analysis indicates the extent to which the analysis results will be valid.

By conducting a sensitivity analysis, the possible consequences of these changes can be anticipated in advance. Any changes in production costs or a declining in productivity affect the feasibility level (measured by NPV). We performed sensitivity analysis by using two scenarios in the CBA method, namely the optimistic scenario using a 9% loan interest rate and a pessimistic scenario with a 11% loan interest rate. With a pessimistic scenario, this project is still feasible to perform.

However, we retested the sensitivity of this project using the cost of GPCB raw materials. The main raw materials in producing GPCB are *gulo puan* and cocoa powder. Based on the interviews to workers and owners of *gulo puan* AFIs, the tendency of *gulo puan* price is relatively stable, means no significant changing in price. However, according to the data published by the ICCO Consultative Board (2010), the international price of cocoa (in the form of cocoa beans) circa 1980-2010 has experienced considerable fluctuation. Hence, the price of cocoa bean induces the price changing of cocoa in the form of semi-processed products, such as cocoa powder. Based on this history, we predicted the price of cocoa powder for five years further using extrapolation. By employing the linear regression analysis, the result indicates that the cocoa powder price could possibly shifts 0.92% higher annually. Because of the fluctuation of cocoa powder price, we therefore conducted sensitivity analysis using two scenarios, namely optimistic and pessimistic. In optimistic scenario, it is assumed that the raw material cost reduces at 3 and 6%. We performed pessimistic scenario to assume the worst risk of raw

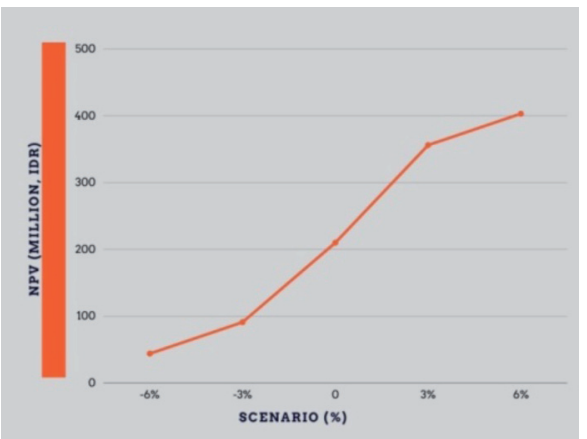
material increases and decline in sales. In this analysis, we employed much higher percentage increase in price per year than that of fluctuating annual rate of raw material, considering the cacao powder price changes contribute 2.4% of total material costs.

Table 7 - Calculated NPV from sensitivity analysis of raw material and sales

Scenario	Indicator	NPV (IDR)
Pessimistic	Sales declined at 3% Raw material cost increased at 3%	91,411,179
	Sales declined at 3% Raw material cost increased at 6%	44,490,017
Optimistic	Sales increased at 3% Raw material cost declined at 3%	356,939,098
	Sales increased at 3% Raw material cost declined at 6%	403,860,260

The results of sensitivity analysis show that positive NPV value (NPV > 0), despite the scenario is assumed to be pessimistic with an increase in raw material costs of 6% and a decrease in sales of 3% (see Table 7) which is depicted in Figure 7. It is concluded that chocolate bar-based artisanal confectionery product project presented herein is feasible and not sensitive to changes in raw material costs up to 6%.

Figure 7 - Plot of sensitivity analysis of raw material and sales



4. Conclusions and Policy Implications

The results of CBA indicate that product diversification of swamp buffalo milk-based artisanal confectionery product named *gulo puan* is financially viable and has high economic potential for implementation. Furthermore, the sensitivity analysis confirms that our results are robust and realistic to be implemented. Hence, the proposed hypothesis is not rejected at NPV IDR 210,519,017 (USD 14,493.56), Net B/C 1.7%, IRR 35.0054% and payback period 43 months, respectively.

With this innovation, it is expected that swamp buffalo milk production can be increased to foster the local economy. The milk itself is potential to be upgraded, thus it become products that represent artisanal confectionery products with value added in it. The extent of the viability of *gulo puan* AFI demonstrated in this study indicates the considerable potential benefits and implications in terms of financial aspect. Apart from financial benefits, this proposed project has a positive impact to conserve the swamp ecosystem, which is the habitat of swamp buffalo. The taste, quality, texture, size, price and diversity of mixed ingredients are important traits in selection of chocolate bar and chocolate bar-like products from the perspective of consumers (Thaichon *et al.*, 2018). Therefore, it is important for this project to maintain the aforementioned factors, taking into consideration that chocolate bar consumers are price sensitive (Romaniuk & Nenycz-Thiel, 2014). Thus, with competitive prices, local products still have wide market opportunities.

On wider scale, product diversification needs to be considered as a means of increasing income and harness the natural resources potentials in LMICs, particularly in rural areas. Limited skills and knowledge, technological constraints, and poor transportation are persistent problems that requires attentions and region-specific policies. With addressed policies, AFIs could access and attract bigger capital, improve the production method (e.g. towards standardized Good Manufacturing Practice, GMP) with the assistance of professionals in their fields in assessing every business operational activity. Hence, the government should play a key role to provide sufficient access to capital, expertise and knowledge in order to improve the competitive edge of AFIs. In addition, further study should examine the impact of project feasibility of AFI on woman entrepreneurs, given that majority of the owners and active workers of *gulo puan* AFIs is female.

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Appendices

Table A1 - Estimated fixed assets and current assets

Asset	Quantity	Price/unit (IDR)	Total cost (IDR)
Fixed Assets			
Oven Vacuum (50 Liters)	1	22,500,000	22,500,000
Display Refrigerator (4 Decks)	3	3,000,000	9,000,000
Chest Freezer (double door 1,200 Liters)	2	10,500,000	21,000,000
Mixer (20 Liters)	1	7,000,000	7,000,000
Cashier Table	1	600,000	600,000
Display Table	3	300,000	900,000
Chair	4	50,000	200,000
Cashier Machine (Casio SE-S10)	1	2,300,000	2,300,000
Air Conditioner (1 PK)	1	3,000,000	3,000,000
Desicator	1	1,600,000	1,600,000
Modified Motorbike	1	13,500,000	13,500,000
Total Fixed Assets			
Current Assets			
Stainless Measuring Container 10 Liters	10	700,000	7,000,000
Stainless Measuring Cup 5 Liters	5	900,000	4,500,000
Stainless Measuring Cup 1 Liters	10	200,000	2,000,000
Silicone Mold 30gr	50	20,000	1,000,000
Silicone Mold 60gr	50	26,000	1,300,000
Silicone Mold 100gr	50	30,000	1,500,000
Spoon 50ml	20	40,000	800,000
Heat Resistant Spatula	5	50,000	250,000
Total Current Assets			

Table A2 - Estimated quality control and packaging costs

Material	Quantity	Price/unit (IDR)	Total cost (IDR)
Protein Analysis:			
– Potassium hydroxide	500 grams	6,000	30,000
– Concentrated sulfuric acid	500 ml	140	70,000
– Aquadest	4 Liters	25,000	100,000
– Boric acid	500 grams	10,000	50,000
Color Analysis:			
– Color checker	1	2,000,000	2,000,000
Lipid content analysis:			
– Shock let	15	50,000	750,000
Food Packaging	60,000	500	30,000,000
Total			**33,000,000**

Table A3 - Estimated transportation cost

Item	Total cost (IDR)
Fuel	2,041,804
Parking	300,000
Total	**2,341,804**

Table A4 - Estimated electricity cost for first-year GPCB small business establishment

Item	Quantity	Electrical Power (kWh)	Electrical Power/year (kWh)	Total Electrical Power/year (IDR)
Oven Vacuum	1	0,4	737,28	1.081.796,20
Display Refrigerator*	3	0,18	2.954,88 (WLBP)	4.335.636,33
			1.088,64 (WBP)**	1.597.339,70
Chest Freezer*	2	0,468	5.121,80 (WLBP)	7.515.102,97
			3.773,95 (WBP)**	5.537.444,29
Mixer	1	1,1	2.027,52	2.974.939,54
Air Conditioner	1	0,35	589,82	865.436,95
Muffle furnance 1.3 L (mineral analysis)***	1	1,06	488,45	716.689,98
Spectrophotometer 1200L/mm grating***	1	0,22	101,37	148.746.98
Lamp (lighting)	6	0,001	11,06	16.226,94
Cashier Machine	1	0,0035	6,45	9.456,71
Electricity Cost for Medium Enterprise ****	–	2,5025 (3,128 kVA)	30,03	2.203.120,92
Total				**27.001.937,51**

* All electricity usage for equipment other than refrigerators and freezers is calculated during peak load time (PLT), except refrigerators and chest freezers which are used every day (30 days) for 24 hours with peak load outside time (PLOT) for 5 hours each day (17.00-22.00).
** The ratio of PLT (K) is between 1.4 to 2. In this case, it is considered that business electricity is charged under PLT of 1.4.
***It is assumed only used two hours in a day of 24 working days.
**** Electricity cost applied minimum account (day hour), the calculation is 40 (hours on) x connected power (kVA) x usage cost.

Table A5 - Estimated fixed assets depreciation

Item	Quantity	Estimated period	Book value	Residual period	Depreciation/ year (IDR)
Oven Vacuum	1	15	22,500,000	0	1,500,000
Display Refrigerator	3	10	3,000,000	0	300,000
Chest Freezer	2	10	10,500,000	0	1,050,000
Mixer	1	10	7,000,000	0	700,000
Cashier Table	1	10	600,000	0	60,000
Display Table	3	5	300,000	0	60,000
Chair	1	5	200,000	0	40,000
Cashier Machine	1	10	2,300,000	0	230,000
Air Conditioner	1	5	3,000,000	500,000	500,000
Desicator	1	10	1,600,000	0	160,000
Modified Motorbike	1	5	13,500,000	2,000,000	2,300,000
Total					**6,900,000**

Table A6 - Forecasting of cocoa powder price circa 2020-2024

Year	Price (ratio)
2020	0.99
2021	1.01
2022	1.03
2023	1.05
2024	1.07

Table A7 - Estimated annual sales target of GPCB

Size	Target (pc)	Total (kg)
100 grams	16,800	1,680
60 grams	19,200	1,152
30 grams	24,000	720
Total	**60,000**	**3,552**

Table A8 - Estimated labor costs

Position	Quantity	Salary/person (IDR)	Months	Total cost (IDR)
Workman/woman	2	1,500,000	12	36,000,000
Marketing	1	3,000,000	12	36,000,000
Total				**72,000,000**

Table A9 - Estimated GPCB sales and revenues

Size	Target sales (piece)	Price/Piece (IDR)	Revenue (IDR)
100 grams	16,800	15,000	252,000,000
60 grams	19,200	10,000	192,000,000
30 grams	24,000	6,500	156,000,000
Total			**600,000,000**

Table A10 - NPV of 9% and 11% interest rate

Year	Net cash flow	Discount factor of 9%	Present value of 9%	Discount factor of 11%	Present value of 11%
2020	21,819,858	0.91743	20,018,218	0.90090	19,657,530
2021	59,455,454	0.84168	50,042,466	0.81162	48,255,380
2022	102,381,672	0.77218	79,057,436	0.73119	74,860,596
2023	150,948,939	0.70843	106,936,034	0.65873	99,434,741
2024	205,775,296	0.64993	133,739,824	0.59345	122,117,623
Total Present Value			389,793,977		364,325,870
Equity			179,274,960		179,274,960
Net Present Value			210,519,017		185,050,910

Table A11 - Net benefit cost ratio of 9% and 11%

Year	Cash In flow	Discount factor 9%	Present worth	Discount factor 11%	Present worth
2020	54,519,858	0.925925926	50,481,350	0.900900901	49,116,989
2021	92,155,454	0.85733882	79,008,448	0.811622433	74,795,434
2022	135,081,672	0.793832241	107,232,186	0.731191381	98,770,554
2023	183,648,939	0.735029853	134,987,452	0.658730974	120,975,244
2024	238,475,296	0.680583197	162,302,280	0.593451328	141,523,481
Benefit			**534,011,716**		**485,181,703**
Year	**Cash out flow**	**Discount factor 9%**	**Present worth**	**Discount factor 11%**	**Present worth**
2020	32,700,000	0.925925926	30,277,778	0.900900901	29,459,459
2021	32,700,000	0.85733882	28,034,979	0.811622433	26,540,054
2022	32,700,000	0.793832241	25,958,314	0.731191381	23,909,958
2023	32,700,000	0.735029853	24,035,476	0.658730974	21,540,503
2024	32,700,000	0.680583197	22,255,071	0.593451328	19,405,858
Cost			130,561,618		120,855,832
Investment			179,274,960		179,274,960
Total			309,836,578		300,130,792
Net B/C			1.7235		1.6165

Table A12 - Internal rate of return

Year	Net cash flow	Discount factor 35%	Present value
2020	21,819,858.00	0.74	16,162,857.78
2021	59,455,453.74	0.55	32,623,019.88
2022	102,381,671.89	0.41	41,612,222.48
2023	150,948,938.77	0.30	45,445,929.47
2024	205,775,296.32	0.22	45,890,669.46
Total Present Value			181,734,699.07
Equity			179,274,960.00
Net Present Value			**2,459,739.07**
Year	**Net cash flow**	**Discount factor 36%**	**Present value**
2020	21,819,858.00	0.74	16,044,013.24
2021	59,455,453.74	0.54	32,145,033.38
2022	102,381,671.89	0.40	40,701,038.65
2023	150,948,938.77	0.29	44,123,954.76
2024	205,775,296.32	0.21	44,228,141.86
Total Present Value			177,242,181.89
Equity			179,274,960.00
Net Present Value			–2,032,778.11

Table A13 - Sensitivity analysis

Scenario	Indicator	NPV
Pessimistic	Sales declined at 3% Raw material cost increased at 3%	91,411,179
	Sales declined at 3% Raw material cost increased at 6%	44,490,017
Optimistic	Sales increased at 3% Raw material cost declined at 3%	356,939,098
	Sales increased at 3% Raw material cost declined at 6%	403,860,260

Table A14 - Operational cost breakdown

Item	Description	Total cost (IDR)
Administration fee	A cost incurred by the company in the form of administrative costs, we assume to set it at IDR 1,000,000 per year with no increasing cost each year.	1,000,000
Maintenance fee		2,000,000
Electricity cost	The electricity is supplied by state-owned utility company. Further, the Basic Electricity Tariff is based on Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia number 41 in 2017 concerning electricity tariff provided by the state. Based on the regulation, calculation of electricity costs uses the formula 80% x 8 hours (operational hours) x 24 days x 12 months x kWh. This business is classified as a medium enterprise (B-2/TR) with a basic tariff of IDR 1,467.28/kWh. Further breakdown of the electricity cost can be seen in Table A4.	27.001.937,51
Water subscription fee		3,000,000
Rental cost	Assuming there is no increasing rent cost for five years.	15,000,000
Rental cost for Brookfield Texture Analyzer	Assuming there is no increasing rent cost for five years.	5,000,000

Table A14 - continued

Item	Description	Total cost (IDR)
Rental cost for Muffle Furnace	No increasing of rent cost for five years.	3,000,000
Rental cost for Spectrophotometer	No increasing of rent cost for five years.	1,000,000
Internet subscription fee		1,800,000
Transportation cost	The distance from Pampangan sub-regency to main consumer base in Palembang is 67.3 kilometers, hence by assuming current petrol price is IDR 6,450/liter and fuel consumption for motor vehicles per mileage is 1 liter/40 kilometers, fuel cost is estimated at IDR 1,041,804. It should be noted the GPCB is transported weekly by employees. For other fuel purposes, it is assumed to be at IDR 1,000,000 per year whilst the parking fee is IDR 300,000 per year (Table A3).	1,041,804
Miscellaneous fee		2,000,000
Depreciation	Straight line method is employed to foresee the depreciation of fixed assets. Depreciation is specified as margin of book and residual values per estimated period. The detailed breakdown of asset depreciation can be seen in Table A5.	6,900,000

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Economia agro-alimentare /
Food Economy

An International Journal on Agricultural and Food Systems

Vol. 24, Iss. 1, Art. 6, pp. 1-23 - ISSN 1126-1668 - ISSNe 1972-4802
DOI: 10.3280/ecag2022oa12293

Factors Influencing Fruits and Vegetable Consumption among Pregnant Women: Evidence from Enugu State, Nigeria

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Abstract

Despite fruits and vegetables' importance and nutrient composition, their consumption is still below the world's recommended threshold in Nigeria, even among pregnant women. Therefore, this study examined pregnant women's critical socioeconomic and demographic factors associated with fruit and vegetable consumption. Multistage sampling techniques and a semi-structured questionnaire were employed to collect data from 100 pregnant women from the study area. The descriptive statistics show that the majority (91%) of the respondents belong to the age bracket of 20 to 36 years. Also, most (56%) of the respondents were in their third trimester, while 30% and 14% were in the second and first-trimester, respectively. The study employed descriptive and inferential statistics to analyse the data. The results indicate that Education, Trading, first-trimester, income, and nutrition advice positively influenced expenditure on fruits and vegetables. On the other hand, age, second-trimester, third-trimester, attending ante-natal, and distance from home to market have an inverse relationship with expenditure on fruits and vegetables. Likewise, education, nutrition advice, trading, first-trimester positively influence the frequency of fruits and vegetable consumption. The study recommended that policymakers, government, and NGOs should be focused on the significant socioeconomic factors to encourage fruit and vegetable consumption among pregnant women.

Article info

Type:
Article
Submitted:
22/07/2021
Accepted:
07/03/2022
Available online:
11/04/2022

JEL codes:
D11, D12, C31, C34, P46

Keywords:
Nutrition
Diets
Fetus
Socio-economics
Count-model

Managing Editor:
Valeria Borsellino

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Introduction

Fruits and vegetable consumption are indispensable for pregnant women's health and fetal growth as it provides sufficient nutrients that help through the antenatal and postnatal periods (Loy *et al*., 2011). It also improves immunity healthiness and provides sufficient nutrients to the mother. Fruits and vegetables are important because, during pregnancy, the fetus depends totally on the mother for energy and nutrient intake. The mother needs to gain weight and maintain an optimal intake of essential nutrients that fruits and vegetables provide (Murphy *et al*., 2014). According to Valmórbida & Vitolo (2014), pregnancy is a critical and delicate period during which good maternal nutrition is a key factor influencing the health of both mother and child. There is evidence that antenatal nutrition has a life-long health effect on the unborn child, even predisposing the child to risks associated with micronutrient deficiencies, diabetes and cardiovascular risk factors (Musaiger, 1993; Okubo *et al*., 2014; Toemen *et al.,* 2016). Thus, the following research questions necessitate the study:

i. what are the socioeconomic and maternal factors that influence the expenditures on fruits and vegetables among pregnant women?
ii. What socioeconomic and maternal factors influence the frequency of fruits and vegetable consumption among pregnant women?

This study aims to:

i. profile the pregnant women based on their socioeconomic characteristics;
ii. examine the socioeconomic and maternal related factors that influence expenditures on fruits and vegetables among pregnant women;
iii. examine the socioeconomic and maternal related factors that constrain and promote the frequency of fruits and vegetable consumption among pregnant women.

1. Background

Maternal nutrition has continued to receive international debate worldwide, including in low-income countries like Nigeria (Shole, 2015). This may be because pregnancy is influenced by an increase in the physiologic, metabolic, and nutritional needs necessitated by the baby (Ugwa, 2016). Consumption of fruits provides adequate health, gives instant energy to the body, and provides vitamins and minerals beneficial to body functioning (Organic Facts, 2018). Fruits and vegetables are an excellent source of many well-known vitamins and minerals, in addition to fibre and antioxidants. They provide vital nutrients, such as ascorbate, carotenoids, folate, and magnesium, all contribute to one's baby's growth and development (Raaijmakers *et al*., 2018).

Vegetables are also important as they help improve overall health, protect the body's vital organs, assist in weight control, and promote healthy skin and hair. According to Hillesund *et al*. (2014), maternal diet pre-conception and during pregnancy may influence pregnancy outcome and the future health of mother and child.

Pregnant women require more energy and nutrients to meet the demands of the developing fetus (Verbeke & Bourdeaudhuij, 2007; Koletzko *et al*., 2019). Thus, their nutrient intake is indispensable or a key factor to the success of fetus development, growth, smooth delivery, and good health of the child and the mother before and after given birth (Koletzko *et al*., 2019). Consumption of fruits and vegetables is promoted as part of a nutrient-dense diet and for chronic disease prevention, displace high saturated fats, sugar, or salt. The consumption of fruits and vegetables among pregnant women is imperative for developing the child and crucial lifecycle phase as it can improve the health of the offspring who, depends on the level of intake by the mother. In contrast, low fruit and vegetable consumption are responsible for micro-nutrient deficiencies. Pregnant women are nutrient vulnerable because of the high nutrient demands and socioeconomic constraints (Lee *et al*., 2012).

Despite multiple benefits attributable to fruits and vegetable intake, their consumption is still below the usual recommendation by WHO (WHO, 2003). In fact, the intake in developing countries, for example, Nigeria, is typically lower than recommended levels, including intake among pregnant women, particularly among the low-income class (WHO, 2003; Kuche, 2014; Murphy *et al*., 2014). In most pregnant women, the consumption of fruits and vegetables is far below the minimum recommended level of 400g per capita per day (Ruel *et al*., 2004; Lee, 2016). This is undoubtedly a precarious situation among pregnant women in Nigeria, particularly those who may be socio-economically constrained. Although fruits and vegetables are important for pregnant women, they are faced with challenges of different socioeconomic and demographic factors (Murphy *et al*., 2014).

Pregnant women of lower socioeconomic groups have been identified as being especially at risk of nutrient deficiency due to low consumption of fruits and vegetables. Poor consumption of fruits and vegetables is one of the main factors responsible for non-communicable diseases (NCDs) worldwide (WHO, 2003; Valmorbia & Vitolo, 2014). Therefore, considering the importance of fruits and vegetable consumption to the health of pregnant women, it is essential to know the critical socioeconomic and maternal related factors that may promote its consumption.

This is expedient for Nigeria, where poor nutrition has been recognised as a major public health problem, particularly in pregnant women and children, contributing significantly to the high maternal and infant mortality (Maziya-

Dixon *et al*., 2006). The vitamin A content of human breast milk is strongly affected by maternal nutrition during pregnancy and lactation (William *et al*., 2009). Research evidence shows that 7.4 per cent of Nigerian women of reproductive age were malnourished, and 3.7 per cent were severely malnourished (National Nutrition and Health Survey (NNHS), 2015). The causes include inadequate food intake, poor nutritional quality of diets, frequent infections, and short inter-pregnancy intervals. The consequence of poor maternal nutritional status is reflected in low pregnancy weight gain, high maternal morbidity, and mortality (Onyeji and Sanusi, 2018). Consumption of calcium 96.2 per cent, sodium 79.4 per cent, zinc 26.6 per cent, magnesium 80.2 per cent, and Vitamin C 83.1 per cent was inadequate in Southeast Nigeria (Onyeji and Sanusi, 2018), and this is reflected in the inadequate consumption of essential food groups such as fruits and vegetables. While in the Enugu state, there is inadequate consumption of sodium 86.8%, zinc 27.2%, Iron 5.3%, Vitamin C (mg) 85.6%, which is a reflection of inadequate consumption of fruits and vegetables (Achikanu *et al*., 2013). The poor quality diet of women found in the Southeast could result from low socioeconomic status and low educational status. This is because 39.4 per cent and 71.4 per cent were on low socioeconomic status and low educational status, respectively (National Bureau of Statistics (NBS), 2018).

Improving maternal nutrition status in Nigeria requires a good knowledge of the consumption of fruits and vegetables by pregnant women and the socioeconomic drivers. Thus, it is important to analyse the socioeconomic and maternal factors that influence pregnant women's fruit and vegetable consumption. Knowledge of the socioeconomic factors that drive the consumption of fruits and vegetables is vital in promoting healthiness among pregnant women.

2. Consumer behaviour theory

The consumer economic theory links preferences to consumer demand curves and consumption expenditures (Solomon, Russell-Bennett & Previte, 2012). It explains why individuals make certain choices and argue that this depends on the prices of goods and services as well as the amount of disposable income they have (Solomon, Russell-Bennett & Previte, 2012). The consumer economic theory suggests that individuals have unlimited and infinite demand, but the resources to meet them are limited; hence must decide on what to consume based on certain factors. According to Stancu, Haugaard, & Lähteenmäki (2016), these factors vary from one individual to another and could be similar among individuals with common socioeconomic traits. This suggests that the tendency to consume a good or service could

be determined by analysing the socioeconomic status and demography of a population. Švecová & Odehnalová (2019) highlighted three categories of factors that might influence consumer behaviour, these include:

i. Psychological factors: these are factors that describe individuals' perceptions and attitude about a good or service. It depends on what motivates an individual, the level of information they know about the goods or service, and how they feel the product is important for them.
ii. Personal factors: these include traits such as age, financial situation, gender, background, occupation, culture and location.
iii. Social factors: Social relations and influences from friends, work or school community, or groups and associations might also determine consumer behaviour.

3. Materials and methods

3.1. *Study Area*

Enugu is one of the six states belonging to the southeast geopolitical zone in Nigeria. It consists of seventeen Local Government Areas (LGAs) of which Nsukka is one of them. These 17 Local Government areas have similar socioeconomic attributes. This opines that findings from one Local Government Area can be a representation of other Local Government Areas. The study was carried out in Nsukka LGA, a town that accommodates the University of Nigeria. Nsukka has a population of 309,633 (NPC, 2010). Nsukka LGA alone was selected because of the financial challenge. However, the findings from this study can be representative of other LGAs based on the similar socioeconomic and cultural characteristics they share. The area comprises moderately rolling plains and a group of hills. It lies within the derived savannah vegetation zone, characterised by incomplete canopy cover, which affects soil moisture (Ozor *et al*., 2015). The major commercial activities in the area are trading and farming.

3.2. *Sampling procedure and data collection*

This study was carried out among pregnant women in Nsukka Local Government Area in Enugu State. The study employed multistage sampling techniques to select respondents (pregnant women) for the study. First, ten (10) communities were randomly selected from the LGA study. Secondly, one government public hospital/health centre was randomly selected from each of the ten communities to make a total of ten (10) hospitals/health

centres/maternity for the study. During the preliminary survey, we visited the selected hospital/health centres to intimate the management of our study's purpose and sought their support and cooperation in the data collection. With the help of the hospital/health centre management, we randomly selected ten (10) pregnant women each from the ten selected hospital/health centres to make a total of 100 respondents for the study. The consent of pregnant women who participated in the study was sought through the management of the hospitals/health centres selected for the study.

The data for the study was obtained through the use of semi-structured questionnaires. The questionnaires were administered individually to pregnant women during ante-natal meetings days. Each respondent was interviewed separately without interference from the other respondents to avoid any influence that could bias the results.

3.3. *Multiple Linear Regression Model and Quantile regression*

To measure the consumption level and frequency of fruits and vegetables among pregnant women, Linear regression and Count model were employed. Ordinary Least Squares (OLS) was used to measure the expenditure of fruit and vegetables in a separate regression model, while the Count model measured the number of times fruits and vegetables that are consumed.

Ordinary Least Square analysis was used to determine factors that affect fruit and vegetable consumption expenditure since the expenditure is a continuous variable. The classical regression explicit form is specified below:

$$LogY = b_o + b_1 logX_1 + b_2 logX_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 + b_9 X_9 + b_{10} X_{10} + b_{11} X_{11} + b_{12} X_{12} + b_{13} logX_{13} + b_{14} X_{14} + b_{15} X_{15} + e \quad (1)$$

Where Y is consumption expenditure which is the total amount spent on fruits and vegetables per week, at the same time, $X_1 - X_{15}$ are the explanatory vectors in the equation, such as socioeconomic and demographic factors.

Due to the shortcoming of partial or average conditional mean impact between explanatory variables and dependent variable in ordinary least square, quantile regression analysis was further employed to assess the full impact of explanatory variables on the dependent variable. Quantile regression is characterised by a comprehensive relationship between dependent and explanatory variables, and it provides a robust estimate in the presence of data sets with outliers (Conyon & He, 2017). Quantile regression is used to measure the full conditional mean function and a conditional median on the dependent variable of a change in an explanatory variable (Koenker & Hallock, 2001; Powell, 2016). It provides an opportunity

for covariates to express themselves at different levels on the dependent variable. For instance, an important covariate that may not be significant at a particular level may be significant in another level on the dependent variable. The dependent variable was analysed at different *q*th quantiles such as 10th, 25th, 40th, 55th, 70th, 85th. It allows measuring the impact of explanatory variables of a range of distribution of the dependent variable.

A linear relationship was assumed for the quantile regression model between the explanatory variables and dependent variable $Q_q(Y/X)$.

Following Marrocu *et al*. (2015) and Conyon & He (2017), we specified our model as follows:

$$Q(Y_i/X_i) = X_i' \beta_i + £ \tag{2}$$

Where Y is the consumption expenditure, X is the socioeconomic factors, and $£$ is the standard error.

Consider the real-valued random variable of Y that is characterised by the following distribution:

$$F(y) = Pr(Y \leq y)$$

Where q is any quantile considered with $0 < q < 1$ and X as the covariates. The qth quantile of Y is defined as:

$$Q(q) = inf\,[y : F(y) \geq q]$$

The estimator for $\widehat{\beta_q}$ is derived by minimising function equation (3) by applying linear programming method:

$$Q(\beta_q) = \sum_{i:y_i \geq X_i'\beta}^{N} q \left| y_i - X_i'\beta_q \right| + \sum_{i:y_i \geq X_i'\beta}^{N} (1-q) \left| y_i - X_i'\beta_q \right| \tag{3}$$

3.4. *Zero Truncated Negative Binomial model*

Considering a situation where the event $y_i = 0$ cannot be observed under the assumption of unobserved heterogeneity, the count probabilities gives the Zero Truncated NB regression model (Moon *et al*., 2001; Cruff *et al*., 2008). Given the importance of fruits and vegetables to pregnant women, it is expected that fruit and vegetables must be consumed at least once a week. Besides, the responses from the study subject show that fruits and vegetables are consumed at least once a week. Thus, there is no zero in the responses.

According to micro-econometrics using STATA by Cameron & Trivedi (2005) and following the equation can be specified as:

$$P_r^{(NB)}(Y_i = y_i | y_i > 0, \mu, \alpha) = \frac{P_r^{(NB)}(Y_i = y_i | \mu_i}{1 - P_r^{(NB)}(Y_i = 0 | \mu_i)} \quad (4)$$

Where $P_r^{(NB)}(Y_i = 0 | \mu_i, \alpha) = (1 + \alpha\mu_i)^{-\alpha-1}$ and the conditional expected value of y_i is given by;

$$E(y_i | y_i > 0, \mu_i, \alpha) = \frac{E(y_i | \mu_i, \alpha)}{[1 - P_r^{(NB)}(y_i = 0) | \mu_i, \alpha]} \quad (5)$$

Thus,

$E(y_i | y_i > 0, \mu_i, \alpha) = 1, 2, 3, 4, 5,$... *n*

$E(y_i | y_i > 0, \mu_i, \alpha) =$ The number of times fruit/vegetables are consumed per week among pregnant women.

The above equations show the positivity of ZTNB model.

Table 1 - Description of the explanatory variable

S/N	Explanatory variables	Unit of measurement	Scale
1	Age of the pregnant women	Years	Continuous
2	Marital status	1 if married or 0 otherwise	Discrete
3	Number of years spent in school	Years	Continuous
4	First trimester	1 if yes or 0 otherwise	Discrete
5	Second trimester	1 if yes or 0 otherwise	Discrete
6	Third trimester	1 if yes or 0 otherwise	Discrete
7	First pregnancy	1 if yes or 0 otherwise	Discrete
8	Nutritional advice	1 if yes or 0 otherwise	Discrete
9	Income	Naira/month	Continuous
10	Civil servant	1 if yes or 0 otherwise	Discrete
11	Trader	1 if yes or 0 otherwise	Discrete
12	Household size	Number	Discrete continuous
13	Consumption time	Number/month	Continuous
14	Unemployed	1 if not employed or 0 otherwise	Discrete

Table 1 - continued

S/N	Explanatory variables	Unit of measurement	Scale
15	Antenatal	1 if attend antenatal or 0 otherwise	Discrete
16	Have children before	1 if yes or 0 otherwise	Discrete
17	Distance from home to market	Kilometre	Continuous

4. Results

4.1. *Socioeconomic characteristics of the pregnant women*

Table 2 shows the socioeconomic characteristics of pregnant women sampled for the study. The majority (91%) belong to the age bracket of 20 to 36 years, depicting that most of the pregnant women studied are young. Likewise, the majority (97%) of pregnant women are married. Regarding education, 36% of the respondents attained secondary education, while 62% attained tertiary education. Regarding their occupation, the result shows that the highest proportion (42.4%) of the respondents are civil servants, 30.3% are not employed, while 17.2%, 6.1%, 2%, and 2% are traders, artisans, farmers, and house wives respectively. Regarding the stage of pregnancy, the result shows that most (56%) of the respondents are in their third trimester, while 30% and 14% were in the second and first trimester, respectively. The average monthly income of the respondents is ₦ 54,438.24. The pregnant women walk an average distance of 2.94 kilometres to the market to purchase fruits and vegetables. Also, 33% of the respondents indicated that they were pregnant for the first time, and the majority (87%) indicated that they received nutrition advice.

Table 2 - Socioeconomic characteristics of the pregnant women

Characteristics	Percentage (%)	Mean (Standard deviation)
Age of the pregnant women		29.04(0.54)
>= 19	2.0	
20-36	91.0	
37 and above	7.0	
Marital status		
Single	3.0	
Married	97.0	

Table 2 - continued

Characteristics	Percentage (%)	Mean (Standard deviation)
Education		
Primary education	2.0	
Secondary education	36.0	
Tertiary education	62.0	
Primary Occupation		
Civil servant	42.4	
Farmers	2.0	
Trading	17.2	
Artisan	6.1	
Housewife	2.0	
Unemployed	30.3	
Stage of Pregnancy		
First trimester	14.0	
Second trimester	30.0	
Third trimester	56.0	
Household Size		
Less than 4	44	4.06(0.19)
4-6	45	
7 and above	1.0	
Monthly Income		
>= ₦ 50,000	55.9	38966.32(4412.45)
₦50,001 – ₦100,000	30.9	
₦100,001 – ₦150,000	11.8	
₦150,001 and above	1.5	
Distance to Market		
>= 5	86.5	
6-8	6.3	
9-12	6.3	
13 and above	1	
First pregnancy		
Yes	33	
Nutritional advice		
Yes	87	
Ante-natal	77	
Having children before		
Yes	61	

Source: Field survey, 2019.

Table 3 shows the common fruits and vegetables consumed among pregnant women in the study area and where they source them. The source of fruits they consumed varied across fruits, although the majority sourced their fruits from the market. For example, the result shows that most (98.0%) indicated that they sourced apples from the market. Also, the majority (90%) obtained the banana they consumed from the market. This finding suggests that the respondents spent money buying fruits and vegetables rather than growing them themselves.

Table 3 - Common fruit and vegetables consumed among pregnant women and their sources in the study area

Fruits and Vegetables (multiple responses)	**Source of Fruit and Vegetables (%)**		
	Homestead garden	**Farm**	**Market**
Common fruits consumed by pregnant women			
Apple (*Pyrus malus*)	2.0	–	98.0
Banana (*Musa balbisiana*)	10.0	–	90.0
Watermelon (*Citrullus lanatus*)	2.0	–	98.0
Orange (*Citrus sinensis*)	27.0	–	74.0
Mango (*Mangifera indica*)	14.0	1.0	84.0
Guava (*Psidium guajava*)	18.0	1.0	81.0
Pineapples (*Ananas comosus*)	5.0	1.0	93.0
Cashew (*Anacardiun occidentale*)	6.0	2.0	91.0
Avocado pear (*Persea Americana*)	10.0	2.0	88.0
Plantain (*Musa spp*)	9.0	3.0	88.0
Tangerine (*Citrus tangerina*)	8.0	1.0	89.0
African cherry (*Chrysophyllum albidum*)	9.0	3.0	86.0
Coconut (*Cocos nucifera*)	12.0	1.0	87.0
Paw paw (*Carica papaya*)	28.0	–	73.0
Soursop (*Amnona muricata*)	14.0	1.0	83.0
Pumpkin (*Cucurbita pepo*)	11.0	3.0	84.0
Bush allowance (*Velvet tamarine*)	9.0	2.0	86.0
Egg plant (*Solanum melongena*)	6.0	3.0	89.0
Jack fruit (*Artocarpus heterophyllus*)	6.0	1.0	91.0
Fruit (*Terminalia catapa*)	12.0	2.0	83.0
Important vegetables consumed by pregnant women (multiple responses)			
Fluted pumpkin (*Teifairia occidentalis*)	30.0	5.0	67.0
Bitter leaf (*Vernonia amygdalina*)	25.0	7.0	70.0

Table 3 - continued

Fruits and Vegetables (multiple responses)	Source of Fruit and Vegetables (%)		
	Homestead garden	Farm	Market
Water leaf (*Talinum triangulare*)	17.0	7.0	76.0
Oha leaf (*Delissearivularis*)	8.0	3.0	89.0
Onions (*Allium cepa*)	4.0	2.0	94.0
Tomato (*Lycopersican esculentum*)	6.0	2.0	92.0
Scent leaf (*Ocimum gratissimum*)	20.0	4.0	76.0
African rosewood leaves (*Hagenia abyssinia*)	12.0	2.0	82.0
Green (*Amaranthus hybridus*)	22.0	5.0	72.0
Jute leaves (*Corchorus spp*)	13.0	2.0	80.0
Wild spinach (*Gnetum africanum*)	14.0	3.0	79.0
Bush buck (*Gongronema latifolium*)	14.0	3.0	80.0
Lemon grass (*Cymbopogon martinil*)	17.0	6.0	74.0
Garden egg leaf (*Solanum melongena*)	16.0	4.0	80.0

Source: Field survey, 2019.

4.2. *Determinants of expenditure on fruits and vegetables consumption*

The multiple regression and quantile regression result in Table 4 shows the influence of socioeconomic and demographic factors on the fruits and vegetable consumption expenditure among pregnant women in the study area. The model shows that the variations in the independent variables explained 48% of the pregnant women's expenditure on fruits. Likewise, 39% of the expenditure on vegetables by pregnant women was explained by the variations in the independent variables. Firstly, the multiple regression results show that the age of pregnant women negatively and significantly (at 5% level of probability) influenced the expenditure on fruits. Also, expenditure on fruits was negatively and significantly (at a 1% probability level) influenced by being in the second trimester and third-trimester stages of pregnancy. The multiple regression results also show that the expenditure on fruits increases significantly (at 5% probability level) with an increase in income of pregnant women. This indicates that respondents with low income are faced with the challenge of low fruits consumption. Likewise, younger respondents will likely spend more on fruit consumption. The consumer's theory explains that personal factors such as age, income, and occupation are among the critical drivers of food consumption, as reflected in our findings (Švecová & Odehnalová, 2019). In terms of pregnancy, respondents perceived the second

and third trimester as an advanced stage which to them the importance of fruit consumption is minimal. However, the first trimester which is the early stage of development of the fetus was perceived as very important, and they may likely spend more on fruit consumption. Regarding expenditure on vegetables, factors like trading and income are important drivers of vegetable consumption as respondents may likely spend more on vegetables if they have more income and more had probably engaged in trading as their occupation.

The result from the quantile regression shows more robust effects as more variables significantly influenced the consumption of fruits and vegetables by pregnant women. The result shows that education positively and statistically (at 5% and 1%) influenced the fruit consumption expenditure of pregnant women under 55th and 75th and 85th percentiles, respectively. This indicates that knowledge of the nutrition composition of fruits will likely influence the expenditure of pregnant women. The result also shows that unemployment inversely and significantly (at a 1% probability level) affected fruit consumption expenditure. This means that respondents with no job may likely not have constant income sources, thereby limiting expenditure on fruits. The result shows that Trading and civil servants are positively and significantly associated with expenditure on fruit consumption. However, pregnant women in their first trimester positively and significantly (at a 1% probability level) influenced expenditure on fruit consumption at all the percentiles. This is expected from our apriori because the first trimester is the early stage of fetus development and requires more minerals and vitamins that may be derived from fruits. This may likely prompt the respondents to spend more on fruits. Nutritional advice is positively and significantly (at a 5% probability level) associated with expenditure on vegetables at the 25th percentile. On the other hand, the result shows that attending ante-natal does not necessarily translate to more expenditure on vegetables. It is inversely and significantly (at a 5% probability level) associated with expenditure on the vegetable. Psychological factors such as the attitude of consumers is reflected in Nutritional advice as one of the factors that influence consumers' behaviour (Stancu, Haugaard & Lähteenmäki, 2016). The result shows that distance from home to market is negatively and significantly (at 5% probability level) influenced expenditure on vegetables at all the percentiles. This shows that pregnant women do not see the distance to the market as a barrier to vegetable consumption. Across the percentiles for both fruits and vegetables, factors such as trading, first trimester, and income are important as they positively associate with fruits and vegetable expenditure. However, education is significant in expenditure on fruits but not with vegetables. Likewise, nutritional advice is significant in vegetable consumption but not in fruits.

Table 4 - OLS and Quantile regression on determinants of expenditure on fruits and vegetables consumption

	Fruits							Vegetables						
Parameters	**OLS**	**Qq10**	**Qq25**	**Qq40**	**Qq55**	**Qq70**	**Qq85**	**OLS**	**Qq10**	**Qq25**	**Qq40**	**Qq55**	**Qq70**	**Qq85**
Age of the pregnant women	-1.538** (0.6050)	-2.704*** (0.829)	-1.748** (0.691)	-0.407* (0.782)	-1.488** (0.691)	-1.952*** (0.649)	-1.359*** (0.431)	0.271 (0.601)	-0.785 (0.627)	-0.081 (0.786)	0.494 (0.736)	0.784 (0.728)	0.755 (0.621)	0.420 (0.620)
Number of years spent in school	1.433 (0.726)	1.919 (0.990)	1.605 (0.824)	1.308 (0.934)	1.949** (0.825)	2.076*** (0.775)	1.725*** (0.514)	-0.496 (0.703)	0.278 (0.732)	-0.370 (0.919)	-1.286 (0.860)	-0.486 (0.851)	-1.272* (0.725)	-0.432 (0.724)
Unemployed	-0.432 (0.658)	-0.374 (0.897)	-0.002 (0.747)	-0.258 (0.846)	0.364 (0.748)	-1.201* (0.702)	-1.637*** (0.466)	0.593 (0.639)	0.796 (0.666)	1.201 (0.835)	0.995 (0.782)	1.063 (0.773)	0.907 (0.659)	0.402 (0.658)
Trading	0.281 (0.299)	1.163*** (0.408)	0.933*** (0.339)	0.654* (0.385)	0.798** (0.340)	0.278 (0.319)	-0.291 (0.211)	0.801** (0.291)	1.042*** (0.303)	0.681* (0.381)	0.985*** (0.356)	1.137*** (0.352)	0.926*** (0.301)	1.208*** (0.300)
Civil servant	-0.365 (0.306)	-0.121 (0.418)	-0.051 (0.347)	-0.057 (0.394)	-0.0793 (0.348)	-0.336 (0.327)	-0.960*** (0.217)	0.261 (0.297)	0.035 (0.310)	-0.232 (0.389)	0.281 (0.364)	0.570 (0.360)	0.459 (0.307)	0.826*** (0.306)
First-trimester	–	1.093*** (0.354)	0.993*** (0.295)	1.024*** (0.334)	0.893*** (0.295)	1.192*** (0.277)	0.984*** (0.184)	0.394 (0.282)	0.748*** (0.264)	0.929*** (0.331)	0.611* (0.310)	0.297 (0.307)	0.504* (0.261)	0.562** (0.261)
Second-trimester	-0.966*** (0.291)	0.266 (0.260)	0.166 (0.216)	0.027 (0.245)	0.101 (0.216)	0.031 (0.203)	0.086 (0.135)	–	0.165 (0.195)	0.167 (0.245)	0.159 (0.229)	0.023 (0.227)	0.137 (0.193)	0.055 (0.193)
Third-trimester	-1.112*** (0.260)	–	–	–	–	–	–	-0.186 (0.187)	–	–	–	–	–	–
Household size	0.059 (0.061)	0.011 (0.082)	-0.041 (0.068)	0.001 (0.078)	0.064 (0.068)	0.051 (0.064)	0.067 (0.042)	0.026 (0.066)	-0.131* (0.068)	0.058 (0.086)	0.090 (0.080)	0.038 (0.079)	0.036 (0.068)	-0.035 (0.068)
First pregnant	-0.103 (0.381)	-0.231 (0.520)	-0.172 (0.443)	0.025 (0.491)	-0.128 (0.433)	0.234 (0.407)	0.262 (0.270)	-0.192 (0.372)	-0.575 (0.388)	-0.488 (0.486)	-0.728 (0.455)	-0.174 (0.451)	-0.144 (0.184)	0.412 (0.383)
Nutritional advice	0.161 (0.296)	0.325 (0.403)	0.457 (0.336)	0.343 (0.381)	0.550 (0.336)	-0.236 (0.316)	-0.248 (0.209)	0.153 (0.291)	0.281 (0.303)	0.768** (0.381)	0.382 (0.356)	-0.030 (0.352)	-0.038 (0.301)	-0.182 (0.300)
Antenatal	-0.283 (0.214)	-0.154 (0.292)	-0.158 (0.243)	-0.246 (0.275)	-0.272 (0.243)	-0423* (0.228)	-0.436*** (0.151)	-0.378 (0.221)	-0.641*** (0.230)	-0.612** (0.289)	-0.328 (0.271)	-0.157 (0.267)	-0.216 (0.228)	-0.331 (0.227)
Income	0.341** (0.145)	0.387* (0.197)	0.315* (0.164)	0.342* (0.186)	0.179 (0.165)	0.234 (0.154)	0.315*** (0.102)	0.332** (0.142)	0.327** (0.149)	0.479** (0.186)	0.456** (0.175)	0.363** (0.173)	0.381** (0.147)	0.191 (0.147)
Have children before	-0.261 (0.383)	-0.609 (0.522)	-0.145 (0.434)	-0.082 (0.492)	-0.264 (0.435)	0.139 (0.409)	0.098 (0.271)	-0.495 (0.381)	-0.750* (0.397)	-0.602 (0.498)	-0.813* (0.467)	-0.275 (0.461)	-0.885 (0.393)	0.233 (0.393)
Distance from home to market	0.012 (0.031)	0.070* (0.042)	0.023 (0.034)	0.024 (0.039)	0.018 (0.034)	-0.011 (0.032)	0.025 (0.021)	-0.049 (0.030)	-0.072** (0.031)	-0.060 (0.039)	-0.045 (0.037)	-0.079** (0.037)	-0.785** (0.031)	-0.100*** (0.031)
Cons_	5.374** (2.079)	5.476* (2.790)	4.086* (2.322)	3.572 (2.632)	3.768 (2.326)	5.618** (2.185)	4.273*** (1.448)	3.214 (2.066)	5.033** (2.136)	1.983 (2.680)	2.774 (2.509)	0.710 (2.481)	3.069 (2.116)	3.983 (2.112)
Pseudo R^2		0.389	0.382	0.373	0.334	0.313	0.383		0.341	0.338	0.350	0.293	0.304	0.257
	F(14, 51) = 3.43, Prob > 0.0006, R-squared = 0.48. Adj R-squared = 0.34							F(14, 49) = 2.33, Prob > 0.0149, R-squared = 0.39. Adj R-squared = 0.22						
	*** indicates 1%, ** indicates 5% and * indicates 10%													

4.3. *Determinants of frequency of fruits and vegetable consumption*

The result in Table 5 shows the endogenous variables that explain the frequency of fruits and vegetable consumption among pregnant women in the study area. Regarding fruit consumption, the result from Table 5 shows that education and nutritional advice positively and significantly (at 5% probability level) influenced the frequency of fruit consumption among pregnant women. It depicts that respondents who have higher education and receive advice on nutrient components of fruits may likely consume fruits regularly. Occupation (civil servant) negatively and significantly (at 5% probability level) influenced the frequency of fruit consumption. This implies that respondents with formal jobs may be less likely to consume fruits regularly. This is not in line with our apriori expectation as it is expected that such a category of respondents would have more knowledge about the importance of fruits. However, these relationships may also depend on the stage of the pregnancy of the respondents. From our findings, pregnant women in second and third trimesters are less likely to consume fruits. Attendance to antenatal negatively and significantly (at 5% probability level) influenced the frequency of fruit consumption. This indicates that attendance to ante-natal may not necessarily translate to an increment in the frequency of fruit consumption.

Regarding the frequency of vegetable consumption among pregnant women, occupation (trading) positively and significantly (at a 5% probability level) influenced the frequency of vegetable consumption. This indicates that respondents who are traders may likely consume vegetables regularly. This may be due to respondents' proximity to the market environment where vegetables are sold regularly. The result also showed that first-trimester positively and significantly (at 1% probability level) influenced the frequency of vegetable consumption. This agrees with our apriori expectation that pregnant women in their early stage of pregnancy will likely consume vegetable regularly because this is a crucial stage for fetus development and require a high level of minerals, iron and vitamins that they can obtain from vegetable.

Table 5 - Zero truncated negative binomial regression of determinants on the frequency of Fruits and vegetable consumption

Parameters	Fruits		Vegetables	
	Coefficient	Standard error	Coefficient	Standard error
Age	-0.1431	0.4995	0.4599	0.4994
Number of years spent in school	1.5901**	0.6401	0.4023	0.6444
Unemployed	-0.9618	0.6481	0.4763	0.5863
Trading	-0.1181	0.2368	0.5900**	0.2732
Civil servant	-0.6474**	0.2593	0.1726	0.2809
First-trimester	0.3501*	0.2113	0.5684***	0.2137
Second-trimester	0.1968	0.1491	0.0050	0.1647
Household size	-0.0759	0.0485	-0.0405	0.0502
First pregnant	0.1284	0.3129	-0.0128	0.3334
Nutritional advice	0.6890***	0.2568	0.1652	0.2572
Antenatal	-0.3763**	0.1738	-0.3140*	0.1818
Income	-0.0133	0.1203	0.0919	0.1244
Has children before	0.2552	0.3269	0.0263	0.3338
Distance from home to market	0.0329	0.0239	-0.0371	0.0288
Cons_	-1.4721	1.8535	-1.5172	1.8774
Inalpha	-2.0073	0.3448	-1.8645	0.3505
Alpha	0.1343	0.0463	0.1549	0.0543
	LR test of alpha = 0: chibar2 (01) = 23.37, LR chi^2 (14) = 27.83, Prob > chi^2 = 0.015, Pseudo R^2 = 0.0683, Log likelihood = -189.673		LR test of alpha = 0: chibar2 (01) = 23.44, LR chi^2 (14) = 18.99, Prob > chi^2 = 0.165, Pseudo R^2 = 0.048, Log likelihood = -187.106	

*** indicates 1%, ** indicates 5% and * indicates 10%.

5. Discussion and conclusion

5.1. *Discussion*

Given the psychological and personal characteristics, the findings suggest that older pregnant women spend less on fruit consumption than young pregnant women who spend more on buying fruits. This finding suggests that older women show less concern for fruit consumption. It agrees with the findings of Zamanian *et al*. (2013) & Goryakin *et al*. (2015) that increases

in age are associated with less consumption of fruits. The educational level shows that having an education makes pregnant women understand the importance of fruit consumption during pregnancy, thereby increasing the consumption frequency. This was reflected both in the expenditure and frequency of consumption. The result shows that education enlightens pregnant women on the nutrients component of fruits and their importance during pregnancy for both mother and child. This agrees with Riediger *et al*. (2007) findings that education increases fruit and vegetable consumption among adolescents. This finding is similar to receiving nutritional advice, which was also found to be a positive and significant determinant of fruit and vegetable consumption. According to Saha *et al*. (2020), receiving nutrition advice can enlighten individuals on the importance and nutrient composition of fruit. Surprisingly, this was not the case in antenatal attendance, suggesting that antenatal has less influence on the expenditure on fruit consumption; perhaps advice in this regard is not emphasised during antenatal sessions.

Unlike civil servants, pregnant women that are traders spend more money buying fruits (Table 3). This may be because they can easily find it and buy where they do their trading. This result agrees with the findings of Amo-Adjei & Kumi-Kyereme, (2015) that occupation such as trading influences fruit consumption. This invariably means that those pregnant women into official employment spent less on fruit consumption (Laverde-Rojas *et al*., 2017; Terin *et al*., 2019). However, at the 85th percentile, a civil servant was positively significant, suggesting that a civil servant with a high salary may have more money to spend buying fruits and vegetables even if she is not close to the trading sites. This means that expenditure and frequency of consumption are not unrelated to the amount of money these pregnant women get from their occupation. The finding shows that pregnant women with higher income may consume more vegetables. This agrees with our apriori expectation and supports the findings of Nogueira *et al*. (2018) that income influences vegetable consumption in adolescents. Just like income, unemployment significantly affected expenditure on fruits and vegetables. This is in line with the consumer demand theory that suggests that the disposable income of individuals predicts their level of expenditure (Solomon *et al*., 2012). This depicts that unemployed, pregnant women spent less on fruit consumption as they might lack money to buy fruit most times.

Finally, an important factor to consider in engendering fruit and vegetable consumption among pregnant women is the stage of pregnancy. Pregnant women in their first trimester consume vegetables more frequently. This means that pregnant women recognise the first trimester as a developmental stage for the fetus. This consequently affects their expenditure on fruit consumption at all the percentiles. This is in line with a report in Ghose &

Yaya (2018), who identified that pregnant women took the first trimester as an important stage of their pregnancy that requires more nutrient intake for the fetus. The negative influence observed at the second and third trimesters shows that pregnant women spend less on fruit consumption in their second and third trimesters of pregnancy. This may be because of the perception of pregnant women that a fetus needs more nutrient foods at the early stage of development. Tus they and not worried about it when they are fully formed in the womb.

5.2. *Conclusion*

The study has identified and examined important socioeconomic and maternal factors that influence pregnant women's fruit and vegetable consumption. Different pregnant women have different budgets on fruits and vegetable consumption during the gestation period; however, these differences have been adduced to different socioeconomic statuses and maternal conditions at a particular period. The study has confirmed that socioeconomic status and maternal conditions are important factors to consider when budgeting and determining the frequency of fruits and vegetable consumption among pregnant women. There are connections between fruits and vegetable consumption and the socioeconomic status of this category of people. This suggests that socioeconomic characteristics and maternal conditions should be considered when examining fruits and vegetable consumption among pregnant women. Even though there have been different studies on fruits and vegetable consumption, most of these studies are yet to showcase the importance of interconnections of socioeconomic status and fruits and vegetable consumption, particularly about pregnant women who are vulnerable health-wise. In line with the consumer economic theory, it is glaring that it is the personal (maternal conditions) and psychological factors that significantly determine the expenditure on fruit and vegetable consumption as well as the frequency of consumption. More so, this study also examines the influence of these factors at different levels of expenditures to avoid the omission of important factors that may be significant at a particular level of expenditures. The following socioeconomic factors: income, occupation, education, and distance from home to market and maternal conditions: first-trimester, second-trimester, third-trimester, nutritional advice have been found to be important factors and essential stages in promoting fruits and vegetable consumption among pregnant women. To increase fruits and vegetable consumption among pregnant women, policymakers and development practitioners should consider the different socioeconomic and maternal status/conditions of pregnant

women in their policy interventions. This study suggests further research into perceptions and effects of income distribution on fruits and vegetable consumption among pregnant women. Financial constraints limited this study as there was no special funding.

Declaration of Conflicting Interests: The authors declared no potential conflicts of interest concerning this article's research, authorship and/or publication.

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Economia agro-alimentare /
Food Economy

An International Journal on Agricultural and Food Systems

Vol. 24, Iss. 1, Art. 3, pp. 1-25 - ISSN 1126-1668 - ISSNe 1972-4802
DOI: 10.3280/ecag2022oa13227

Enhancing Technical Efficiency and Economic Welfare: A Case Study of Smallholder Potato Farming in the Western Highlands of Guatemala

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Abstract

Smallholder farmers in the Western Highlands of Guatemala grow potatoes for subsistence and as a cash crop but their current productivity is 29% lower than the world average. The objective of this study is to provide policy recommendations for improving potato productivity through enhancing technical efficiency in smallholder potato farming in the Western Highlands of Guatemala. In doing so, this study examines the determinants of potato productivity and identifies the sources of technical inefficiency in smallholder potato farming. In addition, the study evaluates the economic welfare impact of potato farm operations and provides policy recommendations for increasing smallholder potato productivity through enhancing technical efficiency. Stochastic production frontier analysis showed that on average farmers are at 57% efficiency. Hence, there is a considerable room for improving efficiency in potato farming. The sources of inefficiency of the farmers were determined to be caused by higher elevation, smaller farm size, and location of the farms. Welfare gains from reaching potential efficiency is US$ 8.79 million in terms of producer surplus per year in Guatemala. Hence, this study provides valuable

Article info

Type:
Article
Submitted:
18/05/2021
Accepted:
08/11/2021
Available online:
18/02/2022

JEL codes:
O12, O13

Keywords:
Guatemala
Potato farming
Producer surplus
Stochastic production frontier
Technical efficiency

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information for policy makers and farmers for improving technical efficiency and producer surplus. Likewise, providing better conservation practices by extension will ameliorate the low productivity associated with higher elevation and locations that are lower in technical efficiency.

Managing Editor: Alessio Ishizaka

Introduction

One of the sustainable development goals adopted by the United Nations in 2015 was to eliminate global starvation and to reach zero hunger by 2030 (Wu *et al*., 2018). This goal faces great challenges with increasing global food demand due to rapid population growth and climate change. According to some estimates, the global agricultural production will be required to increase by about 70-110% to achieve such a goal (Wu *et al*., 2018). Agricultural land expansion has played a significant role in increasing food production in developing countries during the last few decades (Neumann, 2010; Wu *et al*., 2018). However, in recent years, expansion of agricultural land area to satisfy global food demand is at odds with the intention of biodiversity conservation and urban development. This conflict requires identification of other options to increase agricultural production without further expansion of cultivated land area (Neumann, 2010; Wu *et al*., 2018).

Furthermore, FAO (2017) indicated that world under nourished people increased from 777 million in 2015 to 815 million people in 2016. The report revealed that the world should increase global food production by 50% to ensure the food security of additional two billion people, who will add to the world population by 2050. An increase in world food demand will require individual countries to enhance their food production to ensure food security. However, it is not likely food production will increase through increasing cultivated land area due to trade-offs associated with food production, biodiversity conservation, and greenhouse gas emission mitigation (Wu *et al*., 2018). Hence, sustained productivity growth is vital for poverty reduction and improving food security in developing countries (World Bank, 2007). Thiam (2001) showed that technical inefficiency ratio in agricultural sector lies from 32% to 63% in developing countries. A high level of technical inefficiency in agriculture causes low productivity, low income, and food insecurity among farming households. Particularly, low productivity in agriculture is one of the major constraints in meeting future food demand in the world (World Bank, 2007; Conceicao *et al*., 2016). Hence, improving technical efficiency in agriculture remains as a necessary condition for increasing agricultural productivity in developing countries to meet the increasing demand for

global food production (Neumann, 2010; Sokolova *et al*., 2017; Wu *et al*., 2018).

Guatemala had a per capita income of US$ 8,200 in 2017 (UNDP, 2018). The agricultural sector employed 31% of the labor force with 13.5% contribution to GDP in 2018. The Human Development Report in 2018 shows that 29% of total population in Guatemala lives below the poverty line, which is US$ 1.9 per day (UNDP, 2018). Despite moderate economic growth of 3% real GDP in 2018, Guatemala records high level of poverty, inequality, child malnutrition, and child mortality (UNDP, 2018). These socio-economic conditions are worse in rural areas, where indigenous people reside and, where agriculture plays a considerable role in income generation and employment creation compared to urban areas (Sokolova *et al*., 2017; FAO, 2018). Potato is one of the major cash and staple food crops in Guatemala. Eighty eight percent of rural households engage in potato cultivation and the potato sector provides permanent and semi-permanent employment opportunities to over 70 thousand rural families (Sokolova *et al*., 2017). Potato production 29% lower (25 tons/ha) than the world yields (35 tons/ha) and 69% lower than European and North American yield (80 tons/ha). (FAO, 2018; Widanage *et al*., 2019). Thus, Guatemalan potato productivity remains at a low level. In addition, there is a high risk of further declining productivity of potato farming due to the persistence of crop diseases and pests, lack of irrigation and failure to follow the best agricultural practices (Sain *et al*., 2017; Chan *et al*., 2018). Guatemalan potato cultivation has been suffering from a crop disease called "potato cyst nematode (PCN)". Our interviews with farmers in 2016 revealed that about 50% of the yield reduction can be attributed to PCN. This has led to USAID, a development agency, to provide an assistance for finding a solution for the PCN problem. In addition, low productivity associated with crop diseases and high degree of poverty emphasize the importance of improving technical efficiency in smallholder potato farming in Guatemala. In the light of these observations, this study answers to the following research questions:

i. What are determinants of smallholder potato productivity in the Western Highlands of Guatemala?
ii. What are the sources of technical inefficiency in smallholder potato farming?
iii. What is the economic welfare impact on potato farmers due to improving technical efficiency?
iv. What are the policy recommendations of this study for improving potato productivity through enhancing technical efficiency in smallholder potato farming?

In answering those research questions, this study intends to achieve the following overall and specific research objectives.

1.1. *Objectives of the Study*

With the overall objective of providing policy recommendations to enhance potato productivity through improving technical efficiency in smallholder potato farms in the Western Highlands of Guatemala, the specific objectives of this study are two-folds. Firstly, this study aims to investigate the determinants of smallholder potato productivity and to identify the sources of technical inefficiency in potato farming. Secondly, the study evaluates the economic welfare impacts of farm operations on the smallholder potato producers and provides policy recommendations for enhancing potato productivity through improving technical efficiency and for increasing economic welfare of smallholder potato farmers in the Western Highlands of Guatemala.

1.2. *Importance of the Study*

Measuring technical efficiency and associated economic welfare impact of smallholder potato farming has vital importance for both farm managers and policy makers. Particularly, the agricultural sector in developing countries like Guatemala, which faces considerable budgetary constraints of investing in productivity growth. Thus, the primary concern of both farmers and policy makers is to identify strategies to enhance productivity through improving technical efficiency without employing additional resources and new technologies. Hence, the policy recommendations derived from this study can be applied to curtail unnecessary production costs and save both financial and physical resources in smallholder potato farming in the Western Highlands of Guatemala.

The concept of farm level technical efficiency analysis provides information to produce maximum level of output through optimal allocation of resources following the best agricultural practices. These strategies bring valuable policy insight for farm managers, who aim to maximize profit in the presence of market constraints, high input costs and slow adoption of new technologies. In addition, these findings are important for policy makers concerned with enhancing productivity, competitiveness, and sustainable resource use in smallholder potato farming.

Furthermore, the findings of this study can be applied to improve technical efficiency in smallholder potato farming in other developing countries, where similar socio-economic and agro-climatic characteristics are found.

This paper is organized as follows: section two provides a conceptual framework of the method of analysis. Then, section three describes the project sites, data collection and the empirical models used for data analysis.

In section four, we present results and discussions. Lastly, section five provides a conclusion and policy implications of the study.

2. Conceptual Framework

2.1. *Stochastic production function and inefficiency model*

Production theory indicates that all observations are on a single production function, when a sample of farms are specified in input-output space, with a given technology. However, empirical estimation of a production function does not meet such a theoretical expectation due to random variations and farm specific differences in technical efficiency (TE) (Aigner *et al*., 1977; Kalirajan, 1981; Battese, 1992). Economic efficiency is defined as a combination of TE and AE (Allocative efficiency). AE indicates the ability of producing a given level of output at a minimum cost of input. In this study, TE is defined as the ability of a farming unit to produce maximum output given a set of inputs and technology (Kalirajan and Shand, 1986; Thiam *et al*., 2001). Farm specific TE means that there are farms more successful than others in using farming technology efficiently.

Random variations in production have no important economic meaning in describing productivity differences because it accounts for efficiency differences among farms due to random factors. Many production function analyses focused on such random efficiency differences. Those studies used Ordinary Least Square (OLS) method, which permit observations to lie on both side of estimated production function (Kalirajan, 1981; Battese, 1992). Hence, such an estimation method was not consistent with the Neo-classical definition of production function.

Farm specific variations in technical efficiency cause for productivity differences among sample observations. These productivity differences reflect farm specific variability related with decision making as individual farming unit, who employs the available technology efficiently. If a farming unit employs their technology efficiently, then the sample observations locate on the estimated production function (Kalirajan, 1981; Battese, 1992). Similarly, observations locate below the estimated production function if a farming unit employs their technology inefficiently. This study extends the conventional specification of production function to explicitly account for random and farm specific variabilities for investigating productivity differences. In doing so, we employ a stochastic frontier production function to measure technical efficiency in potato farming of Western Highland of Guatemala. The stochastic frontier production function has become a widely used tool in applied production analysis because it is consistent with the notion of profit maximization and cost minimization (Thiam *et al*., 2001).

These stochastic frontier models incorporate a composed error structure, which combines a two-sided symmetric term and a one-sided error component (Battese, 1992; Battese and Coelli, 1995; Thiam *et al*., 2001) In our frontier model, one-sided error component reflects inefficiency and two-sided error captures the random effects, which are outside the control of potato farmers.

Random effects include measurement errors and other statistical noise, which comes from unexplained variability of the estimated empirical relationship. The estimated stochastic frontier model addresses the noise problem characterized in previous deterministic models, which over-estimated the inefficiency component (Battese, 1992; Battese and Coelli, 1995).

The merit of this approach is not only accounts for random variation in production as in conventional methods, but also explicitly considers for the inter-farm variability in using the technology (Kalirajan, 1981; Battese and Coelli, 1995). It is our opinion that this is a more appropriate methodology for investigating the issue of productivity differences compared to conventional production function, which was used in most econometric studies. According to this approach, individual farmer variability or technical inefficiency is the major cause of yield variability not the random variability. Individual farmer variability in production is within the control of farming unit. Hence, TE analysis provides an important policy insight for choosing strategies to improve technical efficiency in agricultural production. One of the weaknesses of this approach is that allocative efficiency of sample farmers cannot be examined because the stochastic frontier production function is estimated using only inputs and output (Kalirajan and Shand, 1986; Thiam *et al*., 2001). In addition, technical efficiency in this study is a relative concept and such an optimum efficiency comes from the sample examined. Hence, it is not the absolute efficiency for all farms located in the Western Highlands of Guatemala. Policy makers should keep this in mind when they apply our findings to improve technical efficiency in potato farming in the study area.

This paper applies the stochastic frontier production function and the technical inefficiency model to evaluate the determinants of potato productivity and the sources of inefficiency in farm operations to answer research questions (1) and (2) respectively. In this analysis, we assume that farmers are profit maximizers and they aim to maximize profits subject to the given technology, constant input level and output prices (Varian, 1992). Furthermore, there are n number of farmers who use k number of inputs to produce single output potato. Assuming a Cobb-Douglas production relationship, the stochastic frontier production function is specified as follows:

$$Y_i = f(X_i; \beta_i)\ exp\ (V_i - U_i) \quad i = 1, 2, \ldots\ldots\ldots\ldots N; \tag{1}$$

where Y_i is the level of potato output of the i th plot, which is $(n \times 1)$ column vector. X_i is a $(n \times k)$ matrix of the production inputs associated with potato yield. β_i is $(n \times 1)$ column vector of unknown parameters to be estimated using equation (1). V_i is a random error term having zero mean, which is associated with random factors such as measurement errors in production and other random shocks. These random factors are not under the control of farm households. If there are no such stochastic elements and the influence of external factors on potato production is minimal, then the stochastic error term becomes zero ($V_i = 0$) (Battese, 1992; Battese and Coelli, 1995). Under such conditions, the random errors are assumed to be independently and identically distributed with zero mean and the constant variance as $N\ (0, \sigma^2)$. The presence of V_i in this model implies that the technical efficiency may vary randomly across the farms or over time across the same farm. Similarly, if there are no functional form errors and influence of stochastic factors, the deviation of potential output from actual output is determined by the level of efficiency in agricultural practices followed by the farmers. If the actual output is less than the potential output, a farmer faces technical inefficiency. The U_i accounts for the technical inefficiency, which measures the deviation of frontier output (Y_i^*) from the actual output (Y_i). *Ui* s are non-negative and identically distributed variables, which are independent from V_i (Battese, 1992; Battese and Coelli, 1995). The merit of this approach is that the relative variability of U_i and V_i provides an indicator to identify the sources of the technical inefficiency (Kalirajan, 1982; Kalirajan and Shand, 1986; Battese, 1992).

Technical efficiency of an individual plot can be stated as a ratio of the actual output to the corresponding potential output at the level of inputs used by a specific farm (Battese, 1992; Kalirajan, 1990; Neumann *et al*., 2010). Based on the stochastic frontier production function (1), the technical efficiency of farm i can be estimated as follows:

$$TE_i = Y_i/Y^* = f(X_i; \beta_i)\ exp\ (V_i - U_i) / f(X_i; \beta_i + V_i) \tag{2}$$

$$TE_i = exp\ (-U_i) = Y_i/Y^* \tag{3}$$

From equation (3) the term $exp\ (-U_i)$ derives the ratio of the actual output (Y_i) to the potential output (Y^*). The ratio Y/Y^* is called technical efficiency of an individual plot i (Kumbhakar and Wang, 1994)[1]. Since $U_i > 0$; the ratio

1. We can approximate $exp\ (-U_i)$ by $1 - U_i$ which gives $TE = exp\ (-U_i) = 1 - TI$ (technical inefficiency).

Y_i/Y^* lies between 0 and 1. If the value is equal to 1, then the potato farm productivity is 100% efficient and if the value is equal to zero, then it implies the potato farm productivity is 0% efficient.

The relative variability of U_i and V_i provides an indicator to statistically examine the sources of differences between the farm plot actual yield and the yield estimated by the stochastic frontier production function. Equation (4) shows the variance ratio parameter (γ), which is the ratio of variance of U_i and the total variability of U_i and V_i (Kalirajan, 1981; Battese, 1992).

$$\gamma = \sigma^2 U_i \,/\, \sigma^2 U_i + \sigma^2 V_i \tag{4}$$

where $\sigma^2 U_i$ = variance of U_i; $\sigma^2 V_i$ = variance of V_i.

The numerator and denominator of equation (4) represents the variance of U_i and the total variance of the estimated model respectively. As defined in equation (1), V_i represents random variation and U_i accounts for technical inefficiency. If the variance of $V_i = 0$; then the variance ratio becomes 1. This indicates that the output of sampled farms differs from the maximum output mainly because of the differences in technical efficiency. If the variance of $U_i = 0$; then the variance ratio will become 0. Hence, the random factors are the main sources of productivity differences among farms. We use the conceptual model in equation (1) to estimate the empirical model in section 3.3.

Many studies have identified various socio-economic and bio-physical factors that influence technical inefficiency in agricultural production (Bettese and Coellei 1992; Thiam *et al*., 2001; Takeshima, 2019). Based on those analyses, the technical inefficiency model can be specified as follows:

$$U_i = f\,(X_i;\, \alpha_i) + w_i \tag{5}$$

where X_i s are the factors that influence technical inefficiency. The literature shows that X_i includes socio-economic factors, biophysical factors, and agroclimatic factors (Thiam, 2001; Neumann *et al*., 2010). α_i represent the parameter of each explanatory variable; w_i is an error term with zero mean and constant variance. The technical inefficiency model in equation (5) is used to identify the factors that contribute to the technical inefficiency.

2.2. *Measuring economic welfare of farm operations using producer surplus*

Economists use producer surplus to measure the economic welfare impacts of farm operations. Economic profit or producer surplus is known as the difference between total revenue (TR) and total cost (TC). In this paper,

we use the producer surplus to measure the economic welfare impacts of farm efficiencies. When a farm achieves economic efficiency, it generates an economic surplus. The value of producer surplus can be used to examine the static economic efficiency of farm operations. Hence, in this analysis, we use the producer surplus to answer research question (3). The producer surplus of a potato farm is given as follows:

$$\text{Producer Surplus (PS)} = \text{Total Revenue (TR)} - \text{Total Cost (TC)} \quad (6)$$

Total revenue earned by a potato crop in quintal (100 kg) per unit area in cuerda (0.393 ha) can be calculated as follows:

$$TR = P_p * Q_p \quad (7)$$

where P_p = Price of one quintal (100 kg) of potato in quetzal (US$ 0.13) and Q_p = Quantity of potato (in quintal) per unit area in cuerda (0.393 ha).

Total cost in quetzal (US$ 0.13) occurred to a potato farm per unit are in cuerda (0.393 ha) can be measured as follows:

$$\begin{aligned} TC = {} & \text{Cost of seed} + \text{Cost of fertilizer} + \text{Cost of weed and pest control} \\ & + \text{Cost of manure} + \text{Labor cost} \end{aligned} \quad (8)$$

The difference between producer surplus generated at the efficient level of output (TR_E) estimated from equation 3 and the actual level of output (TR_A) is the change in the economic efficiency of potato farms if farmers allocate its inputs optimally. Hence the calculation of change in producer surplus due to achieving efficient output is given as follows:

$$\Delta PS = TR_E - TR_A \quad (9)$$

where ΔPS is the change in producer surplus per cuerda (0.393 ha). Equations (7)-(9) will be used to calculate values in Table 5 in section 4.4. In measuring the economic welfare impact of farm operations on the small-scale potato producers, we make several assumptions for our analysis. The assumptions are farmers face perfectly competitive markets both for inputs and output and, since farmers grow potato on farms they own, we do not count the land rent as a cost of production.

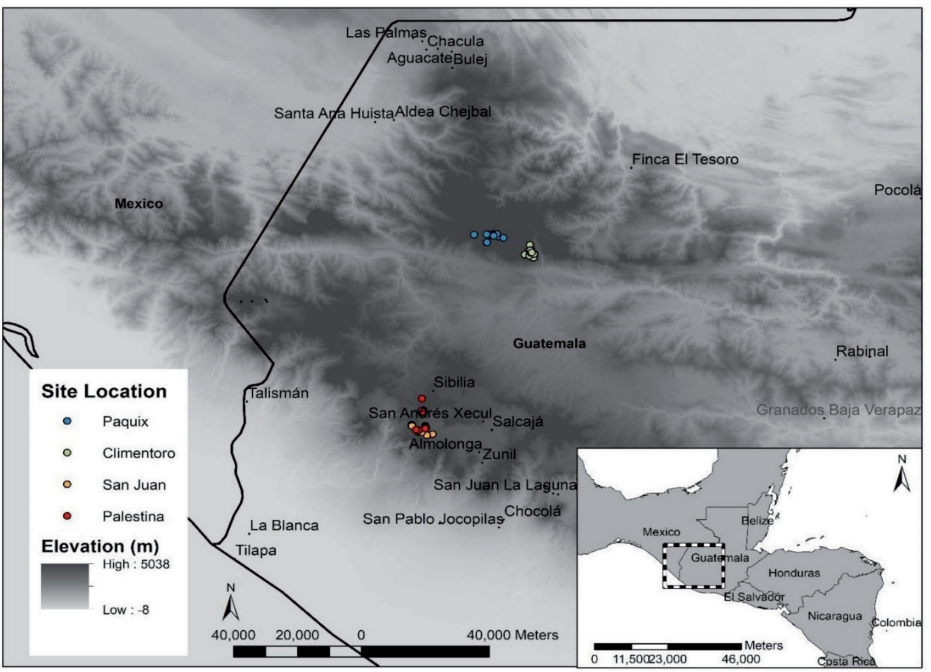
In the next section, we will provide a description of socio-economic and farm characteristics of study sites, data collection methods, and empirical model estimates.

3. Materials and methods

3.1. *Map of the study location*

The field survey was conducted in four potato production locations after consultation with local partners from the Faculty of Agriculture at the University of San Carlos of Guatemala. The four locations are: Palestina, Paquix, San Juan, and Climentoro in the Western Highlands of Guatemala (see Figure 1).

Figure 1 - Locations of study farm sites in the Western Highlands of Guatemala



3.2. Sample and data collection

Farm households were selected for the face-to-face interviews with the assistance of our local partners. Interviews were conducted at farmer cooperative centers or personal visits to the farm. Using a structured questionnaire, the interview was conducted to collect data on socio-economic conditions, demographic characteristics, production, costs, yields and agricultural practices in potato farming in the study areas. One

hundred and four household surveys were completed, and 6 questionnaires were discarded due to incomplete information. Then, 16 observations were removed due to the absence of latitude and longitude data. Thus, the total number of observations is 82. The interviews occurred during the years of 2017 and 2018. The lead interviewer who is from the University of San Carlos of Guatemala is fluent in both English and Spanish. Training sessions with local enumerators prior to surveying the farmers were conducted in Spanish.

3.3. *Empirical model*

According to our field survey experience and focus on main potato growing regions, potato production technology used by farm households in the study area reflects similar characteristics.

Hence, we specified one production boundary for analyzing technical efficiency among farm households in four regions. we were not able to run single models for each region due to the small number of observations. However, we conducted ANOVA (see Table 3 on page 16) and it indicated that there is a difference in technical efficiency between regions. According to our field observation and the review of spatial data, our farms in one region are located within the similar range of latitude and longitude. Thus, there is no considerable variation in climate and soil between farms within the same region. To identify the causes for the difference in inefficiency of potato production across the regions, we included location dummy variable SAN JUAN (DL3) (see Table 4 on page 17) in the inefficiency model.

As mentioned in section 2.1, the stochastic frontier production function is used to estimate the technical relationship between inputs and potato production in the Western Highlands of Guatemala. In this model, we assume that smallholder potato farmers are profit maximizers and the potato market is perfectly competitive. Hence, the input and output prices are given for a smallholder potato farmer and his/her marginal revenue is positive. The technical inefficiency model shows a linear relationship between technical inefficiency and the socio-economic, bio-physical and agroclimatic variables. In this study, the stochastic frontier production function and technical inefficiency model are simultaneously estimated using maximum likelihood method.

Based on equation (1), the stochastic frontier production function can be specified as follows:

$$PTY_{\mathrm{i}} = \beta_0 + \beta_1 PLS_i + \beta_2 COS_i + \beta_3 THL_i + \beta_4 COWP_i + \beta_5 THL_i^2 + \beta_6 CNPK_i + \beta_7 CMNU_i + V_i - U_i \quad (10)$$

where PTY_i = Total potato output in quintal (1 ton = 9.07 quintal) of plot *i*; PLS_i = Farm plot size in cuerda (1 cuerda = 0.393 hectare); THL_i = Total hours of labor used in plot *i;* THL^2 = Total hours of labor squared term; $COWP_i$ = Cost of weed and pest control in quetzal in a plot *i* (1 quetzal 0.13 US$); COS_i = Cost of seeds in quetzal in plot *i;* NPK_i = Cost of fertilizer in quetzal in plot *i;* $CMNU_i$ = Cost of manure in quetzal in plot *i;* V_i = Random error term in plot *i*; and U_i = Technical inefficiency term in plot *i.*

Equation (10) shows the technical relationship between inputs and potato output of plot *i*. PTY_i is the dependent variable in the model. Plot size (PLS_i), total labor hours (THL_i), cost of seeds (COS_i), cost of fertilizer ($CNPK_i$), and the cost of weed and pest control ($COWP_i$) and cost of manure ($CMNU_i$) are explanatory variables in the production function. The betas of stochastic frontier production function analysis intend to examine the contribution of each factor inputs to changes in potato production. V_i is assumed to be independently and identically distributed random variable. It accounts for a deviation of frontier output from the actual output due to the random shocks and measurement errors. U_i is assumed to be identically distributed non-negative variables independent of V_i. U_i accounts for a deviation of frontier output from the actual output due to the technical inefficiency. A prediction of technical inefficiency can be made by decomposing the combined error term ($V_i - U_i$), into its components to obtain farm specific technical inefficiency. The farm specific technical inefficiency is calculated using the prediction of the conditional distribution of U_i given that the combined random error ($V_i - U_i$) is observable.

The technical inefficiency model captures the determinants of variation in technical inefficiency. Based on the equation (5) the technical inefficiency model is specified as follows:

$$U_i = \alpha_0 + \alpha_1 FSZ_i + \alpha_2 DL3_i + \alpha_3 ELEV_i + \alpha_4 CARST5_i + \alpha_5 FSZ_i + w_i \quad (11)$$

where U_i is the farm level technical inefficiency in plot *i;* FSZ_i is farm size in cuerda; $DL3_i$ is a location dummy variable with San Juan = 1 and other locations = 0; $ELEV_i$ is the elevation of potato farm plot *i* from 3D elevation (1m resolution); $CARST5_i$ is the soil carbon stock in ton per/ha at the 5 cm soil depth in plot *i;* α_i s are the contributions of each explanatory variables to create technical inefficiency and w_i is a randomly distributed error term in plot *i.*

Equations (10) and (11) are used to estimate the coefficients of the stochastic frontier production function and technical inefficiency model respectively. Results are given in Table 1 and 4 respectively.

4. Results and Discussion

4.1. *Determinants of potato productivity in the western Highlands of Guatemala*

The stochastic frontier production function and inefficiency model were estimated using STATA version 15.1. As discussed previously, the stochastic frontier production function was applied to describe producer behavior in potato farming. The results of the estimated stochastic frontier production function are given in Table 1.

Table 1 - Estimated coefficients of stochastic frontier production function of Western Highland of Guatemala
Dependent Variable = Total potato output

Explanatory Variables	Coefficient	Standard Error	p Value
Constant	0.477	16.80	0.977
Plot size	13.17	2.29	0.000*
Cost of seed	-0.005	0.008	0.495
Total labor hours	0.185	0.059	0.002*
Total labor hours square	-0.0001	0.0003	0.004*
Cost of weed and pest control	0.0301	0.0082	0.000*
Cost of fertilizer	0.0283	0.0185	0.126
Cost of manure	-0.0249	0.0173	0.152

** Statistically significant at 1% level of significance* Source: Field survey data collected in 2017 and 2018 Number of observations = 82.
Log-Likelihood Ratio = -461.51
Wald chai (2)6 = 60.89 Prob $\chi^2 > 0.000$

According to the estimated model results, plot size (*PLS*), total labor hours (*THL*), weed and pest control (*COWP*) have positive relationships as expected with the Total potato output (*PTY*). Similarly, these explanatory variables are statistically significant at the 1% level. The labor squared term (THL^2) has the expected negative sign and it is also statistically significant at 1% level indicating that labor contributes to increase total potato production up to a certain point and then, begins to decline. This result of the labor variables is consistent with the law of diminishing marginal productivity in the agricultural sector of developing countries, where there is slow technological progress.

Furthermore, the estimated model shows that both fertilizer use (*CNPK*) and the cost of seed (*COS*) have the expected signs, but they are not statistically significant. The insignificance of (*CNPK*) could be due to the budget constraint of farmers compromising, their ability to purchase sufficient fertilizer and their subsequently failure to apply the recommended rate of nutrients.

Similarly, the cost of seed (*COS*) may not have a consistent significant influence on increasing potato yield in the Western Highlands of Guatemala as some farmers do not spend money on seeds or planting materials but use seeds saved from the last year's harvest. In the estimated frontier model, the coefficient of cost of manure (*CMNU*) has a negative sign but it is not statistically significant. This could be due to some farmers using farm manure and others using commercial fertilizer with varying levels of impact to yield. The Log-Likelihood ratio test indicates that the overall model is statistically significant at the 1% level. Thus, the estimated frontier model is consistent with both theoretical and statistical criteria.

Likelihood ratio test (*LR*) was used to determine the presence of technical inefficiency in potato farming. The null hypothesis of this test was formulated as H_0: $\lambda = 0$, where lambda is the ratio of standard deviation of the inefficiency error term to the random error term (i.e. $\lambda = \sigma_u/\sigma_v$). The test indicates no significant technical efficiency at farm level potato production. A rejection of null hypothesis indicates that all the deviation from potential output is due to systematic variation in potato production. The log-likelihood function values of the Ordinary Least Squares and stochastic frontier model were used for the test. The *LR* test is given as follows:

$$LR = -2\,(LLF_R - LLF_u) \tag{12}$$

where LLF_R and LLF_u represents the log-likelihood function values for the restricted (OLS) and unrestricted (Stochastic Frontier) model respectively. LR = -2(-522.23-461.51) = -121.44 is compared with Kodde and Palm (1986) critical values of mixed chi-squared distribution 5.41 at the one percent level of significance with one degrees of freedom. We reject the null hypothesis that there is no technical inefficiency. Thus, the estimated stochastic frontier production function is the most appropriate model to represent the field survey data.

4.2. *Technical efficiency in potato production across study sites*

The potential output was estimated using frontier production function represented by equation (10) in section 3.3. Equation (2) in section 2.1 was

used to estimate the technical efficiency (*TE*). Our estimates show that the technical efficiency in the Western Highlands of Guatemala lies between 0.1 to 0.97. According to the frontier production function analysis, the average technical efficiency is 0.57. This means that farmers' actual output is 43% below the level of potential output. These findings reveal that potato farms in the Western Highlands of Guatemala are quite inefficient. Thus, there is considerable room for policy interventions to enhance technical efficiency. Furthermore, the findings of this study show that there are differences in technical efficiency across the four study sites (see Table 2).

Table 2 - Technical efficiency (TE) across four study sites in the Western Highlands of Guatemala

TE value	**San Juan**	**Climentoro**	**Palestina**	**Paquix**
Average	0.66	0.46	0.52	0.64
Standard Deviation	0.29	0.28	0.32	0.17
MaxMin	0.97	0.93	0.89	0.85
	0.11	0.12	0.09	0.28

Source: Field survey data collected in 2017 and 2018.

Table 2 shows that the average technical efficiencies in Climentoro (0.46) and Palestina (0.52) are smaller than the overall average of four study sites (0.57). Similarly, the average level of technical efficiencies in San Juan and Paquix are greater than the overall average of four study sites. In addition, minimum and maximum values of technical efficiencies in San Juan, Climentoro, and Palestina show that there is a considerable range of technical efficiencies within these three study sites compared to Paquix. Likewise, the analysis of variance was used to examine the variation of all the technical efficiency across the four study sites (see Table 3). Our analysis shows that there is a statistically significant variation in technical efficiency between four study sites. Climentaro and Paquix (high elevation) are Mollisols (high organic matter). Palestina and San Juan (lower attitudes) are Andisols (less organic matter), but yield was higher in the latter than in the former. This suggest that not grower or soils, but other unaccounted climatic factors may be contributing to the differences. This kind of analysis provides information to choose appropriate areas for necessary policy interventions for improving technical efficiency in potato farming.

Table 3 - Variation in technical efficiency of potato farming across four study sites in Guatemala

Source	Sum of squares	Degrees of freedom	Mean square	F	p value
Between study sites	0.5977	3	0.1992	2.91	0.044
Within study sites	3.4285	50	0.0685		
Total	4.0262	53			

Bartlett's test for equal variances: $\chi^2(3) = 7.6896$ Probability > $\chi^2 = 0.053$.

4.3. *Socio-economic and agroclimatic determinants of technical inefficiency*

Next, we estimated the inefficiency model to find the significant socio-economic and agroclimatic factors that determine technical inefficiency in smallholder potato farming. To begin, we normalized the calculated *TE* values (actual output/potential output) using the highest *TE* value in the sample as 1. Then, we used the normalized *TE* value (*NTE*) to estimate the technical inefficiency index (*TIE*) derived from *1-NTE*. The estimated *TIE* index was used as a dependent variable in the inefficiency model.

Equation (11) is used to estimate the inefficiency model and results are found in Table 4.

According to Table 4, all the estimated coefficients have the correct signs and are significant except carbon stock at the 5cm soil depth (*CARST5*). San Juan (*DL3*) has a negative and statistically significant relationship with technical inefficiency, which makes sense as the area has much higher yield and larger plot size than most of the study sites. This result indicates that San Juan (*DL3*) contributes to a lower technical inefficiency. Similarly, larger farm size (*FSZ*) has negative impacts on technical inefficiency, and it is statistically significant at 1% level. This is as expected due to the economies of scale generated by large-scale farms. Elevation (*ELEV*) has a statistically significant positive relationship with technical inefficiency in smallholder potato farming. This is consistent with the theoretical expectation since high elevation sloping areas have more erosion and run-off problems that would cause lower potato productivity (Wang *et al.*, 2002; Mahil *et al.*, 2016).

Furthermore, soil carbon stock (*CARST5*) had the correct sign but was not significant, perhaps this is due to the generally poor soil of farms and failure to capture the complexity of soil carbon content. Hence, we argue that the estimated inefficiency model is consistent with both theoretical and statistical criteria.

Table 4 - Estimated coefficients of the inefficiency model. Dependent variable = Technical Inefficiency Index (TIE)

Explanatory Variables	Estimated Co-efficient	Standard Error	p Value
Constant	-5.38	45	0.905
San Juan	-30.91	9.61	0.001*
Elevation	0.034	0.014	0.023**
Farm size	-0.172	0.081	0.037**
Soil carbon stock	-0.224	0.359	0.535

* Statistically significant at 1% level and ** statistically significant at 5% level.
Source: Field survey, 2017 and 2018.

4.4. *Evaluating the economic welfare impact of farm operations*

As mentioned in section 4.2, smallholder potato farmers attempt to maximize profits. Hence, in this analysis, we use profit or producer surplus generated from farm operations to measure welfare impact of farm operations on smallholder potato producers. The calculated producer surplus values per cuerda (0.393 ha) across four study sites are given in Table 5 under two scenarios, where the wage rate per hour is 10 quetzal in scenario 1 and the wage rate is 5 quetzal per hour in scenario 2. Five quetzal represents the current wage rate, which farmers use to pay their family labor and 10 quetzal is the current wage rate which is used to pay for hired labor[2]. Equations (7) to (9) in section 2.2 are used to calculate statistics in Table 5.

According to Table 5, all the study sites record positive producer surpluses under both wage rate scenarios with current level of productivity. This indicates that though farm operations currently have positive economic returns from potato farming, farmers could increase their economic returns if they are more efficient. There are considerable differences among the four sites in generating producer surpluses, Climentoro has very low producer surplus due to its generally low yield but since its potential yield is comparable to the other study sites so gain will be the greatest for Climentoro if farmers there strive to achieve their potential yield. Using the result of the change in regional average gain in producer surplus 1,246 quetzal from Table 5 and multiplying by the total area harvested in Guatemala in 2017 (21,156 hectares (potatopro.com) and dividing by 0.39 to convert hectare to

2. These wage rates are obtained by e-mail communication with Alfredo Mejia at The University of San Carlos of Guatemala.

cuerda, the aggregate gain in producer surplus for the Western Highland of Guatemala is 67.59 million quetzal or US$ 8.79 million per year. These are substantial gains and returns to producers and to Guatemala. Hence, positive change in producer surplus across study sites reveal that policy interventions are desirable to make potato farms are more efficient production units.

Table 5 - Producer surplus per cuerda (in quetzal)[3] *across study sites*

	San Juan	**Climentoro**	**Palestina**	**Paquix**	**Regional**
$Output_E$ (quintal)	29	28	19	29	28
$Output_A$ (quintal)	19	13	10	19	17
Wage rate (10 quetzal)					
TR_E	3190	3080	2090	3190	3080
TR_A	2143	1380	1077	2044	1834
TC	790	1262	459	829	874
PS_E	2400	1818	1631	2361	2206
PS_A	1335	118	618	1215	960
ΔPS	1047	1700	1013	1146	1246
Wage rate (5 quetzal)					
TC	571	767	540	478	468
PS_E	2619	2313	1550	2712	2612
PS_A	1572	613	537	1566	1366
ΔPS	1047	1700	1013	1146	1246

Source: Field survey, 2017 and 2018, market wage rates were obtained through personal communication had with Alfredo Mejia from the University of San Carlos of Guatemala.

where $Output_E$ = Efficient output per cuerda (in quintal); $Output_A$ = Actual output per cuerda (in quintal); TR_E = Total revenue at the efficient level of output; TR_A = Total revenue at the actual level of output; TC = Total cost of production; PS_E = Producer surplus at the efficient level of output; PS_A = Producer surplus at the actual level of output; and ΔPS = Difference between the efficient and actual level of producer surplus.

3. 1 Quetzal = 0.13 USD.

5. Conclusion and Policy Implications

5.1. *Conclusion*

Guatemala is a country which records a moderate economic growth but high level of poverty and food insecurity. Potato is one of the most important staple and cash crops in Guatemala. Hence, the potato sector is an important area for income generation, poverty reduction and improving food security. Results of this study show that farmers' actual output is 43% below the potential output, indicating that smallholder potato farming operations in the Western Highlands of Guatemala are quite inefficient and have room for improvement. However, technical efficiency in this study is a relative concept and such an optimum efficiency comes from the sample examined. Hence, it is not the absolute efficiency for all farms located in the Western Highlands of Guatemala. The estimated coefficients of stochastic frontier production function indicate that increasing the extent of plot size, transferring labor from potato farming to other non-farm sectors, and increasing financial resources on weed and pest control lead to increase the level of potato production in the Western Highlands of Guatemala. When evaluating the causal factors of inefficiency, farm size, farm elevation, and farm location were the primary driving factors. These results strongly suggest potential opportunities exist to offset input use inefficiencies and other non- input factor inefficiency. In addition, welfare gain from reaching potential efficiency is US$ 8.79 million in terms of producer surplus per year in Guatemala. Furthermore, our sensitivity analysis on wage rate indicates that input subsidies, crop insurance, revenue stabilization, and tax relief lead to increase economic surplus generation for smallholder potato farmers. Similarly better conservation practices through promoting extension may lead to increase potato productivity in higher elevation. Below are policy recommendations.

5.2. *Policy Recommendations*

1. The estimated model results in Table 4 indicate that there is an inverse relationship between technical inefficiency and farm size. This is as expected in economic theory due to the economies of scale generated by large-scale farms. Therefore, large-scale potato cultivation may be an economically efficient farming strategy for improving technical efficiency in smallholder potato farming in the Western Highlands of Guatemala.
2. The estimated frontier model results (see Table 1) show that an increase in labor inputs increases potato productivity. However, the estimated total

labor square coefficient (THL^2) indicates that the contribution of labor to potato productivity becomes negative after a certain level of production. This could be due to the marginal diminishing returns, which occurs from employing too much labor for cultivating a fixed amount of potato land. Hence, it is recommended to either decrease labor use or increase plot size to remove diminishing marginal returns and improve resource use efficiency in smallholder potato farming. In addition, labor transferring from potato farming to non-agricultural sector may lead to remove diminishing returns and increases the marginal labor productivity in potato cultivation.

3. As mentioned previously, the crop disease, PCN significantly reduces potato yield. The estimated frontier model shows that investing more and more resource for weed and pest control makes a positive contribution to increased potato production. An increase in expenditure on weed and pest control implies that there is an increase in quantity used because this econometric analysis is a static partial equilibrium approach. Hence, increasing allocation of financial resources to weed and pest control for improving soil health will increase potato production.
4. Our estimated inefficiency model (see Table 4) shows that potato farming at high elevation on steep sloping lands leads to inefficiency in resource use. Elevation would have additional affects like cooler daily temperatures, a shorter growing season and greater ultraviolet lights exposure to plants. These could all be confounding or contributing "elevation factors". Generally, it is not unreasonable to expect lower yield from higher elevations compared to yield at lower elevations. Higher elevation does not necessarily mean that a place must have greater slope – there are high elevation flat plateaus. Climentaro had sloping land, where the potato was cultivated. I think that some of the potato land in other high elevation site was not as sloping. Previous studies also indicated that high elevation gives low productivity and low elevation gives high productivity (Wang *et al*., 2002; Malhi *et al*., 2016). Hence, adopting erosion control methods may be a good strategy for increasing technical efficiency in potato farming. Furthermore, our interviews and model results reveal that well-developed infrastructure such as good road network, marketing facilities, and extension services favorably impact technical efficiency. Hence, it is worthwhile to conduct more workshops on the best agronomic practices particularly in Climentoro and Paquix because our interviews and direct observations revealed that these sites have relatively less infrastructure compared to Palestina and San Juan. As mentioned in the introduction, smallholder potato farmers suffer from poverty, and they do not have financial resources for investing in improving marketing facilities or extension services in the study area. Thus, it is recommended for the

Guatemalan government or non-governmental organizations like USAID to invest in those services because such investment may lead to improve productivity of potato farming through enhancing technical efficiency.

5. Economic welfare analysis of smallholder potato farming on high elevation slopes reveals that all the farms across the four study sites generate producer surpluses but are below the economically efficient level. Some land tenure is communal, residing with the tribe and not individuals, especially in indigenous communities. To capitalize on this, the government might consider designing appropriate policy interventions to facilitate and encourage farmers to expand their potato production areas.
6. Sensitivity analysis of changes in agricultural wage indicates that high input cost and low commodity prices reduce economic surplus. Thus, the provision of input subsidies, crop insurance, revenue stabilization and tax relief on the farm income are recommended to increase economic surplus generation for smallholder potato farmers.

Acknowledgments

We thank the smallholder farmers for their willingness to participate and contributions and efforts interfacing with and facilitating data collection. We thank Dr. Amilcar Sanchez and Alfredo Mejia for their assistance in identifying villages and working closely with the smallholder farmers in implementing the field tests and recording data. This research was funded in part by USAID Hort Innovation Lab in partnership with Michigan State University and the University of San Carlos of Guatemala.

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Economia agro-alimentare /
Food Economy

An International Journal on Agricultural and Food Systems

Vol. 24, Iss. 1, Art. 1, pp. 1-20 - ISSN 1126-1668 - ISSNe 1972-4802
DOI: 10.3280/ecag2022oa12752

Productive efficiency and trade opportunities for Kazakhstan dairy farms

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Abstract

This study analyses the productive efficiency of dairy farms in Kazakhstan and suggests export implications by the expansion of trade networks and the participation of global value chains. As the world's largest landlocked country and ninth largest area in the world, Kazakhstan has often been considered to have vast potential to produce and export dairy products. The greater openness of markets and improved geostrategic circumstances with the latest rail link between China and Europe are expected to strengthen Kazakhstan's trade opportunities with the rest of the world. Despite these positive prospects, few empirical studies have examined the export potential of the country's dairy products. To bridge this gap, this study surveys 23 dairy farms across nine oblasts in Kazakhstan and performs a data envelopment analysis with milk production as the output variable and feed, labour, and capital as the input variables. The estimation results indicate that Kazakh dairy farms could reduce input use by up to 70% under the most efficient system. A dichotomy of productive efficiency among large and capital-intensive versus small-scale family farms suggests that the country should promote inclusiveness through sharing knowledge and best practices within the industry.

Article info

Type:
Article
Submitted:
14/07/2020
Accepted:
22/07/2021
Available online:
03/12/2021

JEL codes:
O13, Q16, Q18

Keywords:
Data envelopment analysis
Production efficiency
Kazakhstan dairy industry
Belt and Road Initiative

Managing Editor:
Valeria Borsellino

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Introduction

Kazakhstan is considered to have vast agricultural potential on several grounds. First of all, the country has abundant land resources, as it the world's largest of 43 landlocked countries and the ninth largest area in the world. In addition, it owns large reserves of energy and mineral resources such that exports of oil, gas, ore, and metals are its primary source of earning foreign reserves (USEIA, 2017). Despite these advantages, high energy export dependence can be a double-edged sword. For example, the commodity boom in the 2000s triggered significant economic growth, while the global financial crisis in 2009 and commodity price collapse of 2014-16 held back the Kazakh economy.

Indeed, Akhmetov (2017) found that real agricultural output has decreased more than four times since 1990 because of the effects of the Dutch disease. Nurmakhanova (2016) also suggested that the impact of the increase in oil prices could be balanced by the appreciation of the real exchange rate. Kazakhstan now has vast tracts of land falling into neglect, and the combination of better yields, more efficient breeds, and technological advances would increase agricultural production greatly. However, Kraemer *et al*. (2015) countered that the production potential of uncultivated agricultural land is much lower than widely thought.

Besides, economic and policy reforms have been tuned for sustained growth. After the collapse of the USSR, Kazakhstan was the last to declare independence in 1991. Thereafter, the young and independent Kazakhstan rapidly transformed its economic system into a market economy and attracted considerable foreign direct investment (Cohen, 2008; OECD, 2017). In 1997, the "Kazakhstan 2030" program outlined long-term strategic priorities in the areas of national security, internal stability and the consolidation of the people, an open market economy, the healthcare system and environment, energy resources utilization, transport infrastructure, and an efficient public administration (Pomfret, 2014). The subsequent "Strategy 2050" initiative announced in 2012 furthered the country's plans for economic diversification and the privatization of domestic and export sectors to achieve its goal of becoming one of the top 30 developed countries (Borghijs, 2017).

Kazakhstan has made significant progress in regional and global integration. It is worth considering three aspects. One is the formulation of a treaty on the Eurasian Economic Union (EEU) in 2015. Although political motives played a key role in the regional commitments, EEU members agreed to have not only a free trade and customs union, but also the free movement of capital and labour and eventually a common economic policy (OECD, 2016). Kazakhstan's accession to the WTO in 2015, which took nearly 20 years, is another trade initiator, fitting into the country's vision of economic development and international standing.

Finally, the Belt and Road Initiative (BRI), announced in 2003 that connects China through Central Asia and the Middle East to Europe by land and to southeast Asia and east Africa by sea combines investment, development and trade objectives (Chatzky and McBride, 2020). As of 2020, 140 countries have signed a cooperation agreement with China for the BRI of which only 57 countries including Kazakhstan are located in the corridor from China to Europe (Birch, 2021). If the $1.2~1.3 trillion projects by 2027 are proven to be successful, Kazakhstan can be not only a bridge between large markets but also a competitive exporter of agricultural and oil and gas products.

Against this backdrop the country has its eye on fulfilling the export potential in the dairy industry as well. Despite its positive prospects, few empirical studies have examined the country's trade opportunities of dairy products. To bridge this gap, this study examines milk production efficiency based on a survey of dairy farms. These empirical findings are expected to shed light on the development goals of Kazakhstan's dairy sector in that it provides high quality products and is exploring the potential for exports.

1. Development of the dairy sector

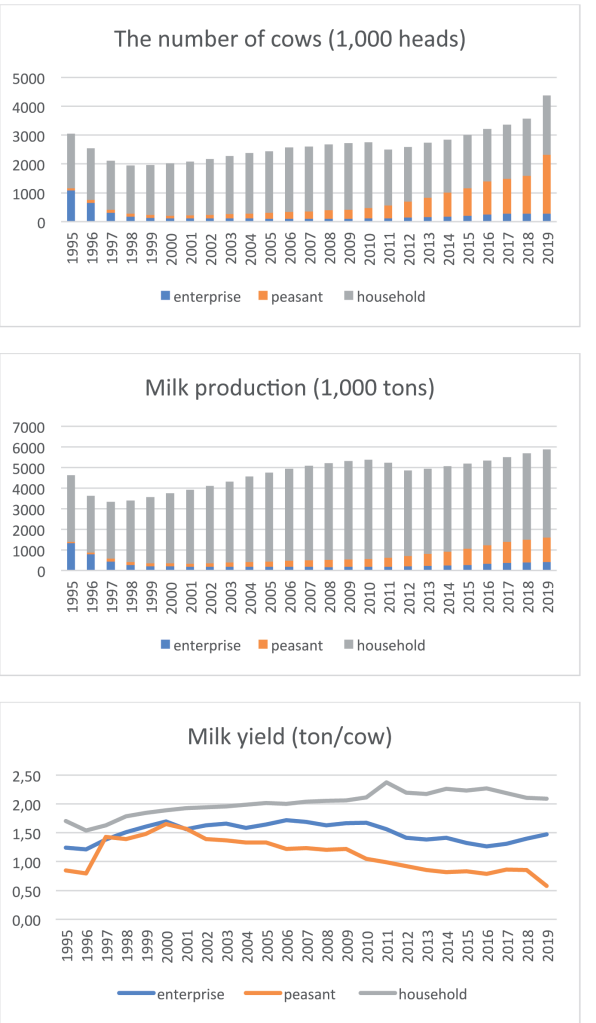
Dairy is the second largest agricultural subsector in the country. It accounted for 29% of agricultural GDP, or $31 billion, in 2014 (Business Sweden, 2016). Against the backdrop of these favourable macroeconomic and institutional changes, this study explores Kazakhstan's export potential in the dairy sector. Few empirical studies have thus far investigated the export potential of the country's dairy products. To bridge this gap, this study examines the productive efficiency of surveyed dairy farms regionally by employing the data envelopment analysis (DEA) method. The milk production efficiencies of Kazakhstan farms are also compared with their counterparts in European countries to shed light on the country's export potential in this sector.

Kazakhstan was the home of nomadic herders with migratory grazing for centuries. During the Soviet era, collective livestock farms, or "kolkhozes", were forcedly created and operated under state intervention (FAO, 2011). After the demise of the Soviet Union, large-scale kolkhozes were dismantled and their livestock distributed to kolkhoz workers. As a result, many newly created small-scale farmers began to account for a considerable share of overall production, even despite losing their access to land, government services, and marketing.

Kazakhstan farms are officially divided into three groups by the Committee on Statistics depending on their size and commercial activities. Firstly, "agricultural enterprises" are legal entities or their subdivisions that

are strictly engaged in the commercial production, storage, and processing agricultural products. As of January, 2020, there are 17,403 agricultural enterprises in the country. These tend to be large-scale operations similar to the collective farms of the Soviet era (average size over 8 000 hectares) and each enterprise hires more than 250 employees (OECD, 2013). They focus on grain production, with only small shares in terms of the number of farms (0.9%), the number of cows (6.4%), and milk production (7.1%) (Figure 1).

Figure 1 - Dairy production and productivity by farm category



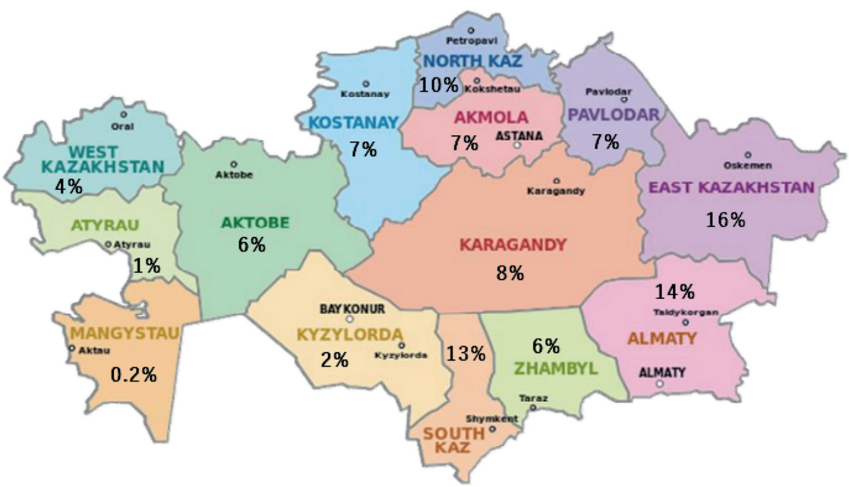
Source: The Committee on Statistics (www.stat.gov.kz).

Secondly, "peasant farms" are family-oriented individual and private farms. The country's 219,449 peasant farms are substantially smaller than agricultural enterprises with an average land size of 270 hectares and they record a middle position for the number of farms (11.7%), the number of cows (46.8%), and milk production (20.2%).

Finally, "household farms" are personal subsidiary farms. Since households are not regarded as legal entities, they neither pay business taxes nor receive production subsidies from the government. About 1.6 million household farms with an average land size of 0.13 hectares farm various plots including collective gardens, vegetable gardens, and country plots. As the dominant agricultural units (87.4%) with between one and five cows, household farms accounted for 46.8% of the number of cows and 72.8% of milk production in 2019.

Reached its peak of about 5.9 million tons in 2019, milk production has grown at 1.2% per year over the 1995-2019 period. As of 2019, household farms are the largest producer group that accounts for 73% of total milk production followed by peasant farms with 20%. However, peasant farms have shown an upward trend in the production share while household farms' share has slipped over years. Cow productivity for household farms in 2019 is 2.1 tons per cow, which is far greater than 0.6 and 1.5 tons per cow for peasant farms and agricultural enterprises, respectively. The increase in milk production observed since 2012 is related mainly to the increase in cow population because cow productivity remains low and in fact is on the decrease.

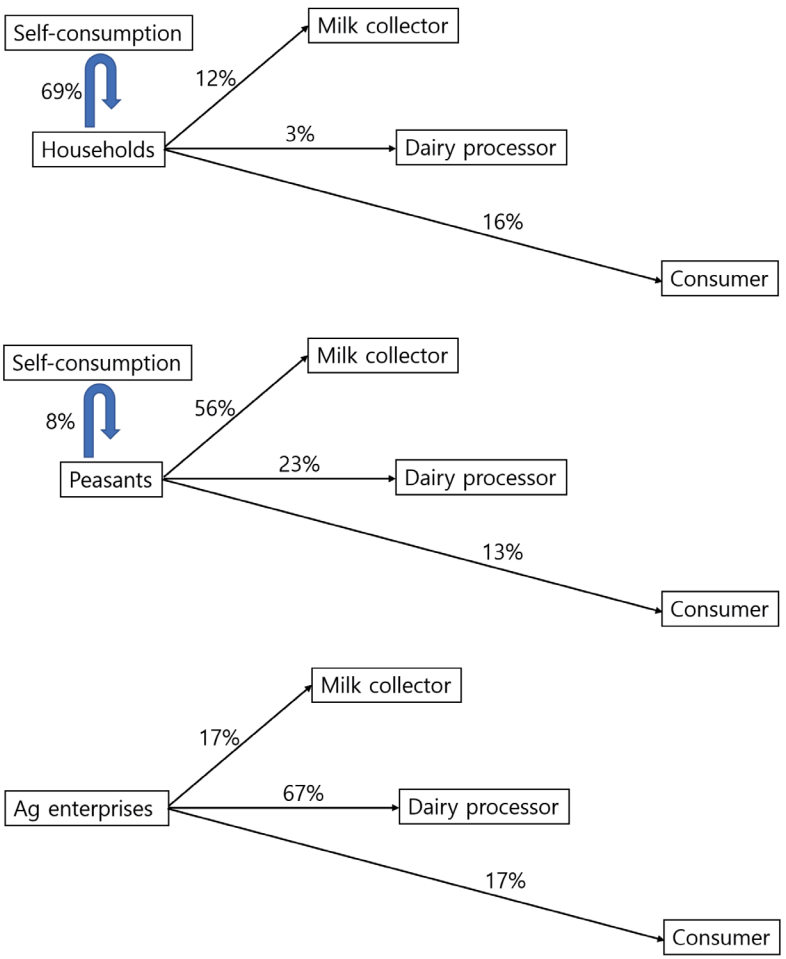
Figure 2 - Geographical distribution of milk production shares in 2019



Note: South Kazakhstan was renamed as Turkestan in 2018.
Source: The Committee on Statistics (www.stat.gov.kz)

Figure 2 shows the regional structure of milk production in 2019. Judged by production shares, the leading provinces are East Kazakhstan 16%, Almaty 14%, South Kazakhstan 13% (it was renamed as Turkestan in 2018), and North Kazakhstan 10%. Agricultural enterprises in the northern provinces, including North Kazakhstan, Akmola, and Kostanay account for relatively larger shares in production while peasant farms play an important role in the central and eastern provinces, including East Kazakhstan, Almaty, and Karagandy. Household farms are concentrated in South and East Kazakhstan and Almaty.

Figure 3 - Aggregation, processing and distribution of milk by farm category in 2011



Source: Netherlands Worldwide (2019).

Milk commercialization and processing are quite limited in the country due to production structure and sparse collection centers across the expansive country. Since small-scale household farms that own fewer than 5 cows, accounting for about 80% of all farms produce milk for self-consumption, only a third of produced milk go to processing or directly to consumers (Figure 3). By contrast, agricultural enterprises forward about 67% of their production to dairy processors.

The low level of commercialization and processing is attributable to the long distance between raw milk producers and milk collectors, which can be more than 600 km, inaccurate temperature conditions during raw milk storage and transport, and high seasonality of raw milk production due to the dominance of pasture breeding.

According to Punda (2016), milk producers sell about 50% of milk unprocessed. Even with a network of milk collecting stations to collect milk from households and peasant farms, processors face increasing raw material costs and experience difficulty in controlling the quality of raw milk. The FAO-developed mobile app, the so-called "Collect Mobile" has been introduced to provide processors with accurate information regarding optimal collection routes, the required capacity for mobilizing cooling tanks and refrigeration transport, and the sources of raw milk across scattered farms (FAO, 2021).

Kazakhstan is a net importer of dairy products (Table 1). Import volumes totalled 5.8 million tons, or about 11.2% of national production in 2019. Key dairy products imported are milk and cream, including concentrated, kephir and yogurt, butter, and cheese. They are largely from the Siberian Federal District of Russia, whose borders are connected with logistics, rendering more efficient exploitation of regional comparative advantages. Ukraine, Belarus and the Netherlands are also important exporters to Kazakhstan. As stated above, imports are largely attributable to the limited and uneven supply of domestic milk, partly caused by sizable seasonable fluctuations and the problem of collecting milk from many scattered household farms.

When carry-over stocks from the beginning of the year are included, the country has about 6.7 million tons of milk available in the same year. Some 6.3 million tons of milk were consumed in 2019, of which 4.3 million tons were food uses and 1.9 million tons were processing uses. Thus, per capita consumption or availability of milk is calculated at 363.1kg.

Table 1 - Milk supply and demand (in 1,000 tons)

	2012	2013	2014	2015	2016	2017	2018	2019
I. Supply								
Opening stock	620	585	511	531	402	371	306	310
Production	4,852	4,930	5,068	5,182	5,342	5,503	5,686	5,865
Imports	620	646	685	569	592	574	541	546
Total	6,092	6,161	6,264	6,282	6,336	6,448	6,533	6,721
II. Demand								
Processing use	1,483	1,507	1,576	1,593	1,634	1,705	1,826	1,903
Other use	1	1	1	1	1	1	1	1
Loss	31	31	31	31	32	32	33	34
Exports	11	33	40	97	47	55	105	154
Food use	3,981	4,078	4,084	4,158	4,252	4,351	4,259	4,311
Closing stock	585	511	531	402	371	306	310	318
Total	6,092	6,161	6,263	6,282	6,337	6,450	6,534	6,721

Note: The total figures for supply and demand may not coincide each other due to rounding error.

Source: The Committee on Statistics (www.stat.gov.kz).

2. Review of literature

There is a paucity of studies of the economic potential or trade opportunities of Kazakhstan's dairy sector. Existing work mainly addresses industry situations and policy development (Kazkenova *et al.*, 2015; Lim, 2016; Nazhmidenov, 2010; Petrick and Promfret, 2016; Van Engelen, 2011). Petrick *et al.* (2014) pointed out that the value chain of dairy products in Kazakhstan is bifurcated into urban and rural consumers. Urban consumers largely depend on processed dairy products under an import-dependent chain, while rural consumers are served from a local value chain of raw, unprocessed products.

This study also highlighted room for improvement to ensure industry competitiveness, such as enhancing food quality standards with the appropriate cooling and sanitary conditions, ensuring better access to grazing land, resolving the overstocking and intermixing of livestock, increasing fodder supply in winter, and developing domestic and global value chains. On this matter, Lashkareva *et al.* (2016) suggested that an additional state subsidy may be required to support the development of areas unfavourable for agriculture.

As for the export aspects of Kazakhstan's dairy products, Pomfret (2014) claimed that Kazakhstan should expand its trade connectivity along the East-West corridor under China's new silk road. In particular, the government should improve transportation and marketing infrastructure to realize niche markets and products. Temyrbekova *et al.* (2015) found that Belarus and Russia have a comparative advantage in trade in relation to Kazakhstan. In particular, the average milk yield per cow in Kazakhstan is far lower than that in Russia and Belarus. Indeed, milk yields of Kazakhstan farms are low by international standards (Petrick *et al.*, 2014). However, a limitation of this study was its use of net exports as a key indicator of competitiveness.

Table 2 summarizes selected DEA studies, noting that no study has thus far attempted to analyse the efficiency of Kazakhstan's dairy production by using a DEA approach. Previous studies indicate that common output variables in DEA modelling are sales receipts and milk production, while input variables include the various production costs and volumes of inputs such as labor, capital, feed, and land. Based on the literature, this study therefore adopts milk production as an output variable and labour, feed, and capital costs as input variables.

Table 2 - Summary of the literature on DEA for dairy products

Study	Subject	Output variables	Input variables
Youn *et al.* (1999)	95 farms in Japan	• Milk sales receipts • Livestock sales receipts • Other receipts	• Variable costs • Depreciation costs • Labor costs • Land size
Cho and Kim (2001)	97-127 farms in Korea	• Milk sales receipts	• Concentrate costs • Fodder costs • Operating expenses • Land size • Own labor hours
Park *et al.* (2006)	146 farms in Korea	• Milk production • By-product receipts	• Concentrate costs • Fodder costs • Operating expenses • Land size • Own labor hours
Lee and Park (2011)	19 farms in Korea	• Gross receipts • Milk sales receipts • Calf's sales receipts • Other receipts	• Concentrate costs • Fodder costs • Own labor costs • Other costs
Cloutier and Rowley (1993)	187 farms in Canada	• Milk production • Milk sales receipts • Gross receipts	• Feed costs • Livestock numbers • Labor hours • Land size

Table 2 - continued

Study	Subject	Output variables	Input variables
Jaforullah and Whiteman (1999)	264 farms in New Zealand	• Milk fat production • Milk solids production • Lacto-protein production	• Feed costs • Livestock numbers • Feed costs • Fertilizer costs • Sanitary expenses • Capital costs • Land size
Stokes *et al.* (2007)	34 farms in the United States	• Milk production per cow • Milk fat production per cow	• Livestock numbers • Labor hours • Land size
Theodoridis and Psychoudakis (2008)	165 farms in Greece	• Gross production	• Labor hours • Fixed costs • Variable costs
Switlyk (2020)	11,055 farms in Poland	• Sales values including subsidies	• Livestock numbers • Land size • Seed costs • Feed costs • Machinery costs • Energy costs • Depreciation costs • Other costs
Luik *et al.* (2014)	147 farms in Estonia	• Sales revenue of milk and dairy products • Sales revenue of animals and other agricultural products	• Livestock numbers • Land size • Labor hours • Feed costs • Capital costs • Other costs
Wilczynski *et al.* (2020)	869~1,308 farms in Poland	• Sales and subsidies	• Livestock numbers • Land size • Forage and concentrates costs • Machinery costs • Energy costs • Depreciation costs • Other costs

3. Materials and methods

First introduced by Charnes *et al.* (1978), DEA has become established as a framework for measuring the efficiency of various inputs and outputs. The DEA approach can assume either constant returns to scale (CRS) or variable

returns to scale (VRS) technology (Cooper *et al.*, 2000). Following Asmild *et al.* (2006), this study adopts a standard DEA as follows.

Assume a set of n production units, also called decision-making units (DMUs), and that m inputs are used to produce s outputs. The input and output vectors for $\mathrm{DMU_j}$, j=1,...,n, are expressed as $x_j = (x_{1j}, \ldots, x_{mj})^T$ and $y_j = (y_{1j}, \ldots, y_{sj})^T$, respectively. Let X be the (m x n) matrix of inputs and Y be the (s x n) matrix of outputs.

The production possibility set T is given as:

$$T = \{(x,\ y) | x \text{ can produce } y\} \tag{1}$$

Given the observed sets of inputs and outputs, $(x_j, y_j), j = 1, \ldots, n$, the production possibility set under VRS technology, which is also known as a CCR model (Charnes *et al.*, 1978), is expressed as follows:

$$T' = \left\{(\acute{x},\ \acute{y}) \middle| x \geq \sum_{j=1}^{\acute{n}} x_j \lambda_j,\ y' \leq \sum_{j=1}^{n} y_j \lambda_j,\ \acute{\lambda}_j \geq 0,\ \sum_{j=1}^{n} \lambda_j = 1\right\} \tag{2}$$

The input-oriented technical efficiency of is given by

$$\begin{aligned} &\min_{\theta} \theta \\ &\text{subject to} \\ &(\theta x_0,\ y_0) \in T \end{aligned} \tag{3}$$

Equation (3) is equivalently expressed as:

$$\begin{aligned} &\min_{\theta,\lambda} \theta \\ &\text{subject to} \\ &\theta x_0 \geq X\lambda \\ &y_0 \leq Y\lambda \\ &1^T\lambda = 1 \\ &\lambda \geq 0 \end{aligned} \tag{4}$$

The solution to Equation (4) provides the efficiency score for $\mathrm{DMU_0}$ under VRS technology. If the convexity constraint $1^T\lambda = 1$ is excluded from Equation (4), it expresses CRS technology, which is also called a BBC model (Banker *et al.*, 1984). The optimal θ indicates how efficiently inputs have been used to produce y_0. If θ<1, $\mathrm{DMU_0}$ is not efficient such that it can

proportionally reduce inputs by (1-θ), maintaining the same level of output, y_0.

DEA efficiency can be decomposed into pure technical efficiency (PTE) and scale efficiency (SE). The PTE obtained by solving the BBC model describes inefficiencies due to only managerial underperformance, while SE refers to an inappropriate choice of scale. So-called overall technical efficiency (OTE) corresponds to the CCR model and measures the inefficiencies arising from the input-output representation and size of production. The relationship $SE=\frac{OTE}{PTE}$ provides a measure of SE. If SE<1, DMU_0 is under increasing returns to scale (irs) technology and can improve SE by adding more inputs.

This study identifies the problems linked with data availability and quality, necessary for the DEA analysis. Unlike most European studies that used public database of the farm accountancy data network (FADN), dairy farm-based microeconomic data in Kazakhstan are quite rare and thus they should be mostly obtained by a targeted survey (Kaliyeva *et al*., 2020). Designing and conducting a survey is also confronted with a couple of common challenges. One has to do with poor bookkeeping by many peasant and household farms such that they often lack clear records of income, expenses, production and other documents. The other arises from the fact that dairy farms scatter all around the vast country, which makes conducting a personal interview survey and striking a balance in geographical regions quite difficult.

Against a backdrop of these limitations, a survey was designed and carried out from February to April in 2017. Participants in the survey were recruited by a university in Nur-Sultan, the capital of Kazakhstan through the Diary Committee meetings (10 samples). A recruitment email was also sent to members of various farm associations inviting them to participate in the survey (11 samples). Additional two questionnaires were secured from personal visits. Survey participation was voluntary without compensation. Participants totalled 23, covering nine out of the 14 oblasts in the country.

Table 3 provides the summary statistics for the output and input variables in 2015. The only output variable is milk production, while the input variables consist of labour hours, feed costs, and capital costs.

The relatively high standard deviation of the output and input variables for these Kazakhstan dairy farms reflects the heterogeneous farming conditions they face. Owing to the vast area of the country, the climatic and soil conditions are diverse; hence, the availability, accessibility, acceptability, and quality of feed and other input resources depend on farm-specific circumstances.

Table 3 - Summary statistics for input and output variables of sample farms

	Milk production (ton)	Labor hours	Feed costs (1,000 tenge)	Capital costs (1,000 tenge)	Milk production per cow (kg)
Average	43,687	266,235	60,750	53,137	4,317
Maximum	636,108	1,460,000	242,399	600,000	7,000
Minimum	305	360	1,000	0	1,969
Standard deviation	131,849	366,449	78,763	142,699	1,383

4. Results and discussion

Table 4 presents the efficiency scores for Kazakhstan dairy farms. The farms on the efficiency frontier show an efficiency score of one. Those with an efficiency score below one are defined as having inefficient production. According to the CCR model, DMU5, DMU6, and DMU13 are identified as having efficient production. In addition to these DMUs, the BCC model adds DMU13, DMU14, DMU15, DMU16, DMU17, and DMU21 as efficient farm units. The average OTE score of 0.188 for all sample farms indicates that they would have reduced the use of inefficient inputs by about 81% in their production. The average PTE score of 0.464 suggests that farms could have achieved the same level of milk production with a reduction in inefficient input use of about 54%. The average SE score of 0.296 implies that if inefficient farms change their scales in the most efficient way, they could cut the use of inputs by about 70%. In production technology, farms other than those on the efficiency frontier are subject to IRS.

As expected, the most efficient farms recorded greater average milk production with far lower labour hours and feed costs compared with inefficient farms. However, the higher capital costs incurred by efficient farms imply that they have relatively capital-intensive production systems (Table 5).

Unlike the promising DEA results, most Kazakhstan dairy farms suffer from unfavourable farming and market conditions as well as physical infrastructure constraints. Household dairy farms make the greatest contribution to overall production and their milk production costs are far lower than those of larger and modern dairy farms, each having 500 to 2,000 head of dairy cattle (FAO, 2011).

However, the existing gap in the production structure between households and agricultural enterprises causes a variety of problems. A chronic problem is that household farms lack access to industrial milk processing, mainly

Table 4 - Efficiency scores for Kazakhstan dairy farms

DMU	Region	OTE	PTE	SE	Returns to scale
1	Akmola	0.006	0.062	0.100	IRS
2	Akmola	0.062	0.237	0.261	IRS
3	Akmola	0.002	0.552	0.004	IRS
4	Akmola	0.048	0.106	0.451	IRS
5	Aktobe	1.000	1.000	1.000	CRS
6	Almaty	1.000	1.000	1.000	CRS
7	Almaty	0.168	0.438	0.383	IRS
8	East Kazakhstan	0.009	0.022	0.421	IRS
9	East Kazakhstan	0.002	0.045	0.033	IRS
10	East Kazakhstan	0.006	0.102	0.063	IRS
11	East Kazakhstan	0.004	0.042	0.097	IRS
12	East Kazakhstan	0.006	0.063	0.095	IRS
13	East Kazakhstan	1.000	1.000	1.000	CRS
14	East Kazakhstan	0.034	1.000	0.034	IRS
15	Karagandy	0.012	1.000	0.012	IRS
16	Karagandy	0.541	1.000	0.541	IRS
17	Karagandy	0.029	1.000	0.029	IRS
18	Kostanay	0.011	0.058	0.191	IRS
19	Pavlodar	0.012	0.034	0.359	IRS
20	Pavlodar	0.323	0.500	0.647	IRS
21	South Kazakhstan	0.042	1.000	0.042	IRS
22	Zhambyl	0.004	0.125	0.031	IRS
23	Zhambyl	0.005	0.278	0.018	IRS
Average	–	0.188	0.464	0.296	–

Note: CRS is constant returns to scale and IRS is increasing returns to scale.

because of their remote location and poor infrastructure for collecting, storing, and transporting fresh milk. Efficient aggregation and storing the small volumes of milk from widely dispersed household farms are a common challenge in many developing countries as well (FAO, 2014). Different food safety practices and qualities of raw milk across individual households create standardization and quality problems. GIS-based digital transformation and innovations can be a practical solution to overcome these inherent constraints.

Table 5 - Summary statistics of efficient and inefficient farms

	All (23 farms)		Efficient farms (3)		Inefficient farms (20)	
	Average	**Std. dev**	**Average**	**Std. dev**	**Average**	**Std. dev**
Milk production (ton)	43,687	131,849	299,304	240,408	5,345	7,165
Feed costs (1,000 tenge)	60,750	78,763	27,767	22,208	65,697	82,901
Labor hours	266,235	366,449	93,440	51,301	292,154	385,853
Capital costs (1,000 tenge)	36,965	121,504	203,757	280,224	11,946	20,003

Besides, the unstable feed supply between summer and winter and variable feed quality regionally are other difficulties faced by the dairy sector. As a result, feed is expensive and it's hard to get high-quality, compound feed. These unfavourable feed conditions correspond to the limited production capacity of premium dairy products. The industry needs to upgrade its supply chains and seek a holistic approach by facilitating bulk feed purchase by farmer groups, contract farming linking farmers to input and output markets, and improved institutional protocols. On the contrary, the fact that cows can be fed with natural feeds out of the country's rich plant diversities can create new opportunities in export markets.

According to the FAOSTAT, Kazakhstan is the 9th milk consumer in the world. The country's milk consumption per capita is 288kg in 2013. Despite its growth in exports over 2018-19, the country maintains a trade deficit in dairy products. Especially, finished dairy products are being imported because of the relatively high domestic milk price coupled with relatively low domestic milk quality compared with its neighbouring countries and European counterparts (Kazkenova *et al.*, 2015; OECD, 2013). Import demand for milk powder is also growing as the consumption of ultra-heat treated (UHT) milk is overtaking that of pasteurized milk. Since domestic milk quality is unsuitable for UHT milk, commercial processors increasingly use imported reconstituted milk powder to produce extended shelf-life milk.

Despite these limitations and difficulties, the Kazakhstan government is striving to modernize and develop the dairy sector. Under its masterplan for the 2013-20 period, the country aimed to construct 2,000 new dairy farms with stocks of 24-200 cows per farm (The Republic of Kazakhstan, 2013). These farms are expected to produce an extra 689,000 tons of milk annually with 187,000 milk cows by 2020. The government also signed a

roadmap that is intended to align the country's dairy safety standards with the Eurasian Economic Union (EAEU), the EU and China and to materialize export potentials for Kazakh producers (Cornall, 2019). Supported by the European Bank for Reconstruction and Development (EBRD) and the Food and Agriculture Organization (FAO), the move includes enhancing milk yields that are equivalent to its neighbouring countries, securing year-round availability and escalating milk safety parameters.

The development of "the Belt and Road Initiative (BRI)" can pave the way for the export potential of agricultural goods, including dairy products. By connecting China, Europe, Africa, and southeast Asia, the initiative is expected to increase transit volumes via Kazakhstan from 47,400 twenty-foot equivalent units (TEUs) in 2015 to 1.7 million TEUs in 2020, about 10% of the total EU-Asia transport volume (Samruk-Kazyna, 2017). In addition, Kazakhstan has several competitive advantages in terms of providing a one-country link between China and the Caspian Sea, furthering the bilateral partnership and cooperation with the EU, and improving the business-enabling environment for trade and investment.

Conclusions

Consistent with expectations, the DEA results suggest a dichotomy of productive efficiency among Kazakhstan dairy farms. Despite the existence of several efficient farms, which have relatively large production and capital-intensive technology, the production of many of the other farms surveyed lag far behind the efficiency frontier. This finding shed light on the importance of promoting inclusiveness through sharing knowledge and best practices within the industry. To bridge the gap between traditional safety practices and the global standards, the country needs to strengthen its commitment to improving the safety of raw milk and dairy products, developing the national monitoring system for animal health and production, and creating the regional dairy value chain, which would enhance the economic sustainability of many small-scale household farms.

Digital transformation and innovations at farms and supply chains, as illustrated by the case of the "Collect Mobile" app could help pave the way for optimizing core functions and links ranging from production to aggregation, processing, and distribution. Ultimately, the dairy industry needs a governance structure that manages the linkages across actors at each stage in the chain and creates enabling environments within the overall chain to be competitive in trade.

A favourable development in external environments including its accession to the WTO and EAEU is likely to expand trade networks and global value

chains for the dairy industry. Of particular importance for Kazakhstan is the creation of transport corridors that connects the country to China, Russia, Western Asia and Western Europe within the BRI. This could serve as a stepping stone to revamp the existing trade structure that depends on Russia and its neighbours.

This study has limitations that attempt to derive trade implications only through production efficiency at the farm level and related elements. Needless to say, many other factors, including product quality, brand and reputations, production and processing methods, and logistics are important determinants of trade. Caution is needed to interpret the empirical analysis since due to practice constraints, surveyed farms were not selected as randomized.

Research should continue in discovering the competitive potential of Kazakhstan's dairy products in a comprehensive manner, but this study is an important first step. Future research could analyse if Kazakhstan dairy farms are efficient in production relative to neighbouring economies, which can serve as a bridge to explore new trade avenues.

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Economia agro-alimentare /
Food Economy

An International Journal on Agricultural and Food Systems

Vol. 24, Iss. 1, Art. 4, pp. 1-17 - ISSN 1126-1668 - ISSNe 1972-4802
DOI: 10.3280/ecag2022oa12367

Short-Term Impact of a Zero Concentrate Supplementation on Organic Dairy Production

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Abstract

This study investigates the short-term economic impact of a zero-concentrate supplementation in organic dairy production systems with Holstein cows. Based on experimental data and using prices recorded in 2018 in Switzerland, the study calculates the difference in profits between two annual herbage-based feed rations: one supplemented with 750 kg and the other containing 0 kg concentrates per cow and lactation. The cut in concentrates led to a considerable increase in the average culling rate (14.4 percentage points). If it is assumed that the culling rate cannot be lowered by means of breeding or management adjustments, a zero-concentrate supplementation leads to a 375 CHF drop in profit per cow and year, which is equivalent to a 14% decrease in the remuneration of labor input. If the culling rate could be decreased to the status quo, then not feeding concentrates leads to a smaller, non-significant decrease in profits of 141 CHF per cow and year. Overall, it is concluded that there is a short-term trade-off between profitability and a reduction in concentrates. A zero-concentrate supplementation would be economically feasible only if the culling rate can be kept under control, for instance, by using adapted cow breeds. However, high-quality roughage is a prerequisite and may be more difficult to produce in alpine regions with less favorable production conditions.

Article info

Type:
Article
Submitted:
12/08/2021
Accepted:
27/11/2021
Available online:
18/02/2022

JEL codes:
Q13, D24

Keywords:
Organic Farming
Dairy Farming
Zero Concentrate Supplementation
Low-Input Strategy

Managing Editor:
Alessio Cavicchi

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Introduction

Different life cycle assessment studies have stated that the most environmentally friendly animal protein is produced by intensive production systems feeding monogastric animals (mainly pork and poultry) with grains (see Frehner *et al.*, 2020 for more detail). However, these studies miss the fact that large parts of the world's agricultural area is permanent grassland, which depends on ruminants to produce human edible food. Therefore, Van Zanten *et al.* (2018) are not the only ones to argue that "the role of animals in the food system should be centered on converting biomass that we [humans] cannot or do not want to eat into valuable products" (p. 4188).

With a share of 69% permanent grassland and alpine pastures in its total agricultural area (Altwegg, 2015), Switzerland's agriculture is predestined to use ruminants for food production. In accordance with Van Zanten *et al.* (2018), the Swiss government promotes the production of grass-fed meat and milk by means of a dedicated support program that requires that the feed ration consists of at least 90% roughage (Mack *et al.*, 2017). BioSuisse, the largest umbrella organization of Swiss organic farmers, will impose stricter rules and decrease the maximal share of concentrates in the annual ration of dairy cows from 10% to 5% by 2022 (BioSuisse, 2020a; FiBL, 2020). Although this limit is already ambitious, it would still be possible to go a step further and completely cut out concentrates from the ration of dairy cows.

While not feeding concentrates may decrease feed-food competition (Van Zanten *et al.*, 2018), the economic outcome is unclear, since decreasing milk yields combined with increasing cow health issues could turn out to be a serious economic impediment. On the one hand, a cut in concentrates decreases concentrate costs; on the other hand, roughage costs could increase, since cows would need to eat more roughage to offset the cut in concentrates. In the short-term, fertility could decrease because of the negative energy balance resulting from the reduced energy uptake. Reduced fertility not only incurs higher costs for insemination (and fertility treatment), but also leads to a decrease in the revenue from sold calves. Quite apart from the effects on animal health and fertility, the cost-benefit ratio of cutting concentrates may be different for different farms, depending on the cost per kg concentrate, the effect of concentrates on milk yield, and the milk price.

Existing studies have investigated the effect of a reduction in or the absence of concentrates in the feed ration. Delaby *et al.* (2009) and Leiber *et al.* (2017), for instance, worked with reduced (not necessarily zero) amounts of concentrates and focused on animal health, milk yield, and milk composition. Soder and Rotz (2001) calculated the influence of different feed rations on profitability in a U.S. context and found that the profit increases with increasing amounts of concentrates. Ertl *et al.* (2017) compared groups

of Austrian organic farms that fed different levels of concentrates in terms of production, animal health, and economics; they found no significant relation between the amount of concentrates fed and the marginal income per cow and year. However, no study has yet analyzed the short-term ceteris paribus effect of not feeding concentrates on the profitability of organic dairy production. This knowledge would help clarify if it were possible to quickly alter the feeding regime while not causing negative economic consequences. In addition, a ceteris paribus setup would allow the most important drivers for changes in profitability to be identified.

Based on a field trial conducted in Switzerland, this study investigates the difference in profitability between a feed ration containing 750 kg concentrates per lactation and a feed ration containing no concentrates (750 kg amounts to 10% of the feed ration per cow and year, given an average herd milk yield above 7000 kg; it is the maximally allowed share, according to the current standards of BioSuisse, until 31 December 2021; BioSuisse, 2021). For that purpose, the study monetizes the performance differences between the two treatment groups by means of standard prices provided by agricultural input suppliers and statistical institutions.

The research questions are:

1. What are the main drivers determining the economic performance of the production system that are influenced by a cut in concentrates?
2. Is a zero concentrate supplementation in the short term economically competitive against the status quo in organic dairy production?

2. Materials and methods

Experimental data

The analysis is based on data from a feeding experiment conducted from 2015 to 2018 on an organic farm in CH-1642 Sorens managing 105 ha agricultural area in the dairy sector (Schori and Münger, 2021). Located in the hill region, the farm represents 503 dairy farms producing under similar climatic conditions, out of the total of 1724 organic dairy farms counted in Switzerland in 2018. The annual base ration consisted of pasture, herbage, and hay. In total, 138 lactations from 92 Holstein cows divided into two different feeding regimes were analyzed. The first regime contained 750 kg concentrates per standard lactation (T750). The second feeding regime did not contain any concentrates (T0). Table 1 shows the number of observations according to the treatment and lactation.

Table 1 - Number of observations and milk yield according to the treatment and lactation

	Number of observations		Total milk yield [kg ECM[1]] per lactation		Weight of cow [kg]	
Lactation	**T750**	**T0**	**T750**	**T0**	**T750**	**T0**
1st	30	30	5868	4923	574	547
2nd	22	21	6123	5555	600	581
3nd	5	6				
4th	6	7				
5th	4	3				
6th	2	2				
3th to 6th (pooled)	18	17	6835	6150	651	657

Source: Authors' calculations based on experimental data.
1. Energy-corrected milk.

Every two weeks during lactation, milk yield was measured and the milk composition (fat, protein, lactose) was analyzed. The number of medical treatments was recorded and grouped in fertility, feeding, claw and leg, mastitis, milk fever, and various issues. In addition, the number of inseminations and the calving intervals were available for each cow and lactation. For the cows receiving concentrates, the amount of protein concentrates and energy concentrates was recorded. Roughage intake was not recorded and had to be estimated based on the intake of concentrates, milk yield, milk composition, body weight, and the pregnancy status of the cow (Agroscope, 2016; assuming 5.7 MJ NEL per kg dry matter of roughage, which is an average value of fresh grazed herbage and hay calculated from the feed analysis results of the experiment).

According to the experimental data, the culling rate of T0 was 14.4 percentage points higher than that of T750. Because the experimental data did not represent a typical herd structure, a different herd structure was assumed to calculate the economic impact of the different treatments (Table 2). Based on a typical Swiss herd structure (Gazzarin *et al*., 2005) with a culling rate of approximately 31%, the culling rates in T750 and T0 were assumed to be 23.5% and 37.9%, respectively.

Starting from the reference herd structure in Table 2, the herd structure was altered as follows: To increase the culling rate, the value of (100 – [probability of survival]) was increased by the same factor for all lactations.

To decrease the culling rate, the value of (100 – [probability of survival]) was decreased. Therefore, the relationship in terms of (100 – [probability of survival]) stayed the same between lactations. However, the probability of survival and the share of cows in different lactations changed. Decreasing the culling rate increases the share of older cows in the herd.

Table 2 - Assumed herd structure

Probability of survival [%]				Share [%]			
Transition	**Reference**	**T750**	**T0**	**Lactation period**	**Reference**	**T750**	**T0**
				1st	24.9	18.0	31.9
1st to 2nd	82.0	89.0	74.4	2nd	20.4	16.0	23.7
2nd to 3rd	86.0	91.5	80.1	3rd	17.6	14.7	19.0
3rd to 4th	72.0	82.9	60.2	4th	12.6	12.2	11.5
4th to 5th	72.0	82.9	60.2	5th	9.1	10.1	6.9
5th to 6th	68.0	80.5	54.6	6th	6.2	8.1	3.8
6th to 7th	65.0	78.6	50.3	7th	4.0	6.4	1.9
7th to 8th	65.0	78.6	50.3	8th	2.6	5.0	1.0
8th to 9th	50.0	69.5	29.0	9th	1.3	3.5	0.3
9th to 10th	50.0	69.5	29.0	10th	0.7	2.4	0.1
10th to 11th	50.0	69.5	29.0	11th	0.3	1.7	0.0
11th to 12th	50.0	69.5	29.0	12th	0.2	1.2	0.0
12th to 13th	50.0	69.5	29.0	13th	0.1	0.8	0.0
13th to 14th	0.0	0.0	0.0	14th	0.0	0.0	0.0

Source: Authors' calculations.
T0 = zero concentrate supplementation treatment.
T750 = treatment with 750 kg concentrate supplementation per cow and lactation.

Assumed Prices

To assess the economic impact of T0 compared to T750, prices had to be assumed for milk, sold calves, sold cows, replacement cows (in first parity), roughage, concentrates, and insemination. Prices were collected for the year 2018, because 2018 represents the most recent year in which the experiment was conducted. It was assumed that the dairy enterprise would not rear on its own, and thus replacing a cow resulted in revenue from selling the culled cow, costs related to buying a cow in her first parity, and revenue from selling a calf.

The cow replacement cost was assumed to be 3660 CHF per cow, whereas sold cows were priced at 3.98 CHF per kg live weight (BioSuisse, 2020b; agristat, 2018). Assuming that crossbreeds were sold for fattening, the price per calve with a 73 kg live weight was estimated to be 377 CHF (BioSuisse, 2020b; agristat, 2018; the optimal live weight for trading calves ranged between 70 and 75 kg in 2018). For roughage, a price of 0.369 CHF per kg dry matter was assumed (Swiss Farmers Union, 2020). The price of energy concentrates and protein concentrates was assumed to be 0.9065 CHF·kg^{-1} and 1.303 CHF·kg^{-1}, respectively (UFA, 2020). Energy-corrected milk (ECM; [kg ECM] = [kg Milk] · (0.38·[% fat] + 0.24·[% protein] + 0.17·[% lactose]) / 3.14; Agroscope, 2016) was priced at 0.8234 CHF·kg^{-1} (Federal Office for Agriculture, 2020). The cost per insemination was assumed to be 59.10 CHF (with the most popular meat breed used to inseminate Holstein cows; Swissgenetics, 2020). Medical treatments did not differ significantly between T0 and T750 in the experiment and were therefore not considered in the economic analysis.

Modelling and calculations

To make most use of the available data, data on each cow in a specific lactation that was recorded during the experiment was "extrapolated" to model all possible lactations during the potential lifetime of that cow. In other words, if data from three lactations of a specific cow were collected, the entire life of that cow was modelled three times. Upon transitioning from one lactation to another, the milk yield of each cow was adapted according to the typical increase in milk yield with increasing lactation, which is shown in Table 1. Because of the limited number of cows in lactations 3 to 6, these lactations had to be collapsed, and, thus, the milk output was assumed constant after the second lactation (e.g., an individual cow in the 750 kg treatment group with a 7000 kg milk yield in the second lactation was assumed to have 7000·5868/6123 = 6708 kg milk yield in the first lactation and a 7000·6835/6123 = 7814 kg milk yield in the third and all following lactations). The weight of the cows was modeled according to the same methodology. The roughage intake was calculated in each lactation (see also section 2.1), while the amount of concentrates, the number of insemination attempts, and the calving interval were held constant for each cow for all lactations. At the start of the lactation, the cow had to be less than 15 years old; otherwise, she was culled. In the last lactation of the cow, revenue was earned from selling the cow. In the first lactation, costs for the replacement of the cow were booked in addition to the revenue from selling the calf.

Using the previously mentioned prices, a cost-benefit analysis was calculated separately for each cow and lactation. Assuming the herd structures given in Table 2, the weighted average revenues per lactation from

selling milk, calves, and the cow, as well as the average costs for roughage, concentrates, insemination, and the replacement of the cow, were calculated. Because the calving intervals differed between the cows, revenues and costs were standardized to 365 days in order make the figures comparable between the cows. The difference in the net average profit per cow between the two treatments (T0 vs. T750) was analyzed by means of an analysis of variance (ANOVA).

Because the culling rate turned out to have a major impact on the resulting profitability, the analysis was carried out twice: once assuming that a reduction in concentrates increases the culling rate (herd structure information given in columns "T0" and "T750" in Table 2), as suggested by the experimental data, and once assuming that such an increase could be avoided in the longer term with managerial adjustments and adapted cow breeds (column "Reference" in Table 2).

Subsequently, a sensitivity analysis with regard to the price of milk, calves, replacement cows, culled cows, roughage, concentrates, and insemination was conducted. For each item, the price was changed by 10%, and the profit calculation was conducted once again. The effect of different culling rates on the profit was also analyzed. All calculations were carried out using R and its standard package suite (R Core Team, 2020).

Up until this point, the setup of the analysis only allowed for a comparison of the differences in profits between the two treatments (T0 vs. T750) and not calculating the total profit for each treatment. Therefore, the results of the analysis were amended by full costing data published by Hoop *et al.* (2017). Whenever possible, cost and revenue positions were adapted from 2010-2014 levels for 2018 using official price indices (Federal Office for Agriculture, 2020; agristat, 2019). This approach allowed for comparing the estimated total profit between the two treatments and calculating the remuneration of labor input.

3. Results

Effect of the Treatment

Table 3 shows the difference in profit, milk yield, and calving interval as well as the revenue and cost positions between T0 and T750. To set apart the influence of the different herd structure on profits from the influence of other factors, first, the results assuming the same herd structure in T0 and T750 will be discussed. Due to the significantly reduced milk yield (-786 kg ECM per year) in T0, the revenue from milk is significantly lower (-647 CHF per year). Not surprisingly, T0 benefits from a significant reduction in concentrate cost (-666 CHF per year). However, roughage costs are slightly increased (145 CHF

per year, also significant), and, therefore, the net feeding costs are 521 CHF lower in T0. Other revenue and cost positions either do not differ significantly between groups or are too small to mention. Overall, not feeding concentrates leads to a 141 CHF reduction in profits per cow and year when compared to the feed ration containing 750 kg concentrates per cow and lactation. This amounts to a decrease in profit of 0.188 CHF per kg concentrate not being fed or is the equivalent of reducing the milk price by 0.022 CHF per kg milk (-2.6%) assuming business as usual (with the initial milk yield feeding 750 kg concentrates). However, due to the observed variance in the sample, the numeric difference in profit is not significant at the 0.05 level.

Table 3 - Difference between the 750 kg (T750) and 0 kg (T0) treatment, i.e. [value in T0] – [value in T750], as well as probability values according to the ANOVA. The values refer to the attributes, costs, and revenues of a cow during a 365-day period

	Same herd structure	**Different herd structure**
Item	**T0 – T750**	**T0 – T750**
Total profit [CHF]	-141.1 .	-375.3 **
Revenue from milk [CHF]	-646.8 ***	-810.4 ***
Revenue from cows [CHF]	-20.2	271.8 ***
Revenue from calves [CHF]	1.8	50.1 ***
Cost of cow replacement	17.8	485.5 ***
Cost of concentrates [CHF]	-666.2 ***	-666.2 ***
Cost of roughage [CHF]	144.8 ***	87.9 **
Cost of insemination [CHF]	-20.5 .	-20.5 .
Milk yield per year [kg ECM]	-785.6 ***	-984.2 ***
Calving interval [days]	-8.4	-8.4
Weight at end of lactation [kg]	-13.8 .	-31.5 **

Source: Authors' calculations based on experimental data.
. Significant at the 0.1 level.
* Significant at the 0.05 level.
** Significant at the 0.01 level.
*** Significant at the 0.001 level.
T0 = zero concentrate supplementation treatment.
T750 = treatment with 750 kg concentrate supplementation per cow and lactation.

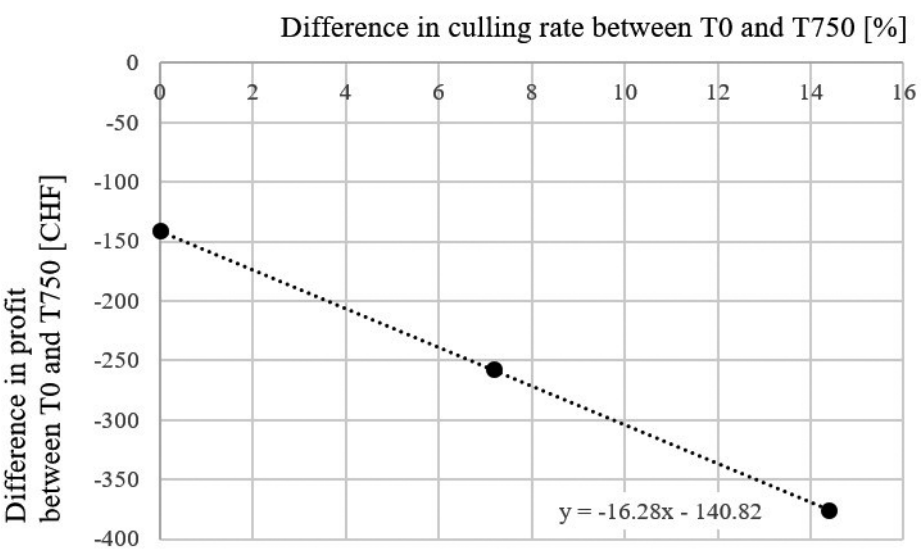
When a different herd structure (according to the average culling rates resulting from the experimental data) is assumed in T0 and T750, then the differences between T0 and T750 are considerably larger. T0 has an even

lower milk yield compared to T750, because, in T750, more cows are in advanced lactations. For this reason, cows in T750 are also significantly heavier at the end of the lactation. The higher culling rate in T0 leads to higher revenues from selling cows and calves but also increases the cost of cow replacement. Overall, not feeding concentrates leads to a 375 CHF reduction in profits per cow and year when compared to a ration containing 750 kg concentrates per cow and lactation. This amounts to a decrease in profit of 0.50 CHF per kg concentrate that is not being fed or is the equivalent of reducing the milk price by 0.057 CHF per kg milk (-6.9%) assuming business as usual (with the initial milk yield feeding 750 kg concentrates). This difference in profit is significant.

Sensitivity Analysis

Figure 1 shows the relationship between the assumed culling rate and the profit difference between T0 and T750. One additional data point was added between "same culling rate" (difference: 0%) and "different culling rates according to the experiment" (14.4 percentage points) to assess whether the relationship is linear. It turned out that the relationship is in fact linear. With each percent difference in culling rate, the profit gap between T750 and T0 increased by approximately 16.3 CHF.

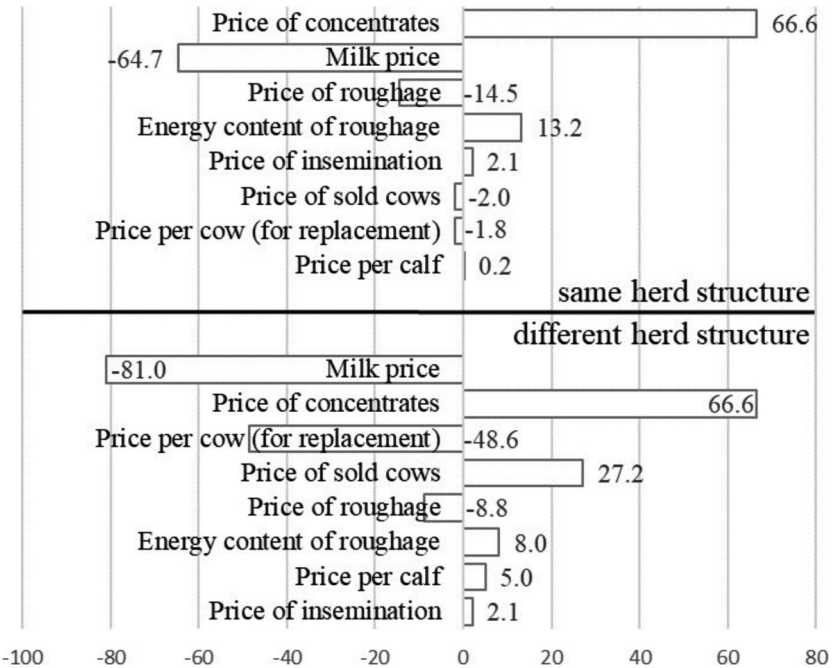
Figure 1 - Sensitivity analysis with respect to the culling rate



T0 = zero concentrate supplementation treatment.
T750 = treatment with 750 kg concentrate supplementation per cow and lactation.

Figure 2 shows the results of the sensitivity analysis with regard to prices. Positive numbers signify that the profitability of T0 compared to T750 improves. Assuming the same herd structures in T0 and T750, if the prices of concentrates were 10% higher, the profit gap between T750 and T0 would decrease by 66.6 CHF from 141.1 CHF to 74.5 CHF per cow and year. Almost equally influential – but with the opposite sign – is the milk price. A 10% increase in milk price would widen the profit gap between T750 and T0 to 205.8 CHF per cow and year. Because the cows in T0 ate more roughage than their counterparts in T750, a higher price for roughage would increase the profit gap between T750 and T0. The energy content of roughage inversely influences outcomes.

Figure 2 - Results of the sensitivity analysis. Influence of a 10% increase in different parameters on the resulting profit difference between the 750 kg (T750) and 0 kg (T0) treatment



Source: Authors' calculations based on experimental data.
T0 = zero concentrate supplementation treatment.
T750 = treatment with 750 kg concentrate supplementation per cow and lactation.

The calculations assuming different herd structures in T0 and T750 are more strongly influenced by the milk price, because, in T750, more cows are in advanced lactations and therefore have higher milk yields. If the milk price were 10% higher, the profit gap between T750 and T0 would amount to 456.3 CHF per cow and year. Because the culling rate is higher in T0, higher cow replacement prices deteriorate the profitability of T0 and therefore widen the profit gap between T750 and T0 by 48.6 CHF per 10% price increase. On the other hand, T0 benefits from more cows being sold, and, therefore, increasing the prices for slaughter cows would increase the profitability of T0 relative to that of T750. However, the effect is 44% smaller than the effect of increased prices for cow replacement.

Income statement

Table 4 contains the income statements of the dairy enterprise according to Hoop *et al.* (2017) as well as adapted income statements for T0 and T750. Assuming equal herd structures in T0 and T750, the changes in revenue and cost positions other than milk, concentrates, and roughage are of minor importance (as already pointed out in Table 3). Assuming different herd structures, T0 generates greater revenue from selling cows and calves (item "Other Revenues") but also has higher animal purchase costs.

Because of the considerable opportunity costs of labor (22.60 CHF per hour) assumed by Hoop *et al.* (2017) and the comparably low profitability of the dairy enterprise, when compared to other enterprises, such as crops, the imputed profit for all variants is clearly negative. When the herd structures do not differ between T0 and T750, remuneration of labor input amounts to 14.15 CHF per hour in T0, which is 4% lower compared to T750. Assuming different herd structures, remuneration of labor input decreases by 12% when no concentrates are fed. For the average Swiss milk producer with 23.8 dairy cows (Hoop *et al.*, 2019), a 4% reduction in the remuneration of labor input sums up to a 3624 CHF decrease in the yearly labor income (a 12% reduction results in a 9638 CHF decrease in yearly labor income).

Table 4 - Income statement of the dairy enterprise according to Hoop et al. (2017) and according to the 750 kg (T750) and 0 kg (T0) treatments. If not stated otherwise, all figures are in Swiss francs per livestock unit of the dairy enterprise (including rearing cattle)

		Same herd structure		Different herd structure	
	Hoop *et al.* (2017)	**T750**	**T0**	**T750**	**T0**
Total revenue	**7950**	**8334**	**7669**	**8388**	**7900**
Revenue from milk sold	3338	3723[a]	3076[b]	3777[a]	2966[b]
Other revenues	928	928	910[c]	928	1250[c]
Direct payments	3683	3683	3683	3683	3683
Total costs	**10347**	**10062**	**9538**	**10062**	**9949**
Direct costs	1633	1400	731	1400	1199
Concentrates	908	666[d]	0[b]	666[d]	0[b]
Veterinary expenses andinsemination	252	252	231[b]	252	231[b]
Animal purchase	128	137	154[b]	137	622[b]
Other direct costs	345	345	345	345	345
Imputed land rental cost	359	359	359	359	359
Joint costs	8356	8304	8448	8304	8391
Additional roughage cost	0	0	145[b]	0	88[b]
Labor, machinery, buildings	8356	8304	8304	8304	8304
Imputed profit	**-2397**	**-1728**	**-1869**	**-1674**	**-2049**
Total labor income	2500	3206	3065	3260	2885
Labor input [h/LU]	217	217	217	217	217
Remuneration of labor input[CHF/h]	**11.55**	**14.81**	**14.15**	**15.06**	**13.32**

Source: Hoop *et al.* (2017; Table 27) and authors' calculations based on experimental data. Nominal values of T0 and T750 were adapted using price indices (see section 3).

h = hours, LU = livestock units, CHF = Swiss francs.

a) Revenue adapted according to the milk yield in Hoop *et al.* (2017) and T750.

b) Revenue/cost adapted according to the difference between T0 and T750.

c) Revenue adapted according to the difference in sales of calves and culled cows between T0 and T750.

d) Cost was set to the actual cost of concentrates in T750.

4. Discussion

Compared to the organic dairying in Hoop *et al.* (2017), the results from the experiment show higher profitability, because the farms analyzed by Hoop *et al.* (2017) were located in mountainous regions. These farms produce under less favorable production conditions, which manifests in lower revenue from milk. Furthermore, the results of Hoop *et al.* (2017) refer to the whole dairy enterprise (including rearing), and, therefore, the system boundaries might not always be 100% consistent.

Some limitations regarding the representability of our findings should be pointed out.

In terms of size, the dairy farm on which the experiment was conducted – 109 ha managed primarily for research and educational purposes – is not representative of an average organic dairy producer in the same production region (24.1 ha agricultural area in 2018). This should not be of concern, however, because the assumed prices (costs) were derived from official data sources, so the analysis should not have been influenced by scale effects. The effect of assumed prices and costs on the results was in turn assessed by a sensitivity analysis. The findings from the sensitivity analysis allow the calculations to be adapted to the situation of other farms facing different conditions; hence, the results should be generalizable. Lastly, in terms of generalizability, the cow breed needs to be addressed.

In the experiment serving as the base for the economic evaluation, Holstein cows of Swiss (2/3 of the lactations) and New Zealand (1/3 of the lactations) origin were investigated. Because of the small number of lactations, the analysis could not be conducted separately for the different Holstein origins. It must be admitted that Holstein of Swiss origin may not be a cow type typically used in low-input systems. Different breeds may have different capacities to produce milk without concentrates. Management may also play an important role. This is supported by the results of Ertl *et al.* (2014), who did not find significant differences in marginal income (per cow and year) between groups of farms with different shares of concentrates in the feed ration. Indeed, farms not feeding concentrates managed herds with higher average cow age compared to farms feeding more than 1400 kg concentrates per cow and year. Ertl *et al.* (2014) also showed that farms not feeding concentrates tended to have lower veterinary costs per cow and year. Both findings are in contrast to our experimental findings and suggest that the negative impact of a zero concentrate supplementation is only relevant in the short-term but can be overcome by means of breeding and/or changes in management.

On the contrary, Soder and Rotz (2001) calculated that cutting concentrates considerably decreases profits. However, in Swiss agricultural markets,

the price of concentrates is high relative to the price of milk. This is even more pronounced in Swiss organic markets and makes a low-input strategy economically more attractive. In Germany, for example, the price of concentrates relative to the price of milk was 83% in 2019. In Swiss conventional markets, it was 94%, and, in Swiss organic markets, it was 111% (FAO 2020; Cerca *et al.* 2019:36; Federal Office for Agriculture, 2020; UFA, 2020).

Reducing roughage costs (increased grazing time, decreased share of conserved roughage) would make low-input strategies even more attractive, but as Ivemeyer *et al.* (2014) pointed out, high roughage quality is essential to succeed in reducing concentrates. As roughage quality depends on production conditions, cutting concentrates in the ration is easier to implement in regions with highly productive grasslands. In mountainous regions, where the energy content of roughage tends to be lower, this could be challenging.

5. Conclusions

The culling rate, milk price, and price of concentrates are crucial for the economic success of a zero-concentrate supplementation. The lower the milk price and the higher the price for concentrates, the more attractive cutting concentrates in the feed ration becomes. If a cut in concentrates considerably increases the culling rate, a zero-concentrate supplementation is not competitive against a 750 kg supplementation. When the culling rate is kept constant, not feeding concentrates may be economically equivalent to feeding 750 kg per cow and standard lactation.

In the setting analyzed, there is a short-term trade-off between profitability and a zero concentrate supplementation; however, the literature suggests that this trade-off can be overcome given that the farm is able to produce high-quality roughage, and management and cow breeds are geared toward a low-input production paradigm.

We conclude that a zero-concentrate supplementation according to the "feed no food" principle should be feasible in organic dairying, but only if the production system is gradually changed. Because the total amount of organic milk produced in Switzerland could decrease due to a mandatory cut in concentrates, there is even a chance of lower milk yields being (partially) offset by a higher equilibrium milk price. Further research would be necessary in order to determine the robustness of our findings with regard to other cow breeds.

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Economia agro-alimentare /
Food Economy

An International Journal on Agricultural and Food Systems

Vol. 24, Iss. 1, Art. 8, pp. 1-21 - ISSN 1126-1668 - ISSNe 1972-4802
DOI: 10.3280/ecag2022oa12888

Asymmetric Price Transmission in the Cocoa Supply Chain in Indonesia

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Abstract

This study investigates the asymmetric price transmission (APT) of global cocoa beans and cocoa pasta prices to farm prices. The cocoa pasta variable is a proxy for Indonesian processed cocoa industry products. We use monthly time series data from January 2007 to December 2020. The NARDL model was used to estimate the APT response behavior. The dummy variable (export cocoa bean tax) explains fluctuations in farm prices before and after the policy implementation. The results showed asymmetric cointegration between the global cocoa market and cocoa pasta prices moving towards farm cocoa prices in Indonesia. APT occurs in the short and long term with different significant levels for each variable. The increase (decrease) in the global market and cocoa pasta prices were transmitted asymmetrically in the short and long terms, except for the variable (PA-pos), which is not significant in the long term. We observe strong evidence of negative asymmetric price transmission. Negative price shocks (decreases) in global markets and cocoa pasta are more rapidly transmitted to farmer prices than positive price shocks. Adjustment prices occur in magnitude, speed, and sign. The high coefficient of negative asymmetric price transmission indicates the uncompetitive of Indonesia's supply-demand cocoa chain. At the same time, the cocoa bean export tax harms farm prices. The export tax policy has reduced farm prices by approximately 2.3%.

Article info

Type:
Article
Submitted:
12/11/2021
Accepted:
07/04/2022
Available online:
31/05/2022

JEL codes:
C13, Q13, Q17

Keywords:
Market integration
International trade
Producer price
NARDL

Managing Editor:
Stefanella Stranieri

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Introduction

Price is the essential mechanism that links the various levels of the market. The study of vertical and horizontal price transmission allows for estimates of the market's entire activity (Vavra & Goodwin, 2005). The focus of this study was prompted partly by societal and political concerns about the food industry and distribution sector's concentration. These changes may impact the competitive position of market participants and price dynamics (Hassouneh *et al*., 2015). The magnitude and speed of the coefficient are the market's ability to change prices and the intensity of competition in the agricultural marketing chain (Meyer & von-Cramon-Taubadel, 2004; Trestini & Penone, 2018).

Smallholder farmers in developing countries act as price takers, meaning they do not have a bargaining position on the price of their products (Jambor *et al*., 2017). Many observers believe that intermediaries are more likely to cut prices than raise them. As a result, a rise in global prices may not be entirely passed on to farm prices, but a decrease in world prices is more likely to be fully passed on to farm prices (Usman & Haile, 2017). The discrepancy in the response of positive and negative shocks from upstream to downstream or vice versa is called asymmetric price transmission.

Asymmetric price transmission (APT) exists in agricultural markets, but the transmission differs based on commodities, countries, and market movements (Mclaren, 2015). APT can occur in the short and long term depending on the stochastic process that governs the price (Rezitis & Tsionas, 2019). Short-term APT is intended to compare the intensity of output price variations with positive and negative price changes in the input variables. Long-term APT is used to look at reaction time, the length of fluctuation, and the speed at which prices move toward an equilibrium level (Frey & Manera, 2007; Mclaren, 2015).

Two types of price transmission are horizontal and vertical. Horizontal price transmission is the large amount of disparate information that moves between markets. At the same time, vertical transmission is price movement along the supply chain (Vavra & Goodwin, 2005). Vertical transmission can describe the price adjustment mechanism between upstream and downstream markets (Chaudhry & Miranda, 2020). Price transmission relationships are typically characterized by price adjustments' speed, direction, and magnitude toward market shocks (Meyer & von-Cramon-Taubadel, 2004).

Several studies have investigated the asymmetric adjustment of vertical and horizontal price processes along supply and demand chains, and the results vary. Rezitis (2018), studies the vertical transmission among livestock and retail for various dairy products in Finland. Panagiotou (2021) tested the asymmetric vertical price transmission in the United States agricultural

market, asserting that positive shocks to producers and distributors of prices are transmitted to retail at a more significant and faster rate than negative shocks in the long term. Korale *et al.* (2016) and Alam *et al.* (2016), found the presence of APT on the rice markets from upstream to downstream in Sri Lanka and Bangladesh. However, the opposite is not a rule.

Several works of literature examine horizontal price transmission, considering the relationship between domestic spot prices and global markets (Arnade *et al.*, 2017; Baffes & Gardner, 2003; Bekkers *et al.*, 2017). Several studies examine vertical price transmission (Acharya *et al.*, 2011). Some studies examine the transmission of future prices to the domestic spot market in agricultural commodities (Trestini & Penone, 2018). Many scientific studies have identified asymmetry in the adjustment of aggregate prices, which has prompted economists to study this phenomenon more in depth (Mclaren, 2015). Studying the transmission of commodity prices provides an outlook about the efficiency of markets and the welfare distribution of consumers and producers (Meyer & von-Cramon-Taubadel, 2004).

Furthermore, Kamaruddin *et al.* (2021), found an asymmetric price transmission between coffee prices in the international market to producers in Indonesia in the long term and short term. In addition, Fafchamps & Hill (2008) found that itinerant traders are the primary source of asymmetric price transmission from global markets to agricultural markets in Uganda. Bonjean & Brun (2011), confirm that the price of chocolate bars in France does not always react to fluctuations in global cocoa bean prices. High adjustment costs and stock management may partly explain this. In the 1970s, the boom in world cocoa bean prices was responded to quickly by the increase in the price of chocolate bars in France. On the other hand, the chocolate industry sector was very slow in responding to the drastic decline in world cocoa bean prices in the 1980s.

In the past, APT has reflected a failure of the market in microeconomics. Each external shock to the market price, either positive or negative, should result in a linear adjustment to the long-term market equilibrium (Frey & Manera, 2007). However, recent literature on APT can appear in perfectly competitive markets. Hence, it is inappropriate to deduce APT to reflect the market failure (Gizaw *et al.*, 2020). Because of the essence of this phenomenon, the researcher investigates what causes asymmetric price transmission. According to Meyer & von-Cramon-Taubadel (2004), market power, search costs, food adjustment costs, the trait of agricultural goods, and inventory storage can cause APT.

The typical explanation for price variations of agricultural products depends on the variations of market integration. The degree of market integration is a function of the magnitude of trading costs, which are often strongly influenced by government policies (Bekkers *et al.*, 2017). Indonesian

government's policies have ratified export duties on cocoa beans since April 2010. Several studies have examined the impact of export taxes on domestic cocoa bean prices, such as Hasibuan & Sayekti (2018), Yudyanto & Hastiadi (2019) and Rifin (2015). The findings showed that the export duty had no significant effect on the price of cocoa beans at the farmers' level.

There is no research from all the studies above that analyzes the farmer's cocoa beans price in Indonesia through the asymmetric model. The cocoa pasta variable in the model is essential for explaining the relationship between the upstream and downstream sectors after the cocoa bean export tax is implemented. This model is significant to get more accurate analysis results.

Prices play an essential role in a market economy. Price volatility has severe implications for the economic well-being of various agents in the distribution management of agricultural products. Therefore, it is necessary to study price transmission to provide recommendations for policymakers. This research is noteworthy as price transmission will be seen from two sides, namely international cocoa bean prices (horizontal) and processed cocoa prices (vertical), combined in one analysis model.

The objectives of this study were (1) to examine the asymmetric price transmission of global cocoa bean and cocoa pasta prices to farmers' cocoa prices. (2) to determine the impact of the export tax policy on the fluctuations of cocoa farmers' prices

This paper contributes to the literature: (i) there are still few studies related to cocoa price transmission with asymmetric models in Indonesia. (ii) to fill the literature gap on the price transmission of processing cocoa industry products and farmers' cocoa prices in Indonesia, which is considered vital after the export tax implementation. Therefore, this paper can assist policymakers, academicians, and stakeholders, mainly related to the asymmetric price of cocoa in the domestic market.

The rest of the paper is organized as follows. Section 1 highlights the background. Section 2 is materials and methods. Section 3 is results and discussions, and Section 4 concludes the study.

1. Background

Indonesia is categorized as a developing country with a GDP per capita of USD 3,870 and the fourth most populous country globally (World Bank, 2020). The cocoa plantation sector plays an essential role in the Indonesian economy since it employs 900,000 farmers, with a cocoa production area of 1.6 million hectares. The people manage 87.4% of the plantation while large state-owned and private companies control the rest 12.6%. The average cocoa production is around 500,000 tons per year. Meanwhile, the number of

exports of cocoa and its derivative products is USD 2 billion (BPS-Statistics Indonesia, 2021). It contributes to poverty reduction by providing employment and income in rural areas (Pratama *et al*., 2019).

The government implemented a cocoa revitalization program from 2009 to 2013 (known as the national movement for cocoa) to increase declining cocoa production and productivity. The decline in production was due to the oldness of trees and diseased cocoa plants. The average cocoa productivity in Indonesia is around 650 kg per hectare. It is still far from the ideal capacity, which can reach up to 1,500 kilograms per hectare. This program targets 450,000 hectares of land in 25 provinces in Indonesia through rejuvenation, intensification, farmer empowerment, disease control, and cocoa quality improvement (Ministry of Agriculture, 2015). The national movement for cocoa program also supports the availability of raw materials for the processed cocoa industry and improves the welfare of farmers by increasing production (Ariningsih *et al*., 2019; Pratama *et al*., 2019).

Cocoa commodities have been exported since the 1980s, especially dominated by cocoa beans (Hasnah *et al*., 2011). Since 2010, the Indonesian government has imposed a cocoa bean export tax to support the domestic cocoa processing industry's raw materials. After implementing the export tax, cocoa bean exports decreased dramatically, and processed cocoa exports showed an increasing trend yearly, especially pasta, butter, and cocoa powder (Rifin, 2015).

According to data from BPS-Statistics Indonesia, farmers' cocoa prices are around 40-65 percent of the world market price. Over the past five years, the average cocoa price for Indonesian farmers has been around Rp. 20,700/kg up to Rp. 33,000/kg. The price of cocoa beans also varies in each province.

Several factors that affect farmers' cocoa prices include the quality of the cocoa beans (Hasnah *et al*., 2011; Pratama *et al*., 2019), the currency exchange rate, and price fluctuations in the global market (Mukhlis *et al*., 2020; Rifin, 2015). Meanwhile, the presence of a solid intermediary agent (Mclaren, 2015), and the lack of a role for farmer cooperatives (Hasnah *et al*., 2011) can also drive prices inefficiently. In addition, the demand for the cocoa processing industry dramatically affects the price of cocoa beans in the domestic market. Therefore, the market connection between the domestic processed cocoa industry and the price of cocoa farmers is determined by the level of price transmission.

2. Materials and Methods

We examined the monthly price series for January 2007 to December 2020, available online. The data from the Statistics Indonesia (BPS), the International Cocoa Organization (ICCO), and the International Trade Center

(ITC). In addition, we use the export tax policy of cocoa beans as a dummy variable to observe the price fluctuations of cocoa beans at the farm level before and after the performance. This policy has been valid from April 2010 until now.

Table 1 - Descriptive Statistics (raw data are in US$/100kg)

Variables	Mean	Max	Min	Std. Dev
fp	169.79	230.76	103.15	29.38
gp	260.64	352.51	170.00	44.48
pa	235.78	400.57	55.56	92.30
lnfp	5.12	5.44	4.64	0.18
lngp	5.55	5.86	5.14	0.17
lnpa	5.36	5.99	4.02	0.51

Source: Author's elaboration.

Where *fp* = farmer's cocoa bean price, *gp* = global/international cocoa bean prices, *pa* = cocoa pasta price, and *ln* = the natural logarithms, respectively.

This paper applies the nonlinear autoregressive distributed lag (NARDL) model developed by Shin *et al.* (2014). NARDL is a dynamic and regression model with distributed lag used to analyze the relationship between dependent and independent variables. This model can capture the effects of regressor variables in a more flexible structure. Additionally, researchers can identify the time required to adjust the impact of shocks on the model. The NARDL specification analyses non-stationary and nonlinear issues in the context of an unrestricted error correction model (Panagiotou, 2021).

NARDL is a derivative of the standard ARDL linear cointegration model. In fact, in this model variable z_t is decomposed into (z_t^+) and (z_t^-) which is described by Shin *et al.* (2014) as follow:

$$z_t = z_0 + z_t^+ + z_t^- \tag{1}$$

where z_t^+ and z_t^- are partial sum positive and negative changes of independent variables.

$$z_t^+ = \sum_{j=1}^{t} \max\left(\Delta z_{it,j}^+, 0\right) \tag{2}$$

$$z_t^- = \sum_{j=1}^{t} \min\left(\Delta z_{it,j}^-, 0\right) \tag{3}$$

Therefore, the asymmetrical relationship in long term equilibrium is expressed as:

$$y_t = \varphi^+ z_t^+ + \varphi^- z_t^- + e_t \tag{4}$$

Where φ^+ and φ^- are asymmetric long term parameters and z_t is the vector kx1 of the decomposition of the regressors. Combining equation (4) with the ARDL model equation (p,q) as performed by Pesaran *et al.* (2001), the nonlinear ARDL model (p,q) becomes:

$$\Delta y_t = \alpha + \sum_{i=1}^{p} \beta_0 \Delta y_{t-i} + \sum_{i=0}^{q} \beta_1^+ \Delta z_{t-i}^+ + \sum_{i=0}^{q} \beta_2^- \Delta z_{t-i}^- + \varphi_0 y_{t-i}^+ + \varphi_1^+ z_{t-i}^+ + \varphi_2^- z_{t-i}^- + \varepsilon_t \tag{5}$$

The letters p and q capture the lag orders for the dependent variable (y_t) and the independent variables (z_t) in the distributed lag section. Substitute $z_{t,j}^+$ and $z_{t,j}^-$ variables in equations (2) and (3) similarly ($lngp^+$, $lngp^-$, $lnpa^+$, $lnpa^-$) to get the unrestricted as well as long- and short-term of the nonlinear autoregressive distributed lag, a dummy variable will be added to this model. The dummy variable consists of 0 and 1 (0 means before the export tax policy implementation and one after its performance). The lag order has been selected starting with max $p,q = 6$. The NARDL model as:

$$\Delta lnfp_t = \alpha + \sum_{i=1}^{p} \beta_0 \Delta lnfp_{t-i} + \sum_{i=0}^{q} \beta_1^+ \Delta lngp_{t-i}^+ + \sum_{i=0}^{q} \beta_2^+ \Delta lngp_{t-i}^- + \sum_{i=0}^{q} \beta_3^+ \Delta lnpa_{t-i}^+ + \sum_{i=0}^{q} \beta_4^+ \Delta lnpa_{t-i}^- + \varphi_0 lnfp_{t-1} + \varphi_1^+ lngp_{t-i}^+ + \varphi_2^- lngp_{t-i}^- + \varphi_3^+ lnpa_{t-i}^+ + \varphi_4^- lnpa_{t-i}^- + du_{t-1} + \varepsilon_t \tag{6}$$

The variables $lngp^+$, $lngp^-$, $lnpa^+$, and $lnpa^-$ are partial sum positive and negative in *lngp* and *lnpa* as equations 2 and 3 above. (φ^+ and φ^-) is a vector of long term parameters to be estimated. $\sum_{i=0}^{q} \beta_i^+ \Delta z_{it-i}^+$ and $\sum_{i=0}^{q} \beta_i^- \Delta z_{it-i}^-$ the short term effect will be estimated coefficient for each of the first differences. (du) is dummy variable and (ε_t) is residual, Δ is difference operator of variables.

Wald's test was conducted to test the short term and long term asymmetry hypothesis. The short term symmetry of the null hypothesis (H_0: $\beta_i^+ = \beta_i^- = 0$), and the long term ($H_0$: $\varphi_i^+ = \varphi_i^- = 0$). The F statistics and critical values are used to explain the null hypothesis. If H_0 is rejected, there

is an asymmetric price transmission. The error correction model of equation (6) as:

$$\Delta lnfp_t = \alpha + \sum_{i=1}^{p} \beta_0 \Delta lnfp_{t-i} + \sum_{i=0}^{q} \beta_1^+ \Delta lngp_{t-i}^+ + + \sum_{i=0}^{q} \beta_2^- \Delta lngp_{t-i}^- + \sum_{i=0}^{q} \beta_3^+ \Delta lnpa_{t-i}^+ + \sum_{i=0}^{q} \beta_4^- \Delta lnpa_{t-i}^- + du_{t-1} + \rho\xi_{t-1} + \varepsilon_t \quad (7)$$

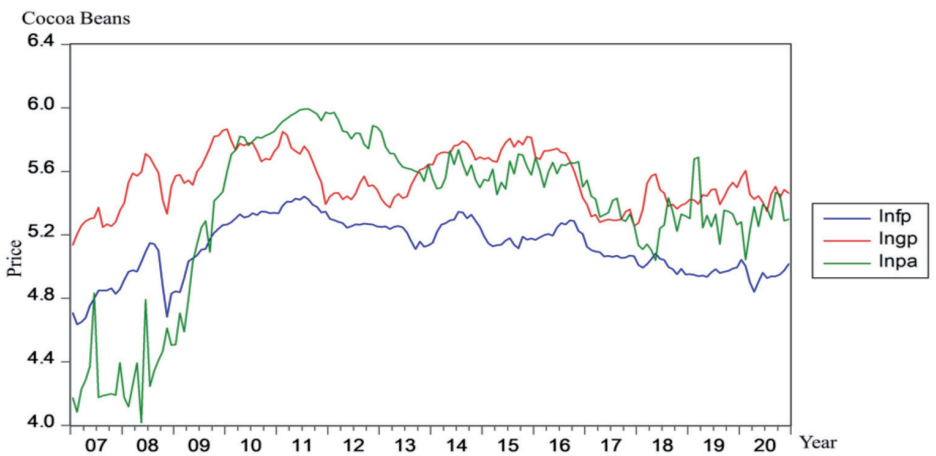
The error correction term is (ξ_{t-1}) shows the speed of price adjustment towards long term equilibrium after a short term price shock.

The NARDL approach has several advantages: (1) it enables asymmetric and cointegration models in the same equation. (2) it can be applied to a small sample size. (3) it can be applied to the integrated variables I(0) and I(1), or a combination of the two (Shin *et al.*, 2014). Besides that, this model can also use lags on both the independent and dependent variables, which makes it a more flexible model.

3. Results and Discussions

Price fluctuations in global markets and the speed of transmission of export prices have an important influence on farmers' income (Mclaren, 2015). The fluctuations in farmers' cocoa bean prices (FP), world cocoa bean prices (GP), and Indonesia's cocoa pasta export prices (PA) can be seen in Figure 1.

Figure 1 - The natural logarithms of farm, global cocoa prices, and cocoa pasta



Source: Authors' elaboration on BPS, ITC, ICCO data (2021).

Fluctuations in the prices of these three commodities from 2007 to 2020 tend to have varied movements. The visual observation of the graph may have a cointegration relationship and asymmetric price transmission in the data.

As a starting point, ensure that none of the variables integrated order I(2). We use Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) for the unit root test. The optimal lag structure of the ADF is reached on the Schwarz information criterion (SIC). The optimal lag of the PP is selected on the Newey-West bandwidth with Bartlett weights. The null hypothesis is rejected if the critical value is greater than the statistical test (p-value less than the significant level). The findings are in Table 2.

Table 2 - Unit root tests

Variables	**ADF Test**		**PP test**	
	C	**C/T**	**C**	**C/T**
lnfp	0.027 (lag = 1)**	0.078 (lag = 1)*	0.129 (lag = 1)	0.303 (lag = 2)
lnpa	0.108 (lag = 1)	0.613 (lag = 1)	0.137 (lag = 5)	0.650 (lag = 5)
lngp	0.036 (lag = 1)	0.090 (lag = 1)	0.038 (lag = 2)	0.104 (lag = 1)
Dlnfp	0 (lag = 0)***	0 (lag = 0)***	0 (lag = 2)***	0 (lag = 4)***
Dlnpa	0 (lag = 0)***	0 (lag = 0)***	0 (lag = 3)***	0 (lag = 6)***
Dlngp	0 (lag = 0)***	0 (lag = 0)***	0 (lag = 3)***	0 (lag = 4)***

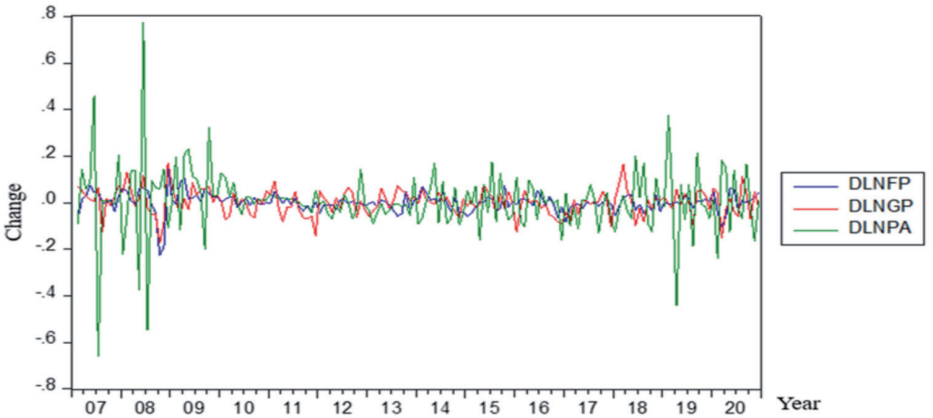
Notes: (D) is the first difference operator. (C) is constant. (C/T) is constant and linear trend. (*, ** and ***) indicate significant at 10%, 5%, and 1%, respectively.

Source: Authors' elaboration.

Figure 2 shows price movement after data changes to the first difference relatively more stable. The output in Table 2 shows that rejecting the null hypothesis of non-stationary price series in levels for all variables except (lnfp) in the ADF test is significant at 5% level. Therefore, tests on first differences I(1) show that all variables are significant at 1% level. This finding allowed us to run a cointegration test.

The cointegration test (Table 3) shows that the value of F-statistics is 19.525, which is greater than the critical value for 1%. The null hypothesis of no cointegration is rejected, which means the variables are cointegrating in the long term among the selected variables. Therefore, we can investigate cocoa price fluctuations in the NARDL cointegrating framework. Accordingly, we estimate equation (5), and the maximum lag order considered is six.

Figure 2 - First difference in the natural logarithms of the Indonesia cocoa supply chain



Source: Authors' elaboration on BPS, ITC, ICCO data (2021).

Table 3 - Bounds test for nonlinear cointegration

F-Statistics	5% level		1% level		Conclusion
	I(0)	I(1)	I(0)	I(1)	
19.525***	2.56	3.49	3.29	4.37	co-integration

Notes: *** significant at 1% level.

Before concluding the estimation results, various diagnostic tests were carried out to ensure the NARDL model was valid (Table 4, part c). The coefficient value of R2 (0.649) shows that 64.9 percent of the price variation of cocoa farmers is affected by the prices in the global market (GP) and cocoa pasta price (PA).

The normality of the residual term uses Jarque-Bera (JB) test. The Breusch-Godfrey serial correlation LM for the autocorrelation and heteroscedasticity tests used ARCH statistics. The NARDL model is well specified because the residuals are normally distributed. There is no heteroscedasticity and no serial autocorrelation in the models.

The asymmetric test using the Wald test shows an asymmetric relationship in price transmission on all variables except the PA-pos variable in the long term. Therefore, the nonlinear autoregressive distributed lag approach used in this research can provide more extensive and accurate information. The lag selected models are (2, 3, 1, 6, 4). The model estimation results, long-run equilibrium, and diagnostic tests, respectively, are presented in Table 4.

Table 4 - The NARDL estimation and diagnostic results

Variables	Coefficient	t-stat	Probability
Part A. Short-term asymmetric			
C	0.021**	2.491	0.038
D(LNFP(-1)	0.158**	2.019	0.045
D(LNFP(-2)	-0.150**	-2.008	0.047
D(LNGP_POS)	0.202**	1.940	0.054
D(LNGP_POS(-1)	-0.211**	-2.021	0.045
D(LNGP_POS(-3)	0.222***	2.528	0.013
D(LNGP_NEG)	0.307***	3.374	0.001
D(LNGP_NEG(-1)	0.318***	3.473	0.000
D(LNPA_POS(-1)	0.071*	1.931	0.056
D(LNPA_POS(-4)	-0.122***	-3.230	0.001
D(LNPA_POS(-6)	0.063*	1.923	0.056
D(LNPA_NEG(-4)	0.135***	3.638	0.000
DU	-0.023***	-2.287	0.025
Part B. Long-term relations			
D(LNGP_POS)	0.323*	1.802	0.073
D(LNGP_NEG)	0.629***	5.293	0.000
D(LNPA_POS)	0.079	0.761	0.448
D(LNPA_NEG)	0.178**	1.967	0.051
Part C. Statistics and diagnostics			
ECT	-0.992***	-11.018	0.000
R^2	0.649		
Jarque-Bera (J-B)	0.042		0.979
Serial Correlation LM test	0.435		0.804
Heteroskadisticity (ARCH)	4.607		0.100
$W_{LR}PA$	0.659		0.418
$W_{LR}GP$	6.568***		0.012
$W_{SR}PA$	3.794**		0.053
$W_{SR}GP$	9.444***		0.002
Cusum	Stable		
CusumSQ	Stable		

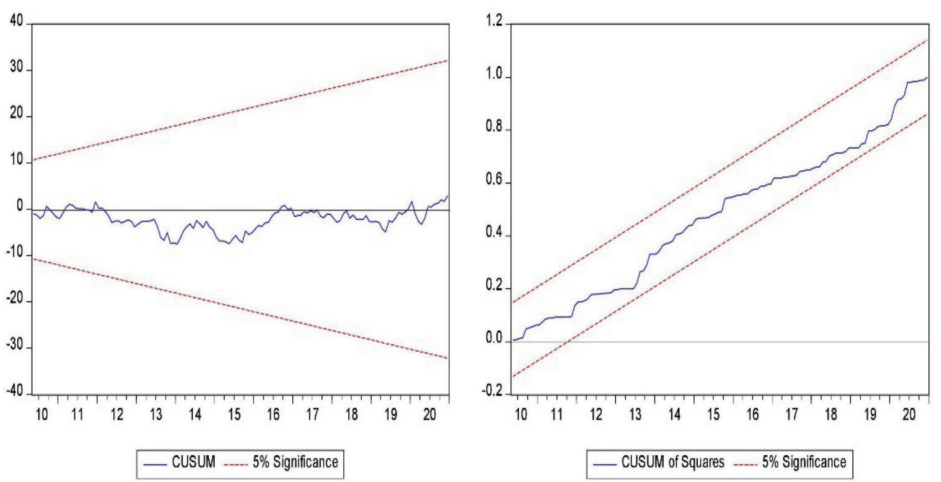
Notes: *, ** and *** indicate significant at 10%, 5%, and 1% level, respectively. W_{LR} is Wald test for long term. W_{SR} is Wald test for short term.

The error correction term (ECT) values are statistically negative and significant, indicating an adjustment towards price equilibrium in the model. The high ECT value indicates a high speed of adjustment to the long term equilibrium and vice versa. The ECT value is -0.992, significant at 1% level. The high value of ECT proves the existence of convergence from short term to long term balance. Meanwhile, this value indicates the rapid adjustment of farmers' cocoa prices due to the well-developed transportation and communication infrastructure.

Other reasons related to the high-speed adjustment can be presented as follows: First, infrastructure development to support the distribution of agricultural products in Indonesia. In the last decade, the development has been carried out on a large scale, integrating rural areas into broader markets in cities. Thus, the link between these regions can reduce logistics costs (McCawley, 2015; Sandee, 2016). It can also reduce the costs incurred by marketing agents, and the prices received by farmers can be higher. Second, farmers can obtain as much information as they can access on the internet. Farmers can find the accurate and up-to-date price of cocoa beans traded in domestic cocoa trading centers, thus reducing their chance of being manipulated. According to Nabhani *et al.* (2015), information technology has made it easier for farmers to increase transactions and access information about the latest market needs.

In order to analyze the structural stability of estimated models, the CUSUM (cumulative sum) and CUSUM-SQ (cumulative sum of squares) tests are used. The results are presented in Figure 3. It indicates that it does

Figure 3 - Cusum and Cusum-SQ



not cross the determined bounds. It demonstrates the stability of the estimated coefficient because CUSUM and CUSUM-SQ are at a significance level of 5% in determining bounds.

Price Transmission of the Global Market and Pasta Cocoa Prices to Farm Price

The NARDL estimation results show that in the long term (Table 4, part B), a 1% rise in the global market prices will fall farmers' cocoa prices by 0.32%. Otherwise, a 1% fall in the global market prices will reduce farmers' prices by 0.63%. The difference in the magnitude of the price transmission coefficient is doubled.

In the short term (Table 4, part A), all variables significantly affected the cocoa farmers' price when the positive (negative) shocks were significant at 10, 5, and 1% level. Price transmission is asymmetric in the short term due to the response to price increases (decreases) at different lags. The negative shock is larger in magnitude than the positive shock. 1% price increase in global price (GP-Pos) makes farmers' price increase 0.20%, for a 5% significant level. Meanwhile, a 1% decline in global prices (GP-neg) will reduce farmers' cocoa prices by 0.31%, for a 1% significant level.

The results of pasta cocoa (Table 4, part B) In the long term, a 1% decrease in cocoa pasta prices (PA-neg) brings down the farm price by 0.17%. On the other hand, the increase in the price of cocoa pasta (PA-pos) is not transmitted to farmers' prices, and this can be seen from the probability value being insignificant (greater than 10% significant level). Meanwhile, in the short-term (Table 4, part A), a 1% positive price shock for pasta cocoa (PA-pos) will increase farmers' cocoa prices by 0.07%. Meanwhile, negative price shocks (PA-neg) were transmitted to farmers' cocoa prices by 0.14%.

Characteristics of price movements in the cocoa distribution chain indicate a lag time and asymmetries. The decline in global market prices and the price of cocoa pasta spread to farmers' prices more quickly. On the other hand, slower transmission is channelled to farmers' prices when there is a positive shock (price increases). This difference can be seen from the magnitude of the coefficient, speed, and sign. Overall, the empirical findings indicate that global cocoa bean prices are the main driver of farm-level prices.

The Paths of Asymmetric Adjustment

The difference in magnitude (GP-Pos and GP-Neg) and (PA-pos and PA-neg) becomes the essential point in this paper. There is sturdy proof of asymmetric price transmission (APT) on the price in the farmer's cocoa bean

market both in the long and short term, so asymmetric testing is needed. Asymmetric price transmission testing is carried out using the Wald test.

The results of the Wald test (Table 4, part C) show an asymmetrical relationship between the global market (GP-pos and GP-neg) and farmers' prices in the long and short term, significant at 1% level, respectively. Meanwhile, APT of the cocoa pasta (PA) only occurs in the short term and is significant at 5% level, while in the long term, it does not exist (p-value greater than 10% critical value).

The Export Tax of Cocoa Beans in Indonesia

This study uses the cocoa bean export tax as a dummy variable (DU). The DU coefficient is -0.023, significant at 1% level (Table 4, part A). The direction of the coefficient is negative, which explains that the export tax policy has reduced the cocoa price of farmers by 2.3%. It is different from the studies of Neilson *et al.* (2013) and Rifin (2015), which stated that the tax policy on cocoa bean export did not negatively affect farmers' cocoa bean prices using a linear approach.

Export taxes change domestic markets by affecting prices, production volumes, consumption, trading, and the well-being of producers and consumers. Consumers benefit from lower prices, but domestic producers lose (Liefert & Westcott, 2016). Implicitly, the export tax is a government stimulus to secure the supply of raw materials for the domestic cocoa processing industry at a lower price (Yudyanto & Hastiadi, 2019).

The real profits of the export tax are in terms of capacity building for the processing industry, increased competitiveness, the availability of employment, and government revenue (Hasibuan & Sayekti, 2018; Liefert & Westcott, 2016).

Discussion

The price transmission model of the global market and the prices of processed cocoa to farmers' prices are presented to understand the mechanism behind price transmission in Indonesia. In this case, the response of negative price shocks is more significant than positive shocks. So it is called "negative asymmetry price transmission". The price of cocoa in the global market is the primary determinant of farmers' cocoa prices, both short and long term. Meanwhile, the price of cocoa pasta will provide a quick response to farmers' prices if there is a negative shock.

The findings of the present investigation are partially in accordance with Mukhlis *et al.* (2020), Rifin (2015), and Tsowou and Gayi (2019) as they

study Indonesian cocoa beans with the linear model. Their research found the transmission of global cocoa prices to farm prices in Indonesia's supply chain in the long term. The results of our study can confirm the above analysis. Negative price shocks are transmitted more strongly to farmer cocoa prices than positive shocks in the long and short term. It causes a disparity in the response received by the market at the producer level. Our study is unique because it uses an asymmetric model to separate positive and negative price shocks.

Some studies have found that the role of uncompetitive behavior of traders and adjustment costs causes asymmetric price transmission (Meyer & von-Cramon-Taubadel, 2004; Rezitis & Tsionas, 2019). In line with many studies, the price transmission from the world market to the domestic agricultural market is incomplete, especially in developing countries where marketing channels and intermediary agents are too numerous and ineffective (Cutts & Kirsten, 2006; Mofya-mukuka & Abdulai, 2013; Subervie, 2011). In addition, the low quality of cocoa beans and farmers' bargaining position cause the price received to be inadequate (Hasnah *et al*., 2011; Sianipar & Widaretna, 2012). According to Hasnah *et al*. (2011), the lack of cooperation between farmers and village cooperatives and the lack of farmer associations are the main factors influencing price volatility in Indonesia.

Another interesting result is that the magnitude of the coefficient for cocoa pasta (PA) is smaller than the global price (GP), both in the short and long term. Meanwhile, the producers (farmers) are indirectly forced to supply the domestic cocoa processing industry through the export tax. Due to the lack of linkage between the domestic cocoa processing industry sector and cocoa farmers, the price of cocoa beans at the farm level is highly vulnerable to falling prices in the global market. It impacts farmers' well-being and causes the supply of cocoa beans to dwindle (Ariningsih *et al*., 2019; Hasnah *et al*., 2011). The cocoa processing industry necessitates a significant investment. High processing, manufacturing, and distribution concentrations can lead to non-competitive environments and asymmetric price transmission (Niemi & Liu, 2016; Rezitis, 2018; Walters, 1975). According to Bonjean and Brun (2011), the processing industry and distributors often use their market power to manipulate prices, which causes prices to be sent out unequally.

Based on several pieces of literature, there are several causes for price asymmetry in the cocoa processing industry sector and farmers' cocoa prices in Indonesia, among others. Firstly, there is a large number of intermediary agents. The imbalance of power of agents in the supply chain causes asymmetric price transmission because agents with market power can delay price adjustments (Mclaren, 2015; Meyer & von-Cramon-Taubadel, 2004). Meanwhile, the geographical spread of farmers and economies of scale in the agricultural market is characterized by market forces from the demand side (Gizaw *et al*., 2020).

Second is the ineffectiveness of Indonesia's farm cooperatives. According to Boer *et al*. (2019) and Hasnah *et al*. (2011), cooperatives can help strengthen ties between farmers and industry. This institution has the potential to minimize the role of intermediaries significantly. Furthermore, an inclusive value chain can improve farmers' cocoa farmers' welfare and price stability. Above all, coaching and training from cultivation through post-harvest management can be conducted with a cooperative role to provide additional incentives.

Furthermore, export taxes have a negative effect on farm cocoa prices in Indonesia. The coefficient value is -2.3%, indicating that the policy direction is unfavorable for farmers. Export taxes should be maximized to improve farmer welfare and ensure a sustainable supply of cocoa beans in Indonesia (Yilmaz, 2006)using a computable general equilibrium (CGE. According to Klasen *et al*. (2013), improving welfare will provide a competitive advantage while positively contributing to smallholder livelihoods and long-term rural economic growth.

4. Conclusions

This study investigates the asymmetric price transmission (APT) of cocoa pasta prices (PA) and global cocoa bean prices (GP) on farmers' prices in Indonesia. Furthermore, adding export tax policy as a dummy variable makes the asymmetric equation function more reliable. The NARDL model is used for estimation, explaining the long-term and short-term asymmetric relationship.

The results show that the price of domestic cocoa beans is integrated with the global cocoa market and cocoa pasta as a proxy for Indonesian processed cocoa. We find strong evidence of negative asymmetric price transmission in the cocoa supply chain. Negative price shocks (drops) in global markets and cocoa pasta are more quickly passed on to farmers' prices than positive price shocks are.

The increase and decrease in the global cocoa market and cocoa pasta prices were transmitted asymmetrically in short and long terms, except for the variable (PA-pos). The increase in the price of cocoa pasta in the long term does not affect the farmgate price. The high coefficient of magnitude asymmetric price transmission shows Indonesia's supply-demand cocoa chain is uncompetitive.

The export tax policy has reduced the cocoa price for farmers by 2.3%. Therefore, the ministry of agriculture needs to make some breakthroughs to stabilize the price of cocoa beans in the domestic market. The asymmetric model's export tax variable (DU) results can strengthen previous research used with another approach.

The existence of negative asymmetric price transmission is very detrimental to the income of cocoa farmers in Indonesia, most of whom are small farmers with low incomes. The potential trespass of market power by intermediary agents may have led to widening gross margins (i.e., the price gap between intermediaries and farmers). The possibility of a high loss of farmer welfare requires government intervention.

In the end, further research can develop in diverse directions. For example, investigate the transmission of cocoa bean prices between countries. Moreover, adding intermediary agents in the vertical and horizontal price transmission models will be more effective in seeing how their role influences the prices.

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Economia agro-alimentare /
Food Economy

An International Journal on Agricultural and Food Systems

Vol. 24, Iss. 1, Art. 2, pp. 1-59 - ISSN 1126-1668 - ISSNe 1972-4802
DOI: 10.3280/ecag2022oa12059

Social Network Analysis: A useful tool for studying Innovation diffusion processes

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Abstract

In our note, we tried to realise a comprehensive document dedicated to Social Network Analysis, in which we focused on its origin, application and adoption in analysing the diffusion of innovation, with particular attention paid to the agriculture sector, because we believe that farmers can easily exchange knowledge with each other and boost the diffusion of innovation in terms of agricultural techniques.

Most of the scientific researches reported in our note in which SNA was applied are carried out in developing countries, we reckon that in these countries information is not usually recorded in a database, and farmers can easily get innovation through their system of acquaintances.

We noted that SNA is a flexible and useful tool because it can be applied jointly with several approaches and theories. Through SNA, we can get relevant information about the network to understand how innovation gets shared and to assess the role and importance of different actors involved in the network.

Article info

Type:
Note
Submitted:
17/06/2021
Accepted:
01/09/2021
Available online:
03/12/2021

JEL codes:
O3, O31, O33, O35

Keywords:
Innovation
Adoption of innovation
Diffusion of innovation
Social network analysis
Agricultural sector

Managing Editor:
Maurizio Canavari

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Introduction

Innovation has different definitions. For businesses and enterprises, it usually means something costly, risky, and time-consuming (Costello & Prohaska, 2013). Croitoru provided the influential interpretation of innovation as the commercialisation of the invention (Croitoru, 2012). He noted that innovation could be founded on new scientific findings, although more frequently it was from re-combinations of existing technologies. As mentioned, innovation is a knowledge research and creation process, demanding the reduction of uncertainty. Innovation can be categorised into two concepts: radical and incremental innovations. Radical innovations are new technologies, which catch the needs that are not yet recognised and involve technology, science, research, and development (Dosi & Grazzi, 2010). Instead, incremental innovations enhance what already exists and mostly come from production workers, engineers, and preservation workers. Innovation can also be explained as a new idea, product, suggestion, or novelty (Hollander, 1965). According to Romer, the essential sources of innovation and economic growth are the new knowledge accumulation (Romer, 1990). Furthermore, Katila stated that the combination of different knowledge allows companies to solve problems and innovate (Katila, 2002). Baregheh *et al.* reported a definition of innovation as a multi-step process by which companies transform an idea into a new or enhanced product, process, or service, aiming to advance, compete and successfully distinguish themselves in their local market (Baregheh *et al.*, 2009). Gisbert-López *et al.* reported a positive relationship between creative climate and innovation (Gisbert-López *et al.*, 2014). Innovation processes are stimulated and supported by a good creative climate, in which various actors act with each other in a way that can prompt or limit the creative climate.

The association between creativity and new ideas is very close. Organisations and economies must innovate and induce innovation to maintain and reinforce their competitive position. Thus, innovation is a fundamental policy and strategic matter (Baregheh *et al.*, 2009). Rogers developed the diffusion of innovation theory to explain how an idea or product achieves momentum and spreads across a specific community (Rogers, 1983). As a result of this process, people adopt a new idea, product, or behaviour. Adoption means that people do something new that they had in the past, such as using or buying a new product, acquiring a new practice or tools, etc. The essential point in the adoption is that people must recognise the idea, product, or behaviour as innovative, and only through this recognition diffusion can happen. However, some individuals are more inclined to adopt innovation than other groups of people. Rogers stated that people who adopt innovation early have distinct features from people

who adopt the same innovation later (Rogers, 1983). Therefore, promoting a specific innovation to a community is helpful to understand the characters of the target population that will speed or block the adoption of that innovation. Rogers, established five adopter categories as following (Rogers, 2003):

i. *Innovators*: 2.5% of individuals want to be the first to get and experiment with the innovation. Rogers recognises that those individuals are aware of taking a risk and are the first to promote a new idea.
ii. *Early adopters*: 13.5% of individuals act as opinion leaders. This category of individuals is already aware of the need to change and is pleasant adopting a new idea.
iii. *Early Majority*: 34% of individuals are infrequently leaders and adopt new ideas before the average person. These people need to see evidence that the innovation works before they are inclined to adopt it.
iv. *Late Majority*: 34% of individuals doubt change and adopt innovation only after the majority has tested it.
v. *Laggards*: 16% of individuals are conservatives, traditionalists, and very doubting about change (most complicated people to get innovation).

Diffusion is completed when an individual adopts an innovation based on steps that include awareness of the need for innovation, decision to adopt (or reject) an innovation, initial use of the innovation to experiment with it, and continued use of the innovation. Five essential attributes influence the adoption of innovation, and each of these elements is at play to a different extent in the five adopter categories.

1. *Relative advantage*: the extent to which an innovation is seen as better than the idea, product, or practice it replaces.
2. *Compatibility*: that is the consistency of the innovation with the needs and experiences of the potential adopter.
3. *Complexity*: that is the difficulty the innovator can face to understand or apply the innovation.
4. *Triability*: the degree to which innovation can be experimented with or applied before a commitment to adopt is made.
5. *Observability*: the degree to which an innovation yields tangible outcomes.

The theory of innovation adoption has been used successfully to explain many sectors' evolution, including agriculture. For instance, according to Pretty *et al.* organic farming is a complex of agricultural innovations and they affirmed that organic farming becomes more acceptable, when it was seen to be more fruitful than conventional agriculture (Pretty *et al.*, 2010). This result explains what is reported in relative advantage and observability attributes. Similarly, according to Padel, diffusion of innovation theory can help to understand the process of diffusion of organic farming into a community, as well as to understand how this process possibly can

be supported and enhanced, i.e., across the agricultural extension or the knowledge and information system in agriculture (Padel, 2001). As affirmed by Finco *et al*., innovation is not a casual process. In their research, they focused on investigating some factors of innovation making start from small size agri-food firms linked with cluster agri-food in the Marche Region (Italy). Results showed that small enterprises separately cannot get innovation due to some constraints and firms' features, as well as clusters, represent an opportunity to get both innovation and to become more competitive in the local market (Finco *et al*., 2018).

Valente reported that the diffusion of innovation via social networks could be clarified by comprehending the fundamental basis of the social networks (Valente, 1996). A social network is recognised as a dense interconnectedness among individuals that furnishes patterns of relationships and reinforces a group of people in a social system. The first method to understand how a network acts as a means of diffusion was to analyse the number of times that any person was named as an associate of the network to gauge his/her leadership and attitude. Thus, inside each network, the opinion leaders or influencers are defined as those individuals who are capable to get to a wide number of individuals and they may have a significant role in the adoption and diffusion of innovation within the network. Following that and as recorded by Rogers, this will be linked to innovativeness as measure by how many times the person adopts an innovation (Rogers, 1983).

This paper is related to a "Note" based on a short literature review and aimed to shed light on the SNA as a tool to analyse how innovation is diffused within a social network, as well as to assess the role and importance of different actors involved in the network. We would like to clarify that the note's goal was not to compare different methods used by several authors in analysing the diffusion of innovation, as well as is not structured as an article.

This "Note" is structured as follows: Section 1 includes an introduction; Section 2 gives a brief overview of the SNA; Section 3 describes some empirical studies in which SNA was applied to understand how innovation is shared; Section 4 reports on the use of SNA in analysing the innovation diffusion in the agricultural sector and Section 5 concludes the note. Instead, in the appendix is reported the methodology applied for the literature review.

1. Brief overview of Social Network Analysis (SNA)

In this paragraph, our objective is to provide readers with a simple description concerning the SNA and not to compare the existing methods applied by several authors to analyse the diffusion of innovation. In the

following paragraph, we reported an explanation of SNA, an overview of its origin and application in several disciplines and sectors, as well as we highlighted its importance in analysing how knowledge is shared within a community. We tried to highlight that SNA could be a useful method to be applied in analysing how innovation is diffused in a social network.

According to Bourne *et al.*, SNA is the process of examining a social network, and a set of research methods, including network matrices, network diagrams, and mathematical measures aiming to depict the social network structure (Bourne *et al.*, 2017). As noted by Scott & Carrington the beginnings of SNA include maths (graph theory), sociology, and psychology (Scott & Carrington, 2011). Network theorists have discovered examples of the concept of SNA in the work of such geniuses of sociological theory as Weber, Durkheim, Marx, Goffman, and even Parsons and the work of leading intellectuals from Heraclitus to Einstein.

SNA is centred on the thought that social interaction is developed principally by relationships and the patterns created by these relationships (Scott & Carrington, 2011). As reported by Freeman, the community itself is nothing more than a network of relations, and there is no community deprived of interactions (Freeman, 2004). Spielman *et al.* noted that SNA is the main key to manage innovation and supply indications about the relationships and roles that exist in a network in which actors are involved, interact and exchange information and resources among them (Spielman *et al.*, 2011).

As reported in Scott & Carrington, these units could be people, organisations, or positions (Boorman and White, 1976; White *et al.*, 1976; Ferligoj *et al.*), journal articles (White *et al.*, 2004) Web pages (Watts, 1999), neighbourhoods, departments within organisations (QuanHaase and Wellman, 2006), Countries (Kick *et al.*, 2014), (Scott & Carrington, 2011). Furthermore, Wasserman and Faust reported that relationships between units could be cooperation, business, friendships, knowledge flows, weblinks, interchange of any kind of support, etc. (Wasserman and Faust, 1994).

Borgatti *et al.* determined four-wide groups of relations: social relations, similarities, flows, and interaction (Borgatti *et al.*, 2018).

i. *Social relations*: include affinity or other types of role relations (e.g., student, friend, etc.); affective ties, which are based on member's feelings for one another (e.g., disliking, liking, etc.); or cognitive awareness (e.g., knowing).
ii. *Similarities*: take place when two units share any kind of attribute, like locations, attitudes, demographic characteristics, or group memberships.
iii. *Flows*: are relations built on interactions and transfers among nodes. These can include relations in which information, resources, etc. spread over the network.

iv. *Interaction*: refers to behaviour-based ties like chatting with, supporting, or hosting someone to house.

In SNA language, in each network units are figured as nodes and are connected by ties, which are information and/or relationships that interchange between nodes. As stated by Scott & Carrington, relations characterised by ties among nodes are essential elements of SNA (Scott & Carrington, 2011).

According to Coulon a network characterised by one kind of node is named homogeneous, conversely is called heterogeneous (Coulon, 2005). Ties linked pairs of nodes could be directed (i.e., bidirectional, unidirectional, such as offering suggestions to somebody) or undirected (as in human being effectively next to) and could be dichotomous (present or absent, as if two individuals are acquaintances or not) or weighted (measured on a scale, as in the intensity of closeness). All ties have values or are weighted; even dichotomous relationships have binary values. When we focus on a single node, we name it "Ego" and we name the set of nodes that ego has ties "Alters".

SNA illustrates how individuals are interrelated and work together, how knowledge and resources flow between and among them, as well as how individuals' roles and relationships are structured (Spielman *et al.*, 2011).

In conclusion, as mentioned in Scott & Carrington, SNA is not considered as a methodology or as a theory rather, it is a viewpoint or archetype (Scott & Carrington, 2011). The starting point of SNA is that social life is founded on relations and on the patterns they form. SNA provides a way of looking at a question and may give only vague answers to the question. Nowadays, SNA is practised and used in several research fields, including education (Kapucu *et al.*, 2010), healthcare (Chambers *et al.*, 2012), agroforestry (Isaac *et al.*, 2007), rural development (Murdoch, 2000; Oreszczyn *et al.*, 2010), natural resources (Bodin *et al.*, 2006), and it has become an interdisciplinary area of research.

2. SNA and the diffusion of innovation: some empirical studies

In this section, in order to analyse the diffusion of innovation, we believe that we can take advantage of using SNA also to identify the main stakeholders or brokers that are responsible for specific innovation diffusion.

According to Coulon, from 1999 ahead, it was registered a rise in the number of scientific studies using SNA, in particular aimed at analysing the structure of the relations among groups/individuals and on the effect of network structure on innovation (Coulon, 2005). According to Valente, the weaker ties guarantee that the small groups will foster the diffusion of innovation within a social system (Valente, 1996). Besides, Rogers, affirmed

that any innovation would have a chance to be adopted quickly by individuals if it does not need much time to be recognised and accepted (Rogers, 2003).

As Coulon reported, the use of SNA in innovation study has been supported by the necessity to describe the causal social process connected to innovation or to analyse how social closeness influences learning diffusion or the process by which "network structure" forms or influences "innovative output" (Coulon, 2005). Besides, Scott & Carrington stated that a network is assumed to enhance the social processes like knowledge and collaboration that allow the community to adopt a powerful and dense social-ecological system (Scott & Carrington, 2011).

Furthermore, SNA was applied to investigate causal process concerning innovation research because a case study solely cannot consider the complexity of the causal process due to the huge number and diversity of individuals engaged within a network. Schuster & Kolleck elaborated a theoretical framework that aids to realise processes related to the dissemination of innovation and interaction networks, e.g., Twitter (Schuster & Kolleck, 2020). Instead, Davies affirmed that in research dealing with agricultural systems, SNA could be a method to evaluate the stakeholder's performance, and it focuses on the structure of the ties between stakeholders engaged in a community (Davies, 2015).

As reported by Schuster & Kolleck, the interest of using SNA is to get both information on the position and the framework bordering an individual involved in a network (Schuster & Kolleck, 2020).

In this regard and as stated in Burt study on structural holes, an individual improves his social capital when he gets an exclusive position that permits him to link numerous clusters in the network (Burt, 2004). According to Scott & Carrington, taking advantage of the structural holes and playing as a broker among clusters, this individual has enlightening functions or benefits and great flexibility to operate (Scott & Carrington, 2011).

3. The use of SNA and innovation diffusion in the agricultural sector

In this paragraph, we tried to report some empirical studies carried out using SNA. We listed several scientific papers, based on different research approaches and reporting the results achieved. Here we gathered the papers according to the complexity of the approach adopted. First, we describe studies in which SNA was used alone, and in the second step, we reported other studies in which SNA was used together with other approaches and in the third step we included papers in which SNA was applied with several systems and frameworks. Papers were ordered to make this section comprehensive to readers because we believe that by classifying all papers as

we did, researchers and students probably can get clear information about the use of SNA.

We paid attention to the agricultural sector because we reckon that innovation is easily shared through social structure, in which farmers can get information through their system of acquaintances. Besides, growers do not care to avoid information flow to other farmers as the inter-farm competition is very weak. They help each other, and in the meanwhile, they boost the diffusion of innovation in their narrow social system and reinforce their positions within their social network. Furthermore, farmers' activities are strictly territorial, and they tend to form tight communities, in which information is easily spread among the same individuals. In the end, farmers usually tend to follow their close similar adopting the same agricultural techniques. In this regard, we found several scientific papers related to SNA, and we aimed to highlight that SNA could be a useful tool to analyse the process of innovation diffusion in agriculture, not necessarily to boost the adoption of innovations, as well as we deduced that SNA could be applied alone or jointly with other methods, theories, and approaches, etc.

The methodology applied for the literature review is reported immediately after references. Furthermore, we classified all articles in a table organised in a framework based on the author, year, research title, scope, the approach used, the method used, dependent variable, independent variables and results obtained-table is available in "Annex A".

At the first step, analysing the literature review, we would like to report some empirical studies in which SNA was used alone, i.e.; Isaac investigated the attributes of information networks about cocoa agroforestry management (Isaac, 2012). He analysed if these attributes could improve a sustainable production system in terms of agro-diversity. The approach was based on SNA employing an Ego network and using the name generator technique to examine the structure of rural agricultural information networks. The study was conducted in two regions in Ghana, which are similar in terms of their natural and socio-demographical features, but different in terms of accessibility to market and organisations. Semi-structured interviews were carried out with professional stakeholders. The author found that if a farmer is near a metropolitan area, he will have a high probability of contacting main stakeholders and his informal network becomes more open and diverse. This helps the success of information exchange and innovation diffusion on agro-environmental practices.

Hermans *et al.* focused on investigating the ability to innovate and to explore the potential for scaling innovations in three multi-stakeholder platforms (MSPs) in Congo, Rwanda, and Burundi (Hermans *et al.*, 2017). They applied SNA in combination with Exponential Random graph modelling (ERGM) to explore the knowledge exchange, structural properties of the

collaborative, and influence networks of three MSPs. Their approach was based on three steps: a) recognise in each country the long-term established partners of the CGIAR (Research Program on Integrated Systems for the Humid-Tropics) centres; b) map the participatory stakeholders based on Humid-Tropics workshops for which the main individuals were invited; c) prepare informative materials related to the program and distribute them in different areas. In each country, data were collected from questionnaires focused on a name generator and asking participants to list the name of five organisations with whom they cooperate. The analysis of network properties showed an imbalance between knowledge exchange, collaboration, and influence networks for the diffusion of innovation and scaling processes. For example, the private sector and NGOs are respectively under and over-represented in the MSP networks, as well as connections among local and public organisations are weak, and influential public organisations are not actively connected to other groups and are often not part of the MSP. Furthermore, they discovered that organisations with a central position in the network are more appreciated for cooperation, and the diffusion of innovations is mainly among the same type of organisations across various administrative levels, but not among various types of organisations.

Ravula focused on using social networks and mapping the network of rural farmers located in two Indian villages to identify the nature of relations (informal and formal) and associations for poor farmers (Ravula, 2012). The study analyses how these networks can boost the diffusion of agricultural innovation and how the relations support rural people to enhance both themselves and their societies. The study focused on a transaction-based approach to record the social network architectures in Aurepalle and Kanzara villages through semi-structured questionnaires and focus group discussions. The author found that both villages have good levels of social capital in terms of social networks. The variation in resources (natural and financial) between the two villages has encouraged the improvement of relationships in one village and self-help communities in another.

In the end, Birkenberg & Birner focused on analysing how Costa Rican coffee cooperative "Coopedota" applied certification for carbon neutrality as innovation, which challenges faced, and how it overcame them (Birkenberg & Birner, 2018). Besides, they analysed the main factors that encourage the diffusion of this innovation. Their approach was based on the SNA and Process Net-Map tool which was applied to visualise the network and to identify the role and importance of different types of individuals. Data were collected from depth interviews with thirty experts and semi-structured interviews with one hundred Coopedota' farmers. On this basis, the authors calculated SNA indicators as centrality, betweenness, closeness, and degree. The results confirmed that the certification for carbon neutrality created

awareness on emission hot spots alongside the coffee value chain. The major successes include a combination of a) visionary and strong individuals who performed the necessary network functions and b) accomplishments in Coopedota's sustainability policy, which was supported by international and national trends. Results indicated that the network of individuals is extremely centralised, as well as the network analysis confirmed the importance of double linkages among individuals, which points to the role that combined services (advice and funding), acted in the introduction of innovation.

At the second step, in the other scientific paper's authors used SNA jointly with the diffusion of innovation theory, learning pathways, social capital, decision-making, and homophily concept, i.e., the approach of Aguilar-Gallegos *et al*. was based on the process of diffusion and adoption of innovation, homophily concept and SNA. They stated that in the agricultural sector, networks illustrate the engagement of many stakeholders that provide information and resources to farmers (Aguilar-Gallegos *et al*., 2015). Those stakeholders could be NGO's, farmer field schools, and extension agents. They are in contact with farmers, establishing and building ties. Moreover, they found that various farmers have different rates of adoption of innovation, as well as innovation is adopted based on farmers' incomes. Growers with high incomes are advanced adopters and they have more contacts with various stakeholders. Furthermore, they found that homophily in the network can impede the diffusion of certain knowledge among actors.

Garbach & Morgan applied SNA to investigate the farmer's familiarity with three different pollination techniques, their experience and the benefits obtained from each practice (Garbach & Morgan, 2017). Their approach was based on quantitative interviews to analyse the farmer knowledge systems, demographic characteristics, communication networks to understand the prominent individuals and knowledge origin through which farmers communicate information about pollination management. Diffusion of innovation theory was used to describe how information about pollination practices diffuse within farmer networks. After network visualisations, logistic regression was applied to analyse the influence of technical learning and social learning considering numerous variables of each farmer (role, age, experience, education level, etc.). They discovered that social learning was positively correlated with adopting the use of combinations of bees, underlining the potentially critical roles of farmer-to-farmer networks and social learning in supporting the initial stages of adoption of innovations.

Grünbühel & Williams investigated how decisions are made when innovation about cattle management is introduced in two Indonesian areas (Grünbühel & Williams, 2016). They focused on the decision-making concept and Homo oeconomicus model of classical economic theory. They developed the decision narratives through 296 in-depth interviews collected through

snowball sampling techniques. They used SNA to assess the diffusion of knowledge and identify different stakeholders that influence the farmers' decisions. They found that it is easy for farmers located in South Sulawesi to test and adopt an innovation because the land is more plentiful in comparison to farmers located in Lombok, where land is insufficient and more dedicated for crop production. Innovation is applied and adapted by farmers through cultural rationality. Furthermore, innovation is diffused through a range of existing social networks when it is compatible with farmers' livelihood strategies.

The research of Wood *et al.* was based on innovation systems theory by investigating the significance of the networks in which New Zealand shepherds discuss scientific issues (Wood *et al.*, 2014). The authors analysed how farmers share their knowledge (pastoral farming) with scientists and other individuals, concentrating on communication and facilitation in the network. Their approach was based on ego network and sociometric analysis. The sample was gathered identifying 17 farmers who are in direct contact with five scientists, to explore the network cohesiveness and to evaluate the significance of networking. Personal interviews were carried out to collect sociometric data for the quantitative analysis. Also, free form interviews with the farmers were carried out to collect data for the qualitative analysis and using a mix of roster formats and a name generator. Using a mix of tools (NVivo, Ucinet and statistical software), they found that farmers characterised by dense ties and homogenous contacts increased their network compared to other farmers characterised by soft and dissimilar ties.

Levy & Lubell used SNA to investigate the structure of social networks between Californian wine farmers that facilitate the diffusion of the agroecological system and resolve collaboration matters (Levy & Lubell, 2018). Their approach was based on three social processes: cooperation, diffusion of innovation, and boundary-spanning. They surveyed 500 individuals (farmers and stakeholders) located in three regions to analyse their social network relationships. Farmers were selected from County Agriculture Commissioners' Pesticide Use Reports, additional farmers and stakeholders were selected through snowball methods. Surveys were mailed to interviewed people. Each interviewee was invited to list eight farmers and eight other individuals with whom he talked about viticulture management. Each individual in the networks was classified in one of the three following categories: farmer, stakeholder, or both (farmer-stakeholder). The findings reflect that both stakeholders and farmers have relatively low-betweenness centrality, while stakeholders-farmers have a high betweenness centrality in all the networks, and it was observed the presence of open structures that facilitate the diffusion of information. In all regions, results indicate a tendency for individuals to form ties with popular people, and stakeholders-

farmers have a greater tie propensity than farmers or stakeholders. Moreover, individuals who share three contacts are significantly more likely to be connected than people with non-common contacts.

Hoffman *et al*. applied SNA to study knowledge networks and social learning in Central Coast, Lodi, and Napa Valley – three American viticulture regions in California – (Hoffman *et al*., 2015). They used a different approach based on learning pathways (social, formal, and experiential), diffusion of innovation, social capital, and cultural evolution theories. These theories provided a basis to explain farmers' behaviour and understand how and why knowledge is or not assessed, accepted, and adopted by people. They collected data through an e-mail survey from 25 farmers and 12 types of stakeholders and calculated the response rates using AAPOR guidelines (AAPOR 2009). Their surveys were based on asking interviewers to rate on a scale of one to three the usefulness of 21 information resources for learning about vineyard management. Furthermore, they used conventional network data collection methods asking farmers to list the names of other farmers and stakeholders with whom they speak about vineyard management. Besides, matrices of relational data were constructed from this survey. Other surveys were addressed to farmers to investigate if they had participated in learning activities. Using a linear regression model, they finally assessed the hypothesis that farmers' position in the network is a function of their participation in learning activities. The results confirmed that empirical and social learning are more essential to get information about farm management than formal learning. Natural Resources Cooperative Extension (UCCE) and UC Agriculture are well-positioned to get and disseminate knowledge through the farmers' networks. Farmers' participation in technical activities, e.g., gathering and field trials, is essential for their knowledge-sharing relations. Moreover, UCCE and other agricultural support associations have an essential role to play in reinforcing networks.

Spielman *et al*., used SNA together with an innovation system approach to study agricultural systems in developing countries, as well as in smallholder-farming groups (Spielman *et al*., 2011). They applied SNA to examine how market-driven factors and social networks promote the diffusion of information among Ethiopian small farmers and how the network influenced farmers' decisions to innovate. They carried out twenty focus group interviews and semi-structured interviews with key actors named by the focus group members. Data collected were used to implement the SNA of each geographic site (ten areas). They discovered that public extension and administration exercise a powerful influence over smallholder networks, potentially keeping out civil society and market-based actors, and thus represent a boundary for the diffusion of innovation processes.

Quiédeville *et al.* applied SNA to study the role acted by the network, in which rice farmers and research institutes are engaged during the innovation process, specifically during the transition to organic farming in South France, Camargue (Quiédeville *et al.*, 2018). Their approach was based on social capital and SNA. They based on face-to-face interviews with nineteen individuals (rice farmers, researchers, and traders) to collect data for SNA and to analyse research outputs, the factors that facilitate or block innovation diffusion. Individuals were invited to identify their relations with other similar individuals, as well as to assess the intensity of those relations on information flows, collaboration links and finances. A workshop was organised with three researchers from the CFR (French Centre of Rice), three participants from two organic rice traders, two researchers from INRA (French National Institute of Agronomic Research), and seven organic and partially organic farmers. Participants were invited to draw the impact pathway of the research by connecting several components (e.g., the output x with the outcome y or activity z). The outcomes include changes, behaviours, actions undertaken and actors' relations. The authors calculated SNA indicators as betweenness centrality, clustering coefficient, average clustering coefficient, degree centrality, and average degree centrality. The results have shown an increasing role acted by INRA in the network and its impact on the transition to organic agriculture due to closer relationships between rice farmers and INRA. Besides, the results also indicate an increasing role acted by CIRAD (Agricultural Research Centre for International Development) thanks to an increase in relationships with growers. Moreover, the results showed a significant impact of Biosud on the transition to organic farming.

At the third step, SNA was applied with other approaches such as those reported in Spielman *et al.* their research was based on the use of SNA with the complex adaptive system (CAS), National agricultural system (NARS) and agricultural knowledge and information system (AKIS). They described that the diffusion of sustainable agricultural techniques derived by the network formed by the transfer and the exchange among producers and stakeholders (Spielman *et al.*, 2009).

Bourne *et al.* applied SNA to assess the performance of agricultural advisory systems in Kenya, Tanzania, and Rwanda (Bourne *et al.*, 2017). Their approach was based on measuring knowledge flow and capacity for collective action, considering that the improvement of these two elements is the basis of a modern advisory system. For this purpose, they applied ego network analyses in eleven sites of East Africa. Actors and network boundaries were chosen using a two-step approach. A personal interview was carried out by locally trained personnel, and SN data were collected using a list of question and code it in an adjacency matrix of binary variables. SNA was processed using UCINET and homophily, density, core-periphery,

and average degree of nodes were calculated. Core-periphery structure was measured utilising the model from Borgatti and Everett (2000) and expressed as the correlation between tested and ideal model. The research shows a limited capacity for collective action within farmer groups and communities in Rwanda and some areas of Kenyan. Also, in Tanzania, low connections with external actors were found. These results have shown that there are both a limit and a delay in the introduction of innovation within the population.

The approach of Misra *et al*. was focused on the introduction of the concept of system to describe the sustainable livelihood (SL) framework, succeed by comparing the rural living system with common attributes of the system to determine the system characteristics of rural living in which SNA was applied.

Concerning SNA they used both the whole and ego network approach to analyse the complex system of rural livelihood and the related function of rural organisations (Misra *et al*., 2014). Their approach was focused on the introduction of the concept of "system" to describe the Sustainable Livelihood framework. They collected data at the micro-level (community level) and macro-level (through focus group discussion with a set of actors) and concluded that stakeholders should make the decision for significant livelihood actions in a region and boost the innovation diffusion within the organised system.

Instead, the approach of Conley & Udry was based on the Bayesian framework and on the use of SNA to analyse communication networks between small farmers in Ghana concerning chemical fertilisers on new pineapple cultivation (Conley & Udry, 2001). They conducted investigations with 450 people in four villages in the Eastern Region of the country for more than twenty-one months. They discovered that geographical closeness did not guarantee that small farmers can get knowledge easily (adoption of new techniques by his similar). Conversely, the networks (restricted channel) in which a farmer was engaged allowed him to learn and innovate from new sources.

In the end, the approach of Fafchamps & Lund was based on Udry' approach with several variations and SNA to analyse the risk-sharing behaviour of Philippine rural households (Fafchamps & Lund, 2003). They surveyed four villages in the Cordillera mountains with 206 rural households. Three interviews were carried out with each household at three-month intervals and recorded. Everyone was asked to identify several people on whom it could be dependent in case of need or to whom the respondent gives support, and they called it the network of insurance. Data were collected on loans, gifts, and asset sales of each individual and all its network partners (household composition, cultivated area, professional skills, and age of head). They discovered that shocks have a dominant effect on informal

loans and gifts, but a weak effect on sales of grain and farm animals. The households receive support primarily through networks of families, friends, and acquaintances without a charge of interest on the loans used.

Conclusions

Starting from the note's goal, we described the SNA and its usefulness in analysing the knowledge diffusion in a social network. In our note, we decided to not focus on comparing other methods usually used in this regard, but our centre point was to shed light on SNA.

We tried to give to readers an overview concerning the origin, application, and use of SNA in the analysis of the processes that drive the diffusion of innovation in agriculture. We believe that readers can both use this note as a basis for future research and can get a comprehensive paper appropriated to the use of SNA (it could be used alone or applied as an explorative method with other methods and theoretical frameworks).

In our note, we highlighted that SNA is a process of assessing a social network, in which actors are involved, interact and exchange knowledge concerning any specific issue, and technical innovation too (Spielman *et al.*, 2011). SNA is centred on the idea that interaction is developed by relationships and the patterns created by these relationships (Scott & Carrington, 2011). Through SNA, we can understand how innovations are implemented and diffused in agriculture, and the role played by the main actors (brokers) to spread the innovation. To depict the social network structure, it is necessary to use a set of research methods, such as matrices, diagrams, and mathematical measures, etc. (Bourne *et al.*, 2017).

In the agriculture sector, most of the research – reported in our note – in which SNA was applied are conducted in developing countries. Furthermore, we noted that in a few research authors have only used SNA calculating the SNA' indicators, besides in most scientific paper's authors have used SNA with other methods, frameworks and theories. That means that SNA is a flexible tool and can be applied jointly with several approaches and theories. Other essential points are that in all research SNA was applied: a) to analyse how the existing networks can spread the diffusion of the existing innovation; b) to analyse communication networks and knowledge exchange between actors concerning an existing innovation; c) to analyse the role acted by the actors involved in the network during the diffusion of innovation and d) to identify how relations support actors to enhance both themselves and their communities.

We summarise that through SNA, we can get relevant information about the network to understand how innovation is shared, as well as to assess the role and importance of different actors involved in the network.

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The Methodology applied for the Literature Review of SNA and Diffusion of Innovation: Research Issues and Insights for Future Research:

For a better understanding of how we made a literature review concerning SNA and Diffusion of Innovation, in this section we will face deeply the following points:

a) Information data source,
b) The approach applied to select different articles,
c) The guidelines.

a) Information data source:

To find scientific papers related to the SNA and Diffusion of Innovation through Proxy service we accessed the library system of the University of Bologna, in section database, Scopus. Furthermore, using google scholar it was possible to find further articles and/or documents.

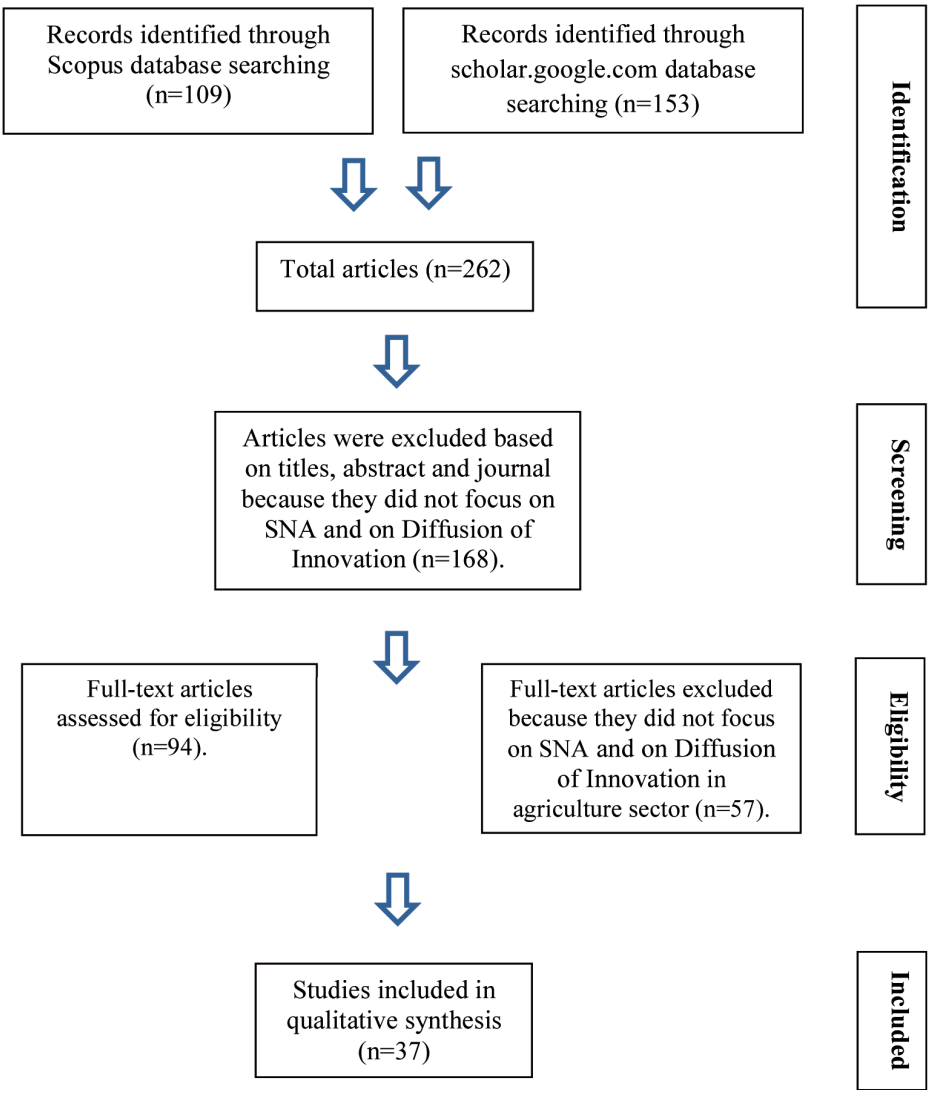
b) Approach applied to select different articles:

During the research of scientific papers, the framework adopted was based on:

– Keywords: typing Social Network Analysis; Diffusion of Innovation, Application of Social Network Analysis; Social Network Analysis in agriculture.
– Methodological approach used to select the papers:

Database	Search String
Scopus	*TITLE-ABS-KEY (social AND network AND analysis AND in AND agriculture) AND (LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA, "AGRI") OR LIMIT-TO (SUBJAREA, "ECON")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (PUBYEAR, 2019)) AND (LIMIT-TO (LANGUAGE, "English"))* *TITLE-ABS-KEY (social AND network AND analysis AND diffusion AND of AND innovation) AND (LIMIT-TO (SUBJAREA, "SOCI")) AND (LIMIT-TO (SUBJAREA, "ECON")) AND (LIMIT-TO (SUBJAREA, "AGRI")) AND (LIMIT-TO (LANGUAGE, "English")).* *TITLE-ABS-KEY* (application AND of AND social AND network AND analysis) AND (LIMIT-TO (SUBJAREA, "SOCI")) AND (LIMIT-TO (SUBJAREA, "ECON")) AND (LIMIT-TO (SUBJAREA, "AGRI")) AND (LIMIT-TO (DOCTYPE, "ar")). TITLE-ABS-KEY (*diffusion* AND *of* AND *innovation*) AND (LIMIT- TO (PUBYEAR, *2020*) OR LIMIT-TO (PUBYEAR, *2019*) OR LIMIT-TO (PUBYEAR, *2018*) OR LIMIT-TO (PUBYEAR, *2017*) OR LIMIT-TO (PUBYEAR, *2016*) OR LIMIT-TO (PUBYEAR, *2015*) OR LIMIT-TO (PUBYEAR, *2014*) OR LIMIT-TO (PUBYEAR, *2013*) OR LIMIT-TO (PUBYEAR, *2012*)) AND (LIMIT-TO (DOCTYPE, "*ar*")) AND (LIMIT-TO (SUBJAREA, "*ECON*")) AND (LIMIT-TO (EXACTKEYWORD, "*Diffusion Of Innovation*")) AND (LIMIT-TO (LANGUAGE, "*English*"))
Website	*https://scholar.google.com/* TOPIC: "Application of Social Network Analysis"; AND TOPIC: "Social Network Analysis in agriculture"; AND TOPIC: "Social Network Analysis and Diffusion of Innovation". Refined by: DOCUMENT TYPES: (ARTICLE) Timespan: 1995-2020. *https://scholar.google.com/* TOPIC: "Diffusion of Innovation" Refined by DOCUMENT TYPES: (ARTICLE) Timespan: 1965-2020.

c) The guidelines:



Annex A
The approach used by several authors using SNA to assess how innovation is diffused in the agricultural sector

Author	Year	Research title	Scope	Approach used	Method used	Dependent variables	Independent variables	Results obtained
Isaac, M.E.	*2012*	Agricultural information exchange and organizational ties: The effect of network topology on managing agrodiversity.	Investigate information network structures within the agrarian environment to understand the barriers to, and development of, effective farm management, specifically the management of agrodiversity.	– Social network analysis (network structure, homophily, network density).	– Ego-network analysis: personal network consists of an individual producer (ego) and their contacts (alters). – Name-generator technique: to collect network data. – Adjacency matrix: to create personal network socio-grams for each actor. – Personal network data analysis: for size (number of actors), ties (number of connections) and density (a measure of existing ties as a percentage of all possible ties).	– Cocoa cultivation.	– Extension agent from the Ministry of Agriculture. – Individuals in NGO's – Individual in local development providers	– Networks with a greater size with low organizational ties, had a lower efficiency and more redundant ties in comparison to networks with small size and high organizational ties (increase efficiency). -Individuals in open networks with few redundant ties are more likely to adopt agroforestry practices. – Farmer field schools had shown that approximately 60% of farmers continue to meet after farmer field schools (personal communication), thus creating greater self–reliance and an effective system in the adoption of sustainable agrarian practices. – The closer you are to a city and the greater the access to organizations, the more open and

Author	Year	Research title	Scope	Approach used	Method used	Dependent variables	Independent variables	Results obtained
					– Triad structures within the personal networks were analysed to assess the position of the interviewee using UCINET. – %size difference: to value the effects of the presence of an organization on network size. – Semi-structured interviews: addressed both to individuals from various organizations and to farmers. – T-tests: to test the effect of location (Site A or B) on size, number and type of ties and density values. – A correlation analysis: was conducted			diverse your informal network becomes (efficient networks, greater adoption of agroforestry).

Author	Year	Research title	Scope	Approach used	Method used	Dependent variables	Independent variables	Results obtained
					between network efficiency values and reported agrodiversity values at the plot level. – UCINET and Netdraw: to analyse and visualize the network.			
Hermans, F., Sartas, M., van Schagen, B., van Asten, P. & Schut, M.	*2017*	Social network analysis of multi-stakeholder platforms in agricultural research for development: Opportunities and constraints for innovation and scaling.	Their research aimed to investigate the ability to innovate and to explore the potential for scaling innovations in 3 multi-stakeholder platforms (MSPs) in Congo, Rwanda, and Burundi.	Their approach was based: 1) recognize in each country the long-term established partners of the CGIAR centres; 2) map the participatory stakeholders according to Humidtropics meetings for which they were invited; 3) prepare marketing materials about the program and distribute them in different areas.	Data were collected from questionnaires carrying out in each country focusing on a name generator asking participants (n. 45) to list the name of 5 organisations with whom they cooperate. The analysis of network properties and ERGM specification were carried out in R, using the statistical statnet package and the associated ergm ego package.	– Farmers. – Agro-ecological and demographic features. – Agricultural productivity. – Soil fertility. – Formulation and implementation of policy.	– NGOs (non-governmental organisations) – Private sector. – Government agencies. – Research organisations.	They found that in each country there is an imbalance between knowledge exchange, collaboration, and influence networks for the diffusion of innovation and scaling processes. For example, the private sector and NGOs are respectively under and over-represented in the MSP networks, as well as connections among local and public organisations are weak, and influential public organisations are not actively connected to other groups and are often not part of the MSP. Furthermore, they discovered that groups with a central position in the network are more appreciated for

Author	Year	Research title	Scope	Approach used	Method used	Dependent variables	Independent variables	Results obtained
				– According to the research goal, they applied SNA in combination with Exponential Random graph modelling (ERGM) to explore the knowledge exchange, structural properties of the collaborative, and influence networks of 3 MSPs.				cooperation, and the scaling of innovations is mainly among the same type of groups across various administrative levels, but not among various types of groups.
Padmaja Ravula (2012)	*2012*	Mapping the social network architecture of rural communities: Gender and technological innovations in the semi-arid tropics of India.	She focused on using social networks and mapping the network of rural farmers located in two Indian villages to identify the mean of relations (informal and formal) and	The study was focused on a transaction-based approach to record the social network architectures in the two villages, for 3 transactions (socio-cultural-political, technological,	Data were collected from Aurepalle and Kanzara villages through semi-structured questionnaires and focus group discussions. Data were processed using a quantitative analysis	– Rural farmers (men and women)	– Economic, socio-cultural and technological	She found that both villages have good levels of social capital in terms of social networks. The variation in resources (natural and financial) between the two villages has encouraged the improvement of relationships in one village and self-help communities in another. The mapping of networks

Author	Year	Research title	Scope	Approach used	Method used	Dependent variables	Independent variables	Results obtained
			associations for poor farmers. Besides, to understand how these networks can boost the diffusion of innovation (agricultural technology) and how the relations support rural people to enhance both themselves and their societies diffusion of innovation (agricultural technology) and how the relations support rural people to enhance both themselves and their societies.	and economic). To assess the relations among people "egocentric networks" based on the name generator at a micro-level was used, as well as whole networks was applied at the macro level.	software STATA to convert the raw data and using UCINET software to record the visual analysis and to calculate the centrality measurements. For deep analysis, a descriptive analysis of all network maps was utilized.			in two villages shown that rural people have demonstrated social connectedness to a larger degree. Both the degree of social connectedness and density of the networks varies within the villages and depending on the attributes of the villages.
Birkenberg, A. & Birner, R.	*2018*	The world's first carbon-neutral coffee: Lessons on certification and innovation from a pioneer case in Costa Rica.	Analyse how coopedota cames to apply the carbon neutrality certification, which challenges it.	– Social Network Analysis. – Innovation systems.	– Process Net-Map: to visualize the social networks that enable the actors to pursue the certification scheme and to	– Certification of carbon neutrality (CN). – PAS 2060.	-Coopedota cooperative (800 associate farmers). – NAMA-cafe experimental farm Hacienda Aquiares.	– Through the process, Net-Map were identified the actors involved in achieving the PAS 2060 certification. – The network shows a high diversity of actors from different sectors,

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			faced and how the coopedota solved them. In addition, examine the social, political and institutional factors that fostered this innovation.		identify the role and importance of different types of actors. – Qualitative Research: expert interviews (30 experts), semi-structured interviews (100 farmers), focus group discussions, the Process Net-Map tool and direct personal observations (the interviews gave insights into how the PAS 2060 has been applied by the copedota). – Cradle-to-gate approach for green coffee, based on considering only the GHG emissions along the value chain up until the port in Limon (Costa Rica).			which illustrates the expert knowledge and assistance required from different groups to achieve the certification as a pioneer. Many actors can be categorized into two project groups: Institutions that assisted in calculating the CF and Institutions involved in the different emission reduction projects. -In terms of linkages between actors, only a few direct funding connections between actors were identified. Most external advice was accompanied by funding or provision of experts, in particular, to assist with the LCA required for the certification. Therefore, the same pair of actors were often linked by two different types of linkages: for example, groups in charge of the biodigester, ethanol and pulp composting advised the central actors and additionally provided financing for the

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					– PAS 2060: internationally recognized as a standardized method for the certification process and based on: quantifying, reducing, offsetting, and declaration.			implementation. Equally, the LCA group provided advice and sent their staff to actively help with the LCA. This combination LCA linkages is referred to as double linkages. – The low density of the network indicates a rather poorly interlinked network. One reason for this observation might be the nature of the network as a project-related one, which implies limited boundaries. Only two actors, the general manager, and the CN project manager are well interlinked, which results in a centralized network that consequently displays a high degree of centrality. The degree values are consistent with the values of normalized closeness, which supports the observation that not many actors have direct connections with each other. Instead, all are connected to the two central actors of the network. The normalized

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								betweenness values illustrate that these two central actors hold broker positions. – The Net-Map identified strong individual actors, with commitment and visions, as essential for the successful CN certification. The findings also indicate a high awareness of participants regarding the importance of obtaining reliable data from farmers during the certification process. – The Net-Map interviews also showed that funding was usually combined with advice, resulting in 'double linkages' in the Net-Map diagram.
Aguilar-Gallegos, N., Muñoz-Rodríguez, M., Santoyo-Cortés, H., Aguilar-Ávila, J. & Klerkx, L.	*2015*	Information networks that generate economic value: A study on clusters of adopters of new or improved technologies and practices among oil palm growers in Mexico	Determine the factors that influence the adoption of new or improved technologies and practices and their relationship with the generation of the economic	– Scalling-out: process of broader diffusion and adoption of innovation. – Factors influencing adoption of innovation: economic benefits, psychological	– Random sampling was applied to select palm oil farmers. – Survey to palm oil farmers – Index (INTAI): refers to the average adoption of innovation.	– Characteristic of growers – Perception of the grower. – Characteristic of the production unit (oil palm). – Adoption of innovation (plant nutrition, Plant health, Plantation	– AIM: agency for innovation management – Government organizations (GO). – Educational and research organizations (ERO), – Agro-industries and input and	– Different clusters of farmers have different rates of adoption of innovation, and higher adoption contributes to higher incomes. – The adoption of innovation (new or improved technologies and practices) is related to higher levels of production and generation of economic value.

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			value of oil palm.	and behavioural process, the efficiency of production, formal schooling, extension agents. – Social Network Analysis: based on the study of the relationships among actors and of the social structures that emerge from the recurrence of these relationships. – Homophily concept: individuals tend to maintain links with others who are similar to them in the same cluster.	– UCINET® and NetDraw®: used to obtain information about the network indicators. – Output degrees: are the links that the grower establishes in his search for sources of information. – Input degrees: is the number of times the grower was referred to by his peers as a source of information. – Multivariate analysis: cluster analysis: squared Euclidian distance, basic characterization units (BCU) or operative taxonomic units (OTU) to indicate how similar or	management, Administration, Organization, Harvest, Reproduction, and genetics). – Information network (using UCINET® and NetDraw®). – Production and economic indicators (yield, average selling price (US$/t), gross income (US$/ha).	equipment suppliers (AEIS) – NIG: other oil palm growers (non-interviewed growers).	– Net profits are higher for advanced adopters than for farmers with lower levels of adoption of innovation. – Advanced adopters have more contact (links) with extensionists (AIM case) than those who adopt less innovation. That means the levels of adoption increase, and better productive and economic parameters are achieved -Homophily in networks can impede the flow of certain kinds of relevant information. For this reason, AIM could play an essential role in connecting homogenous networks of growers among each other and with other actors in the broader value chain and innovation system.

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					dissimilar the growers are; Ward minimum variance used for Clustering of the BCU; Pseudostatistical tools t2 of Hotelling and the cubic grouping criteria to define the number of groups. – SAS, version 9.0, software to make multivariate analysis. – ANOVA or chi-squared: tests to measure the variance between and within the clusters. – Scheffe test: to determine where the difference exists among the means (clusters).			– Net profits are higher for advanced adopters than for farmers with lower levels of adoption of innovation. – Advanced adopters have more contact (links) with extensionists (AIM case) than those who adopt less innovation. That means the levels of adoption increase, and better productive and economic parameters are achieved -Homophily in networks can impede the flow of certain kinds of relevant information. For this reason, AIM could play an essential role in connecting homogenous networks of growers among each other and with other actors in the broader value chain and innovation system.

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Garbach, K., & Morgan, G.P.	*2017*	Grower networks support the adoption of innovations in pollination management: The roles of social learning, technical learning, and personal experience.	– Investigate Michigan grower experience and benefits associated with pollination management practices and the influence of grower networks, which are comprised of contacts that reflect potential pathways for social and technical learning.	– Diffusion of innovation theory describes how information about innovative practices spreads throughout a community of practitioners. – Knowledge systems: comprise the actors, organizations, and resources that link information and know-how with action. – Decision-making: individual belief systems that encode people's knowledge and perceptions. -innovative management in the agricultural ecosystem:	– Quantitative survey: to investigate grower knowledge systems, communication networks, and demographic characteristics to build understanding about key actors and information sources through which growers share information about pollination management. – Social network analysis (path length, network diameter, density, direct and indirect connections, brokers). – Four-point Likert scale to evaluate growers' ratings	– 3 pollination management practices: a combination of bees cover crop and permanent habitat.	– Cooperative Extension – Beekeepers – Growers (age, year experience, educational level, farm size, and income). – Extension specialists (Michigan State University (MSU), etc.) – Commercial suppliers – Commodity groups – Government agencies – Non-profit organizations (NGOs)	– No significant difference in the frequency with which growers of different crops reported buying or renting pollinators. – No significant differences in frequency of use of pollinator types across different crops or other pollination practices. – Crop pollination was the top-rated management priority for growers (high and medium farm size). – Growers with large farms ranked the effectiveness of pollinator species as a higher priority than growers with small farms. – 65% of the current practice is represented by "Buying or renting honeybees" as a pollination management practice. – 60% of growers reported currently retaining areas of permanent habitat, (including wooded lots and farm edges, old

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				based on communication networks that facilitate both technical and social learning. -Social learning: refers to how individuals learn from each other as well as actors with different roles and are supported by social capital and networks.	(Always, Often, Sometimes, or Never). – Analysis of variance (ANOVA) to evaluate responses followed by Tukey means separation tests. – Chi-squared analysis is used to analyse count data or frequency of responses. – Name-generator technique: to collect Network data. – Levenstein procedure was used because names of network contacts were anonymized and transformed for spelling errors. -ORA software: to visualize the resulting networks.			fields, swamps, and marshes). – 49% of growers reported using flowering cover crops to encourage pollinators and 13% of growers reported using combinations of bees. – Source of information: beekeepers are an important source of information representing 28% of connections; grower-to-grower communication represents 26% of connections; Extension represents 25% of grower networks. Commercial suppliers, commodity groups, government agencies, non-profit organizations, and other organizations were represented less frequently. – In networks of growers that adopted a combination of bees had significantly more connections to both government agencies and innovative neighbours, 18%, versus non-adopters, 2%.

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					– Regression analyses were combined with descriptions of network structures to identify influential organizations, and key organization types and roles of contacts, related to the binary response variable of adoption (yes/no) of three key practices: combinations of bees, flowering cover crop, and retaining permanent habitat areas. – Logistic regression to examine the influence of technical learning measured through connections to			– The adopters and non-adopters had similar percentages of innovative neighbours currently using cover crops (19% and 18%, respectively). -Networks of growers that adopted the practice of retaining permanent habitat did not differ significantly from non-adopters. – Connections with the Natural Resources Conservation Service (NRCS) had a significant positive correlation with adopting the use of combinations of bees and adopting flowering cover crops. – Growers' personal experience with potential benefits and concerns associated with practices to attract and retain diverse pollinators had significant positive and negative correlations, respectively, with the adoption of all three innovative practices. – Using combinations of bees (adopted by 17%

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					government and extension, and social learning on the adoption of innovative practices as measured through connection to other innovative growers.			of growers) is positively linked to government and to interact with other innovators, as well as using Internet resources. – Results suggest that different types of information brokers can be important for practices at distinct stages of adoption. Social learning through social contacts is especially important for early adopters. Michigan State University Extension and beekeepers serve as information brokers, evidenced by unusually high numbers of unique links.
Grünbühel, C.M. & Williams, L.J.	*2016*	Risks, resources and reason: understanding smallholder decisions around farming system interventions in Eastern Indonesia.	– Investigated how decisions are made and diffused when innovation (adoption of techniques for improved cattle management) is introduced in two Indonesian areas (South Sulawesi and Central Lombok).	– Decision-making concept and application of methods to measure this context, such as social networks, mental models, and communication patterns. – Homo oeconomicus model of	– Decision narratives: were developed from in-depth interviews, which explored the various steps of deciding whether or not to accept new livestock management practices. – Social Network Analysis (SNA)	– Cattle management practices (buffalo and cattle): Introduction of new forage varieties, strategic forage production, feed budgeting to improve cattle nutrition and health, controlled	– 216 interviews in South Sulawesi (Indonesia). – 80 interviews in Central Lombok (Indonesia). – Household Farmers – Neighbours, – Village heads, – Religious leaders, – Government agencies.	They found that is not complicated for farmers located in South Sulawesi to test and adopt an innovation, because the land is more plentiful in comparison to farmers located in Lombok, where land is insufficient, and more dedicated for crop production. Innovation is applied and adapted by farmers through cultural rationality. Furthermore, innovation is diffused through a range of

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				classical economic theory (an independent agent who acts rationally to maximise self-interest).	was used to examine how knowledge about new practices spread among households and communities, as well as, the type of households, relationships or institutions critical for promoting adoption. – Data for SNA was collected as part of the decision narratives and focused on capturing: Interactions and influence between households and local institutions; The spread of information; The spread of resources as concomitant to information.	mating and weaning to enable higher fertility rates.		existing social networks when it is not conflicted with farmers' livelihood strategies.

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					– The interviews were structured according to Geertz' (1975). – Sample: selected through both snowball and random techniques.			
Wood, B.A., Blair, H.T., Gray, D.I., Kemp, P.D., Kenyon, P.R., Morris, S.T. & Sewell, A.M.	*2014*	Agricultural Science in the Wild: A Social Network Analysis of Farmer Knowledge Exchange	– Investigate the networks in which farmers discuss science. – Explore how farmers' participation embed science in the complex networks of agricultural innovation systems. Investigate how farmers participate with scientists and how they share knowledge (pastoral farming) with other individuals concentrating	– Theory of agricultural innovation systems: based on open-ended interactions with heterogeneous actors and the complexity of their interaction makes the knowledge they produce unpredictable. – Ego-centric network and sociometric analysis.	– Network surveys: open-ended interviews collected farmer statements about their most valuable contacts – Ego-centric network analysis – Personal interview surveys to collect sociometric data for the quantitative analysis of knowledge exchange networks. -Free-form interviews	– Herb-based pastures – Farmers. – Farmers features (age, experience in herb pasture, farm system, etc.) – Climatic condition. – Scientists. – Local research stakeholders in agricultural science. – Herb-based pastures. – Farmers' acquaintances.	–	– Farmers exchange knowledge in densely tied and strongly organized interpersonal networks. – Low density and shortest path indicate a cohesive network (suggesting that everyone in the network is close together and that group members can communicate with each other easily), but the betweenness centralization value is 11.6%, suggesting relatively little difference between the 22 group members' ability to control the flow of knowledge. – The 17 participating farmers had discussed the farmlet with 63.2%

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			on the role of communication and facilitation in the network.		are used to collect data for qualitative analysis of the perspectives on the knowledge that inform farmer networking. – Use of a mix of name-generator and roster formats. – Ucinet software to analyse the survey data. – Qualitative data collected from the interview were coded by the sociologist using NVivo 9 software. – Linear Regression was used to measure the growth rate, the growth on density and the growth on heterogeneity.		–	of their pre-existing contacts and with 113 new individuals not previously identified. Seed merchants are in distant second place, comprising 16.0% (20) of prior farmers' contacts and 8.3% (16) of the farmers' ego networks. They are followed by a mix of other occupations at 0–10% and 1– 5% respectively. The farmers intend to make contact with their social peers more than with anyone else. – The smaller networks tended to grow more than the larger networks. – Farmers' networking was driven by sociological traits and the denser and more occupationally homogenous a network, the more it grew. – Triadic analysis shows that the 17 farmers are positioned to deliver multi-member messages more frequently than

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					– Social structure: calculating density and occupational heterogeneity (measures the diversity of information sources used by each farmer). – Occupational heterogeneity has been calculated using Blau's heterogeneity index. – Ucinet's brokerage routine was used to identify the triadic forms in the network.			the five agricultural scientists. In addition, farmers are much more likely to receive such messages than any other occupational grouping. – Farmers regularly contact numerous other people to secure the farming resources they need. This practical networking sustains wide-ranging and durable relationships that emphasize the interpersonal value of knowledge exchange. – Farmers intend to make contacts with fellow farmers and other agricultural individuals to share experience-based knowledge. – Farmers also exchange knowledge directly by visiting each other's properties and that increase the sharing of farmer experience. – Farmers seek knowledge that can be applied to their farm by contacting individuals

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								who can share the experiences of other equally individual farms (homophily concept). – Farmers move experience across farms by comparing examples.
Levy, M.A. & Lubell, M.N.	*2018*	Innovation, cooperation, and the structure of three regional sustainable agriculture networks in California.	Analyse the structure of social networks among wine grape growers in three regions of CA, USA, that have implemented sustainability partnerships.	– Social capital and social networks theories: are theorized to facilitate social processes such as learning and cooperation that enable human societies to adapt to dynamic and complex social-ecological systems. – Social processes: Diffusion of innovation theory (innovation is facilitated by networks that efficiently	– Survey data (500 growers) to measure the communication networks of growers in three viticulture regions in California. – Surveys were administered in 2011 for Lodi and 2012 for Napa and Central Coast. Growers were identified from county Agriculture Commissioners' Pesticide Use Reports, and additional eligible growers and outreach professionals	– Agroecological systems. – Sustainability partnerships.	– 500 individuals: growers, outreach professionals and outreach-grower present in three different regions.	– The survey response rate was 24% in Central Coast, 39% in Napa, and 45% in Lodi. – The Lodi's network is the smallest (447 nodes) and most dense (0.0068, fraction of possible ties present), connected (0.84, fraction of dyads with a path between them), and centralized (0.081, normalized sum of deviation of degrees from the most popular actor) of the three, and Central Coast's network is largest (785 nodes) and least dense (0.0031), connected (0.73), and centralized (0.019), with Napa's network intermediate on all measures. – Outreach professionals and Growers both have relatively low-

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				transmit information); Cooperation (facilitated by networks that allow the development of reputation and trust); boundary-spanning networks (link together specialized components of food systems, which help bring different types of expertise into the overall agricultural value chain); and structural holes (individuals whose ties span different parts of the system can access more and a greater variety of resources).	were identified through snowball methods. Surveys were issued by mail, and non-respondents were asked several times to respond. – Networks were constructed from survey questions that asked respondents to list up to eight growers and up to eight other individuals with whom they communicate about viticulture management in decreasing order of frequency of communication in Napa and Central Coast and up to four of each in Lodi.			betweenness centrality, but outreach-growers have high betweenness centrality in all three networks. – Network centralization is greatest in Lodi and least in Central Coast. The empirical networks feature a few highly popular actors, more popular than any nodes in the random graphs. In terms of distances between dyads, Central Coast has the longest average path length. In Napa and Lodi, where the observed path lengths are shorter. These results demonstrate the presence of open structures that enable the diffusion of information. In addition, Lodi is the most centralized with the lowest HMPL, while the Central Coast is the least centralized with an HMPL no different from the expectation in a random graph. In terms of clustering coefficient,

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				– Transitive triangle: relationships between individuals i–j and i–k facilitates the relationship j–k. These structures help maintain reputation and trust by enabling indirect reciprocity and social sanctions for free-riders and by providing third-party verification of cooperative or uncooperative behaviour.	– To enable comparisons across regions, only the first four individuals listed in each category for Napa and Central Coast were used. Edges are treated as undirected and dichotomous. – Each node in the networks was assigned an attribute type based on whether they are exclusively a grower, exclusively an outreach professional, or both a grower and outreach professional, based on county records and survey question responses. Network data were manually			Lodi has the greatest value, followed by Napa and Central Coast. – In all three regions, GWD estimates were significantly negative, indicating a tendency for actors to form ties with popular actors. At the aggregate level, this creates centralized networks with short paths between nodes. Furthermore, the positive coefficient estimates on GWESP indicate a strong force for triadic closure in all three regions. – In terms of the boundary-spanning role, in all three regions, outreach-growers have a greater tie propensity than growers or outreach professionals. All else accounted for, in Napa, outreach professionals are substantially less popular than Growers, while in Lodi, outreach professionals are somewhat more popular than growers.

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					cleaned to merge duplicate entries, correct misspellings, etc. – All analyses were performed in R version 3.3.3 (R Core Team 2016) using the statnet suite of packages, version 2016.4. – For each region, we simulated 1000 random graphs with uniform edge probability and the same size and density as the observed network. – For each region, have been compared the empirical value of three graph-level indices of interest to the distribution from the			– There is strong regional homophily at the zip code level in all regions. – Across the three networks, actors who share three contacts are an order of magnitude more likely to be connected than actors with non-common contacts.

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					random graphs: normalized degree centralization, harmonic-mean path length (HMPL), and clustering coefficient. – A combination of descriptive statistics, conditional uniform random graph tests and exponential random graph models (ERGMs) were used to provide empirical support for the hypotheses. – For each network, it was analysed the path length (HMPL), which accounts for disconnected dyads, and degree centralization, a measure of			

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					the absolute difference of degree of each node in the network from the highest-degree node, normalized to the maximum possible value for a network of that size. – In the ERGM context, network centralization was tested with a geometrically weighted degree (GWD) term, which measures repulsion of edges from high-degree nodes. -For closed network structures: comparison between observed levels of triadic closure to levels found in uniform random			

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					graphs of the same size and density and then via the geometrically weighted edgewise shared partners (GWESP) statistic in ERGMs to test whether there is a tendency for triadic closure above what would be expected by other tie-formation forces in the network (e.g., regional homophily). – Parameter estimates were obtained via Markov chain Monte Carlo (MCMC) maximum likelihood estimation.			

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Hoffman et al., (2015)	*2015*	Network-smart extension could catalyse social learning.	They applied SNA to study knowledge networks and social learning in Central Coast, Lodi, and Napa Valley (three American viticulture regions in California).	They used a different approach based on learning pathways (social, formal, and experiential), diffusion of innovation, social capital, and cultural evolution theories. These theories were used as a basis to explain farmers' behaviour and to understand how and why knowledge is or is not assessed, accepted, and adopted by people.	For each region from 2010 to 2012, they have collected data through an e-mail survey from 25 farmers and 12 types of stakeholders following the Dillman method, as well as they, have calculated the response rates using AAPOR guidelines (AAPOR 2009). Their surveys were based on asking interviewers to rate on a scale of 1 to 3 the usefulness of 21 information resources for learning about vineyard management. Furthermore, they used conventional network data	– Farmers. – Wine grape cultivation. – Geographical area' features. – Learning activities about vineyard management. – Agricultural techniques. – Outreach professionals. – Boundary-spanning professionals. – Agricultural support organisations.	–	The results showed that farmers confirmed that social learning and experiential are more useful to get information about farm management than formal learning. Some stakeholders are well-positioned to get and diffuse information through the farmer networks. Farmer's participation in learning activities confirmed that these activities are still a strong tool for the dissemination of knowledge.

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					collection methods asking farmers to list the names of other farmers and stakeholders with whom they speak about vineyard management. Besides, matrices of relational data were constructed from this survey. Centrality and coverage were calculated as well. Other surveys were addressed to farmers to investigate if they had participated in learning activities and using a linear regression model, they assessed the hypothesis			

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					that farmers' position in the network is a function of their participation in learning activities.			
Spielman, D.J., Davis, K., Negash, M. & Ayele, G.	*2011*	Rural innovation systems and networks: findings from a study of Ethiopian smallholders. Agriculture and Human Values.	They applied SNA to examine how Ethiopian small farmers innovate and market-driven factors, as well as how social networks promote the diffusion of information outwardness and how those outwardness influenced farmers' decisions to innovate considering the growers' agricultural practices and choices.	Their research was based on SNA used together with innovation systems approach aimed to assess how community engenders, interchange, and utilizes knowledge, as well as how these processes can induce innovation and disseminate the benefits derived from the innovation in Ethiopia.	They carried out 20 focus group interviews comprised of 5 people each. Semi-structured interviews were carried out with key actors named by the focus group members. Data collected from both interviews were used to carry out the SNA of each geographic site (10 areas).	Households – Economic activities. – Behaviours of smallholders. Geographic site. – Innovative agricultural practices. – Marketing practices.	– Bureau of Agriculture and Rural Development (BoARD). – Manager of credit and saving institutions. – Traders. – Brokers. – Staff of NGOs.	They discovered that public extension and administration exercise a powerful influence over smallholder networks, potentially keeping out civil society and market-based actors, and thus represent a boundary for the diffusion of innovation processes.

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Quiédeville, S., Barjolle, D. & Stolze, M.	*2018*	Using social network analysis to evaluate the impacts of the research: on the transition to organic farming in the Camargue.	Assess the relevance of undertaking an SNA to better understand the role played by the network of actors during innovation processes as well as validate stakeholders' views on actors' relationships in a case study on the transition to organic farming in the South of France.	– Social capital: bonding, linking and bridging links. – Social Network Analysis (SNA). – Indicators of betweenness: represents a high degree of intermediation in the network. – Clustering coefficient: to assess actors' access to relevant information and resources by calculating the level of connectivity between actors in the neighbourhood. – Degrees: account for the number of relationships among actors. – Participatory Impact Pathway Analysis (PIPA).	– Face-to-face interviews. – Social Network Analysis (SNA): identifying the relationships between actors and evaluating the intensity of those relationships. As well as, calculating indicators as betweenness centrality, clustering coefficient, average clustering coefficient, degree centrality and average Degree centrality. – Building the impact pathway: through the organization of stakeholder's workshop, in which actors were asked to draw the	– Organic rice cultivation.	– INRA: (French National Institute of Agronomic Research. – CIRAD: Agricultural Research Center for International Development. – CFR: French Centre of Rice. – Organic and partially organic farmers. – Rice traders. – CEBIOCA: Organic Cereals in the Camargue – ORPESA: Organic Rice Production in Environmentally Sensitive Areas – BIOSUD: associating a cereal cooperative and two trading companies. – France AgriMer: French public agency for agriculture. – CFR: French Centre of Rice	– 4 different groups of pathway links were obtained: PL1: CEBIOCA and ORPESA have contributed to the growing influence of INRA in the actor-network. PL2: The CEBIOCA and experimentations carried out (by INRA and CIRAD) have contributed to an increasing influence of CIRAD in the actor-network. PL3: INRA and CIRAD have become a knowledge broker in the network influencing positively innovation development and the transition to organic farming. PL4: the high selling price, the growing demand for organic rice, and the adoption of organic farming have contributed to an important and growing influence of Biosud in the network. – Through SNA tests it was demonstrated: INRA has a high centrality in the

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					impact pathway by linking the different components (e.g., the output x with the outcome y or activity z).			transition to organic farming and a high influence in the network due to an increase in relationships between its adjacent actors (farmers); an influence of FranceAgriMer and CFR on the growing role played by CIRAD alongside the development of innovations focalized on the transition to organic farming; the increasing influence of INRA and CIRAD in the network becoming knowledge broker; based on betweenness indicator the Biosud was not positioned as an obligatory crossing point and so did not facilitate much communication between actors in the network.
Spielman, D.J., Ekboir, J. & Davis, K.	*2009*	The art and science of innovation systems inquiry: Applications to Sub-Saharan	Explore methodologies that can help improve the study of agricultural innovation	– Complex adaptive systems'' (CAS): evolve through the combination of initial		–	–	– Description of different methodologies that can help to study the agricultural innovation systems to resolve matters related to (a) how agents interact in the

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		African agriculture.	processes and their role in transforming agriculture.	conditions, multiple interactions, trends, and random variations in agents and their interactions. – National agricultural research system (NARS) approach and Agricultural knowledge and information system (AKIS) approaches: emphasize the role of public-sector research, extension, and educational organizations in generating and disseminating new technologies. – Agricultural innovation system (AIS) approach: makes use				production, exchange, and use of knowledge and information within a network; (b) how agents respond individually and collectively to technological, institutional, or organizational opportunities and constraints; and (c) how policy changes can enhance the welfare effects of these interactions and responses.

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				of individual and collective absorptive capabilities to translate information and knowledge into a useful social or economic activity in agriculture. – Social network analysis – Innovation histories: method of recording and reflecting on innovation processes as part of wider institutional learning and change. – Cross-country comparisons: based on using benchmarks, scorecards, and indices. It is a useful tool				

Author	Year	Research title	Scope	Approach used	Method used	Dependent variables	Independent variables	Results obtained
				for guiding innovation policy in many countries. – Game-theory modelling: illustrates the spontaneous processes of social self-organization and how public policy and organizational structures can affect these processes.				
Bourne, M., Gassner, A., Makui, P., Muller, A. & Muriuki, J.	*2017*	A network perspective filling a gap in the assessment of agricultural advisory system performance.	This research proposes a framework linking social network measures to information flow and capacity for collective action and applies it to personal (egocentric) networks in 11 sites within East Africa.	– Advisory systems: includes the entire set of organizations that support and facilitate people engaged in agricultural production to solve problems and to obtain information, skills, and technologies to improve their livelihoods and well-being.	– Network boundaries and actors were selected using a two-step approach: in each target country, an administrative unit was selected; each selected administrative unit was divided into high, medium and low elevation zones and from	– Rural agricultural advisory systems in eastern Africa. – Conservation Agriculture with Trees (CAWT) practices in East Africa (Rwanda, Tanzania, Kenya).	– Tanzania: 268 farmers. – Kenya: 433 farmers. – Rwanda: 383 farmers – Advisory provider (WWF, Government, KENDAT, FFS, World vision, etc.).	– 43% from Bugesera District (Rwanda), 34% from Mbarali District (Tanzania) and 6% from Machakos County (Kenya) said they consulted no one when asked whom they talk to about agricultural issues. The results show a low response rate for Bugesera and Mbarali districts. Respondents from Mbarali District named at least three actors. For Bugesera and Machakos most respondents named one

Author	Year	Research title	Scope	Approach used	Method used	Dependent variables	Independent variables	Results obtained
				– Centralised approaches for transferring technologies such as training and visit. – Social Network Analysis: density, centrality, the existence of subgroups, levels of homophily and number of bridging or bonding ties. – Egocentric network.	each zone, an administrative sub-unit was selected. – Social Network Analysis: survey data, UCINET 6, calculation of density, the average degree of nodes, core-periphery, homophily and core-periphery structure. – Key actors: degree centrality, and key player Problem/ Positive KPP-POS (is used to identify the type of actors that are most important for information dissemination and degree centrality for the most connected actors).			or no actors. The findings reflect the overall network densities, which can be considered low. – In all administrative units the number of bonding ties was higher than the number of bridging ties. In Bugesera and Mbarali, the highest numbers of bonding ties were observed with friends while in Machakos it was with neighbours. For the bridging ties, extension agents were found to be the most named actors in all administrative units. Respondents in Bugesera also named organisations as an important group of actors, whereas only in Machakos veterinary officers were named. – For Bugesera and Mbarali administrative units, farmers were more likely to name actors who were members of farmer groups served by the same advisory provider, than farmers from other groups or other

Author	Year	Research title	Scope	Approach used	Method used	Dependent variables	Independent variables	Results obtained
					– Results were displayed in interactive maps through R-igraph package. – Analysis was carried out at two different levels. First level: at the administrative unit level, an overview of response rates and analysis of variation in response rates from the different questions used, as well as, the type of relationships (bonding and bridging ties and homophily) was completed. Second level: more detailed network analysis was carried out for each administrative sub-unit separately.			advisory providers (scores closer to 1 indicating homophily). In Machakos, the networks were homogeneous within the advisory approach (0.82) but more heterogeneous with farmers being more connected to actors outside of their group (0.78). – Lowest density was found for all sub-units within Bugesera, the highest density for all sub-units, except for Madibira Ward, was found in the Mbarali sub-units. The networks of the administrative sub-units in Machakos were slightly denser than in Bugesera but lower than in Mbarali. From all actors present in the networks only 24 had more than 11 connections. These 24 actors are considered central, as they are the most connected in the network. Most of these central actors (15) were extension agents. Only in Mbarali District were central actor's family members and friends.

Author	Year	Research title	Scope	Approach used	Method used	Dependent variables	Independent variables	Results obtained
								-None of the networks were found to fit a core-periphery arrangement. -In terms of centrality, farmer group members were found to be the least important group for information dissemination. Instead, In Bugesera District almost all key actors were friends. In Mbarali District friends were also most key actors in most sub-units, while in Machakos County extension agents, family and neighbours were also prominent for key actors.
Sanchaye-eta Misra et al.	*2014*	Application of Social Network Analysis in Livelihood System Study	The study aims to analyse the complicated system of rural livings (small farmers) and the related function of rural organisations.	Their approach was focused on the introduction of the concept of "system" to describe the Sustainable Livelihood (SL) framework (DFID, 1999). Succeed by comparing the "rural living system" with common	Data were collected at the micro-level (community level) and macro-level (through focus group discussion with a set of actors). Data collected were processed using statistical and visual techniques.	– Small farmers.	– Natural assets, Social capital, physical capital, human capital, financial capital, vulnerabilities, policies, institutions and processes and livelihood strategies.	They deduced that stakeholders should make the decision for significant livelihood actions in a region and boost the innovation diffusion within the organized system.

Author	Year	Research title	Scope	Approach used	Method used	Dependent variables	Independent variables	Results obtained
				attributes of the "system" to determine the system characteristics of rural livings, on which SNA is used.				
Conley and Udry	*2001*	Social Learning through Networks: The Adoption of New Agricultural Technologies in Ghana.	Analyse communication networks between small farmers in Ghana concerning the use of chemical fertilizers on new cultivation (pineapple).	Their approach was based on the Bayesian framework and SNA.	They conducted investigations with 450 people in 4 villages in the Eastern Region of the country for more than 21 months.	– Farmers. – Maize and Cassava cultivation. – Urban consumers. – Pineapple cultivation. – European market. – Agricultural chemicals (fertilisers). – Agents.	–	They discovered that geographical closeness did not ascertain that small farmer can get knowledge in an easy way (adoption of new techniques by his similars); conversely, it was the networks (restricted channel) in which farmer was engaged that allowed him to learn and innovate from new sources.
Fafchamps and Lund	*2003*	Risk-sharing networks in the rural Philippines.	Used a social network to analyse the risk-sharing behaviour of Philippine rural households.	Their approach was nearest to Udry' approach (1994), with numerous variations, and SNA.	They carried out a survey in 4 villages in the Cordillera mountains with 206 rural households. 3 interviews were carried out with each household at 3-month intervals and recorded.	– Household. – Informal institution. – Gift giving. – Informal credit. – Sales of livestock and grain. – Friends and acquaintances.	– Mutual insurance.	They discovered that shocks have a dominant effect on informal loans and gifts, but a weak effect on sales of grain and farm animals. The households receive support primarily through networks of families, friends, and acquaintances without a charge of interest on the loans used.

Author	Year	Research title	Scope	Approach used	Method used	Dependent variables	Independent variables	Results obtained
					Everyone was asked to identify several people on whom it could be dependent in case of need or to whom the respondent gives support (they called it the network of insurance). Data were collected on loans, gifts, and asset sales of each individual and all its network partners (household composition, cultivated area, professional skills, and age of head).			

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ISSNe 1972-4802