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# Contents



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# Foreword

The year 2020 will be memorable for the whole world, for sure. With the outbreak and global spread of the coronavirus, our everyday life has significantly changed and the world, as well as the food system, has been confronted with one of its most challenging periods. 2020 will also be memorable for our journal, Studies in Agricultural Economics, as we got listed by Scopus this springtime, one of the most important recognitions an international journal can receive.

We have seven papers in this issue. The first paper, written by our previous Editor-in-Chief, Fieldsend, analyses agricultural knowledge and innovation systems in the European Union policy disclosure. The paper begins by reviewing recent international theoretical development of the AIS concept and of equivalent concepts in the EU and argues that different perspectives in international and EU concepts can be integrated into a single 'multi-level' model, with family farming at its centre. The paper then explores current agricultural innovation policy discourse in the EU and suggests that 'Agricultural Productivity and Sustainability' (EIP-AGRI) may result in the adoption of a new and contestable use of the term 'Agricultural Knowledge and Innovation System' or 'AKIS' that is reminiscent of the EU's treatment of the term 'Rural Development'.

The second paper, written by Szerb, Horváth and Szente, investigate consumer perception of Hungarian agroforestry products and the market for products derived from them. Agroforestry products are not yet in the public domain, so their research focused on the latent market for agroforestry products. This allowed the participants to form only an opinion, reactions which we were able to reveal using the Q-method. In their paper, the authors have targeted average consumers who are independent from agroforestry systems and products. As a result of their Q-analysis, "Alternative, Green", "Inquisitive" and "Busy" consumer groups were created and analysed. Potential consumers appear to be willing to pay a higher price if they find an attractive product from an agroforestry system.

The third paper, written by Daglis, Konstantakis and Michaelides, analysed the early effects of the Covid-19 pandemic on global wheat and oats markets. Using relevant time series specifications, the authors established a hypothesis regarding the effect of the Covid-19 pandemic on the values of these two commodities. Based on their findings, the commodities were affected by the Covid-19 spread and moreover, the Covid-19 confirmed cases provide useful information for the predicting and forecasting of these values. Findings are robust, since the out-of-sample forecasting accuracy of the alternative model employed, that explicitly incorporates the pandemic induced by the Covid-19 virus, is superior to the baseline model.

The fourth paper, written by Brandao and Rist, analysed the dichotomies between the space of irrigated agriculture and the space of traditional agriculture in the Brazilian semi-arid region. Results show that until 1980, public policies favoured the development and consolidation of modern irrigated agriculture in selected spatial fragments. From 1990 onwards, policies have become inclusive, aimed at the Family Farmers social group. Policies have entailed local solutions for access to water, contextualised technical assistance, alternative markets, income stabilisation for family farmers and improvement in food production and consumption. However, despite the inclusion of family farming in the agrarian structure, imbalances of power remain among the food systems, highlighting the great contradiction brought about by these public policies.

The fifth paper, written by Obekpa, Frimpong and Ayuba, investigated the influence of foreign direct investment and exchange rate on fisheries in Nigeria using time series data that spans from 1980-2018. A Vector Autoregressive Model was also used alongside a growth model. The findings indicate positive growth in the fisheries subsector. FDI to agriculture and exchange rate movements were both found to affect the fisheries subsector positively in the long run, whereas only FDI to agriculture was found to exert a positive influence in the short run. Policies to attract FDI to the sector are thus advocated for, while macroeconomic policies to stabilise the Nigerian currency (naira) against the US dollar are also advised.

We also have two short communications in this issue. The first one, written by Asseldonk, Muwonge, Musuya and Abuce, investigated the adoption and preferences for coffee drought index-based insurance in Uganda with a stratified household survey. According to their results, farmers preferred the option of premium payments proceeds on delivery, mobile premium payments and delivering insurance through cooperatives/associations. Deepening insurance uptake among coffee farmers will therefore, as the authors suggest, require a strong focus on communication and information sharing facilitated by cooperatives/associations (e.g. farmer cooperatives, village and saving associations, or women's associations).

The second one, written by Isik and Ozbugday, investigated the role of tax cuts in determining agricultural input prices in Turkey as on January 1, 2016, the 18% Value Added Tax (VAT) rate in fertiliser was reduced to 1 percent, while afterwards, on February 10, 2016, fertiliser was included in the scope of the exception. As these tax reduction decisions exogenously affect fertiliser prices, there is an opportunity to conduct a natural experiment. Using the difference-in-differences (DID) method, this paper examines whether the decisions reduce fertiliser prices. The analysis results provide some hints that consumers received benefits from the tax reduction decisions.

On the whole, I hope this issue also reflects the diversity of different topics relevant for ECA agriculture and food systems. I wish Merry Christmas and a Happy New Year to all of our readership with the hope that everyone stays healthy and keeps safe during these hard times.

**Attila JÁMBOR**
Budapest, December 2020

**Andrew F. FIELDSEND***

# Agricultural Knowledge and Innovation Systems in European Union policy discourse: *Quo vadis*?

'Sustainable intensification' of agricultural production, or 'producing more with less', has been widely adopted as a policy approach by national governments and international agencies, including the European Union (EU) through its Common Agricultural Policy. Sustainable intensification will be facilitated through on-farm innovation in a process that is fostered by knowledge sharing between actors with complementary forms of knowledge. These actors, their organisations, the knowledge flows between them and the so-called 'enabling environment' constitute an 'agricultural innovation system' (AIS). This paper begins by reviewing recent international theoretical development of the AIS concept and of equivalent concepts in the EU. Although the international and EU development paths are similar, there are clear differences between them. It is argued that these different perspectives can be integrated into a single 'multi-level' model, with family farming at its centre. The paper then explores current agricultural innovation policy discourse in the EU. Based on the European Innovation Partnership 'Agricultural Productivity and Sustainability' (EIP-AGRI), this may result in the adoption of a new and contestable use of the term 'Agricultural Knowledge and Innovation System' or 'AKIS' that is reminiscent of the EU's treatment of the term 'Rural Development'. The paper argues, however, that this development may in fact add clarity to the understanding of the agricultural innovation systems concept. Greater dialogue between researchers, policy makers and others in the EU and beyond offers the welcome prospect of greater coherence between future EU and international approaches to fostering agricultural innovation.

**Keywords:** family farms, enabling environment, Quadruple Helix, CAP Strategic Plans
**JEL classification:** Q18

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## Introduction

In its influential publication *Save and Grow*, the Food and Agriculture Organisation of the United Nations (FAO) proposed a new paradigm of intensive farm production, one that is both highly productive and environmentally sustainable (FAO, 2011). It stems from the recognition that, over the past half-century, agriculture based on the intensive use of inputs has increased global food production and average per capita food consumption. In the process, however, it has depleted the natural resources of many agro-ecosystems, jeopardising future productivity, and added to the greenhouse gases responsible for climate change. At the global level, it has not significantly reduced the number of chronically hungry, which FAO (2011) estimated to be 870 million people.

The subtitle of *Save and Grow* is *A policymaker's guide to the sustainable intensification of smallholder crop production*, and this reflects an emphasis on helping family farms to achieve higher productivity, profitability and resource use efficiency, while enhancing natural capital. 'Sustainable intensification' of agricultural production, or 'producing more with less', has been widely adopted as a policy approach by national governments and international agencies, with 'sustainable' including the economic (e.g. profitability of farming), environmental (e.g. minimising unfavourable environmental impacts) and social (e.g. maintaining farming communities) dimensions. In particular, sustainable intensification is consistent with the European Union's (EU) Common Agricultural Policy (CAP), which has for many years been built on the idea of a 'European Model of Agriculture', based on family farming and consisting of a competitive and diverse agricultural sector that is environmentally responsible and addresses issues of food quality and animal welfare (Lowe *et al*., 2002; Swain, 2013).

Sustainable intensification will be facilitated through on-farm innovation, by combining traditional knowledge with modern technologies. The term 'innovation' can be used to refer to either a process or an outcome. Through the process of innovation, individuals or organisations master and implement the design and production of goods and services that are new to them, irrespective of whether they are new to their competitors, their country, or the world (World Bank, 2006). The resulting innovation can be a technologically new or remarkably improved product, service, process, a new marketing or management method in the business practice, organisation or external relationship (OECD, 2005). OECD/Eurostat (2018) uses the term 'innovation activities' to refer to the process, while the term 'innovation' is limited to outcomes.

Change can involve farm products, production processes and/or farm organisation and management. In addition to facilitating sustainable intensification, innovation helps farmers to expand, change or diversify their marketable output, thereby increasing the profitability of their farms, to free up resources for use in other economic activities, or enhance the provision of important ecosystem services (FAO, 2014). But innovators rarely work in isolation and the process of innovation is fostered by knowledge sharing between actors with complementary forms of knowledge (Fieldsend *et al*., 2020). These actors, their organisations, the knowledge flows between them and the so-called 'enabling environment' constitute an 'agricultural innovation system' (AIS).

The changes in the physical, social and economic environment for agriculture are being accompanied by increas-

ing interest in, and understanding of, innovation systems approaches. This paper begins by reviewing recent international theoretical development of the AIS concept and of equivalent concepts in the EU. Although the international and EU development paths are similar, there are clear differences between them. It is argued that these different perspectives can be integrated into a single 'multi-level' model, with family farming at its centre. The paper then explores current agricultural innovation policy discourse in the EU. Based on the European Innovation Partnership 'Agricultural Productivity and Sustainability' (EIP-AGRI), it may lead to the adoption of a new and contestable use of the term 'Agricultural Knowledge and Innovation System' that is reminiscent of the EU's treatment of the term 'Rural Development'. The paper argues, however, that such a development can in fact add clarity to the international understanding of the agricultural innovation systems concept. It concludes with some perspectives on the future.

## Evolution of the agricultural innovation systems concept

The evolution of agricultural knowledge frameworks has been succinctly reviewed by Rivera. (2006) and later by other authors (e.g. Klerkx *et al*., 2012). Rivera *et al*. (2006) point out (p.581) that "[f]rameworks are conceptual models that structure reality. A framework identifies the elements that are considered relevant and specifies their relative importance and relations. As such, a framework represents the mental model of how reality is perceived". Rivera *et al*. (2006) examined four major frameworks, characterised by different acronyms, which have gained international importance, and sought to identify the strengths and weaknesses in each. The first two, which are now of little more than historical interest, can be described in one paragraph each, just for completeness.

The *National Agricultural Research Institute* (NARI) approach was adopted from the 1950s and 1960s onwards and focused on building public sector research departments/institutes and its extension services. Investments in 'bricks and mortar' facilities and the building of public sector human and organisational capacity were intended to drive innovation in agriculture. Such an approach was firmly grounded in the modernisation paradigm which emphasises the supremacy of modern science and technology. 'Top-down' in nature, agricultural extension was seen as a 'pipeline' for one-way channelling of information to farmers, who were often perceived as being 'backward'. Rivera *et al*. (2006) note that the NARI approach contributed greatly to promoting agriculture as an engine of economic development.

From the 1980s, international agencies began to shift their agricultural development emphasis toward system approaches that involved a wider range of organisations in technology programmes. Scientists and technicians from private sector firms, NGOs, farmer organisations and universities were more directly involved in promoting innovation and technical change. The *National Agricultural Research Systems* (NARS) approach included *National Agricultural Extension Systems* (NAES) and *National Agricultural Education and Training Systems* (NAETS). This more inclusive approach led to improved linkages between organisations, helped to reduce duplication of efforts and encouraged sharing of experience and best practice.

The recognition of these three national knowledge systems gave rise to the term *Agricultural Knowledge and Information Systems* (AKIS), which developed in the 1980s and gained wide acceptance among development agencies in the 1990s. This was a more integrated concept that stressed the connections among the three knowledge systems, viewing them as part of an integrated 'triangle' that extended beyond public sector organisations to include all those involved in generating and disseminating knowledge. The concept was intended to promote linkages between organisations and with existing and potential end users of knowledge.

The AKIS framework was conceived with the recognition of the inappropriateness of the perceived unidirectional flow of knowledge from only researchers to farmers. Knowledge was envisioned as flowing not only *from* research, education and extension (and *through* extension), but also from input suppliers and credit organisations as well as markets. In other words, information flowed to farmers throughout the agricultural development process, not just within the triangle of agricultural research, extension and education. Furthermore, the triangle concept represented a change in perceptions about the role and relative importance of the different organisations. Instead of the former 'pipeline' idea, the farmers are placed at the centre of the system, with research, extension and education as equal partners. 'Participation', 'demand-driven' and 'market orientation' are elements emphasised in this approach.

Rivera *et al*. (2006) identified several major achievements of the AKIS concept, including its promotion of linkages between the different systems that support knowledge flows and the recognition of farmers as central actors in the dissemination and diffusion of innovations. Extension is viewed not just as the dissemination of agricultural information and technology, but as a non-formal education system paralleling the formal system. They considered that its main limitation is a focus on organisations, their functions and their strategic alignment, and insufficient emphasis on the importance of particular problems.

The *Agricultural Innovation System* (AIS) framework was developed in the 1990s and started to gain increasing attention in the international development community by the early 2000s. While stressing the need for linkages between actors, according to Rivera *et al*. (2006) AIS moves 'innovation' (rather than 'organisations') to the centre of attention and emphasises a wide range of stakeholders and pluralistic networking among agriculturally relevant organisations. These authors consider that what renders AIS distinct from the systems discussed above is "its emphasis on innovation related to value added commodities, integrated supply chains and market chains" (p.587). The AIS framework seeks to foster the integration of research and education systems, as well as develop public-private partnerships, develop and strengthen farmer organisations, establish technology transfer units, build decentralised regional innovation centres, and implement

new governance models for research and extension.

An important aspect of the AIS framework is its inclusion of the so-called 'enabling environment' (Spielman and Birner, 2008). Related enabling constraints are defined by Klein Woolthuis *et al*. (2005) as the legal (e.g. regulation and law) and customary institutions (e.g. culture and values) that together constitute the 'rules of the game' or the 'codes of conduct'. This distinction between the 'formal' ('hard') and 'informal' ('soft') institutions is widely accepted. The former tend to be more tangible and include laws, regulations, contracts, standards, product specifications and property rights (Coenen and Díaz López, 2010). By contrast, informal institutions influence social and economic life in a subtle, often intangible way. Examples include trust, habits, norms and values, beliefs, conventions, traditions, routines and preferences (ibid.). Klein Woolthuis *et al*. (2005) emphasise the clear distinction between *institutions* and *organisations*. The former correspond to rules and the latter are players.

The term AIS is currently preferred by many international agencies, including the World Bank, FAO and the Global Forum for Rural Advisory Services (Sulaiman, 2015). World Bank (2006) identifies several distinguishing features between AKIS and AIS (Table 1). Like any 'system', the AIS encompasses the different stakeholders or actors as well as the linkages between them. It is seen by international agencies as the most effective and efficient instrument to reach agricultural policy goals, since it allows innovations to be developed faster, and upscaled in many more areas and farm holdings in a cost-efficient way.

Rivera *et al*. (2006) concluded that the four frameworks they examined "underscore the fact that effective knowledge systems for enabling agricultural development generally require (a) a core capacity in public sector technology institutions that (b) promote pluralistic research systems and extension services that are (c) strategically aligned in knowledge and information systems *that increase coordination* [their emphasis] and respond to client demands (d) to advance innovation fostered by a facilitating policy and institutional environment" (p.588).

**Table 1:** Defining features of Agricultural Knowledge and Information Systems (AKIS) and Agricultural Innovation Systems (AIS).

| Defining feature | AKIS | AIS |
|---|---|---|
| Actors | Farmer, research, extension and education | Wide spectrum of actors |
| Outcome | Technology adoption and innovation | Different types of innovation |
| Organising principle | Accessing agricultural knowledge | New uses of knowledge for social and economic change |
| Mechanism for innovation | Knowledge and information exchange | Interaction and innovation among stakeholders |
| Role of policy | Linking research, extension and education | Enabling innovation |
| Nature of capacity strengthening | Strengthening communication between actors in rural areas | Strengthening interactions between all actors; creating an enabling environment |

Source: World Bank (2006)

# Innovation systems in the European Union

Two separate concepts have been used in recent EU policy discourse.

## Agricultural Knowledge and Innovation Systems

The European Commission (EC) prefers to use the acronym AKIS (rather than AIS) in its policy discourse (e.g. EU SCAR, 2012). This decision was strongly influenced by the study of Dockès *et al*. (2011) which was based on the results of the EU Framework 6 research project 'IN-SIGHT'. The authors argued that although when first introduced into EU policy discourses AKIS referred to the concept of *Agricultural Knowledge and Information Systems*, this acronym has since evolved to describe *Agricultural Knowledge and* Innovation *Systems*, "a concept that seeks to encompass and influence the complexity of knowledge and innovation processes in the rural sphere" (p.7). They attempted (p.8) to offer short definitions for several acronyms such as AKS, AKIS, AIS and LINSA (*Learning and Innovation Networks for Sustainable Agriculture*).

The logic of Dockès *et al*. (2011) in opting for the term AKIS is precisely that used by Rivera *et al*. (2006), as recounted above, that it moves 'innovation' to the centre of attention. The emphasis is on "innovation related to value added commodities, integrated supply chains and market chains" which Rivera *et al*. (2006) ascribed to the concept of AIS. But the definition of AKIS that has been adopted by the EC, i.e. "the combined organisation and knowledge flows between persons, organisations and institutions who use and produce knowledge for agriculture and interrelated fields"[4] is narrower than that of AIS. The definition uses the term 'institutions', but not in the same clearly defined sense as Klein Woolthuis *et al*. (2005). Policy documents refer to "farm advisors, researchers, farmer organisations and other relevant stakeholders that form the Agricultural Knowledge and Innovation Systems".[5] In other words, the emphasis is on the actors, organisations and knowledge flows directly relevant to agricultural innovation, which is a legacy of the Agricultural Knowledge and *Information* Systems definition of Röling and Engel (1991) (Table 2). The research-advisor-farmer axis remains dominant in EU AKIS-based policy discourse.

The difference in terminology between AIS and AKIS (i.e. the inclusion of the word 'knowledge' in the latter) is somewhat illogical, and simply historical.

In practice, policy makers in many countries actively monitor and intervene in the sector with specific policies for creating knowledge, providing R&D financing, enabling extensive and effective cooperation and networks,

[4] Proposal for a Regulation of the European Parliament and of the Council establishing rules on support for strategic plans to be drawn up by Member States under the Common agricultural policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulation (EU) No. 1305/2013 of the European Parliament and of the Council and Regulation (EU) No. 1307/2013 of the European Parliament and of the Council.{SEC(2018)305final} -{SWD(2018)301final, p.101.

[5] Ibid., p.45.

**Table 2:** Example definitions of Agricultural Knowledge and Information Systems (AKIS) and Agricultural Innovation Systems (AIS).

| AKIS | AIS |
|---|---|
| A set of agricultural organisations and/or persons, and the links and interactions between them, engaged in the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilisation of knowledge and information, with the purpose of working synergistically to support decision making, problem solving and innovation in agriculture. | A network of organisations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organisation into economic use, *together with the institutions and policies that affect the way different agents interact, share, access, exchange and use knowledge* [my emphasis]. |
| – Röling and Engel (1991) | – Leeuwis and van der Ban (2004) |

Source: own composition

improving intellectual property rights regimes, facilitating technology transfer, supporting skill formation and public procurement etc. (Edquist *et al*., 2004). In the EU, interventions implemented under several Rural Development Programme (RDP) measures[6] can address 'innovation'.[7] Guidelines for the evaluation of innovation in RDPs specifically identify 'building the enabling environment for innovation' as one of three 'pathways' by which RDP measures/sub-measures can support innovation (EC, 2017).[8] Interventions can improve various enabling conditions such as institutional (e.g. the policy/legislative environment), procedural (e.g. sources of funds), professional (e.g. access to training), organisational (e.g. possibility to interact with partners), operational (e.g. enabling transnational or cross-sector innovation) and technical (e.g. supporting new techniques and technologies).

The relevance of the enabling environment to agricultural innovation is therefore clearly acknowledged in EC programming guidelines, even if it does not form part of the EC's AKIS model. Policy makers and funders have considerable influence in shaping the enabling environment, but it is also strongly influenced by political history and cultural context (Nemes and High, 2013). In addition to administrative competences, which can influence how guidelines are interpreted and programmes are implemented, social attitudes such as trust vary between different regions of Europe (and elsewhere) (Augustyn and Nemes, 2014).

### 'Quadruple Helix' innovation system

Alongside the evolution of the two compatible, but slightly differing, approaches described above, i.e. the World Bank – FAO AIS and the EU AKIS, another relevant concept that appears to have developed somewhat independently is the so-called 'Quadruple Helix' innovation system (QHIS, see e.g. Carayannis and Campbell, 2012). This is an extension of the 'Triple Helix' model of knowledge, developed by Etzkowitz and Leydesdorff (2000), that identifies three 'helices' that intertwine and by this generate a national innovation system: *academia/universities*, *industry* and *state/government*. To this, Carayannis and Campbell (2012) and others add a fourth 'helix' that they identify as *culture and civil society*.

The QHIS concept has been integrated into the EU's Europe 2020 flagship initiative 'Innovation Union' which, among other things, is the context for the EIP-AGRI which was first implemented during the 2014-2020 programming period[9] and which will be carried forward to the next one. Sargsyan (2016) describes (p.54) the QHIS as "where government, industry, academia and civil participants work together to co-create the future and drive structural changes far beyond the scope of what any one organisation or person could do alone". The QHIS approach is also incorporated into the EU's research and innovation strategies for smart specialisation (RIS3). EC (2012) sees QHIS as allowing "more direct involvement of users in various stages of the innovation process. RIS3 processes can develop environments which both support and utilise user-centred innovation activities also with the aim of securing better conditions to commercialise R&D efforts" (p.37). The smart specialisation approach is entirely applicable to agriculture and rural areas (da Rosa Pires *et al*., 2014; Dax, 2019).

## An integrated approach to innovation systems thinking

Partnerships and networks are key features or core elements of the innovation systems concept (Fieldsend *et al*., 2020), and the development of innovation systems theory reflects primarily the improvements in our understanding of the processes of knowledge sharing and innovation involving farmers, rather than changes in the processes themselves. In particular, whereas in the 1950s and 1960s, farmers were often perceived as being 'backward', the role of tacit (as opposed to formal, codified or explicit) knowledge in the process of innovation is now widely appreciated (EC, 2013). Lowe *et al*. (2019) clearly demonstrated that not only is it incorrect to believe that knowledge flows in one direction, from researchers, through advisors, to farmers, but farm advisers themselves draw extensively on the knowledge and experience of those they advise. Through these interactions, farmers contribute extensively to the process of knowledge sharing between the diversity of actors in the agricultural innovation system.

Figure 1 illustrates a model that integrates the various ideas discussed until now. In line with common practice, farmers are placed at its centre, but one useful revision would be to replace 'Farmers' with 'Farm households'. Both globally and in the EU, most farms are family farms, defined by FAO as agricultural holdings which are managed and operated by a household and where farm labour is largely supplied by that household. Numerous studies have shown

[6] Art. 8(1)(c)(v) of Regulation (EU) No 1305/2013 and Annex I, Part I.5(c) of Regulation (EU) no 808/2014.

[7] 'Innovation' is one of three cross-cutting rural policy objectives in the current (2014-2020) programming period. The other two are 'environment' and 'climate change mitigation and adaptation'.

[8] The others are 'identify and nurture potential innovative ideas' and 'build capacity to innovate'.

[9] Communication from the Commission to the European Parliament and the Council on the European Innovation Partnership 'Agricultural Productivity and Sustainability'. COM (2012) 79 final. Brussel: European Commission.

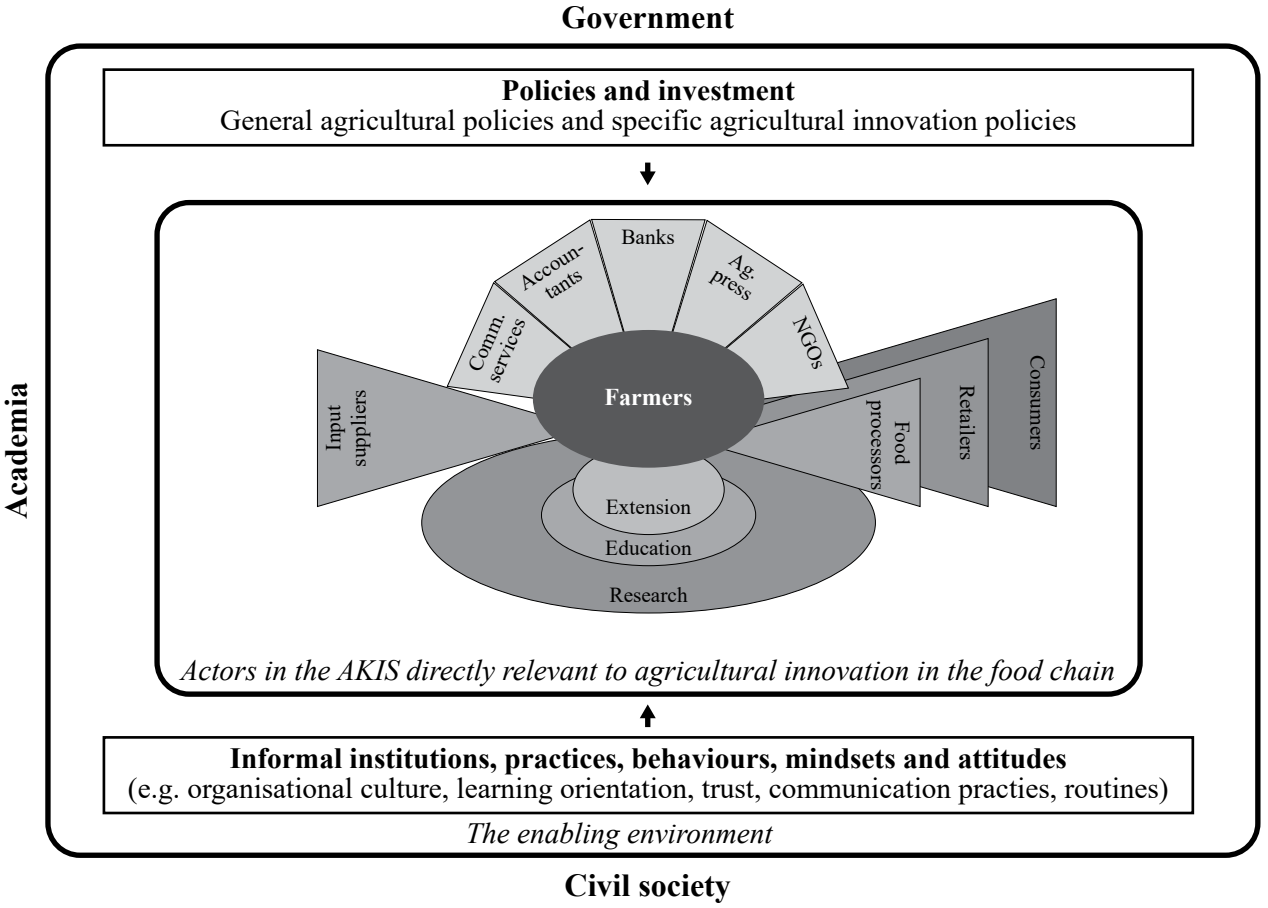


**Figure 1:** A multi-level innovation system model that integrates the 'Quadruple Helix', WB/FAO Agricultural Innovation System and EU Agricultural Knowledge and Innovation System concepts.
Source: own composition including a graphic derived from EU SCAR (2012)

'friends and family' to be important sources of information and knowledge for family farmers (Garforth *et al*., 2003), but the farming family is often omitted from models of the AIS/AKIS. Similarly, Koutsouris *et al*. (2017) observed that farmers tend to be most influenced by proof of successful farming methods by their peers, so-called peer-to-peer learning. Focusing on the 'primary farmer' may discriminate against spouses (particularly women) and younger household members who play a major role in decision-making in many farm households (Sutherland *et al*., 2018).

Figure 1 uses the graphic from EU SCAR (2012) to depict the AKIS as recognised by the EC. There are many other depictions of the EC's AKIS model and this one is preferred because it clearly illustrates three key features. Firstly, the (mainly public sector) education and research institutes and advisory services which have long been recognised as sources of knowledge for agricultural innovation and which continue to play an important part in this process. Secondly, the (mainly private sector) actors in the value chain,[10] including input suppliers and food processors. Knowledge sharing and innovation occur extensively along this axis (Swinnen and Kuijpers, 2019), although frequently outside the sphere of formal projects and public sector funding. Thirdly, various other actors such as banks and the agricultural press (both printed and electronic) are important sources and brokers of expert knowledge in their own right. Spielman and Birner (2008), and many other authors, adopt similar approaches within their models of AISs.

A concept proposed more recently is the farm-level 'micro-AKIS', defined by Sutherland *et al*. (2018) as the knowledge system that farmers personally assemble, including the range of individuals and organisations from whom they seek services and exchange knowledge, the processes involved, and how they translate this into innovative activities (or not). So, within the AKIS, numerous micro-AKISs exist. Knowledge sharing in a micro-AKIS may occur through informal networks, interactions with advisory organisations or participation in partnerships such as (multi-actor) projects (Šūmane *et al*., 2018). The diversity of sources of knowledge in the farmer's micro-AKIS is clearly illustrated by several studies, including Varanka (2014) in Hungary and Fieldsend *et al*. (2019) in Ukraine. In both these instances, most of the different actors depicted in Figure 1 are consulted, and the research and education sectors together account for a relatively small part of many farmers' micro-AKIS.

The enabling environment has been introduced earlier in this paper and can be denoted according to the widely shared approach used by Spielman and Birner (2008). The actors,

[10] A value chain can be understood as a sequence of business relationships that allow the consequent addition of value as a commodity passes from one segment in the chain to the next reaching from primary production, over various steps of transformation to the final consumer (Hartwich *et al*., 2010).

organisations and knowledge flows in the AIS operate within this enabling environment.[11]

How, then, does the Quadruple Helix concept relate to the foregoing? Analogous to our emerging understanding of the nature of agricultural innovation systems, the Quadruple Helix idea is associated with the recognition that until the 1990s, the R&D community often drove research trajectories and the public played the part of passive innovation recipients. Now it is accepted that research trajectories must be legitimised among relevant publics, aim at positive public impact and be defined with the public's help (Schütz *et al*., 2019). The expectation is that involving societal stakeholders and individual laypersons will help to re-align research trajectories with public preferences and lead to more welcome, sustainable, solutions.

The Quadruple Helix is the framework in which the innovation system, including the enabling environment, operates. The 'consensus' (tacitly) agreed between the components of the Quadruple Helix, albeit one that is constantly evolving, with the relative influences of the four helices fluctuating over time (and differing between countries and regions), regulate the operation of the AIS. In other words, the 'hard' and 'soft' rules set by the enabling environment are dictated by the prevailing consensus in the Quadruple Helix. An innovation such as, for example, genetically modified crops requires academia to develop the methodology for transformation and business to commercialise it. However, the success (or otherwise) of the innovation process depends on the legal framework put in place by government and acceptance by civil society (the latter also having an impact on the former).

This model is comparable to that outlined by Renting and Wiskerke (2010), in which the development and functioning of food systems are subjected to a 'governance triangle' of market, state and civil society. FAO (2013) defined a food system in terms of its components: "[f]ood systems encompass the entire range of activities involved in the production, processing, marketing, consumption and disposal of goods that originate from agriculture, forestry or fisheries, including the inputs needed and the outputs generated at each of these steps. Food systems also involve the people and institutions that initiate or inhibit change in the system as well as the socio-political, economic and technological environment in which these activities take place". By contrast, HLPE (2014) emphasised the objectives: "a system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised".

Using the CAP as an example, Renting and Wiskerke (2010) illustrated the initial dominance of the state during the modernisation era, the subsequent increase in the importance of the market in successive CAP reforms, to the current inclusion of 'societal demands'. Clearly, the food systems concept is fully compatible with that of AIS, and a well-functioning AIS is indeed essential for food systems development. The inclusion of 'academia' in the governance framework of the AIS is a logical extension of that adopted for food systems.

[11] For completeness, it should be recorded that Spielman and Birner (2008) also refer to a set of 'linkages' from the AIS (such as to other economic sectors), but these are not shown in Figure 1.

## Current agricultural innovation policy discourse in the EU

Rivera *et al*. (2006, p.588) noted that the AIS approach "does point up the over-whelming complexity of a multifunctional, institutionally pluralistic system of agricultural development in an increasingly globalised world". Innovations only can leverage substantially the national agricultural goals if an appropriate enabling environment for the generation and adoption of innovations is established. Any programme to advance a pluralistic agricultural innovation system must ascertain that there is, in the words of Rivera *et al*. (2006, p.588), "the *political will* to promote agriculture in general and AKSs more specifically, an *institutional environment* that is conducive to the flow of knowledge, to collaboration, experimentation and implementation of innovations, a *well-articulated demand for new knowledge and technology*; and the *effective supply of new knowledge and technology*, from the public research system as well as from other sources, including indigenous knowledge private sector research and transfers from abroad". The aim should be to offer a sufficiently flexible means of dealing with the varied conditions and contexts in which innovation must occur.

All four prerequisites are present in the EU. A cross-cutting objective of the EU's CAP for the 2021-2027 programming period is to modernise the sector by fostering and sharing knowledge, innovation and digitalisation in agriculture and rural areas, and encouraging their uptake.[12] Each EU Member State will be expected to prepare a CAP Strategic Plan which, *inter alia*, shall describe their contribution to this cross-cutting objective by describing (a) the organisational set-up of their AKIS; (b) how advisors, researchers and CAP networks will work together within the framework of the AKIS; and (c) how advice and innovation support services are provided.[13] A requirement is to include a system ('farm advisory services') for providing impartial farm advice to farmers and other beneficiaries of CAP support by advisors that have no conflict of interest. These advisors can be staff from NGOs, farmers' organisations or innovation support services, as well as from 'formal' advisory services. They will also offer innovation support, in particular for preparing and for implementing 'Operational Group' (OG) projects in the frame of the EIP-AGRI. OGs, which are already financed by the current CAP, are farmer-driven partnerships that are expected to develop innovative solutions based on the interactive innovation model. They shall disseminate their plans and the results of their projects, in particular through the CAP networks.

While these measures are to be welcomed, they are a necessarily limited set of interventions, owing to the constrained resources of the EU in comparison to the multiplicity of actors, organisations, partnerships, knowledge flows and enabling environments that make up the European agricultural innovation system. But they may lead to the term

[12] SEC(2018)305final; see earlier footnote for full reference.

[13] According to Article 113 of the draft Regulation, CAP networks will network organisations and administrations, advisors, researchers and other innovation actors in the field of agriculture and rural development at national level.

'AKIS' being appropriated to refer solely to the activities covered by this EU policy instrument rather than a model, as now. In line with the multi-level model proposed in this paper, many EU communications already depict the AKIS as being 'at the heart of the agricultural innovation [eco]system'. But the term has also been specifically linked with the phrase 'cross-cutting CAP support to systematically share knowledge and innovation in agriculture and rural areas'.

There is a precedent for this evolution of terminology. Schucksmith (2010) observed that the term 'rural development' carried an "essentially territorial" (p.2) meaning when first used by the EU in the early 1980s, but then acquired a new and highly contested meaning in EU parlance through the establishment of the CAP's second pillar, the Rural Development Regulation (RDR). Dwyer *et al*. (2002, p.13) described the RDR as "primarily a structural adjustment policy for agriculture". This example shows that it is not unknown for a new meaning to be applied to established terminology in CAP discourse. Quite separately, any shortcomings in the content of the new CAP, for example, in any failure to address core environmental needs, are likely to have important implications for innovation activities in those areas (Pe'er *et al*., 2020).

But is it a problem if the term 'AKIS' acquires a new meaning in the EU?

No.

The concurrent use of two compatible but different models with similar acronyms is causing confusion. For example, Sutherland *et al*. (2018) stated that "[t]he current usage of the term AKIS more accurately represents the literature on AIS" (p.22) and observe that, according to different authors, the two approaches can be considered competing or complementary. Reflecting their assessment, they defined 'AKIS' as "the collection of agricultural information providers, the flows of information between them, *and the institutions regulating these relations*" (my emphasis). Such confusion is clearly unhelpful for both theory and policy development. The problem would be at least mitigated if in the next EU programming period, as seems possible, the term 'the AKIS' comes to be associated specifically with those interventions in CAP Strategic Plans that are designed to foster and share knowledge, innovation and digitalisation in agriculture and rural areas. 'The AKIS' would be an EU policy instrument which forms (a relatively small) part of the European agricultural innovation system, and the term 'AIS' would retain its internationally recognised meaning.

## Conclusions

Development of the innovation systems approach has shifted our thinking away from seeing research as the central actor in an innovation system to being one important part of the whole system. It allows a clear distinction to be made between 'invention' and 'innovation'; and 'institution' and 'organisation' and looks at the multiple conditions and relationships that promote innovation in agriculture. This includes adopting a multi-level perspective. Such a perspective argues that transitions come about through interactions between processes at different levels (Geels and Schot, 2007). In other words, the day-to-day knowledge sharing between actors and organisations does not operate independently of the enabling environment or the 'governance rectangle' represented by the Quadruple Helix.

Undoubtedly the concept of AIS will continue to evolve and may even gain a new acronym in the future. For example, as long ago as the late 1990s, the AKIS framework was perceived as an essential contribution not just for agricultural development, but also more broadly for 'rural development', and began to be referred to as AKIS/RD (e.g. FAO/World Bank, 2000). This change reflects the fact that many farmers are multi-occupational, having both on-farm and off-farm sources of household income. In many countries in Europe, to a greater or lesser extent, the role of agriculture in the rural economy is declining. In these countries 'rural' cannot be equated to 'agriculture': the former is a much broader topic. The idea of ARKIS (Agricultural and Rural Knowledge and Information Systems) for Europe has recently been revived by the Agricultural and Rural Convention 2020, a multi-stakeholder platform of civil society networks and organisations that are pushing for reform of the CAP to encompass an integrated rural agenda (ARC2020, 2020).

Similarly, reflecting the increasing diversification of the economic role of agriculture, EU SCAR (2016) hinted (p.78) at the need for a bioeconomy knowledge and innovation system (BKIS). However, this concept is very much in its infancy and may prove to refer to a concept that is simply to broadly-based to be addressed in a meaningful way.

The features of the 'AKIS' listed in Table 1, such as 'linking research, extension and education', continue to be reflected strongly in the way the 'AKIS' is to be considered in CAP Strategic Plans. This may point up the role of path dependencies in policy making, whereby specific concepts and associated acronyms become embedded in policy discourse. Rivera *et al*. (2006, p.582) rightly noted that "there is no blue-print solution, [innovation systems] approaches need to be country specific". Even so, the risk of path dependency and the historical disconnect in the development of the AIS and AKIS demonstrate the need for even greater dialogue between researchers, policy makers and others in the EU and beyond during the future development of innovation systems theory, quite apart from any parallel debate on the most important priorities for innovation in agriculture and rural development.

As a first step, EU researchers might consult the publications of international agencies such as FAO more fully, while these agencies could publish more of their analyses in peer-reviewed academic journals. Enhanced cooperation offers the welcome prospect of greater coherence between future EU and international approaches to fostering agricultural innovation. In turn, it should lead to more progress on the mutual aspiration of sustainable intensification.

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# Consumer perception of Hungarian agroforestry products – results of a Q-methodology attitude research study

In our study we investigated agroforestry systems and the market for products derived from them, from a consumer perspective. Agroforestry products are not yet in the public domain, so our research focused on the latent market for agroforestry products. This allowed the participants to form only an opinion, reactions which we were able to reveal using the Q-method. In our study, we targeted average consumers who are independent from agroforestry systems and products. Out of the 174 Q-Sort questionnaires, 85 were filled out with valid responses. As a result of our Q-analysis, we created 4 factors in order to minimise the number of factors and achieve a given level of total variance. Factor 'A' (N=26) "Alternative, Green Consumers" are committed to the products of the sustainable economy, so agroforestry products would also be of interest. Factor 'B' (N=21) "Inquisitive Consumers" are interested in and eager to be informed about the products purchased, and they are willing to pay more for agroforestry products. For Factor 'C' (N=10) "Busy Consumers", the low ecological footprint of agroforestry products is a big advantage, and they can be reached with articles published on various news portals and online media most effectively. Opinion Groups 'A' and 'B' choose the traditional market for their purchases - this is why direct selling at local or farmers' markets, fairs, or short supply chains can be beneficial. Potential consumers also appear to be willing to pay a higher price if they find an attractive product from an agroforestry system.

**Keywords:** agroforestry, perception, Q-method, willingness to pay, attitude

**JEL classifications:** Q13, Q23

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## Introduction

Nowadays agricultural systems, ecosystem health, landscape integrity, and rural resource-based livelihoods are in crisis all over the word (Diaz *et al.,* 2019; Plieninger *et al.,* 2020). The worsening effects of climate change and measures taken to counteract it will place an emphasis on alternative, non-intensive agricultural production on both the international and national markets, and this requires radical changes in the food systems (Willett *et al.,* 2019). Responsible farmers strive to develop and use farming and production methods that are as environmentally friendly as possible. These include alternative and sustainable farming methods, such as agroforestry systems.

In Europe, the term "agroforestry systems (AFS)" defines a diversity of farming landscapes having in common woody vegetation (scattered or clumped trees and scrubs) used in combination with livestock grazing and crop production (Mosquera-Losada *et al.,* 2018). The beneficial effects of the elements of the resulting multifunctional system on one another can lead to more ecological, social and economic management than monoculture farming. These systems include shelterbelts (coastal and field hedges, hedges), grazed forests, wooded pastures, wooded groves, forest gardens, improved fallow land, forests combined with crop production, intermediate crop cultivation and municipal green infrastructure. The goal of agroforestry is to integrate sustainable woody crops into agricultural activities to create an economically, socially and ecologically beneficial structure (Csonka *et al.,* 2018). Agroforestry products could include typically agricultural, forestry and forest-based products such as fruits, vegetables, meat, eggs, dairy products, decoration floral products, timber and other wooden products, mushrooms, herbs, honey and products derived therefrom.

In our study we investigate the agroforestry systems and the market for products that can be bypassed from them from a consumer perspective. There is an increasing demand from the consumer society for natural lifestyles, organic products and green products (forest fruits, mushroom, herbs, etc.) (den Herder *et al.,* 2017) or even for the development of new food brands for agroforestry systems (Deliza *et al.,* 2003; Elghannam *et al.,* 2020). The public is also increasingly conscious of using environmentally friendly solutions in their everyday lives, buying products from ethical and eco-friendly farms. Earlier research has shown that consumers are not sufficiently aware of agroforestry systems, nor are they aware of the benefits of their products (Hannachi *et al.,* 2017). Consequently, our research goal is to contribute to the presentation of the products and advantages of the farming method and with our results we would like to help scale up the strategy of market for agroforestry. Similar studies have not yet been carried out in the sector, except for a few which concentrate on the producers. Agroforestry products are not yet in the public domain in Hungary, so our research focused on the latent market for agroforestry products. This allowed the participants to form only an opinion, reactions which we could reveal by using the Q-method.

## Current situation of Hungarian agroforestry

As in the case of conventional agriculture, agroforestry solutions vary from region to region with regard to how they achieve the most efficient production and landscaping. Agroforestry itself is diverse. Wood is also used in various ways (raw material, energy use, food, furniture, etc.), but

agricultural production varies according to crop or livestock. Europe is unique in terms of its traditional agroforestry systems of high natural and cultural value, and the continent has great potential for developing innovative and modern systems with the support of research centres. The development of rural areas has become a key element of the European Union's Common Agricultural Policy. The European Union's rural development policy supports the development of agroforestry systems, which play a positive role in creating social, economic and environmental externalities (den Herder *et al*., 2017).

There are potentially large areas available in Hungary for the establishment of agroforestry systems. According to the survey by den Herder *et al.* (2017), agroforestry systems occupy a total of 38.1 thousand hectares, out of which 2 thousand hectares of arable agroforestry, 36.1 thousand hectares of livestock agroforestry and 2 thousand hectares of high-valued tree agroforestry system. They represent less than 1% of the utilised agricultural area of Hungary where the same products are available as in other parts of the continent coming from agroforestry systems.

Products coming from animal husbandry include meat, cheese and dairy products, while forest products, mushrooms, honey, forest fruits and herbs originate from these systems. Wild pear or apple, jams and brandy are becoming increasingly popular among traditionally made products (Moreno *et al.,* 2018). These products are not recognised on the market, have no unique designation or channel and therefore they are not recognised by the average consumer. There is no defined consumer segment on the market yet, although there would be a variety of quality products. The situation is the same in other European countries, however, they have bigger agroforest areas and more typical, in many cases branded, products. For example, in Spain the results of a study using focus group interviews revealed a lack of citizen familiarity with the agroforestry system, as well as with the services it supplies, besides those that are purely associated with food production. Other key findings were the low importance given by consumers to the item "production system" (Gaspar *et al.,* 2016). A study with 386 consumers in Italy indicated that the majority of respondents (74%) knew little about the positive effects of agroforestry (Bondesan *et al.,* 2016).

In the international market, there are some marketing strategies which work effectively. For example, the Amazonia Hub (www.amazoniahub.com) is an organization which helps agroforestry farmers and enterprises from the Amazon area of Brazil in their marketing activity. The members of this association produce gastronomic and cosmetic products as well. We can find good practices in Sub-Saharan Africa as well, where indigenous and exotic fruits are cultivated and can bring increased revenues for smallholders on the domestic market and improve the diets of local consumers (Jamnadass *et al.,* 2011).

In Europe, the Galician honey (www.mieldegalicia.org) is a widely known trademark from the Galician region of Spain. It contains the honey collected by the bees in the Galician forests and made with traditional procedure. In the Veneto region of Italy, outdoor free-range pig production is rare. However, farmers who use agroforestry systems for pig production often process a large proportion of meat on-farm and they expect to receive a premium price from consumers for products such as traditional fermented salami. The eggs with woodland egg mark are from hens living in an agroforestry system. This label can be found in New Zealand (http://www.woodlandeggs.co.nz) and England as well.

These examples show that agroforestry could improve the effectiveness of small farmers and farmer's groups and foster local economy and cultural habits. Moreover, agroforestry could be able to give added value for the products. The above introduced and other high quality products that have traditionally been products of agroforestry are of particularly high value include the Iberian pig ham from Iberian *dehesas* (one of the most representative agroforestry systems in Europe situated in the southwest of the Iberian Peninsula and characterised by the use of large pasturelands in wooded areas) or reindeer meat in the boreal forest (Gaspar *et al.,* 2016; Moreno *et al.,* 2018). New needs for natural and high-quality products derived from agroforestry systems need also to be explored, such as tannins for tanning leather and antioxidants or gluten-free flours (Moreno *et al.,* 2018). According to Hernández-Morcillo (2018), increasing the portfolio of AFS products, coupled with improved marketing of agroforestry products could be essential. Furthermore, as a good practice, we can mention the certification schemes of the Rainforest Alliance, which tries to improve the financial stability of farmers adopting AFS with shaded coffee plantations in Latin America, which increased coffee yields and provided additional profits (Perfecto *et al.,* 2005). According to Sollen-Norrlin *et al.* (2020), similar schemes for agroforestry products from Europe might increase awareness amongst the public and provide a potential financial incentive for farmers to adopt AFS.

## Methodology

During the primary research, we worked with our own collected data that we analysed. Consumers are most easily reached through online questionnaires, and this is probably the most common method these days. For our research, we chose to apply the Q-Method, which was able to examine the opinion of consumers about agroforestry products.

The Q-method was developed by psychologists in the 1930s (Stephenson, 1953), and was used to seek to objectively uncover and analyse (dis)similarities in the subjective viewpoints of individuals. Q-method operates on the assumption of a 'finite diversity' within a particular discourse domain; it attempts to elicit this limited variety of existing discourses among small populations of respondents in a structured and statistically interpretable form. Q allows insight into individuals' subjectivities in a more holistic way than conventional surveys, while providing clearer structure, better replicability, and a more rigorous analytical framework than purely qualitative approaches (Louah *et al.*, 2017). For these reasons, Q methodology is popular across a wide range of research fields, e.g. in psychology, political science and marketing (Lehrer *et al.*, 2017), such as political public opinion and attitude research, clinical psychology, pedagogy, gender research, product development, advertising effectiveness research, consumer attitudes and behavioural research. It is a popular research method in the Anglo-Saxon areas, but only

a few Hungarian research have used Q-Method (Hofmeister-Tóth and Simon, 2006). According to Donner (2001), Q is particularly well-suited for topics in which it is necessary to recognise social complexity and, therefore, it has slowly gained popularity in environmental research (Louah *et al.,* 2017). Moreover, Previte *et al.* (2007) stated that Q-method could be successfully applied to address rural research questions in farming research as well. The Q-Method combines the specifics of a qualitative and a quantitative research method. It is qualitative because it focuses on the subjectivity of opinions and attitudes, but analyses and evaluates data in a quantitative way (e.g. factor analysis, correlation).

According to Davis *et al.* (2011), a Q-Study generally consists of six steps:

1. Research question (s),
2. Compiling a Q-Sample (a list of selected statements),
3. Selection of participants (P-Sample)
4. Completing the questionnaire
5. Data analysis
6. Interpretation of results

Compiling the Q-Sample means selecting statements that are written on cards, which is preceded by previous research on the topic. There are three types of Q-Samples: natural, ready-made and standardised Q-Samples. The natural sample is based on the selection of oral or written statements from interviewees. The ready-made sample takes statements from empirical research results or concepts. Standardised samples use standardised personality tests and value lists. Of course, Q-Samples can also be constructed by using a combined method (Hofmeister-Tóth and Simon, 2006). The selected Q-Samples or so-called statements are placed on cards which are randomly numbered. Participants will rank these cards in order, depending on how much they agree with them or how typical they are. This is known as a Q-sort technique, which is a card layout process in which statements (e.g. opinions, individual words, attributes, values, images, figures) are arranged relative to one. Thus, the method focuses on the active combination of cards by the interviewees (Hofmeister-Tóth and Simon, 2006). The sorting process can be bound and open. The difference between the two procedures is that while the open procedure does not specify the normal distribution of statements, the cards must be placed in a system called a Q-Sorting grid in a bound distribution (Figure 1), according to how much the participant agrees with the statement. According to Brown (1996), individuals are often unaware of their own preferences. For example, they are not aware of the reasons behind their consumer decisions, so the knit sorting principle can help them to make the decision and can also be fun for the filler.

During the evaluation, groups and factors are formed from those who have similar opinions. The mathematical background is provided by the correlation calculation and the modified approach factor analysis. The uniqueness of the method stems from the fact that respondents are treated as variables rather than statements. Statistical evaluation processes rely on factor analysis, correlation, and factor values, where mathematical procedures serve only the creation of subjective (typical) structures. The so-called Q-Correlation forms the basis of factor analysis, which creates similarities and differences between individuals and types. Each participant's response, Q-rating, is compared and correlated with all participants in the research (Hofmeister-Tóth and Simon, 2006).

Data analysis is supported by several software packages. Q-methods can also be applied to standard statistical programs such as SPSS, STATA, etc. There are programs specifically supporting the Q-Method that follow the process from input of values through factor analysis to interpretation of the values obtained. PQMethod is perhaps one of the most widely used software that provides statistical indicators for a given factor analysis. There are already systems available online that support research from the time the questionnaire is compiled and completed. In our study we used an online software called "Q Method Software" (www.qmethodsoftware.com). The fillers were not needed to be personally in a room, they could participate in the research via computer.

During our Q-method examination, we followed the six steps presented above, which we used to compile the Q-sample and evaluate the results. Due to the exploratory nature of the Q-Method, it can respond to potentially complex and socially disputed requests and focus on identifying and interpreting respondents' reports and views (Davis *et al.,* 2011).

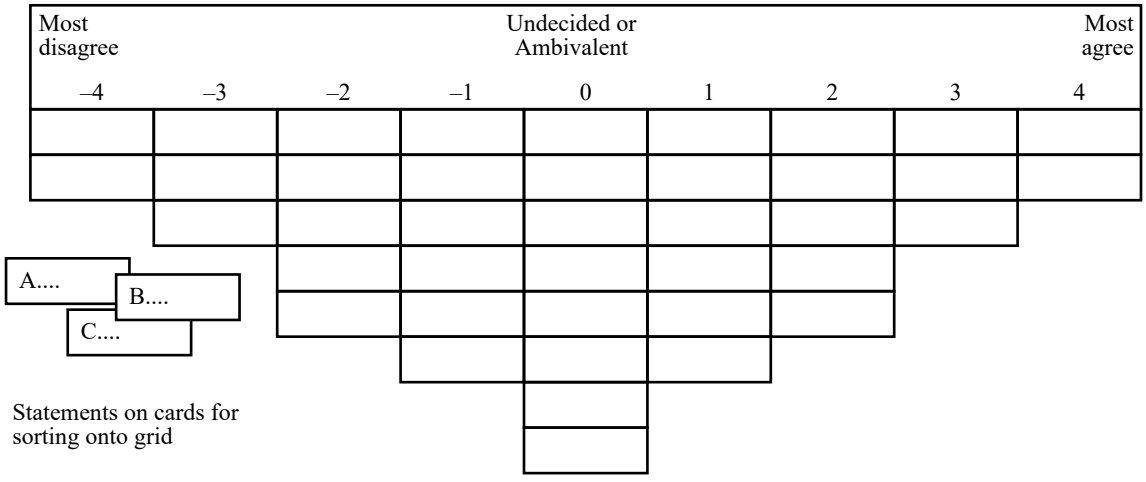


**Figure 1:** Example of Q-Sort grid.
Source: Eden *et al*., 2005., pp. 415

In the compilation step (Step 2), we explored the research question in the broadest possible terms, in as many ways as possible. We compiled a Q-Sample of 25 statements from a combination of natural and ready-made patterns. Secondary research preceded the compilation of the sample. In order to formulate and select the statements correctly, we first read and studied a number of Q-Studies and reviewed the marketing opportunities of the agroforestry branch based on international literature. Finally, the most widely used literature in our Q-Study is the study presented in Hofmeister-Tóth and Simon's (2006) article. One of the aims of the literature review presented in the first part of our study was to collect the statements. The domestic interpretation of international trends and good practices can provide a good basis for the successful marketing strategy of Hungarian agroforestry farms and the delivery of products to consumers.

Based on Mosyagina *et al.* (1997) and Hofmeister-Tóth and Simon (2006) who used the Q-method in marketing research, we also took the four dimensions of the marketing mix to compile Q-statements. With the help of the marketing mix, we can create a general strategy that can be effectively used to develop a marketing strategy for a latent market (such as domestic agroforestry products market). Finally, with multiple reviews and comments from outsiders, we made 25 statements based on the four dimensions of the marketing mix. We made seven statements for the product dimension, four statements for pricing policy, six statements for sales and product placement and eight statements for advertising policy.

As to the selection of participants (Step 3), most Q-Study requires preliminary work to select the participants. Sometimes it requires to select a specific group, members of an organization, or just as diverse participants as possible to complete the questionnaire. It is important to note that the Q-method is not suitable for representative typing, as the P-sample consists of an average of 1–50 participants. The method is suitable for exploring a specific topic whether there are similar patterns in people's thinking, and this is already a smaller pattern identifiable.

We targeted average consumers who are independent from agroforestry systems and products. Out of the 174 questionnaires sent out, 85 were filled out with valid responses. After the Q-Sorting, the participants filled a traditional questionnaire. As a result, 45 women and 40 men participated in the study. The youngest questionnaire filler is 19, the oldest is 65 years old, and the average age is 36. Out of the respondents, 13 live in the capital city, 10 live in rural areas, 46 live in county seats and 36 live in cities. The majority of the respondents, 64 in total, have a university or college degree, 19 have graduated from a high school, and only a few have vocational or elementary school qualifications as the highest level of education, but they are most probably still studying in high school.

The largest number of the fillers was employees (51 people). We received answers from 20 entrepreneurs, 8 people in managerial positions, 5 students and one housewife. Out of the background variables, we also asked about the financial situation to see the complexity of the participants. Most of them have an average income based on their response, 34 people make a living from their earnings, while 26 people can save some money in each month. 13 fillers live in good financial conditions. Out of the total, 12 people are dissatisfied with their financial situation, with 8 people having financial problems, 3 just hardly being able to live from their salary and one person who is struggling with financial problems in the capital.

Based on the data of the respondents, we tried to reach the average Hungarian consumers in terms of age, education, work and income. Only the type of place of residence was concentrated in the county seat, this can be attributed to the place of research, the University of Kaposvár, and our personal acquaintances, who are concentrated in Pécs and its surroundings. We sent an email with the study and questionnaire information to each participant, as well as a link to complete the questionnaire and a unique entry code.

In Step 4, participants evaluated the statements we created after the pilot version. Our target group was the average Hungarian consumer; consequently, we also formulated the questionnaire in Hungarian, which is more sophisticated than the statements in English presented in the publication. Participants first divided the statements into three groups, either agreeing, expressing neutrality, or disagreeing with them. After dividing the 25 statements into three groups, they had to place the same statements in a knit pyramid. According to this, -4 was the least specific statement, with neutral cards drawn to 0 and the most preferred card assigned to 4. The Q-Method survey was followed by a short questionnaire in which participants had to answer nine questions about daily habits and socio-demographic parameters.

The online "Q Method Software" was used to make calculations, but for the sake of completeness, we found it important to present the statistical and mathematical background as well. The purpose of the Q-Study is to find out whether there is a concordance between the opinions of the contributors and whether it is possible to form a common opinion from the evaluation of the statements (Q-Sample). As a result of the factor analysis, a hypothetical Q-order has been obtained for each group based on the order of opinion. The online software worked in beta version, so we had to verify the results with PQMethod Software and correct some data.

## Results and Discussion

As a result of our Q-analysis, we created 4 factors to minimise the number of factors and achieve a given level of total variance. Table 1 shows the main characteristics of the factors.

A total of 65 respondents were placed in different groups (factors), 76% of all participants (85 people). Factor 'A' con-

**Table 1:** Factor Characteristics.

| Factor Characteristics | A | B | C | D |
|---|---|---|---|---|
| Average Reliability Coefficient | 0.8 | 0.8 | 0.8 | 0.8 |
| Number of loading Q-Sorts | 26 | 21 | 10 | 8 |
| Eigenvalues | 15 | 14 | 8 | 7 |
| Explained variance | 18 | 16 | 9 | 8 |
| Composite Reliability | 0.99 | 0.99 | 0.98 | 0.97 |
| Standard Error of Factor Scores | 0.098 | 0.108 | 0.156 | 0.174 |

Source: own composition

tains the highest number of items, 40% of the participants in the factors. In the statistical hypothesis test, we examined how the given factor explains the opinion of the variables (respondents). It is observable from Table 4 that the Eigenvalues of all four factors are greater than 1, i.e. all the factors meet the criteria formulated in the Q-method.

The factor analysis gives the normalized factor values (Z-scores) for each statement, showing how much the given statement differs from the mean. Statements that have an absolute Z-Score greater than 1 are called factor-specific statements. The highest value indicates the statements with which the members of the opinion group are most in agreement, while the lowest value statements are the least characteristic.

### Factor 'A' (N=26) – "Alternative, Green Consumers"

Nowadays the products from alternative farms are more and more popular. The actors of Factor 'A' are also committed to the products of the sustainable economy, so agroforestry products would also be of interest. 77% of the players in the factor are women, visit forests relatively regularly and are willing to pay extra for agroforestry products. Table 2 contains the statements that determine the factor the most.

The members of the opinion group choose producer and local markets for their shopping, and would not buy agroforestry products in hypermarkets, supermarkets or online. The environmentally friendly nature of agroforestry products positively influences their purchasing decision, and they would be willing to replace their usual product if they found an alternative towards agroforestry.

### Factor 'B' (N=21) – "Inquisitive Consumers"

Opinion Group 'B' is interested in and eager to be informed about the products purchased. They are not as committed to alternative/sustainable farming products as Factor 'A' but are willing to pay more for them.

Table 3 presents the statements which are significantly specific for the Factor 'B'. Participants of the Factor 'B' are typically communicative and inquisitive. They are eager to be informed about the products and their origin by the sellers/producers influencing their decision. Like Factor 'A', they choose the traditional markets for their purchases. They would be happy to visit agroforestry if they were to organise programs (e.g. pick your own) and organise workshops. With TV commercials and a wholesale presence, the sector's products would not be of interest. They like catalogues as well.

### Factor 'C' (N=10) – "Busy Consumers"

Factor 'C' actors are said not to have a financial problem but live in a better financial position than other Factors. Most of them are men and a high proportion of them are in leadership positions. From demographic data, we conclude that they are busy due to their work and lifestyle. They are less biased towards the products of alternative/sustainable farming. According to their opinion (Table 4), they obtain information from the Internet. The participants of this factor can be reached with articles published on various news portals and online media most effectively. The low ecological footprint of agroforestry products is a product advantage

**Table 2:** Specific statements of Factor 'A'.

| # | Statement | Z-Scores |
|---|---|---|
| 11 | I like to consume at local markets from producers. | 1.6311 |
| 5 | Agroforestry products have a lower ecological footprint than conventional farm products. | 1.3918 |
| 10 | It would be a good idea for farms/businesses to give discount for loyal and regular customers. | 1.1214 |
| 24 | If it is mentioned that a product comes from a sustainable economy (e.g. organic farming, agroforestry), it is more likely that I will buy it. | 1.0298 |
| 4 | I would replace a conventional product if I found an alternative coming from agroforestry. | 1.0169 |
| 14 | I would only buy agroforestry products if I found them in super- or hypermarkets. | -1.4883 |
| 1 | I rely more on products from conventional or industrial production than those from alternative production (e.g. organic farming, agroforestry) because I believe they are better controlled. | -1.6009 |
| 16 | Convenience is important to me, so I prefer to shop from the catalogue and/or online. | -1.6384 |
| 6 | The quality of products from a traditional farm (e.g. honey, fruit, herb, mushrooms, meat, eggs, wooden products, etc.) is better than the ones coming from conventional agriculture because they only have to focus on one type of cultivation. | -1.8375 |

Source: own composition

**Table 3:** Specific statements of Factor 'B'.

| # | Statement | Z-Scores |
|---|---|---|
| 11 | I like to consume/buy at local markets from producers. | 1.7526 |
| 7 | It is worth paying a little more for products from a sustainable economy (e.g. organic farming, agroforestry). | 1.3447 |
| 17 | I would be happy to go and visit an agroforestry farm if they organised programs and workshops. | 1.2540 |
| 12 | I like to talk to the producers before I buy their product. | 1.1354 |
| 13 | A producer can persuade me to buy their product. | 1.0771 |
| 3 | Trademarks only make products more expensive. | -1.0584 |
| 15 | I do not trust the products ordered from catalogues. | -1.1262 |
| 18 | It bothers me when a seller/producer starts talking to me while I am shopping. | -1.2148 |
| 14 | I would only buy agroforestry products if I found them in super- or hypermarkets. | -1.5299 |
| 20 | With TV commercials, it is more likely that my interest in agroforestry products will be aroused. | -1.7932 |

Source: own composition

for them. The appearance and packaging of the products are important to Factor "C" in influencing the purchasing decision. Presumably busy and less interested than Factor 'B', they would not visit an agroforestry farm, but could be accessed through catalogues. They prefer loyalty discounts.

### Factor 'D' (N=8) – "Bargain Hunter Consumers"

Most of the participants of Factor 'D' are men and work as employees. Their financial position is no higher than average and, moreover, they are not satisfied with their income. As a result, Factor 'D' is the most price sensitive consumer group. Table 5 presents the statements that are the most specific for the Factor and create the characteristics of the consumers' opinion.

The most effective way to reach Factor 'D' is to offer favourable pricing. Loyalty discounts, a favourable introductory price, gifts and samples can influence their purchasing decision in a positive way. There is also a product advantage for the environmentally friendly nature of agroforestry products, and this group would therefore be willing to pay higher prices. They are less informed about TV commercials and social media than Factor 'C' actors.

## Conclusions and Policy Recommendations

During Q-analysis, we distinguished four consumer categories based on their opinions. The answer was formulated with the help of the four dimensions of the marketing mix, product, pricing, distribution and communication. In terms of the product dimension, all consumers believe that the ecological footprint of agroforestry products is lower than that of conventional, intensive or industrial products, but there is a clear willingness to switch to factor 'A' and 'B'. By changing consumer preferences and becoming increasingly "fashionable" in terms of environmental protection, the sector can create product benefits through the positive environmental impacts of products from alternative economies, including agroforestry systems.

In terms of price, 83.5% of the respondents would be willing to pay a higher price if they found an attractive agroforestry product. Preferring loyalty discounts was typical of Factors 'A' and 'D', that is why agroforestry farmers should strive to establish the widest possible range of them. As a result, they are difficult to reach because they may be loyal customers of other farmers/businesses. Consumers in Factor 'D' are bargain hunters positively influenced by a favourable introductory price.

Regarding place, Opinion Groups 'A' and 'B' choose the traditional market for their purchases. Direct selling at local or farmers' markets, fairs, or short supply chains can be beneficial to the sector as it can be addressed personally by shoppers such as Factor 'A' and 'B', thus enabling them to more effectively buy their own products communicating added value. Today, more and more Local Product Days, farmers' markets and fairs are being organised by communities and towns. Their appearance could effectively reach the potential consumer base of the sector. Factor 'C' cares about convenience, they are willing to shop online or from catalogues. They can be reached through webshops, social media sites (e.g. Facebook, Instagram); that is why we recommend agroforestry farmers to use these channels actively.

As to promotion, the most effective means of delivering agroforestry products to Factors 'A', 'B' and 'D' is through direct sales. These are channelled through local and farm-

**Table 4:** Specific statements of Factor 'C'.

| # | Statement | Z-Scores |
|---|---|---|
| 5 | Agroforestry products have a lower ecological footprint than conventional farm products. | 2.0639 |
| 23 | I occasionally purchase from farms because I read about them in articles published on trusted news portals. | 1.3572 |
| 10 | It would be a good idea for farms/businesses to give discount for loyal and regular customers. | 1.3525 |
| 24 | If it is mentioned that a product comes from a sustainable economy (e.g. organic farming, agroforestry), it is more likely that I buy it. | 1.1957 |
| 15 | I do not trust the products ordered from catalogues. | -1.1357 |
| 14 | I would only buy agroforestry products if I found them in super- or hypermarkets. | -1.1701 |
| 22 | I don't care about the packaging of the product. | -1.2178 |
| 17 | I would be happy to go and visit an agroforestry farm if they organised programs and workshops. | -1.3207 |
| 3 | Trademarks only make products more expensive. | -2.0983 |

Source: own composition

**Table 5:** Specific statements of Factor 'D'.

| # | Statement | Z-Scores |
|---|---|---|
| 10 | It would be a good idea for farms/businesses to give discount for loyal and regular customers. | 2.2522 |
| 19 | If a seller offers a product tasting, I'm more likely to buy it. | 2.1457 |
| 7 | It is worth paying a little more for products from a sustainable economy (e.g. organic farming, agroforestry). | 1.0525 |
| 5 | Agroforestry products have a lower ecological footprint than conventional farm products. | 1.0121 |
| 13 | A producer can persuade me to buy their product. | -1.1044 |
| 20 | With TV commercials, it is more likely that my interest in agroforestry products will be aroused. | -1.1698 |
| 8 | I usually don't try a new product just because it's sold at a bargain or introductory price. | -1.2538 |
| 21 | I get information about new products from social media (Facebook, Instagram, news portals etc.). | -1.6289 |

Source: own composition

ers' markets, fairs, where the positive characteristics of the products can be easily communicated to potential consumers by agroforestry farmers. Factor 'B' has a significant interest in visiting agroforestry systems, but it is also possible to arouse the interest of consumers in Factors 'A' and 'B' with various events. In addition, providing direct sales and gifts and tasting can also have a positive impact mainly on Factor 'D'. Factor 'C' can be achieved through well-established online marketing. Appearance on social media (Facebook, Instagram) and news portals could also deliver agroforestry products to the group of consumers who are busy and cannot be reached through direct sales.

As final conclusion, we suggest that it is important to increase awareness amongst the general public, which can create incentives for consumers to buy agroforestry products and in addition, pay premium prices for them. Moreover, emphasising local origin as a unique-selling-proposition can play an important role for all opinion groups.

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**Theodoros DAGLIS*, Konstantinos N. KONSTANTAKIS* and Panayotis G. MICHAELIDES***

# The impact of Covid-19 on agriculture: evidence from oats and wheat markets

The Covid-19 pandemic has changed the dynamics of the overall economy, impacting many fields, including the agricultural sector. In this paper, we examine two important commodities of the agricultural sector, namely oats and wheat, during the Covid-19 spread and the lockdown measures. Using relevant time series specifications, we establish a hypothesis regarding the effect of the Covid-19 pandemic on these two commodities. Based on our findings, the commodities were affected by the Covid-19 spread and moreover, the Covid-19 confirmed cases provide useful information for the prediction and forecasting of these values. Our findings are robust, since the out-of-sample forecasting accuracy of the alternative model employed, that explicitly incorporates the pandemic induced by the Covid-19 disease, is superior to the baseline model.

**Keywords:** Covid-19, agriculture, oats, wheat, commodities

**JEL classifications:** C22, C58, C50, C51

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## Introduction

The recent Covid-19 pandemic has spread from one country to another, having its origin in Wuhan-Hubei, China (Liu *et al*., 2020). The total cases globally amount to over 51 million people (November 2020), showing the cruel face of this pandemic (WHO, 2020). The case of Covid-19 is unique, differing in many ways from previous disease spreads, such as the severe acute respiratory syndrome (SARS) spread in 2003 (Wilder-Smith *et al*., 2020). The rapid spread of the Covid-19 disease in a worldwide context has spread fear globally.

The Covid-19 pandemic has changed the dynamics of the overall economy, impacting many fields, including the agricultural sector, as the fear spread by the Covid-19 has led to an excess demand, of the major commodities of the primary sector. The lockdown measures made the matters worse, as the fear of a long-term quarantine had an impact on the consumers. This led to a phenomenon, known as "panic buying", where consumers emptied the shelves in the supermarkets (Sim *et al*., 2020).

The situation following the Covid-19 lockdown measures was unprecedented. Covid-19 disrupted the agricultural sector in many ways. To begin with, government organisations posed interruptions in the acquirement of nourishment grains. This included lockdown measures, panic spread, leading to lack of labourers to collect the crops, deficiency of drivers in the transportation area, disturbances in the assortment of harvests from the homesteads by private dealers. Moreover, the export restrictions and other trade policy measures that were introduced following the Covid-19 crisis made the situation even worse (Laborde *et al*., 2020).

Since in many countries the retail markets continued to function during the Covid-19 pandemic, in fear of the lockdown measures and long-term quarantine, consumers got into a state of "panic buying", emptying the shelves in the supermarkets (Sim *et al*., 2020), leading to a an increase in prices, caused by the excess demand. The excess demand and the decreased supply led to an important effect in the prices of the agricultural commodities, out of which oats and wheat turned out to be very important ones. Our aim is to depict this effect on the prices of oats and wheat.

In the presence of such post-apocalyptic situations, stock traders and investors adapt their trading behaviour. More precisely, traders swap from other stocks, to the assets considered more stable or more profitable. Since the market demand for agricultural commodities increased, consequently, the values of these stocks also increased, and this effect is depicted in the present paper's results. In this paper, using relevant econometric techniques, we capture the impact of the Covid-19 spread on two important commodities from the agricultural sector, namely oats and wheat. The present paper contributes to the literature in the following ways: (a) it is the first attempt, to the best of our knowledge, to investigate the effect of the Covid-19 spread and the lockdown measures on certain agricultural commodities, using global data; (b) it proposes an alternative approach to the examination of the economic effect of the crisis on the agricultural sector, based on a financial framework; and (c) it provides a robustness analysis of the findings based on out-of-sample forecasting accuracy measures.

The paper is structured as follows: Section 2 presents the literature review; Section 3 describes the methodology used, Section 4 presents the empirical results and finally, Section 5 concludes.

## Literature Review

To begin with, Bonny (1998) studied a number of factors that may play a role in agriculture, including crises and changing demand. Based on the results, farming ought to become fine-tuned and environmentally harmless, multiform and multi-functional, with its production model being diversified and adaptive.

Agricultural commodities have special characteristics, differing from other commodities. For instance, they are known to converge faster to long run equilibrium than other commodities, e.g. metal and energy commodities. Moreo-

ver, a spillover effect among agricultural commodities may be included, as has been shown in the past (Vandone *et al*., 2018). That is why oats and wheat may be linked, as many products require both of them, for their production, and moreover they are an important and basic means of diet.

More interestingly, it has been shown that stock markets exhibit a great impact on agricultural price dynamics during extreme movements. Such movements occurred during the 2007–2008 financial crisis, highlighting a potential influence of financial markets on the financialisation of commodities (Aït-Youcef, 2019). As for wheat, it has been shown that wheat prices exhibit a negative and statistically significant leverage effect (Sadorsky, 2014). This indicates that negative residuals tend to decrease the variance of the commodity, stabilising its value.

Ben Amar *et al.* (2020) argue that there is a strong effect of the Covid-19 crisis on various stocks and commodities, leading to spillovers. The export restrictions and other trade policy measures, following the Covid-19 crisis, were thought to increase global food prices, with consequences including the exacerbation of hunger and income losses for producers in export-restricting countries (Laborde *et al*., 2020).

## Methodology

In order to econometrically investigate (non-)causality between the Covid-19 confirmed cases and agricultural prices, we will make use of the state of the art step-by-step (non-) causality test, introduced by Dufour and Renault (1998) and extended by Dufour *et al*. (2006). In this context, following standard time series literature (Hamilton, 1994), before turning to (non-)causality testing, we examine the level of integration of the time series that enter our analysis using the Phillips–Perron (1988) unit root test. More specifically, the hypothesis tested for the Phillips–Perron test is that the time series do not have a unit root. In addition, in case of integrated of degree one time series, i.e. I(1), we also test for the potential existence of long-run relationships among the variables, using the popular Johansen (1990) cointegration test, and the hypothesis tested is that the time series are not cointegrated. Finally, the optimal lag length of the time series variables was investigated using the Schwartz-Bayes information criterion (SBIC).

We should note that in case of non-stationarity (existence of unit root), the statistical properties of the time series are time dependent. This, could end up in misleading results. Moreover, co-integration is the case in which two or more time series have a long-term relationship that must be included in the model. That is why, in cases of co-integration, an error term must be included in the model. More specifically, the Johansen co-integration test is robust against non-normality whereas heteroscedasticity may have a minor effect on it.

Additionally, in order to cross validate the fact that the Covid-19 confirmed cases are causal and thus have predictive ability on the agricultural commodities, we will also make use of forecasting strategies. In detail, using a Vector autoregressive model as a baseline, we will investigate whether an alternative specification that could also incorporate the information provided by the Covid-19 confirmed cases as an exogenous variable, outperforms the forecasting accuracy of the baseline model. To do so, three distinct measure of forecasting accuracy are used, namely the mean absolute error (MAE), the mean absolute percentage error (MAPE) and the root mean square forecasting error (RMSFE), to investigate the magnitude of the predictive power of Covid-19 spread on the agricultural commodities.

In what follows, we offer a brief outline of the techniques and procedures used in this work.

As a first step, we check for the potential existence of unit roots in our time series, using relevant unit root tests. More analytically, we implement the Phillips–Perron unit root test. The null hypothesis of the test is that the time-series contain a unit root. In case of I(1) variables, we test for cointegration among the time-series. If cointegrating relationships are present, Error Correction Terms (ECM) have to be included in the model. In this work, we implement the Johansen (1988) test.

As a next step, we investigate (non-)causality between the Covid-19 confirmed cases and the agricultural commodities, using (non-)causality test. In order to study the exact timing pattern of the causality relationship, we make use of the state-of-the-art step-by-step causality introduced by Dufour and Renault (1998) and extended by Dufour *et al*. (2006).

Based on recent advancement of the related literature of causality, other non-causality tests (for instance Granger non-causality test) fail to unveil the potential timing pattern of a causal relationship. In this context, in a seminal paper in *Econometrica,* Dufour and Renault (1998) introduced the notion of *step-by-step* or *short-run* causality based on the idea that two time series $X_t$ and $Y_t$ could interact in a causal scheme via a third variable $Z_t$. More precisely, despite the fact that $X_t$ could not cause $Y_t$ one period ahead, it could cause $Z_t$ one period ahead i.e. $Z_{t+1}$, and $Z_t$ could cause $Y_t$ two periods ahead i.e. $Y_{t+2}$. Therefore, $X_t \rightarrow Y_{t+2}$, even though $X_t \nrightarrow Y_{t+1}$. For testing the step by-step causality, consider the following VAR (p) model:

$$Y_t = a + \Sigma_{k=1}^{p} \pi_K Y_{t-k} + \\ + \Sigma_{q=0}^{Q} \beta_q X_{t-q} + u_t \quad (1)$$

where: $Y_t$ is an (1×m) vector of endogenous variables, a is a (1×m) vector of constant terms; $X_t$ is a vector of exogenous variables and $u_t$ is a (1×m) vector of error terms such that $E(u_t u_s) = \sigma_{ii} I if\ t = s\ and\ E(u_t u_s) = \sigma_{ij} I\ if\ t \neq s$, where I is the identity matrix. The lags in the baseline model are selected using the Schwartz-Bayes Information criterion (SBIC).

Following Dufour *et al*. (2006), the model described in (1) corresponds to horizon h=1. In order to test for the existence of non-causality in horizon h, the procedure continuous in the same context.

Vector autoregressive (VAR) is a model used to capture the linear interdependencies among multiple time series. Each variable in the VAR model, has an equation explaining its evolution based on its own lagged values, the lagged values of the other model variables, and an error term. A VAR model of order p, with exogenous variables is structured as follows:

$$\begin{cases} y_{1,t} = c_1 + \sum_j^n \sum_i^p (a_{j,i} y_{j,t-i}) + \\ + \sum_j^k \sum_i^q (b_{j,i} x_{j,t-i}) + e_{1,t} \\ y_{2,t} = c_2 + \sum_j^n \sum_i^p (a_{j,i} y_{j,t-i}) + \\ + \sum_j^k \sum_i^q (b_{j,i} x_{j,t-i}) + e_{2,t} \\ \cdots \\ y_{n,t} = c_n + \sum_j^n \sum_i^p (a_{j,i} y_{j,t-i}) + \\ + \sum_j^k \sum_i^q (b_{j,i} x_{j,t-i}) + e_{n,t} \end{cases} \quad (2)$$

where n is the number of the endogenous variables ($y_{i,t}$) of the model, $c_i$ are the fixed terms, p is the lag order of the endogenous variables and $e_{i,t}$ are the error terms of each equation of the model, as before. In the case of exogenous variables, k is the number of the independent or exogenous variables of the model ($x_{i,t}$) and q is the lag order of the exogenous variables. In case of co-integration between the variables, error correction term must be included in the model. In such a case, a Vector Error Correction Model (VECM) should be employed instead.

In this paper, we make use of the so-called Schwartz-Bayes Information criterion (SBIC) introduced by Schwarz (1978), because it is an optimal selection criterion when used in finite samples. We used the SBIC criterion for order and lag selection when needed. Additionally, in order to cross validate our results, we make use of the AIC (Akaike, 1973), Hannan-Quinn (Hannan and Quinn, 1979) and FPE (Ljung, 1999) criteria.

We also make use of the following forecasting accuracy measures: the mean absolute error (MAE), the mean absolute percentage error (MAPE) and the root mean square forecast error (RMSFE). In general, the smaller the values of each forecasting criterion, the better the forecasting value.

A model's MAE for forecast horizon h is given by the following:

$$MAE = \frac{1}{h} \sum_{t=0}^{h} |F_t - A_t| \quad (3)$$

where: $h$ is the forecast horizon of the model, $F_t$ are the out-of-sample forecasted values of the model, and $A_t$ are the actual values. The smaller the MAE values of a model the better its forecasting ability. However, one of the main disadvantages of the MAE is the fact that is has no standard scale and it is not as comparable as a percentage. To overcome this problem, we will also base our analysis on MAPE.

A model's MAPE is given by the expression:

$$MAPE = \frac{100}{h} \sum_{t=0}^{h} \frac{|F_t - A_t|}{|A_t|} \quad (4)$$

MAPE is measured as a percentage change and again, the smaller the MAPE of a model, the better its predictive ability.

The RMSFE is used to measure the forecasting error distribution. It is given by the expression:

$$RMSFE = \sqrt{E\left[(Y_{T+1} - \hat{Y}_{T+1|T})^2\right]} \quad (5)$$

Overall, both in MAE and RMSE measures, we get the mean error or the root of the mean error of a forecast. Therefore, the values of the measures depend on the forecasted values. The MAPE measure, on the other hand, is measured as a percentage change. That is why we can compare its success on different and even unrelated datasets.

## Empirical Analysis

The data used in the present paper are the global confirmed cases of Covid-19 in daily format and were downloaded by the Johns Hopkins University database and span the period 22 January 2020 until 2 June 2020. The confirmed cases were transformed into logarithms. Moreover, we used two major commodities of the agricultural sector, namely oats and wheat, adjusted close prices, derived from finance.yahoo in daily frequency, and span also the period 22 January 2020 until 2 June 2020. The two agricultural commodities were chosen based on the fact that they were considered among the most important and multipurpose agricultural commodities, and moreover, because these commodities were used (primarily) for the same reasons, namely for food source of animals and food source or beverage for people.

The descriptive statistics of the time series are depicted in Table 1. Furthermore, the plots of the logarithmic confirmed Covid-19 cases and the two logarithmic values of the commodities are depicted in Figures 1 & 2.

Figures 1 & 2 provide graphical evidence of the impact of the Covid-19 spread on the agricultural sector, a fact that needs to be investigated thoroughly using econometric

**Table 1:** Descriptive statistics of the time series.

| Variable | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|
| Log_Confirmed Covid-19 cases | 5.5821 | 1.0203 | 2.7443 | 6.8047 |
| Log_Oats | 2.4604 | 0.0304 | 2.4035 | 2.5179 |
| Log_Wheat | 2.7290 | 0.0183 | 2.6974 | 2.7638 |

Source: Authors' elaboration

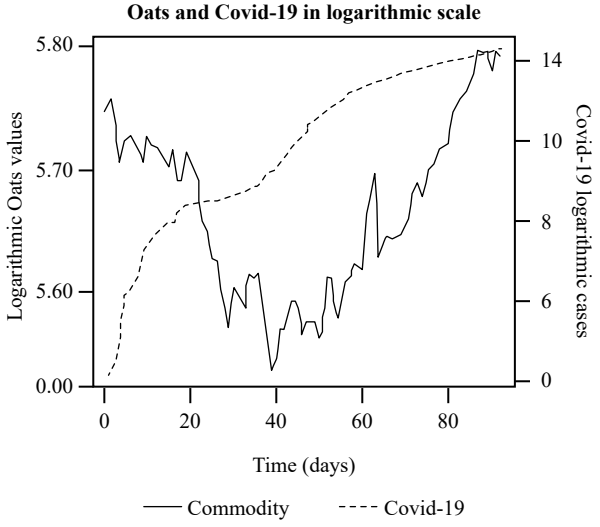


**Figure 1:** Log confirmed Covid-19 cases and log values of oats.
Source: Authors' elaboration

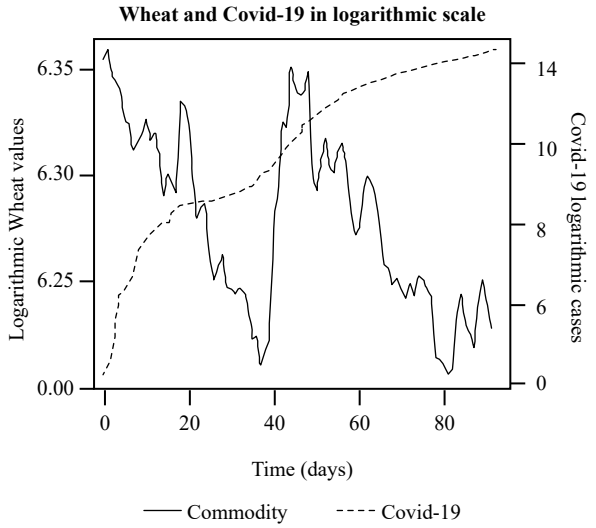


**Figure 2:** Log Confirmed Covid-19 cases and log values of wheat.
Source: Authors' elaboration

methods. We set out the hypothesis tested, that the Covid-19 spread, affects the prices of these two commodities.

We make use of step-by-step causality in order to identify whether the Covid-19 spread "causes" the values of the two commodities. As a next step, we test the contribution of the information derived by the Covid-19 confirmed cases on the forecasting of the aforementioned commodities. To do so, we make use of two econometric models in the form of Vector autoregressive model (since there is connection among the two prices). The first model, declared as the baseline, is a Vector autoregressive model only with endogenous variables (the two commodity prices) and an alternative model being the same with the baseline, augmented with one exogenous variable, the Covid-19 global confirmed cases. The comparison of these two models, in terms of forecasting ability, will unveil a possible contribution of the exogenous variable on the forecasting of the two commodity prices.

A first step in every econometric modelling is the unit root test (Phillips–Perron unit root test are used here). The results are depicted in Table 2.

As stated in the methodology section, the Phillips–Perron null hypothesis is that the time series have a unit root. If we reject the null hypothesis for p-value less than 0.1, it means that the specific time series does not have unit root.

Since the results in Table 2 show that the Covid-19 p-value is smaller than 0.1, we reject the null hypothesis and therefore, the Covid-19 confirmed cases do not have a unit root, meaning that the time series is stationary. Moreover, oats and wheat have p-values greater than 0.1, so, for these time series, we cannot reject the Phillips–Perron null hypothesis, and therefore, these timeseries are I(1). In the case of the non-stationary variables (oats and wheat), the presence of co-integration should be tested.

The results of the co-integration test are depicted in Table 3, indicating that there are no cointegration relationships among the timeseries since we cannot reject the rank r = 0. Since the Covid-19 cases are I(0), and the I(1) variables are not co-integrated, in such case, no error correction

**Table 2:** Phillips–Perron unit root test results for the time series.

| Variable | PP test P-value | Integration term |
|---|---|---|
| Log_Confirmed Covid-19 cases | 0.010 | I(0) |
| Log_Oats | 0.923 | I(1) |
| Log_Wheat | 0.393 | I(1) |

Source: Authors' elaboration

**Table 3:** Johansen Cointegration test results for the I(1) time series.

| Rank | Test | 10pct | 5pct | 1pct |
|---|---|---|---|---|
| r<=1 | 2.140 | 6.50 | 8.180 | 11.650 |
| r=0 | 7.850 | 12.910 | 14.90 | 19.190 |

Source: Authors' elaboration

**Table 4:** Step-by-step causality results for the case of oats and wheat.

| Oats | | | Wheat | | |
|---|---|---|---|---|---|
| Wald test | P-value | Order | Wald test | P-value | Order |
| 3.178 | 0.079 | 16 | 3.582 | 0.063 | 18 |
| 3.113 | 0.082 | 18 | - | - | - |
| 5.139 | 0.027 | 19 | - | - | - |
| 3.873 | 0.053 | 21 | - | - | - |
| 2.660 | 0.108 | 24 | - | - | - |

Source: Authors' elaboration

term should be included in the econometric models, but first difference transformation must take place at least for the I(1) variables. The next step is the use of the step-by-step causality tests (Table 4).

Again, as stated in the methodology section, the null hypothesis of the Wald test in the step-by-step causality is that the exogenous variable does not step-by-step cause the endogenous one. If the p-value of the Wald test is less than 0.1, then, we may infer that the null hypothesis is rejected and therefore, the independent variable step-by-step causes the endogenous one. The results in Table 4 indicate that the Covid-19 variable "causes" the commodities in multiple steps, since in these steps the results of the Wald test reject the null hypothesis of non-causality.

Having shown that the Covid-19 spread "causes" the values of the two commodities, and therefore it provides useful information for their interpretation and their modelling, we will test if the Covid-19 spread contributes to their forecasting. To do so, we first decide for the lag order of the econometric models (baseline and alternative), based on the SBIC criterion. The results are depicted in Table 5 & 6.

Based on the results, the AIC, SBIC, HQ and FPE criteria indicate the lag order 1 as the most appropriate for both models since the smallest criteria values indicate the most appropriate lag order. In this case, the lag order of the baseline and alternative model will be selected to be equal to one (1).

The baseline model incorporated one lag order for each endogenous variable (oats and wheat). Using out of sample forecast with a fixed window, for horizon h=1,2,…,10, we forecast for two weeks, based on the business calendar. Then, we employ the same model incorporating as exogenous variable the logarithm of global confirmed Covid-19 cases and test again the forecasting ability of this alternative model.

**Table 5:** Results of the AIC, SBIC, Hannan-Quinn and FPE criteria for the case of the Baseline model.

| Order | AIC(n) | HQ(n) | SC(n) | FPE(n) |
|---|---|---|---|---|
| 1 | -1.638E+01 | -1.630E+01 | -1.620E+01 | 7.731E-08 |
| 2 | -1.629E+01 | -1.617E+01 | -1.600E+01 | 8.401E-08 |
| 3 | -1.623E+01 | -1.606E+01 | -1.581E+01 | 8.967E-08 |
| 4 | -1.621E+01 | -1.599E+01 | -1.567E+01 | 9.177E-08 |
| 5 | -1.614E+01 | -1.588E+01 | -1.549E+01 | 9.830E-08 |
| 6 | -1.607E+01 | -1.576E+01 | -1.530E+01 | 1.052E-07 |
| 7 | -1.601E+01 | -1.565E+01 | -1.512E+01 | 1.129E-07 |
| 8 | -1.593E+01 | -1.552E+01 | -1.492E+01 | 1.226E-07 |
| 9 | -1.584E+01 | -1.539E+01 | -1.471E+01 | 1.348E-07 |
| 10 | -1.584E+01 | -1.535E+01 | -1.460E+01 | 1.347E-07 |

Source: Authors' elaboration

**Table 6:** Results of the AIC, SBIC, Hannan-Quinn and FPE criteria for the case of the Alternative model.

| Order | AIC(n) | HQ(n) | SC(n) | FPE(n) |
|---|---|---|---|---|
| 1 | -2.186E+01 | -2.172E+01 | -2.151E+01 | 3.196E-10 |
| 2 | -2.172E+01 | -2.147E+01 | -2.110E+01 | 3.702E-10 |
| 3 | -2.160E+01 | -2.124E+01 | -2.071E+01 | 4.190E-10 |
| 4 | -2.152E+01 | -2.105E+01 | -2.036E+01 | 4.564E-10 |
| 5 | -2.167E+01 | -2.110E+01 | -2.025E+01 | 3.956E-10 |
| 6 | -2.164E+01 | -2.096E+01 | -1.995E+01 | 4.108E-10 |
| 7 | -2.155E+01 | -2.076E+01 | -1.959E+01 | 4.582E-10 |
| 8 | -2.142E+01 | -2.053E+01 | -1.921E+01 | 5.289E-10 |
| 9 | -2.129E+01 | -2.029E+01 | -1.881E+01 | 6.196E-10 |
| 10 | -2.127E+01 | -2.017E+01 | -1.852E+01 | 6.553E-10 |

Source: Authors' elaboration

**Table 7:** MAE, MAPE and RSMFE forecasting accuracy of the VAR (baseline model) and VARX (alternative model) for the case of oats.

| Horizon | MAE_VAR | MAPE_VAR | RMSFE_VAR | MAE_VARX | MAPE_VARX | RMSFE_VARX |
|---|---|---|---|---|---|---|
| 1 | 0.019 | 1.087 | 0.019 | 0.019 | 1.050 | 0.019 |
| 2 | 0.044 | 1.032 | 0.050 | 0.044 | 1.021 | 0.050 |
| 3 | 0.033 | 1.062 | 0.041 | 0.033 | 1.025 | 0.042 |
| 4 | 0.027 | 1.098 | 0.036 | 0.026 | 1.032 | 0.036 |
| 5 | 0.022 | 0.982 | 0.032 | 0.021 | 0.973 | 0.032 |
| 6 | 0.018 | 1.227 | 0.029 | 0.018 | 1.044 | 0.030 |
| 7 | 0.017 | 1.236 | 0.027 | 0.016 | 1.047 | 0.027 |
| 8 | 0.015 | 1.237 | 0.026 | 0.015 | 1.048 | 0.026 |
| 9 | 0.015 | 1.229 | 0.024 | 0.014 | 1.047 | 0.024 |
| 10 | 0.015 | 1.212 | 0.024 | 0.015 | 1.045 | 0.024 |
| 11 | 0.015 | 1.207 | 0.023 | 0.014 | 1.045 | 0.023 |
| 12 | 0.015 | 1.182 | 0.023 | 0.014 | 1.039 | 0.023 |
| 13 | 0.015 | 1.173 | 0.023 | 0.015 | 1.037 | 0.022 |
| 14 | 0.015 | 1.176 | 0.022 | 0.014 | 1.038 | 0.022 |
| 15 | 0.014 | 1.267 | 0.021 | 0.013 | 1.079 | 0.021 |
| 16 | 0.014 | 1.257 | 0.021 | 0.013 | 1.076 | 0.021 |
| 17 | 0.013 | 1.257 | 0.020 | 0.013 | 1.074 | 0.020 |
| 18 | 0.013 | 1.199 | 0.020 | 0.012 | 1.061 | 0.019 |
| 19 | 0.013 | 1.192 | 0.020 | 0.013 | 1.059 | 0.020 |
| 20 | 0.013 | 1.188 | 0.020 | 0.013 | 1.058 | 0.019 |
| 21 | 0.013 | 1.194 | 0.019 | 0.012 | 1.059 | 0.019 |
| 22 | 0.013 | 1.210 | 0.019 | 0.012 | 1.061 | 0.018 |
| 23 | 0.012 | 1.207 | 0.018 | 0.012 | 1.059 | 0.018 |
| 24 | 0.012 | 1.206 | 0.018 | 0.012 | 1.058 | 0.018 |
| 25 | 0.013 | 1.200 | 0.018 | 0.012 | 1.057 | 0.018 |
| 26 | 0.012 | 1.176 | 0.018 | 0.012 | 1.051 | 0.018 |
| 27 | 0.012 | 1.201 | 0.018 | 0.011 | 1.055 | 0.017 |
| 28 | 0.012 | 1.191 | 0.017 | 0.011 | 1.053 | 0.017 |
| 29 | 0.012 | 1.187 | 0.018 | 0.012 | 1.052 | 0.017 |
| 30 | 0.012 | 1.172 | 0.017 | 0.011 | 1.048 | 0.017 |

Source: Authors' elaboration

We then compare the two models in terms of their forecasting ability, based on the MAE, MAPE, RMSFE. The results are depicted in Tables 7 & 8.

The results above show that the alternative model is better in terms of forecasting ability than the baseline, for the two commodities analysed, since MAE, MAPE and RMSFE values are smaller for the case of the VARX (alternative model with exogenous variable Covid-19 confirmed cases) than the respective accuracy measures' values for the case of the VAR (alternative model without exogenous variable). This implies that Covid-19 provides useful information for the forecasting of the values of oats and wheat.

Finally, using the impulse – response function, and more precisely, the orthogonalised impulse responses, the results

**Table 8:** MAE, MAPE and RSMFE forecasting accuracy of the VAR (baseline model) and VARX (alternative model) for the case of wheat.

| Horizon | MAE_VAR | MAPE_VAR | RMSFE_VAR | MAE_VARX | MAPE_VARX | RMSFE_VARX |
|---|---|---|---|---|---|---|
| 1 | 0.005 | 0.756 | 0.005 | 0.006 | 0.891 | 0.006 |
| 2 | 0.003 | 0.699 | 0.004 | 0.003 | 0.616 | 0.004 |
| 3 | 0.004 | 0.741 | 0.004 | 0.004 | 0.640 | 0.004 |
| 4 | 0.006 | 0.787 | 0.008 | 0.006 | 0.696 | 0.007 |
| 5 | 0.008 | 0.817 | 0.010 | 0.008 | 0.740 | 0.010 |
| 6 | 0.007 | 0.753 | 0.009 | 0.007 | 0.634 | 0.009 |
| 7 | 0.007 | 0.768 | 0.009 | 0.007 | 0.648 | 0.008 |
| 8 | 0.007 | 0.844 | 0.008 | 0.006 | 0.779 | 0.008 |
| 9 | 0.006 | 0.840 | 0.008 | 0.006 | 0.765 | 0.008 |
| 10 | 0.006 | 0.828 | 0.008 | 0.006 | 0.747 | 0.007 |
| 11 | 0.006 | 0.857 | 0.008 | 0.006 | 0.797 | 0.008 |
| 12 | 0.006 | 0.855 | 0.008 | 0.006 | 0.787 | 0.007 |
| 13 | 0.007 | 0.875 | 0.008 | 0.006 | 0.820 | 0.008 |
| 14 | 0.006 | 0.830 | 0.008 | 0.006 | 0.790 | 0.007 |
| 15 | 0.006 | 0.827 | 0.007 | 0.006 | 0.783 | 0.007 |
| 16 | 0.006 | 0.815 | 0.007 | 0.005 | 0.751 | 0.007 |
| 17 | 0.007 | 0.823 | 0.010 | 0.007 | 0.761 | 0.009 |
| 18 | 0.007 | 0.783 | 0.009 | 0.006 | 0.777 | 0.009 |
| 19 | 0.006 | 0.775 | 0.009 | 0.006 | 0.753 | 0.009 |
| 20 | 0.006 | 0.773 | 0.009 | 0.006 | 0.744 | 0.009 |
| 21 | 0.006 | 0.804 | 0.009 | 0.006 | 0.796 | 0.009 |
| 22 | 0.007 | 0.815 | 0.010 | 0.007 | 0.809 | 0.010 |
| 23 | 0.007 | 0.828 | 0.010 | 0.007 | 0.827 | 0.010 |
| 24 | 0.007 | 0.832 | 0.010 | 0.007 | 0.828 | 0.010 |
| 25 | 0.007 | 0.828 | 0.010 | 0.007 | 0.819 | 0.010 |
| 26 | 0.007 | 0.828 | 0.010 | 0.007 | 0.814 | 0.010 |
| 27 | 0.008 | 0.836 | 0.011 | 0.008 | 0.825 | 0.011 |
| 28 | 0.008 | 0.846 | 0.011 | 0.008 | 0.838 | 0.011 |
| 29 | 0.008 | 0.848 | 0.011 | 0.008 | 0.838 | 0.011 |
| 30 | 0.008 | 0.850 | 0.011 | 0.008 | 0.838 | 0.011 |

Source: Authors' elaboration

indicate that the effect of Covid-19 on oats is positive, as depicted in Figure 3, since the orthogonalised impulse-response function is positive, and statistically significant, since the 95% confidence intervals do not include zero. This means that a unit shock in the Covid-19 spread, will lead to an increase in oats prices. In the same context, the effect of the Covid-19 variable on wheat is positive, as depicted in Figure 4, since again the orthogonalised impulse-response function is positive, but is statistically significant only in the beginning of the shock, since the 95% confidence intervals do not include zero in the beginning, but later on, they include it, and therefore, it is not statistically significant. Note that for the impulse-response function plots, the Covid-19 cases are in logarithms, for graphical reasons.

In an attempt to minimise the spread of the coronavirus, most economies and policy makers have taken extreme lockdown measures that adversely affect the overall micro-economic, macroeconomic and financial conditions in a global scale. As a result, the lockdown caused a massive shock that could lead to inflation. Many governments have posed interruptions in the acquirement of nourishment grains and/or imposed export restrictions and other trade policy measures (Laborde *et al.,* 2020). These, led to the intensification of shocks in the agricultural sector. Moreover, due to "panic buying", as a result of the fear of the lockdown measures and long-term quarantine, consumers emptied the shelves in the supermarkets (Sim *et al*., 2020), leading to a greater increase in the prices, caused by the excess demand. The excess demand and the decreased supply led to an important effect in the prices of oats and wheat. As shown by our results, the impact of Covid-19 on oats and wheat is positive, meaning that Covid-19 increases the price of both commodities.

At this point, we should highlight the variability in the data used in the present paper. More analytically, the global Covid-19 cases are in an aggregate format and hide probable heterogeneity. This means that different regions across the globe adopt different measures, and faced different Covid-19 cases. We capture the aggregate dynamics, but there could be different effects in different regions. As an extension of the present paper, one could examine the impact of Covid-19 around the world on different regions through economic and financial framework. Last but not least, in some countries, the actual numbers are questionable due to misreporting.

Our findings are in accordance with the existing literature since it has been shown that stock markets exhibit a great impact on agricultural price dynamics during extreme movements, such as during financial crises (Aït-Youcef, 2019).

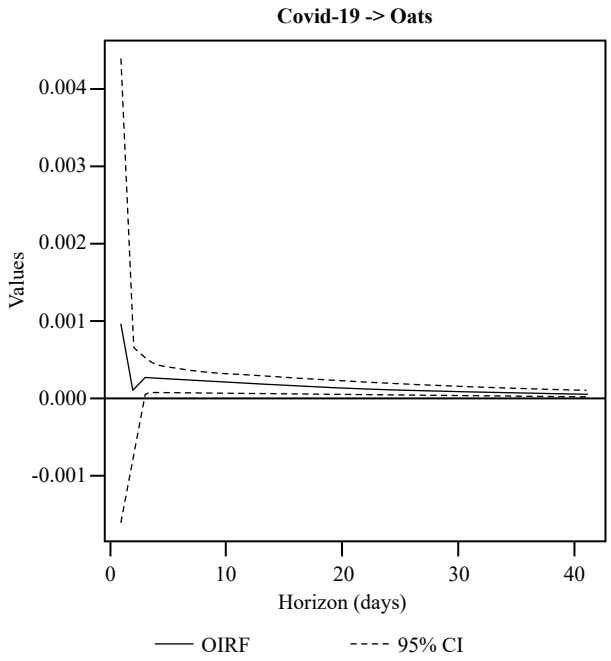


**Figure 3:** Impulse response function for the case of oats.
Source: Authors' elaboration

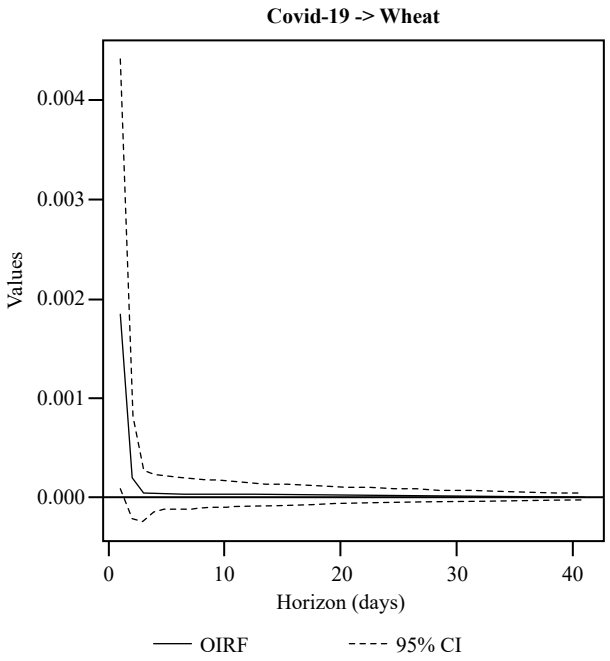


**Figure 4:** Impulse response function for the case of wheat.
Source: Authors' elaboration

Moreover, it has been also shown that there is a strong effect of the Covid-19 crisis on various stocks and commodities, leading to spillovers (Ben Amar *et al*., 2020). Finally, Laborde *et al*. (2020) have already argued that the export restrictions and other trade policy measures, following the Covid-19 crisis, would increase global food prices (Laborde *et al*., 2020).

## Conclusions

The paper investigated the early impact of Covid-19 on the prices of oats and wheat in the global market. By using relevant time series specifications, we established a hypothesis regarding the effect of Covid-19 on the prices of these commodities. The evidence supported the stated hypotheses , as based on our findings, the Covid-19 spread "step-by-step caused" prices of oats and wheat. Furthermore, the Covid-19 spread provides useful information for the forecasting of these commodities, as shown by the forecasting comparison of the baseline and alternative model, indicated by the forecasting criteria MAE, MAPE and RMSFE. Our findings are robust, since the out-of-sample forecasting accuracy of the alternative model employed, that explicitly incorporates the pandemic induced by the Covid-19 disease, is superior to the baseline model.

Our findings imply that the Covid-19 spread not only contributes with statistically significant information to the modelling of both agricultural commodities but also increases the forecasting ability of these commodities in the 22/01 – 02/06 time period (2020). This fact shows the great impact of Covid-19 on the agricultural sector worldwide, affecting the total economy.

We hope our work can serve as a basis for more sophisticated models, testing for other factors that could play a significant role in forecasting the prices of various agricultural commodities.

## Acknowledgement

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**Emily Aparecida Ferreira BRANDÃO *,** and Stephan RIST *,*****

# The agrarian space of the Brazilian semi-arid region: the dichotomies between the space of irrigated agriculture and the space of traditional agriculture

There is a relevant debate in the literature regarding the influence of the State in the production of space. The State was the main agent of the production of the agrarian space in the Brazilian semi-arid region, which is characterised by the territorialisation of two contrasting food systems: the irrigated productive model and the traditional family farming model. This study investigates the extent to which the spatial and sectoral selectivity of public policies has interfered in dichotomous agrarian space. The agrarian space is analysed on two spatial scales, the municipal and the local. On the municipal scale, we have selected the municipalities of Petrolina and Casa Nova. The local scale, by contrast, refers to spatial fragments of these municipalities, where food systems spatially manifest themselves (modern irrigated and traditional rainfed agriculture). The results show that until 1980, public policies favoured the development and consolidation of modern irrigated agriculture in selected spatial fragments. This was due to public investments in irrigation, transport, communication and energy infrastructure, facilitated access to land, technical assistance and agronomic engineering services. From 1990 onwards, policies have become inclusive, aimed at the Family Farmers social group. Policies have entailed local solutions for access to water, contextualised technical assistance, alternative markets, income stabilisation for family farmers and improvement in food production and consumption. However, despite the inclusion of family farming in the agrarian structure, imbalances of power remain among the food systems, highlighting the great contradiction brought about by these public policies.

**Keywords:** food system; public policies; fundo de pasto communities; irrigated agriculture

**JEL classifications:** Q15, Q20

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## Introduction

It has been sixty years since the productivist paradigm emerged as a possible solution to food insecurity (De Schutter, 2014). The productivist model was supported by institutions worldwide due to the alarmist discourse of the demographic explosion, which was linked to the widespread hunger in developing countries. It entails the 'progress' engendered in the process conventionally called the 'Green Revolution', based on mechanisation and the intensive use of agro-industrial inputs, natural resources, genetically improved seeds, irrigation, and chemical fertilisers (Borlaug and Dowswell, 2003). The advance of the model was translated into, on the one hand, the implementation of a series of technological innovations to improve the productivity performance of agriculture and, on the other hand, the subsequent insertion of agriculture into the agro-industrial complex.

In Brazil, the productivist model was implemented during the second half of the 20th century, when the State began to intervene in the agriculture and husbandry sectors through policies aimed at reducing production costs, stabilising producers' income and the granting of credit. Between 1960 and 1970, the State increased its efforts to promote the modernisation of agriculture by incorporating the technological package imposed by the Green revolution, associated with tax incentives and easy access to means of production. Politically, the 1960s and 1970s were marked by the military dictatorship. During this period, civil society representatives linked to family farming had no space in the public arena to discuss and build together with public managers, policies for their social category (Grisa, 2012). Policies in this period had a triple selective character: they (1) were targeted at medium and large farmers; (2) had an export-oriented character; and (3) encouraged the expansion of agribusiness (Guedes Pinto, 1978).

Throughout the second half of the twentieth century, socioeconomic inequalities and interregional disparities became more evident in Brazil (Prado Junior, 1981; Furtado, 1997). Geographically, uneven development intensified in the 1950s, due to the intensification of industrialisation that took place in the southeast and south regions, which triggered rapid urbanisation, whose corollary was the emptying of the rural areas (Baeninger, 2003).

The 1990s were marked by political and economic changes in the agrarian conjuncture, given the advance of economic neo-liberalisation. The new strategies included reducing the State's intervention, deregulation of economic activities, privatisations of State-owned companies, liberalisation of markets, etc. (Lopes *et al*., 2011; Sallum Jr., 2003). During this period, the Southeast region was responsible for contributing more than 58% to the Gross Domestic Product and the South region for more than 17%, both regions accumulating more than ¾ of the wealth produced in the country (IBGE, 2010).

Despite the abstention from the State, the possibilities rendered in a re-democratisation pushed representatives from civil society and small rural producers to demand specific policies for the category (Grisa, 2012). In the light of increasing social movement's pressure, the State rebuilt institutions that had been dismantled and started implementing a new generation of agrarian policies targeted at family farmers and female rural workers (Schneider, 2003). This set

 

of policies prioritised local development and aimed at stabilising the family farming food system. Most new policies were institutionalised during the government of former president Luiz Inácio Lula da Silva (2003–2011). However, the asymmetries between macro-regions have not been reduced, since the Midwest, North and Northeast regions together, which comprise more than 82% of the country's territory, and where more than 43% of the population live, contributed only with 27.4% to Brazilian GDP (IBGE, 2010). Thus, the inequalities that persist – on different scales, between rural and urban areas, between macro-regions and micro-regions – have been the result of the unequal advance of these productive activities.

## The influence of the State in the production of the agrarian space

The State plays a fundamental role in the development and distribution of space and in this regard, it is essential to remember the contributions of Henri Lefebvre (1974). In addition to the State, multiple actors influence the spatial dynamics, even though they have converging and diverging interests and different degrees of influence over decision making. According to Santos (1996), space formation involves civil society, geographic objects (natural and artificial), institutions and the State as the regulator of the development and distribution of the capitalist system. Agrarian space is defined as a subspace used for agricultural activities that has peculiarities in terms of a territorial and socioeconomic organisation. These characteristics have their origin not only in the productive activities but also in previous and external influences (Galvão, 1987).

The production of space approach is relevant to understanding the implicit interests and influences of actors – especially the State – in territorial dynamics, providing inputs to help identify and solve conflicts, and is also relevant to analysing spatial imbalances in terms of socio-economic development, environmental degradation and the consequences of the productive (re)organisation of territory. Also, possible mismatches between social demands and development policy can be identified. In this sense, the time variable is also crucial, as it yields a broad picture as to how the State's interventions, the performance of civil society and public and private entities have acted over time to generate the current landscape.

Agrarian space was continuously influenced by development trends that transformed productive standards. The influence of the productivist paradigm in the Brazilian agrarian space began in the mid-1960s as a potential and easy solution for tackling food insecurity by increasing food production. The Green Revolution, based on mechanisation, intensive use of agro-industrial inputs, natural resources and chemical fertilisers, was the strategy for boosting agricultural productivity and solving the mismatch between supply and demand for food (Borlaug and Dowswell, 2003). Since then, the Brazilian semi-arid region has been subjected to spatially selective economic growth. The most visible manifestation of this phenomenon is the presence of two main food systems in the semi-arid agrarian space that contrast with each other, namely, the irrigated productive model and the traditional family farming model.

Buainain and Garcia (2015) question the irrigation policy by highlighting that, due to the limited water availability in the semi-arid region, irrigation increases pressure on the water resources that supply the region. Sobel and Ortega (2010) meanwhile analysed the impacts of the irrigation policy on social inclusion degree and concluded that historically, public investments in irrigation have privileged the consolidation of agro-companies and capitalised farmers. The authors concluded that the policy privatised the irrigation benefits. The links between the top-down character of the irrigation policies and the little or no participation of the population in the policy formulation were the topics analysed by Pontes *et al*. (2013). For their part, Brito *et al*. (2010) analysed the environmental impacts of the irrigation policies in the semi-arid region, discussing the impacts on the soil compaction, salinisation, nutrient imbalance, loss of organic matter and the reduction of microbiological activity. The authors indicated that the interaction of these factors results in the loss of agricultural productivity in the medium and long terms.

There is also quite some research about alternative models for the semi-arid agrarian development. Silva (2006) analysed the main paradigms for development historically introduced in the semi-arid and identified existing local forms of sustainable development that considers contextualized rural practices, specifically adapted to edaphoclimatic semi-arid conditions. More recently, Santos (2016) has analysed how social demands became public policies since the 1990s. The author emphasises the important role played by NGO's in assisting the population and enabling access to water and food between 1980 and 1990, when the State abstained from regulating socio-economic imbalances. In addition, some studies have assessed the contribution of progressive policies to family farming. Wittman and Blesh (2017) assessed the impacts of the food procurement for land reform beneficiaries, indicating that the programmes are key to ensuring farmers' food sovereignty. However, despite the number of pertinent studies, the specific features of food systems in the Brazilian semi-arid region, and the challenges family farmers from that region face in linking their production to the wider food systems of which they also form part have not been extensively analysed.

This study aims to fill this research gap by investigating the dichotomies of the Brazilian semi-arid agrarian space, taking into account the State's interference on the activities of both food systems (input provision, producing, processing, trading, and consuming). This research differs from other studies, since the analysis concerns the impact of a group of policies on the activities of the irrigated and rainfed food systems that are part of the agrarian space in the semiarid region.

The agrarian space was analysed on two spatial scales, the municipal and the local. On the municipal scale, we selected the municipalities of Petrolina and Casa Nova. The local scale, by contrast, refers to spatial fragments of these municipalities, where the food systems spatially manifest themselves (modern irrigated and traditional rainfed agriculture). The main research question was through which mechanisms did the State influence the activities (input provision, producing, processing, trading, and consuming) of modern irrigated and traditional food systems over time?

# Conceptual Framework

## The modern State and the production of space

Lefebvre argues that the "Production of Space" approach must offer inputs for a critical understanding of the peculiarities of space and the history behind the organisation of geographical objects in order to enable a dialectical analysis of the social complexities through which space is produced in the end of the 20th Century capitalism (Lefebvre, 1991). The production of space refers to the spatio-temporal rationalisation of social relations, whose results are coextensive (Lefebvre, 1991).

Still according to Lefebvre, the space of modern capitalism is permeated by contradictions which the State must tackle, especially the contradictions involving exchange value and use value, production and consumption spaces, rural and urban, centre and periphery (Lefebvre, 1978; 1991). In order, to repair such contradictions that are engendered by the capitalist accumulation process, according to Lefebvre, the State must adopt several strategies, which include the production, control and surveillance of the social space. Among the strategies it is worth highlighting the control over flow (energy, raw material, labour, etc.), capital mechanisms (investments, credits, techniques, etc.), in addition to introducing instruments and control institutions and regulation to promote regional equity and reduce socio-economic inequalities (Lefebvre, 1978).

Finally, Lefebvre (1977) argues that during the second half of twentieth century, the State assumed the role of facilitator of the reproduction of capitalism. The 'State mode of production' emerges when there is a shift in the modern State's criteria in intervening the space, from the strategy to correct contradictions to act as a mediator, regulator and facilitator of the reproduction of the capitalist order (Lefebvre, 1977). The modern State continuously shapes and reshapes the spaces of capital accumulation and commodity exchange, exposing them to fragmentation, hierarchisation and homogenisation. In parallel, as the State's strategies of intervention are oriented toward the restructuring of specific spaces, scales and territories, they are deeply spatially selective.

## Food system approach

The food system approach (FSA) contributes to understanding the complexities of food chain (production, processing, distribution and consumption) and key actors by interconnecting inputs, flows, and outputs (FAO, 2018). The FSA provides powerful analysis on the relationship between food chain, actors and public policies, making outcomes of activities apprehensible, in terms of socio-economic, production practices, access to means of production and environmental terms. The framework is a relevant interdisciplinary analysis instrument for research and policy-making processes aimed at sustainable solutions for access to means of production, production models and supply of sufficient and healthy food. The FSA also highlights rooted causes of problems such as poverty, malnutrition and socio-economic and geographical inequalities (FAO, 2018).

Food systems entail processes related to food production and use, such as producing (growing and harvesting), processing, packing, transporting, marketing, consuming and disposing of food waste. Their activities demand inputs and engender products and/or services, income and access to food, as well as environmental impacts (UNEP, 2016; HLPE, 2014). A food system is also defined as interconnected networks of stakeholders (NGOs, public and private organisations, citizens, financial institutions, and companies) coexisting in a geographic space (region, state, multinational region) that contribute directly or indirectly to generation of flows of goods and services oriented towards meeting the food needs of groups of consumers located in the same geographic space or elsewhere (Rastoin and Ghersi, 2010). Such a food system is strongly influenced by social-economic, political, technological, cultural, and natural means (Global Panel, 2016; HLPE, 2017).

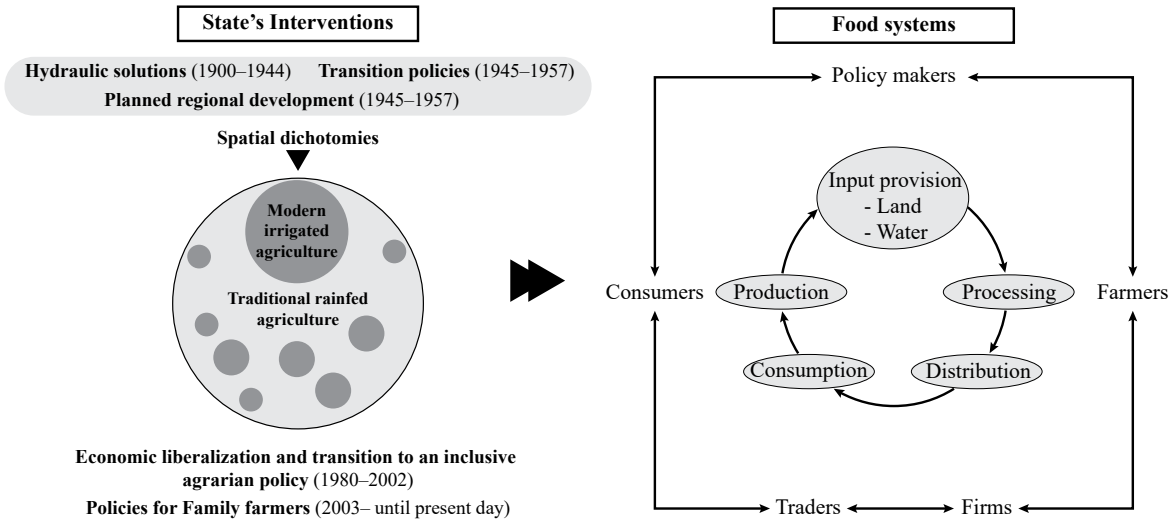


**Figure 1:** Conceptual Framework.
Source: own composition

### Conceptual scheme

The conceptual framework contains two parts: the State's intervention, and the food system's activities. The first part concerns public policies implemented in the semi-arid region. The period between 1900 and 1980 was decisive towards creating spaces for modern irrigated agriculture, outlining the dichotomies of the agrarian space. The second part corresponds to the policies' influence over the activities of the food systems (input provision, producing, processing, trading, and consuming).

## State's intervention and the production of the agrarian space dichotomies

The Portuguese occupation of the Brazilian territory in the colonial period (16th Century) was characterised by the appropriation of sparse sites, especially in the coastal areas due to the fertile lands. Thus, remote regions, such as the semi-arid, were neglected for years (Andrade, 2004; Prado Jr, 1981). The first interventions of the federal government were launched in the 20th century to mitigate effects of droughts. The policies involved the construction of hydraulic infrastructure, such as public and private dams, irrigation canals, reservoirs, well drilling and drainage (Alves, 1982; Silva, 2006).

Between 1945 and 1957, the federal Government launched policies to promote socioeconomic development by exploring the economic potential of the São Francisco River and granting credit lines to foster the local economy (Duarte, 2002). Transition policies went beyond the pattern of the previous period since in addition to mitigating the effects of drought, the policies aimed at a deeper structural change in economy and society.

In 1958, studies were carried out by the Working Group for the Development of the Northeast (GTDN) aiming at identifying the causes of regional poverty and underdevelopment and raise possible solutions (Furtado, 1997). The reports concluded that poor management of the resources, unequal access to means of production such as inputs, land, water and capital were the main issues (Furtado, 1997). The study also revealed the aptitude for irrigation of spatial fragments, especially the São Francisco river humid Valleys. Based on the results and also influenced by the productivist paradigm, the federal government started to invest in industrial and agricultural projects.

Thereafter, the State devoted itself for creating a space for the development of a modern agriculture, based on irrigation. For that purpose, three main actions guided public investments (Ortega and Sobel, 2010):

1. Investments in the construction of federal highways to link irrigated areas to urban centres in the country, construction of electrical grids to supply electricity, networking and communication infrastructure, Petrolina airport and the Sobradinho dam (Sobradinho hydroelectric power plant). These investments were prior to the implementation of the perimeters and were fundamental to connect the region to markets.
2. Investments in irrigation comprised the construction of canals, water pumps and irrigation reservoirs. The São Francisco Valley Development Company (CODEVASF) and the Brazilian Agricultural Research Corporation (EMBRAPA) cooperated in planning and execution of the works and preparation of agricultural studies, respectively.
3. Incentives for private investment, such as financial and fiscal incentives such as the Financial Assistance Programme for Agroindustry and Industry of Inputs, Machines, Tractors (Proterra/Pafai, 1971), and further financing programmes for the capitalisation of agroindustrial companies, such as the Northeast Agroindustry Development Programme (PDAN, 1974), the Agroindustrial Development Programme and the National Agroindustry Assistance Programme.

In the 1960s, irrigated agriculture pilot projects started to be implemented in the humid valleys of the São Francisco river situated in the municipalities of Petrolina and Juazeiro.

Between 1980 and 1990 the trend towards neoliberal policies promoted a dismemberment of the public sector, through the privatisation of public institutions. From 1990 onwards the State expanded the process of agrarian reform across the country and launched programmes to include traditional family farming in the regional development project. The National Programme for Strengthening Family Farming (PRONAF), created in 1996, was one of the first programmes that granted credit to family farmers.

The State's movement towards policies to Family farmers from the 2000 onwards is especially characterised by the expansion and consolidation of more inclusive measures, based on the conception of territorial development, unlike the sectorial previous model of development, which focused on the modernisation of agriculture and irrigation. The State launched programmes to promote access to water through cisterns to traditional rainfed farmers (One Million Cisterns for Drinking Water – P1MC , 2003), created institutional markets and food security programmes (Food Procurement Programme – PAA; 2003 and National School Feeding Programme – PNAE, 2003) and implemented programmes to offer rural technical assistance to family farmers (Technical Assistance and Rural Extension programme – ATER, 2010).

## Materials and Methods

### Case study

Our case study entails sites situated in the municipalities of Petrolina and Casa Nova, which are part of the Brazilian semi-arid region. High temperatures and droughts are characteristic of the region, which features annual average rainfall and temperature of 800 mm and 25.4 ºC, respectively (Malvezzi, 2007). The regional aridity relates to spatiotem-

poral rainfall concentration, since 71% of the precipitation occurs between January and April. In addition, the rate of evaporation of 3,000 mm/year is three times higher than the precipitation (Malvezzi, 2007). The region is crossed by the São Francisco River, which is the main source of water for irrigation in the region. The semi-arid space is covered by seasonally dry tropical biome, so-called Caatinga, which presents a great diversity of species resistant to long periods of drought, such as xerophilous and deciduous vegetation (Por *et al.*, 2005).

The semiarid region's levels of poverty have historically stood out as the highest in the country. Out of the nearly 13.4 million Brazilians (6.5% of the country's population) currently living in a situation of extreme poverty (monthly household income per capita below R$133,70 – maximum of US$1,90 per day), about 7.3 million are residents of the semiarid region (PNAD, 2016). In Figure 2, the location of the municipalities of Petrolina and Casa Nova can be seen.

The municipality of Casa Nova covers an area of 9.697 km² and is home to 64,940 inhabitants, 42% of whom reside in rural areas (IBGE, 2010). The extension of the territory of Petrolina is 4.561 km² and presents a population of 293,962 inhabitants, 25% of whom are from rural areas (IBGE, 2010). The criteria we used to select both municipalities were as follows: (1) availability of secondary data from agricultural census survey at the municipal level; (2) the differences and convergences between Petrolina and Casa Nova in terms of agrarian space; and (3) the prevailing food systems (irrigated agriculture and rainfed agriculture) that are relevant for the regional economy. In Petrolina we visited irrigated agricultural areas, the so-called irrigated perimeter, and in Casa Nova we visited traditional rainfed farming communities.

## Data collection

Both primary and secondary data were used in this study. Primary qualitative data were collected during the fieldwork we conducted in the municipalities of Petrolina and Casa Nova in two occasions: the first in July 2018 and the second from October 2018 to January 2019. Secondary data were sourced from agricultural census of 2017, published by the Brazilian Institute of Geography and Statistics (IBGE). Primary data were gathered through participatory observation, focus groups and semi-structured interviews. We also took notes and made audio recordings. In Petrolina we visited irrigated areas and interviewed the representative of a fruit-growing agro-company, three family farmers who grow fruits and annual crops (e.g. onions, beans, cassava, maize) in the irrigated areas and three family farmers that occupy the peripheries of the irrigated areas (*agrovilas)*. In Casa Nova we visited the rainfed areas, where we conducted six focus groups with traditional family farmers from the *fundo de pasto* communities of Melancia, Riacho Grande and

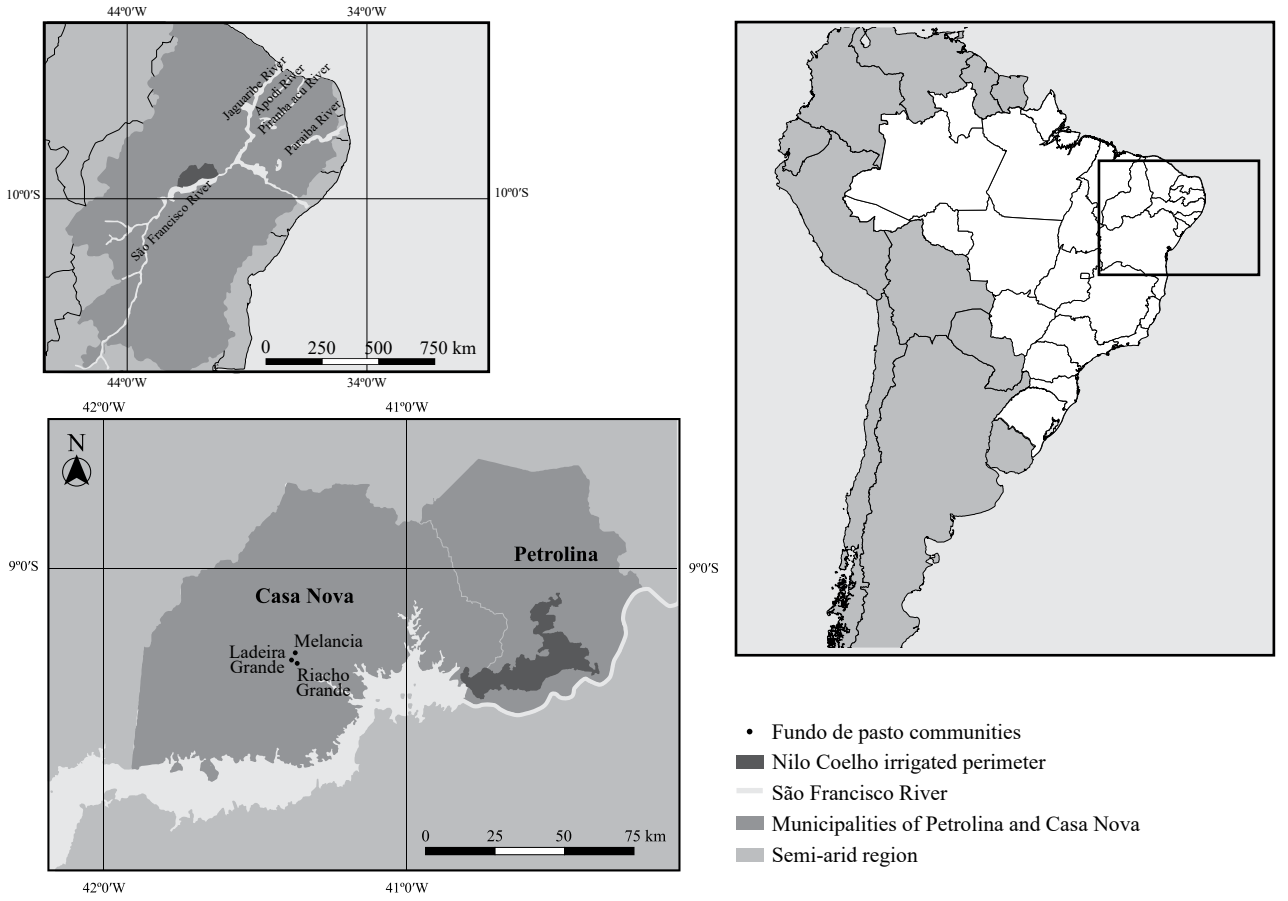


**Figure 2:** Location of the case study on two spatial scales: municipal (Petrolina and Cana Nova) and local (rainfed area, *fundo de pasto* communities and irrigated perimeter of Nilo Coelho).

Source: own composition

Lagoa Grande. We also conducted eleven semi-structured interviews with academics and representatives from NGOs, social movements, and private and public institutions[4]. Secondary data were obtained through digital platforms of the public institutions mentioned above. We collected data on the following topics: area occupied by the food systems (irrigated agriculture and rainfed agriculture), number of farmers and companies in the irrigated and rainfed areas, main crops grown, animal rearing and trade.

### Data analysis

Primary data were used to support local-scale analysis of the agrarian space, which comprises the irrigated areas (irrigated perimeter) and rainfed areas (traditional *fundo de pasto* communities). Secondary data were collected to support analysis at the municipal scale considering differences and convergences of agrarian spaces of Petrolina and Casa Nova. We analysed the forms of the State's intervention in the different activities of the food systems, which include input provision, producing, processing, trading, and consuming.

According to the federal law (Act No. 11.326, July 24, 2006), family farmers are the rural family entrepreneurs who practice activities in rural areas and, simultaneously, meet the following requirements: (1) do not hold, in any way, proprietary property of a size greater than four fiscal modules[5]; (2) use, predominantly, the labour force of their own family in the economic activities of their property or enterprise; (3) the family income must come, predominantly, from economic activities linked to the property or enterprise; (4) manage their property or enterprise with their family. The remaining productive models that do not fit this definition are considered "non-family farming", according to the Brazilian Institute of Geography and Statistics (IBGE). Since the data from the agricultural census uses this criterion to define the types of farmers in Brazil, we also use the same nomenclature.

### Hypothesis

The construction of the agrarian space is influenced by the interaction of different actors and elements (civil society, geographic objects, institutions and the State). However, in this study, we approach the State's contribution as central to the agrarian space (re)production. The study hypothesis consists in the assumption that the historical spatial and sectoral selectivity of public policies was decisive for building a dichotomous agrarian space, characterised by traditional agriculture and modern irrigated agriculture. Policies were translated into differentiated opportunities for rural development in the Brazilian semi-arid agrarian space.

## Results

### The dichotomies of the agrarian space

Petrolina and Casa Nova present spaces of both modern irrigated agriculture and traditional rainfed agriculture, but different proportionalities in terms of the food systems' spatial distribution. As can be seen in Figure 3, the area covered by the rainfed food system is more significant in comparison to the irrigated fields in both municipalities. However, looking at the detail, we perceive that in Casa Nova the rainfed area is around double that of Petrolina's. On the other hand, the irrigated area of Petrolina is about four times larger than Casa Nova's, measuring approximately 397 km² and 90 km², respectively. Based on this data, we chose to analyse irrigated areas of Petrolina and traditional rainfed areas of Casa Nova.

The space of irrigated agriculture is composed of public irrigation projects, so-called 'irrigated perimeters'. These projects resulted from the period of planned regional development (1958–1980). The creation of the perimeters involved two primary actions of the State: (1) the transformation of public lands into private lands and (2) investment in the construction of canals, water pumps, irrigation reservoirs, as well as infrastructure for transportation, energy, communication, etc. We visited the irrigated perimeter of Nilo Coelho, which is located in the municipality of Petrolina and covers an area of 18.667 hectares, being equivalent to 46% of the Petrolina's irrigated area.

The irrigated perimeters are occupied by agricultural companies (national and multinational) and capitalised family farmers. Fruits of temperate and tropical climate are grown in the lands of agribusiness. In contrast, fruits and annual crops are grown in the lands of family farmers. The labour employed by agribusiness comes from urban areas (people who make the countryside-city commute every day)

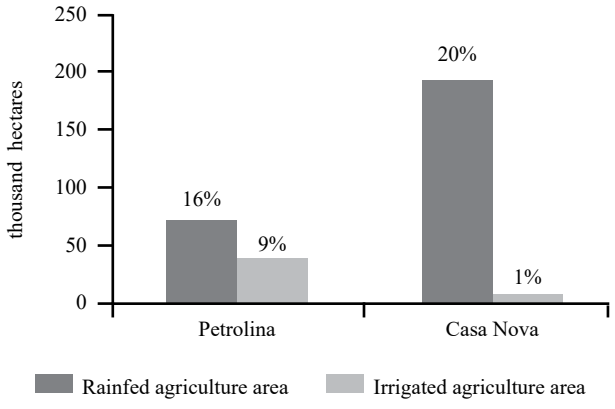


**Figure 3:** The proportion of food systems' spatial occupation in Petrolina and Casa Nova (2017).

Source: IBGE, 2017 and EMBRAPA (fieldwork data collection)

[4] The institutions that participated in this study break down as follows: Brazilian Agricultural Research Corporation (EMBRAPA), Food and Nutrition Security National Council (CONSEA), Regional Institute for Appropriate Small Farming and Animal Husbandry (IRPAA), Advisory Service for Rural People's Organizations (SASOP), Pró-Semiárido, Pastoral Land Commission (CPT), Agrarian Development Coordination (CDA) and Secretariat for the Promotion of Racial Equality (Sepromi), São Francisco Valley Development Company (CODEVASF) and Irrigation District of Nilo Coelho.

[5] Fiscal module is the unit applied to define the land size (in hectares). The minimum lot size must be sufficient to meet the families' necessity in terms of food production for their livelihood and for economic purposes. The size of a fiscal module varies according to the municipality where the property is located. In Petrolina a fiscal module covers an area of 55 hectares, while in Casa Nova a fiscal module covers an area of 65 hectares.

and from the rainfed areas. The land occupation of the irrigated perimeter of Nilo Coelho is shown in Table 1.

At the perimeter of Nilo Coelho, we visited an agribusiness plot of 390 hectares (340 hectares for growing mangos and 50 hectares for grapes) that during the harvest hire approximately 900 workers. We also visited three lots of family farmers, whose area varies from 8 to 14 hectares, one focused exclusively on mangoes and two of which growing mangoes, acerola and annual crops. Permanent employees range from 4 and 6 and in the harvest period, the number of extra persons working on the farm might reach 15 temporary workers. In addition, we visited three small lots of family farmers that occupy the peripheries of the perimeter, so-called *agrovilas*, each lot-sizing approximately 2 hectares, which are used for growing mangoes and organic annual crops. The irrigated perimeter is managed by the Irrigation District, which is a non-profit legal entity responsible for maintaining the hydraulic infrastructure, controlling water use and collecting fees.

The traditional rainfed food system occupies public lands and farmers are dependent on rainwater for self-consumption and food production. We visited three traditional communities in the municipality of Casa Nova that occupies an area of 15,100 hectares, which corresponds to approximately 8% of the rainfed area of the municipality. The rainfed area is occupied by family farmers from traditional communities (*quilombolas, povos de terreiro, fundo de pasto,* artisanal fishermen, etc.) and family farmers settled on agrarian reform settlements. They produce crops such as fruits, vegetables, greenery and practice extensive livestock production with such animals as cattle, chicken, pig, but mainly goats. The traditional rainfed farmers we visited in Casa Nova are so-called *fundo de pasto* communities, whose main feature is the communal land (used for animal rearing) combined with individual areas (used for family crop production). Table 2 shows the key characteristics of each community.

Table 3 shows the main crops grown in both municipalities, according to the type of producer (family farmers and non-family farmers). Petrolina produces more fruits, while Casa Nova stands out more for the cultivation of vegetables and grains, such as onions, beans and corn. When comparisons involve the type of producers, it is noticeable that non-family farmers produce considerably more grapes and mangoes while family farmers are engaged in producing fruits, vegetables and grains in a more balanced way.

The goat production, as shown in Figure 4, is more prominent among family farmers of Casa Nova. Goats are the main source of income of the *fundo de pasto* communities

**Table 1:** Land occupation of the irrigated perimeter of Nilo Coelho.

| | Family farmers | Agribusiness |
|---|---|---|
| Number of lots | 1,983 | 244 |
| Area in hectares | 12,027 | 6,024 |

Source: Fieldwork data collection

**Table 2:** Main features of the *fundo de pasto* communities participating in this study.

| Community | Total number of families | Size of land occupied (hectares) |
|---|---|---|
| Melancia | 42 | 600 |
| Riacho Grande | 211 | 12,000 |
| Ladeira Grande | 60 | 2,500 |

Source: Fieldwork data collection

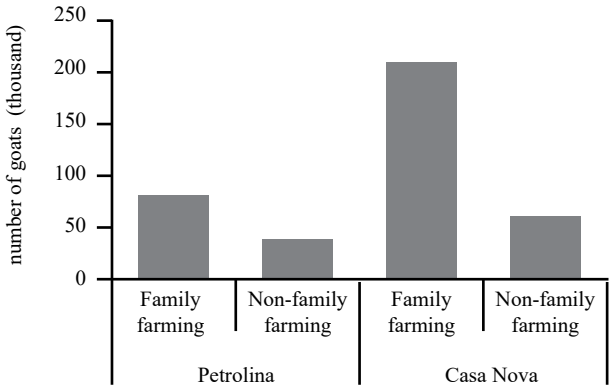


**Figure 4:** The goats rearing (number of goats) by region and area.
Source: IBGE, 2017

**Table 3:** Quantity produced by family and non-family agriculture according to the municipality (tons).

| | Petrolina | | | | | Casa Nova | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Family farming | % | Non-family farming | % | Total | Family farming | % | Non-family farming | % | Total |
| Pumpkin | 724 | 59 | 496 | 41 | 1,220 | 181 | 58 | 132 | 42 | 313 |
| Onion | 0 | 0 | 0 | 0 | 0 | 3,743 | 34 | 7,329 | 66 | 11,072 |
| Beans | 232 | 78 | 67 | 22 | 299 | 292 | 79 | 79 | 21 | 371 |
| Cassava | 7,404 | 92 | 607 | 8 | 8,011 | 534 | 76 | 168 | 24 | 702 |
| Corn | 443 | 76 | 143 | 24 | 586 | 329 | 30 | 774 | 70 | 1,103 |
| Watermelon | 1,306 | 57 | 992 | 43 | 2,298 | 1,651 | 51 | 1,558 | 49 | 3,209 |
| Acerola | 8,894 | 57 | 6,746 | 43 | 15,640 | 380 | 86 | 63 | 14 | 443 |
| Banana | 15,049 | 62 | 9,042 | 38 | 24,091 | 254 | 13 | 1,630 | 87 | 1,884 |
| Cashew | 436 | 13 | 2,796 | 87 | 3,232 | 20 | 100 | 0 | 0 | 20 |
| Guava | 10,009 | 52 | 9,183 | 48 | 19,192 | 2,889 | 28 | 7,309 | 72 | 10,198 |
| Mango | 15,646 | 15 | 88,236 | 85 | 103,882 | 3,566 | 8 | 40,311 | 92 | 43,877 |
| Grape | 10,190 | 7 | 132,968 | 93 | 143,158 | 2,145 | 13 | 14,188 | 87 | 16,333 |
| Total | | | | | 321,609 | | | | | 89,525 |

Source: IBGE, 2017

and are raised extensively, feeding on native vegetation and consuming water from dams. Also, in Petrolina, family farmers produce more goats than non-family farmers.

In face of the above results, we interpreted that in Petrolina, where the irrigated areas are larger than the Casa Nova's, non-family farming stands out for fruit production, whilst in Casa Nova, where the rainfed area is considerably superior, the amount of vegetables, grains and goats is greater. In both municipalities, family farming produces more vegetables, grains and goats than non-family farmers.

## The State's influence over the activities of the food systems

### Input provision: land access

In the case of Nilo Coelho perimeter, there are disagreements concerning the land's occupation before its transformation into irrigated perimeters. While the irrigation district employee affirmed that the lands used for the activities were vacant, the representatives from Pró-Semiárido and the Pastoral Land Commission (CPT) stated that the lands were occupied by landless squatters and family farmers that had no land title. As a consequence of the irrigation policy, squatters and family farmers were expropriated and communal public land were transformed into private properties.

The access to the lands of the irrigated perimeters is made through land purchases. In the first years of the occupation, land payment could be made within 10 years, with low interest rates and tax incentives. The historical occupation of the perimeter may be divided into two main periods, according to the member from the irrigation district. At first, in the 1970s, the land was occupied by traditional farmers and small family farmers from nearby areas who had experience with small-scale irrigation practices. In the second phase, mid-1980s, the federal government moved away from the administration of the perimeters, under the influence of the neoliberalism and also because of the deep economic crisis that hit public accounts. The crisis affected the farmers in the perimeters, who sold their land and moved to the rainfed area nearby the perimeters (*agrovilas*). Subsequently, the traditional farmers were replaced with small agricultural entrepreneurs and national and international companies (agribusiness). According to the irrigation district employee, it was when the fruit growth and trade expanded to national and international scales. Currently, only 10% of the first farmers continue occupying the land of the Nilo Coelho perimeter, which means that family members are no longer the natural successor.

The three farmers who live in the *agrovila* explained how they failed to subvert the logic of capitalist accumulation and sold their land. Below we highlight an excerpt from the testimony of one of the farmers.

"I know a lot of people who left the business, went back to work as employee. They lost everything. At least I live here in *Agrovila* and I have my land. It's small, but I can live. Better than in the city. I was unable to complete the payment for the land because the profits went down. I had to sell it. I sold it to a businessman from São Paulo. The problem of selling to these people is that they do not diversify [the production]. They prefer monoculture … then people in the region lack food."

The traditional communities of farmers occupy rainfed land for over two hundred years and many do not have the land title, according to the Regional Institute for Appropriate Small Farming and Animal Husbandry (IRPAA).

In 2013 the State of Bahia launched a plan (Law 12.910), which provides for a contract regarding the right of land usufruct for up to 90 years, with the possibility of renewal for an equal period. Participants from the *fundo de pasto* communities reported that they have rights to this land and, for this reason, they claim that they deserve land titles, not simply an authorisation to occupy the land for a certain period. They also stated that accepting the contract meant confirming the premise that the land does not belong to them, as dictated by the State government.

As reported in focus groups the communities' land struggles began in the 1970s when the federal government built the Sobradinho hydroelectric dam, flooding an area of 4,214 km² and displacing approximately 12,000 families, including some of the study participants. The dam construction set a precedent for land grabbing in the region. Land grabbing is an old practice in Brazil, typically beginning with irregular occupation of land, supported by fraud and falsification of property titles. In 1979, there was an intense and violent conflict between the communities and a company that illegally occupied their lands for cattle production. Families were displaced, farmers were threatened with death, and a community leader was murdered. Nowadays, communities fear losing their lands to wind power companies, agribusinesses, and mining companies, which have been advancing in the region with the collusion of the government of Bahia[6].

### Input provision: water access

The irrigated perimeter of Nilo Coelho was created by the federal government between 1984 and 1996. The public investments entailed the construction of irrigation infrastructure (canals, water pumps, irrigation reservoirs) and electrical station to pump water from the São Francisco River. The Irrigation District manages the system and charges farmers and companies for water use. Families settled in the *agrovilas* collect water irregularly from the canals to grow crops such as organic fruits and vegetables. Given their illegal status, they do not pay the fee for water consumption. This situation is, constantly, the cause of conflict between insiders and outsiders. The Irrigation District takes strict measures, interrupting clandestine access to water.

Despite being close to the São Francisco river (see Figure 1), irrigation sourced from the river is not possible to the *fundo de pasto* communities. Rainwater is the main

[6] The government of Bahia implemented a series of measures to attract investments, including offering concessions of State land for industrial and agricultural use and energy production; offering reductions and exemptions from State taxes, and offering low-interest financing (FIEB, 2019; SEI, 2019).

source of water for drinking and producing. The water is collected through the gutter installed on the roof of the houses and drained to the cisterns, where it is stored. Cisterns are given to the families through the federal programme One Million Cisterns for Drinking Water (P1MC). The P1MC became public policy in 2003 and participants confirmed they had at least one cistern.

Among the benefits of the cisterns, focus group participants highlighted its role in freeing women from daily long walks for water collection, since they were in charge of ensuring household water security. The testimony bellow we got from a female farmer from the *fundo de pasto* community.

"Now that we have the cisterns, the pain in my back reduced because I used to carry water since I was seven years old. We used to walk about 15 km a day or more. Now that we have cisterns at home, we can store water. In the past, the water truck brought water, but since we had no cistern, the water was thrown to the ground. Sometimes having a place to store is so much more important than having access to water itself."

In the same focus group, we also discussed the role of the cisterns in food production. We selected the following testimony to illustrate the perception of a rainfed farmer on the subject.

"They [cisterns] were important because now we have water for small irrigation. At home, we began to produce more fruits and vegetables, for example. We also consume more of the food grown on our farm."

The cisterns' efficiency depends on the availability of rainfall throughout the year. As reported by the participants in focus groups, due to recurrent droughts the water in the cistern runs out in certain periods of the year, forcing families to rely on government assistance for water supplies. To improve people's autonomy regarding water access, one academic interviewed recommended implementation of structuring measures to mitigate the effects of the drought, including the construction of small water aqueduct systems to connect the communities to the São Francisco River.

As mentioned above, another way to access water is through the water truck provided by the federal government, which is an emergency supply. The municipal government is responsible for planning water distribution and the army is in charge of hiring water suppliers and controlling the water supplied per house. However, according to participants in the focus groups, there is a mismatch between the plan and the execution of the project. In general, the water provision is inefficient because the amount does not meet the real needs of the communities. Below we selected a statement taken from the focus group dialogues.

"A clear example of disconnected measures is that last year the municipality of Casa Nova was provided with 10 water trucks, when actually its rural population demands water consumption of at least 90 trucks."

## Producing and processing

The State has been involved in helping production and processing activities in irrigated areas by providing technological and scientific knowledge through the Brazilian Agricultural Research Corporation (EMBRAPA). EMBRAPA's office in semi-arid was created in 1975 to develop scientific studies in the field of agronomy to support the agriculture in irrigated areas. Below we highlight the testimony of an employee from EMBRAPA semi-arid on the importance of the institution for the development of the initial phase of fruit growing in irrigated areas.

"Embrapa was crucial in transforming the perimeter of Nilo Coelho into a station dedicated exclusively to the cultivation of fruits. This occurred around the end of the 1980s. EMBRAPA tested different fruit species, such as mangoes and grapes, so that the region would become attractive to private capital. We knew already that mangoes and grapes were well accepted in the global market."

Embrapa's representative informed us that the genetic modification of the seeds allowed the cultivation fruits of temperate climate in edaphoclimatic conditions of the semi-arid region, which has high temperatures, high insolation and low humidity throughout the year. Besides, it helped to improve productivity and resistance to pests, to meet market demands (e.g. seedless grapes, mangoes with little fibre, fruits with uniform colours and appropriate balance between sugars and acids) and to extend the post-harvest conservation capability.

As a result of the adaptations, currently, grapes are produced twice a year and the length of the mangoes' growth cycle has been reduced to 10 months. With no influence of genetic engineering services, this period would be nine months for grapes and 12 months for mangoes. In addition, producers manage the harvest in order to make it coincide with the off-season periods of other producers located in Brazil and abroad, benefiting from their competitive advantage. EMBRAPA also offers assistance to producers to get their products certificated, meeting the requirements imposed by the world market. Table 4 illustrates the mangoes and grapes growth cycle.

The State also offers technical assistance for farmers in rainfed areas, but the assistance was institutionalised in 2010, through the creation of the Technical Assistance and Rural Extension programme (ATER). The main goal of ATER is to transfer technical knowledge to family-farm food systems via environmental education, introduction of endogenous production techniques, and transition to agroecology (Brasil, 2018). In Bahia, policymakers opted for outsourcing this service to NGOs and other private entities, which are contracted through public calls.

**Table 4:** Mangoes end grapes growth cycle.

| Crops | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mangoes** | 1 cycle | | | | | | | | | | | |
| **Grapes** | 1 cycle | | | | | | 1 cycle | | | | | |

Source: Fieldwork data collection

According to farmers, environmental education includes discussions of sustainable solutions to cope with the semi-arid climate. Regarding food security, the NGOs help farmers and associations make applications in response to public calls to participate in the PNAE (National School Feeding Programme) and PAA (Food Procurement Programme). This assistance has been fundamental, because farmers affirmed that they were not used to dealing with bureaucracies and formal contracts. Concerning agricultural practices, the projects involve assistance with soil management, creation of a seed bank, and preservation of the region's characteristic biome (Caatinga). The NGOs also encourage the transition to agroecology through the use of organic matter (manure) as a natural fertiliser (thus avoiding use of chemical fertilisers). Participants reported that the technical assistance enabled them to understand the benefits of agroecological practices that they applied intuitively, providing insights into how they work to maintain a resilient environment.

One of the problems identified by the communities was that by outsourcing the technical assistance service, the number of family farmers receiving support had fallen. Participants stated that when the Bahia State government provided the service in the past, it covered more families. They said that the institutions that replaced the State in this function have a limited budget, which translates into less coverage. Participants pointed out that since some families were not informed and properly guided regarding the procedures and bureaucratic steps involved in applying for contracts, they had difficulties accessing public policies.

## Trading and consuming (food security)

The producers from the irrigated perimeter have easy access to the market, as they are close to the urban centre of Petrolina. In other words, producers have access to transport infrastructure, such as airport and federal roads (see Figure 1). The State's investments in transport, communication and energy infrastructures turned the irrigated territory more fluid to exchange goods and movement of people. Differently, famers in rainfed areas – especially the communities we visited – are distant from urban markets and devoid of adequate transportation infrastructure. Figure 5 shows the infrastructure implemented in the region.

In Figures 6 and 7, we see the main commercialisation niches for food produced in the municipalities of Petrolina and Casa Nova. The data from the agricultural census did not cover the differentiation between family farming and non-family farming for this indicator.

The most important common aspect shared by the municipalities is the sales to middlemen/ intermediaries. Many middlemen are farmers or micro-entrepreneurs from nearby localities that purchase a variety of products from producers at a lower price and resell to large supermarket chains and export. The intermediaries are strong because, according to farmers from both areas, for many years they were one of the only forms of trade. Farmers and intermediaries created strong bonds over time and built relationships based on of trust and friendship. Therefore, despite the advent of food procurement and other trade mechanisms, intermediaries are still very important for the production flow.

In Casa Nova, sales of food through cooperatives and associations involve products such as corn, cassava, beans and onions. Data on the destination of the goats were not available through census data, but according participants most part of the animals are sold through cooperatives. According to farmers, sales through cooperatives and associations usually occur within the standards of the mediated market, through the Food Procurement Programme (PAA) and National School Feeding Programme (PNAE). In both municipalities, products are pooled together for collective sales, enabling economies of scale.

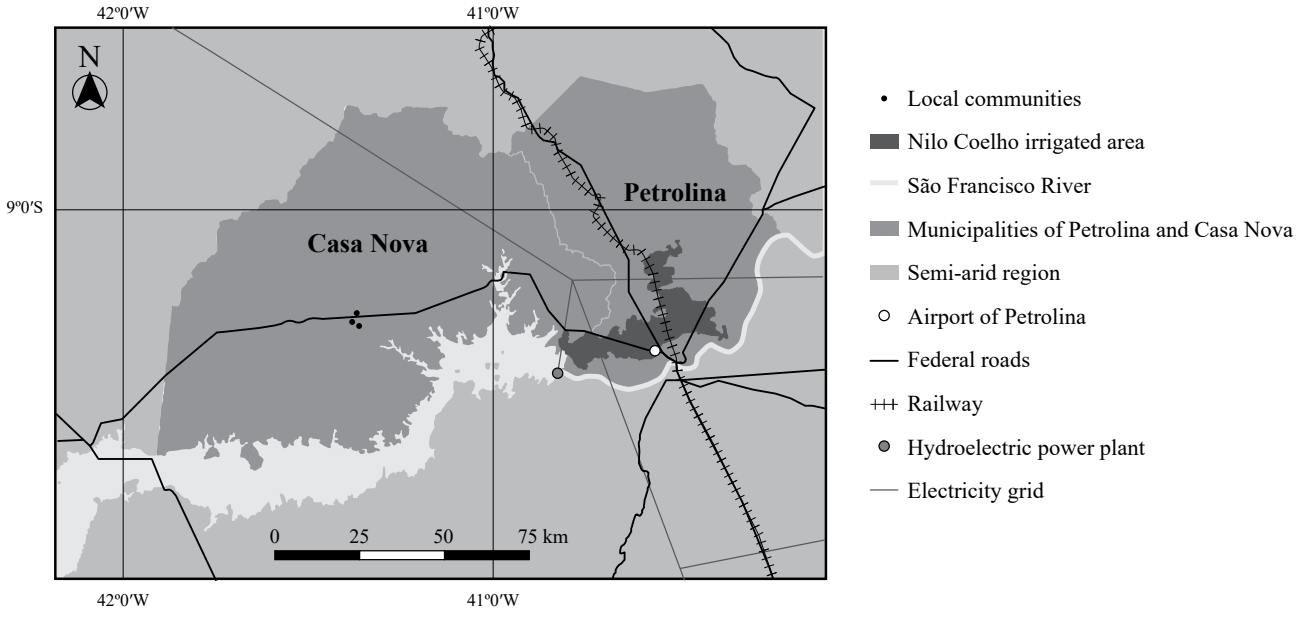


**Figure 5:** Geographical distribution of physical infrastructure in the agrarian space.
Source: own composition

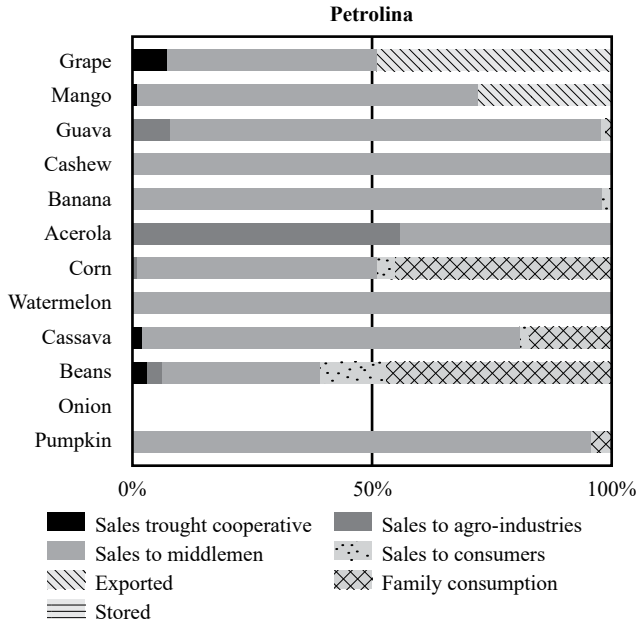


**Figure 6:** Destination of the products, Petrolina
Source: IBGE (2017)

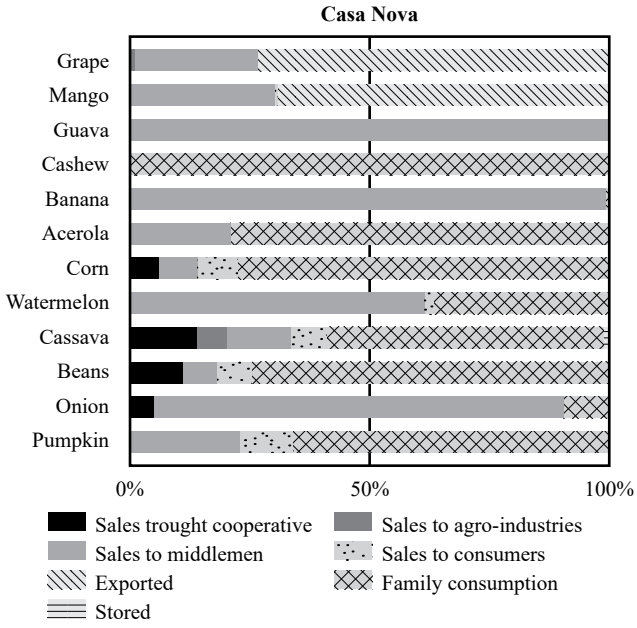


**Figure 7:** Destination of the products, Casa Nova
Source: IBGE (2017)

Exports are also expressive in both municipalities, especially mangoes and grapes, which are fruits mainly produced in irrigated areas. Petrolina exports 70 thousand tons of grapes and 29 thousand tons of mangoes, respectively, which corresponds to approximately three times more than Casa Nova exportation. In terms of absolute values, Petrolina exports more, but in figures 3 and 4 we see that Casa Nova exports most of mangoes and grapes produced in its territory. Also, annual crops (pumpkin, beans, cassava and maize) are sold directly to consumers, which means that these products are mostly sold at local fairs, in addition to being highly consumed by families, especially those from the municipality of Casa Nova.

As for access to food in satisfactory quality and quantity, as food security advocates (FAO, 1999), rainfed areas stand out for subsistence agriculture, with a low level of food insecurity. Figures 5 and 6 show that a large amount of the food produced is consumed. However, farmers admitted that vulnerability to food insecurity is more imminent in periods of drought, pointing out that the semi-arid climate aggravates food insecurity, but the problem is rooted in low household income and high levels of poverty. The drought that occurred between 2005 and 2009 was remembered as a difficult time for food production and in this period families in the communities received cassava, milk, rice and beans from PAA. They also highlighted the importance of food procurement programmes (PAA and PNAE) as an important means for achieving income stability, translating into household financial planning concerning family feeding.

In the irrigated areas, there is also no evidence of food insecurity, given that farmers in these lands are financially able to purchase food. However, if food supply is considered on a regional scale, productive specialisation is a negative indicator, as it means that family farming is using land to produce food to satisfy market demands and not to satisfy the population's demands for food that meet their dietary needs.

## Discussion and Conclusion

Public policies transformed the agrarian space of the semi-arid region for generating productive restructuring of activities and spatial dichotomies. The territorialisation of the capitalised food systems was based on a set of policies launched between 1900 and 1990 that involved the construction of hydraulic infrastructure for irrigation, arrangements for communication and energy supply, easy access to land and technical information. The consequences of these commercially oriented policies include the dichotomies of agrarian space, the emergence of capitalised food systems in the humid valleys of the Rio São Francisco, the imposition of productive specialisation and connections with the global market scale.

Policies for traditional family farmers lasted almost a century after being implemented in the 1990s. Despite the delay, they improved the activities of the farmers from rainfed food system, as we have analysed. The cisterns provided household access to good quality water. Previously, people collected unsuitable water from dams located far from the communities. Technical assistance helps in the development of a contextualised agriculture, considering edaphoclimatic conditions of the semi-arid region. The projects also preserve the caatinga biome and guarantee food security conditions for family farming. Finally, food procurement programmes enabled an alternative market for family farmers. The issue not yet resolved concerns the regulation of communal land, since the communities fight for the title of the land and reject the contract that authorises the use of the land for a limited time. Among the most significant impacts it is worth highlighting the empowerment of family farmers, access to the institutional market, income stabilisation, and improvements in food production and consumption (food security), as well as the promotion of contextualised practices to deal with semi-arid edaphoclimatic conditions. Table 5 demonstrates

the connections between public policies, process factors and policies' impacts.

The most relevant differences between the set of policies of the two periods are (1) the focus on the modernisation of agriculture versus a more integrative emphasis; (2) commercially oriented goals versus an alternative market for family farmers; (3) the imposition of an artificial landscape to deal with the edaphoclimatic peculiarities of the semi-arid region versus endogenous development. The policies implemented between 1900 and 1990 had a biased sectoral character, channelling public investment to food systems modernisation and prioritising the activities of agribusiness and capitalised family farming. In contrast, the policies that have been launched since 1990 are inclusive and aim to develop productive activities for family farmers. These policies have achieved greater coverage since they were targeted at the social group of family farmers, being a counterpoint to previous policies that aimed at developing specific productive activities in selected space fragments.

In this sense, the second characteristic of the policies is the contrasts between the commercially oriented policies and the programmes targeted at family farmers. The first policies comprised investments to make the space more conducive to trade, and through the role of the capitalised food system sought adaptations of productive practices and food in order to serve the national and international market. In contrast, the second group of policies were targeted at family farmers' activities, aiming at the stabilisation and resilience of their food system through the creation of alternative markets.

Finally, the first group of policies transformed the landscape to promote capital accumulation through investments in irrigation. Currently, tropical and temperate climate crops share space with original drought-resistant species, such as cacti, the original species of the caatinga biome. In contrast, the new policies strategically respect and preserve the edaphoclimatic conditions of the semi-arid climate (e.g. cisterns provide household water consumption, without the need to transform the landscape).

The great contradiction is that the first group of policies strengthened modern irrigated agriculture in a way that they became self-sufficient and their activities were consolidated. During this period small-scale producers were marginalised and did not benefit from policies. In contrast, recent policies have strengthened family farmers by stabilising their food system activities and safeguarding farmers' livelihoods. However, despite these improvements, the disparities in power between the actors from irrigated and rainfed areas remain very large.

Federal policies targeted at family farmers clearly did not equalise the differences between food systems in the region. Family farmers face disadvantages, since they lack the capital and transport infrastructure – being far from the markets they need to access – and furthermore, they have limited access to water, and legally no access to land. All of these elements together translate into powerlessness.

Achieving a more equal environment means strengthening the voice and participation of small-scale producers in policymaking, while reducing the power of agribusiness. Policies must support producer organisations, increase the participation of family farmers in the policy making process, devise a competition policy that protects these small producers, and impose high export taxes. Also, to improve the living conditions of *fundo de pasto* communities, the public agenda must include expanding access to rural infrastructure and services, such as roads, public slaughterhouses, physical markets, telecommunications, and electricity.

**Table 5:** Links between public policies, process factors and policies' impacts.

| **Policies** | **Agribusiness/irrigation farmers** | | **Policies** | **Rain feeding farmer** | |
|---|---|---|---|---|---|
| **1900–1990** | **Factors of the process** | **Impacts of the public policies** | **1990 – present days** | **Factors of the process** | **Impacts of the public policies** |
| Hydraulic solution (1900–1944)<br><br>Transition policies (1945–1957)<br><br>Planned regional development (1958–1980)<br><br>Economic liberalization and transition to an inclusive agrarian policy (1980–1990) | **Input provision**<br>Access to land: easy access through instalment purchase and tax incentives<br>Access to water: hydraulic infrastructure – dams, irrigation canals, reservoir, well drilling and drainage<br>**Producing and processing**<br>Access to technical information that enabled the adaptation of temperate fruit seeds to the edaphoclimatic conditions of the semi-arid region<br>Access to energy through the grid network<br><br>**Trading and consuming**<br>Access to transport infrastructure: highways and airport<br>Access to communication infrastructure | Emergence of capitalised food systems in the humid valleys of Rio São Francisco<br><br>Commercially oriented agriculture<br><br>Connection with the global market scale<br><br>Productive specialisation<br><br>Dichotomy of agrarian space<br><br>Artificial landscapes | Economic liberalisation and transition to an inclusive agrarian policy (1990–2002)<br><br>Policies for Family farmers (2003 – until present day) | **Input provision**<br>Access to land: the land usufruct contract was rejected by the communities<br>Access to water: cisterns<br>**Producing and processing**<br><br>Technical assistance: environmental education, introduction of endogenous production techniques, transition to agroecology and knowledge to participate in public programmes<br><br>**Trading and consuming**<br>Food procurement programmes and mediated market | Alternative market<br><br>Increased food production and consumption<br><br>Stable income<br><br>Feasible access to water<br><br>Dealing with semi-arid edaphoclimatic conditions |

Source: own composition

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**Hephzibah Onyeje OBEKPA*, Ebenezer FRIMPONG** and Ali AYUBA***

# Influence of foreign direct investment and exchange rate on fisheries in Nigeria

Many studies have explored the impact of macroeconomic factors on the growth and output of the agricultural sector in Nigeria with focus on the aggregate output. Some studies narrowed down focus on the crop subsector while neglecting the fisheries subsector which is an important source of cheap protein for our increasing population, a source of employment for the unemployed and also key to achieving the first three sustainable development goals 2030. In this study, we investigated the influence of FDI on agriculture and exchange rates on the output of the fisheries subsector using time series data that spans from 1980-2018. A Vector Autoregressive Model was also used alongside a growth model. The findings indicate positive growth in the fisheries subsector. FDI to agriculture and exchange rate movements were both found to affect the fisheries subsector positively in the long run, whereas only FDI to agriculture was found to exert a positive influence in the short run. Policies to attract FDI to the sector are thus advocated for, while macroeconomic policies to stabilise the Nigerian currency (naira) against the US dollar are also advised.

**Keywords:** FDI, exchange rate, fisheries, Nigeria

**JEL classifications:** Q02, Q14

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## Introduction

The driving force behind economic globalisation and trade liberalisation for the past 50 years has been Foreign Direct Investment (FDI) and FDI inflows to developing countries have risen enormously during this period (Nathaniel *et al*., 2020). Agricultural production remains low despite the enormous increase in FDI to developing nations (Dhahri and Omri, 2020). The agricultural sector in Nigeria employs the majority of the population, who are subsistent farmers and still poor compared to employees in other sectors of the economy. The production of food in the advanced nations has been viewed by some as inadequate and demands significant expenditure in agriculture due to the limitations of agricultural technologies and adverse weather conditions (Donato and Marino, 2018). FDI, as opined by Ahmed *et al*. (2017), is an engine for agricultural development in many developing countries. FAO (2009) recommended that US$ 83 billion (in 2009 US$) should be annually invested in the agricultural sector of developing countries to ensure food production for a projected 9.1 billion worldwide population by 2050. Anetor *et al*. (2016) more recently stated that the main problem facing the country's agricultural industry is the shortage of sufficient finance required to revitalise the sector. A country's exchange rate provides a strong indicator of how well an economy is performing. The value of Nigeria's currency began to nosedive in relation to the dollar from 1986 when a second-tier exchange rate was introduced, and it has since not recovered from this decline. In today's world, where international trade laws and technology are constantly changing, the role of exchange rates is significant in determining the value of agricultural output and equipment.

Considered a significant agricultural sector in the coastal states, 'fishery' is one of the most important, most relevant and vital sub-sectors in terms of income generation, poverty reduction and meeting dietary requirements in Nigeria. Fish remains a very important source of protein to most Nigerians, a fact which was emphasised by the Food and Agricultural Organization (2018), who further underlined the importance of fish to strengthening food nutrition and security in most rural areas. Fish has been found to be a rich source of good protein, some micronutrients and fatty acids that are important for the development of the human brain (Tacon and Metian, 2013). The fisheries subsector has strengthened a lot of livelihoods in Nigeria, but the future of the sector still remains uncertain. The Nigerian fisheries subsector has been reported specifically to have created outright job opportunities for more than 8,700,000 Nigerians and an additional 19,600,000 partially, with women up to 70%. Recent investigations have shown that fish production in Nigeria currently amounts to only 1,000,000 metric tons as compared with an estimated demand of about 3.3 million metric tonnes, leaving an estimated imported deficit of over 2.2 million metric tons annually (Nigeria Fishery Statistics, 2016; WorldFish, 2018). The fishing sector in Nigeria involves 3 main subsectors, artisanal, industrial and aquaculture (Adewuyi *et al.,* 2010). The fishery sector in Nigeria contributes 3.2 percent to the total output of the agricultural sector, thus huge investment potential can arise for this sector if it receives foreign direct investment directed at bridging the gap between local levels of consumption and production (Oyinbo *et al*., 2013).

The purpose of this analysis is to find out if FDI to agriculture and stable exchange rates can be linked to growth in the Nigerian fisheries sub-sector in such a way as to maximise the potential of this sector. In Nigeria, studies on the effect of FDI on economic growth have yielded varying results and many of the submissions documented over time have not considered the sheer lucrativeness of the agricultural sector should it succeed in attracting FDI, thereby boosting the country's exchange rate as well as contributing to overall economic development and growth. The agricultural sector has been overlooked for years and the government seems not

to be attentive to the sector in such a way as to revive it (Olagbaju and Akinlo, 2018; Akinyemi *et al*., 2018).

While it is possible for FDI to achieve high returns on the output of the fisheries subsector, we also want to examine the counterfactual. First, we have chosen the fisheries subsector because fish are more efficient in converting feed into protein compared to other animal source of proteins. They are also a cheap protein source as opposed to other animal sources, as they can be found in the wild and also cultivated domestically. Secondly, Sub-Saharan Africa, which houses about 14 percent of people living in the world, has suffered from hidden hunger and as the most populous country in Sub-Saharan Africa and Africa, Nigeria's overall fish exports were estimated at $284,390 million, while the imports stood at around $1.2 billion in 2013. Accordingly, Nigeria is considered one of the worlds 's biggest importers of fishery products (FAO, 2018), making Nigeria an important and good area to study.

Based on the foregoing, Nigeria was selected for this study as the rest of the region can base some policy actions on the conclusions arrived at. In light of the significance of both FDI and exchange rate movements for agricultural production, a considerable amount of research literature has attempted to investigate different factors that could be responsible for the poor performance of the fishery sector in Nigeria. Some of the factors include micro and macroeconomic factors like labour cost, cost of inputs, exchange rate, GDP, inflation rate and agricultural policies like food importation (Akpan *et al*., 2012; Edet and Akpan, 2019; Akpan, 2012; Oluwatoyese *et al*., 2016; Oloyede, 2014 and Kareem *et al*., 2013). Against this backdrop, unlike previous studies that focused on exchange rate and other macroeconomic variables on the agricultural sector, this study aims to contribute to this growing area of research by exploring simultaneously the impact of foreign direct investment and exchange rate movements on the fisheries subsector in Nigeria, an area that has not been studied to the best of our knowledge, while also controlling for other significant variables. The span of the data the study uses extends from 1980 to 2018 to capture the recent recession of 2016, and sporadic flooding which occurred in 2018 in Nigeria.

The remainder of the paper proceeds as follows. First comes a literature review; next, the methodology section explains the data and method used; then the results and discussion section outlines and explaining the results of our analysis. The final part concludes.

## Literature Review

The literature is filled with different arguments concerning the extent to which foreign direct investment and exchange rate stability foster economic growth and development of agricultural sector. Capital inflows (private and public inflows) have been opined to boost the performance of the economy according to the endogenous and neoclassical growth theory.

The neoclassical theory of growth suggests that the inflow of international capital gives emerging countries the ability to acquire the technologies needed to improve and encourage production, accelerate demand and ensure a sustainable agricultural development (Adegbite and Adetiloye, 2013). Guided by the neoclassical theory of growth, we therefore review the literature in this section so as to put our discussions in the proper empirical perspective. The literature is subdivided into two sections, one dealing with FDI and agricultural production, and the other exchange rate movements and agricultural production.

### Foreign Direct Investment and Agricultural Production

Many papers show FDI has become a sustainable strategy conducive to profitable investment, taking into account the future prospects of the allocated agricultural production. Agricultural production has the potential to attract FDI, especially in developing countries, which need much more investment to enhance the positive and/or ameliorate the negative effect on agricultural productivity given the agricultural resources available. Macro-economic adjustments and deregulation, plus policies to attract foreign direct investments are believed to strongly affect the overall productivity of the agricultural sector of a developing nation like Nigeria (Odior, 2014).

Ikpesu and Okpe (2019) investigated the impacts of capital inflows and exchange rates on agricultural output in Nigeria from 1981 to 2016. They explored this relationship using the autoregressive distributed lag model and revealed that both private and public capital inflows have a positive impact on the growth of the agricultural sector. Ajuwon and Ogwumike (2013) meanwhile examined how uncertainty affects FDI inflows to the agricultural sector using data from 1970 to 2008. They examined this relationship by utilising an investment-cointegration error correction model and revealed that FDI positively impacted agriculture in the short and long run. Similarly, Oloyede (2014) using a Granger causality test found a positive relationship between FDI and agricultural sector development in Nigeria with data that spanned from 1981 to 2012. Other research works showed a positive relationship between FDI and agricultural output includes Kareem *et al*. (2013) and Gameli Djokoto *et al*. (2014). They all used different techniques but arrived at similar conclusions.

Contrary to previous studies, Djomo *et al*. (2017) examined the effect of FDI and exchange rate movements on agricultural production in Cameroon from 1978-2014 using VECM. The results revealed that FDI accounted for a negative response in agricultural growth for both the short and long run periods, whereas exchange rate stability accounted for positive response of agricultural growth in the short and long run. Owutuamor and Arene (2018) investigated the effect of foreign direct investment and other macroeconomic factors on Nigeria's agricultural development from 1981 to 2014, using co-integration tests, ordinary least square (OLS) regression and Granger causality test. They pointed out a strong, non-significant relationship between agricultural growth and FDI, implying that FDI in agriculture has no direct impact on agricultural development.

Meng and Li (2014) observed that agricultural foreign direct investment will have a significant and negative effect on Total Factor Productivity (TFP), with no enhanc-

ing impact on technical development considering the Data Envelopment Analysis (DEA) method to find the correlation with agricultural TFP and FDI in agricultural from fifteen city capitals from 2000 to 2011 in China. Since 1990 to 2012 a bilateral data that involves the flows of FDI with host countries of 108 with resident nations of 240.

### Exchange Rates and Agricultural Production

Exchange rates have been theorised to affect agricultural outputs through prices of products and cost of inputs. Since the seminal work of Schuh (1974), a country's exchange rate has been considered a medium for transferring macroeconomic policy to the agricultural sector. Some research results (Obasan and Maduekwe, 2013; Juselius *et al*., 2014) indicated that there was a savings-investment deficit in most African economies (including Nigeria) as well as a foreign exchange gap that has discouraged emerging countries from embarking on growth programmes. Depreciation of the exchange rate allows the market price of exported goods to decline in foreign exchange and leads to an increase in domestic currency, thereby stimulating domestic production (Odior, 2014). Baek and Koo (2007) studied the effect of the US's exchange rate, income, money supply and major trading partners on agricultural trade balance using an autoregressive distributed lag model. The exchange rate was found to be a key determinant of the manners of short- and long-term trade equalisation. Imoughele and Ismaila (2015) more recently observed that exchange rates, money supply, private sector credit and real GDP had significant effects on non-oil export production, while exchange rate appreciation had a negative influence on Nigeria's non-oil exports. In another analysis by Akinlo and Adejumo (2014), the impact of exchange rate fluctuations on non-oil exports in Nigeria between 1986 and 2008 was studied using the error correction model (ECM) methodology. They argued that lagging international income and actual exchange rates had strong and significant impacts on exports outside of the oil sector. According to the researchers, variability in the exchange rate still has a long-term impact, but not a short-term impact.

Similarly, Obayelu and Salau (2010) applied cointegration and VECM methods to the agricultural production response to price and exchange rates from 1970 to 2007. They reported that total agricultural production responded positively to exchange rate changes (i.e. exchange rate depreciation) in the short run and long run but negatively to food price increases. Oyinbo *et al*. (2014) explored the relation between deregulation of exchange rates and agricultural share of gross domestic product in Nigeria using the Granger causality test and VECM over the period 1986-2011. They noticed there was unidirectional causality from the exchange rate to the share of real GDP in the agricultural sector. They also found that deregulation of exchange rates had a detrimental effect on the agricultural share of GDP. The impact of exchange rate changes on components of agricultural production was studied by Yaqub (2013) using the two-stage-least-square techniques for the duration 1970 to 2008. The result obtained indicates that variations occur in how the performance of various sub-sectors reacts to changes in the exchange rate. Changes in the exchange rate have negative effects on crop and fisheries output, while it had positive impact on forestry and livestock.

Conversely, Oluwatoyese *et al*. (2016) established a long run relationship between the agricultural sector and some macroeconomic variables using a multivariate cointegration approach and a vector error correction model. They concluded that the inflation rate, exchange rate and unemployment rate all exerted insignificant influence on agricultural growth in Nigeria. Eyo (2008) found that the exchange rate system did not stimulate agricultural exports after investigating the macroeconomic strategies' impact on agricultural growth in Nigeria. Oyinbo *et al*. (2014) also reported that exchange rate variability affects the share of GDP in agriculture negatively.

Most of the literature available exhibits conflicting views on the contribution of FDI and exchange rates to the output of the agricultural sector. Besides, there is still no study that has investigated the simultaneous influence of FDI and exchange rates on the fisheries subsector in Nigeria using the available data 1980-2018.

## Methodology

The study uses time series data for exploring the relationship between FDI, exchange rates and the fisheries subsector in Nigeria. Table 1 shows all the variables used in this research and their sources. In order, to obtain more meaningful insight, logarithmic transformation of these variables was adopted to remove large and extreme bias that might be associated with the variables.

First of all, the unit root test of all variables was carried out. The Phillip and Perron (1988) test alongside with the Dickey and Fuller (1981) method was used to check for the presence of unit root in each variable (an indication for non-stationarity). As the use of data characterised by unit roots may lead to serious errors in statistical inference, lag length structure was used to select lag length for the model. A third test, the Zivot and Andrews (1992) test was also used to check for bias when there is a structural break, a weakness not covered for in the previous two tests. The Johansen procedure was employed to test for co-integration in the model.

**Table 1:** Description of variables.

| Variables | Measurement | Source | Symbol |
|---|---|---|---|
| Fisheries | Naira equivalent | CBN annual report | FIS |
| FDI to agriculture | Naira to USD equivalent | CBN annual report | FDI |
| Exchange rate | Naira to USD equivalent | CBN annual report | Exch Rate |
| Labour | Number of persons involved in agric. | CBN annual report | Labour |

Source: Author's Compilation from CBN Annual Bulleting (www.mundi.com)

A growth model was used to arrive at the direction of growth in the sector. A VECM was used to determine the impact of FDI and exchange rate on fisheries in the long and short run. The forecast error variance decomposition was utilised to forecast the contribution of FDI and exchange rate to the fisheries subsector.

### Growth Model

A growth model was used to ascertain direction and growth rates of variables of interest. Specifically, the variables of interest were modelled as follows:

$$\ln Y_t = \alpha + \beta fs_t + \mu_t \quad (1)$$

$$\ln Y_t = \alpha + \beta fdi_t + \mu_t \quad (2)$$

$$\ln Y_t = \alpha + \beta exch\ rate_t + \mu_t \quad (3)$$

$$\ln Y_t = \alpha + \beta labour_t + \mu_t \quad (4)$$

where $\alpha$ = intercept, $\beta$ = vector of the trend variable and $\mu$ is the econometric error term, $\beta_{fs}$, $\beta_{fdi}$, $\beta_{exch\ rate}$ and $\beta_{labour}$ = coefficients stand for the trend variables for Fisheries, FDI, Exchange rate and Labour, respectively. Instead of a linear trend model, a semi-log growth rate model was developed, since the analysis is interested in both absolute and relative change in interest parameters for this research. The parameter of $\beta$ is the coefficient of $\beta$, the slope coefficient that calculates the constant proportional / relative change in $Y$ for a given absolute change in the regressor $t$ value.

Firstly, calculating IGR over time, $\beta$ was multiplied by 100. Secondly, in calculating Compound Growth Rate (CGR), the difference after subtracting 1 from the $\beta$ antilog was multiplied by 100. The Compound Growth Rate (CGR) in percentage can be recovered from the equations in the following manner:

$$CGR = (e^{\beta i} - 1)100 \quad (5)$$

where $\beta_i$ = the coefficient of the trend variable in the respective cases. Finally, the analysis shows that growth accelerates when $\beta$ is positive and proves to be significant statistically, growth decelerates when $\beta$ is negative and proves to be significant statistically, but the growth cycle stagnates when $\beta$ is not significant statistically.

### Vector Error Correction Model (VECM)

The following models were calculated:

$$\ln FS_{t-i} = a_0 + a_1 \ln EXCH_{t-i} + \\ + a_2 \ln FDI_{t-i} + a_3 \ln LABOR_{t-i} + \\ + a_4 \ln FS_{t-i} + \partial ECM_{1t} + u_{1t} \quad (6)$$

$$\ln FDI_{t-i} = a_0 + a_1 \ln EXCH_{t-i} + \\ + a_2 \ln LABOR_{t-i} + a_3 \ln FS_{t-i} + \\ + a_4 \ln FDI_{t-i} + \partial ECM_{2t} + u_{2t} \quad (7)$$

$$\ln EXCH_{t-i} = a_0 + a_1 \ln FDI_{t-i} + \\ + a_2 \ln LABOR_{t-i} + a_3 \ln FS_{t-i} + \\ + a_4 \ln EXCH_{t-i} + \partial ECM_{3t} + u_{3t} \quad (8)$$

$$LABOR_{t-i} = a_0 + a_1 \ln EXCH_{t-i} + \\ + a_2 \ln FDI_{t-i} + a_3 \ln LABOR_{t-i} + \\ + a_4 \ln FS_{t-i} + \partial ECM_{4t} + u_{4t} \quad (9)$$

where:
$FS_{t-i}$ = fisheries in naira
$EXCH_{t-i}$ = Exchange rate in (dollars/naira)
$FDI_{t-i}$ = Foreign Direct investment in naira
$LABOR_{t-i}$ = Labour (Number of persons involved in agricultural sector)
$ECM_t$ = error correction term
$u_t$ = error term

## Results and Discussion

The descriptive statistics of the variables used in the analysis is presented in Table 2 below. Results showed that fisheries, FDI, exchange rate and labour showed positive

**Table 2:** Descriptive Statistics.

| Descriptive Statistics | Fisheries | FDI | Exchange Rate | Labour |
|---|---|---|---|---|
| Mean | 13.0262 | 21.0133 | 3.3144 | 17.4468 |
| Median | 13.0760 | 20.9131 | 4.5255 | 17.4617 |
| Maximum | 13.9958 | 25.1345 | 5.7239 | 17.9186 |
| Minimum | 11.9732 | 18.5803 | -0.5979 | 16.9668 |
| Std. Dev. | 0.6292 | 2.01358 | 2.0539 | 0.2947 |
| Skewness | 0.7471 | 0.5806 | 0.7095 | 0.0210 |
| Kurtosis | 1.7537 | 2.3691 | 2.1312 | 1.7701 |
| Jarque-Bera | 2.5384 | 2.8383 | 4.4986 | 2.4610 |
| Probability | 0.2810 | 0.2419 | 0.1055 | 0.2921 |
| Sum | 508.0226 | 819.5171 | 129.2595 | 680.4241 |
| Sum Sq. Dev. | 15.0420 | 154.0707 | 160.2978 | 3.3011 |
| Observations | 39 | 39 | 39 | 39 |

Source: own composition

skewness to the right tail and are all platykurtic. Also, the Jarque-Bera probability test of normality indicates all variables were normally distributed.

Table 3 presents preliminary investigation of the properties of variables prior to regression using Phillip-Perron (PP) PP and Augmented Dickey–Fuller (ADF) tests. Results indicate that all the variables were not stationary at level but stationary at first difference, implying that the level form of these variables exhibited a random walk pattern, had multiple means of covariance or else featured both. However, the first difference between these variables is integrated or stationary. The existence of a unit root when the variable is level necessitated a test of co-integration to determine whether there is a long-term relationship between those variables.

The linear combination of non-stationary variables according to Enger and Granger (1987) is often co-integrated. Variables were also stationary at first difference with the Zivot and Andrew method, given the potential break points of each variable with their respective break point year in other to correct for the tendency towards bias in Philip-Perron and ADF statistics, which could not themselves account for a structural break in the model.

Table 4 presents the result of lag length from six different selection criteria; AIC was chosen because of its lowest value -5.680 at lag 1. Lag 1 is the appropriate lag to be in used for the model.

Figure 1 presents the results of testing for structural break in the model using the CUSUM and CUSUM of squares test. The CUSUM line is situated between the gridlines; this implies that it lies between two standard deviations or at a 95% confident interval level. The graphs show that the fitted model is parsimonious, stable, and relevant for policy direction.

**Table 3:** Unit Root test for all Variables.

| Variables | Phillip-Perron (PP) | | Augmented-Dickey Fuller (ADF) | | | |
|---|---|---|---|---|---|---|
| | At level | Difference | At level | | Difference | |
| | T-statistic | T-statistic | T-statistic | Prob | T-statistic | Prob. |
| Ln*FS* | -0.7988 | -6.6874 | -0.7109 | 0.8319 | -6.5784*** | 0.0000 |
| Ln*FDI* | -0.3587 | -4.7041 | -0.6889 | 0.8378 | 4.3344*** | 0.0000 |
| Ln*EXCH* | -1.8403 | -5.2373 | -1.8393 | 0.3565 | -5.2373*** | 0.0001 |
| Ln*Labour* | -0.2853 | -35.6600 | -0.2689 | 0.9201 | -6.8002*** | 0.0000 |

| Variables | Zivot and Andrew Test | | | |
|---|---|---|---|---|
| | Level | | First Difference | |
| | t-statistic | Break Year | t-statistic | Break Year |
| Fisheries | -3.2764 | 2006 | -3.5484 | 1989 |
| FDI | -2.0267 | 2001 | -6.6523 | 1995 |
| Exchange Rate | -2.8897 | 2001 | -3.7248 | 1999 |
| Labour | -2.5673 | 2004 | -7.8563 | 1995 |

*** denotes rejection of the null hypothesis at 1 percent level of significance.
Source: own composition

**Table 4:** Lag Structure for the Model.

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -47.1165 | n.a. | 0.0002 | 2.7631 | 2.9372 | 2.8245 |
| 1 | 111.8176 | 274.9131* | 8.27e-08* | -4.9632* | -4.0924* | -4.6562* |
| 2 | 141.0904 | 44.3047 | 4.17e-08 | -5.6806 | -4.1132 | -5.1280 |

* indicates lag order selected by the criterion.
Source: wn compositiono

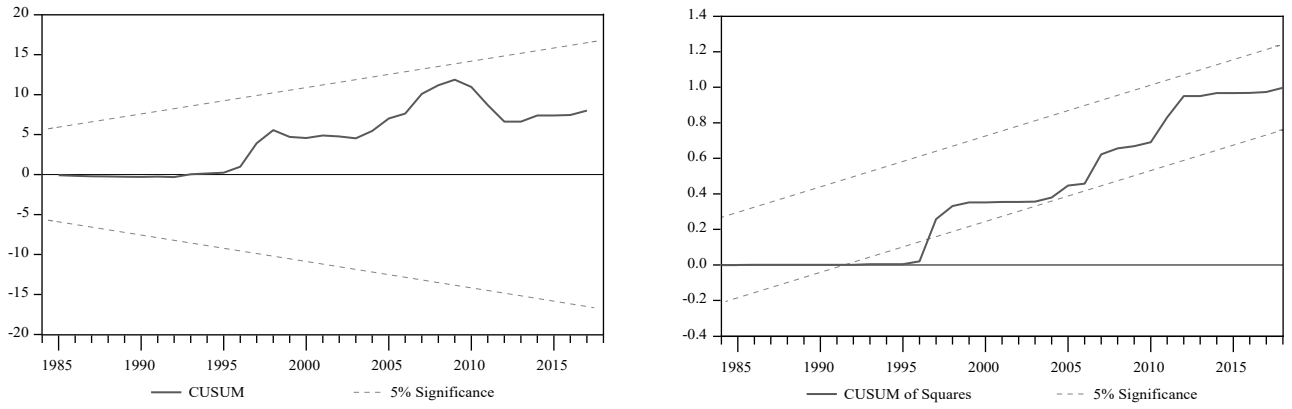


**Figure 1:** CUSUM and CUSUM sum of squares graphs.
Source: own composition

Co-integration test investigation was carried out on the series properties of I (1) variables through the Johansen co-integration test to determine whether long run linear combination of non-stationary variable is stationary. This assumes that linear combination of non-stationary variables can be stationary (Enger and Granger, 1987). The result of the Johansen Co-integration tests is shown in Tables 5. Using trace statistics, the result revealed that combination of these variables has one co-integrating equation, and this implies that the linear combination of these variables has a single long run linear combination or relationship.

However, the maximum Eigen statistics criterion also shows one co-integration equation, and this means that the linear combination of these variables has one co-integration equation. The implication is that the linear combination of these variables can be modelled with OLS without the risk of spurious results. However, trace statistics have been adopted in this research for the purpose of simplicity in analysis. Thus, based on the trace statistics value (85.43), which is greater than the critical value of (54.0), a long run relationship can be said to exist between fisheries, FDI, exchange rate and labour with one co-integrating equation.

The result of the trend analysis is presented in Table 2. The exponential growth model was chosen from the different function forms as the fitted model to the data based on the low level of Akaike Information Criterion and coefficient of determination (R-square). The result showed that 99.2% variation in agricultural subsector (fisheries) is explained by the trend model. The result revealed that the coefficient of fisheries was positive (0.054) and significant at 1% probability level. This positive and significant value of fisheries implies that there is acceleration in the growth of this agricultural sector output over time which implies that there is still more room for the government and private sector to make investment in this growing sector.

The result of foreign direct investment (FDI) using the parametric growth model further revealed that the exponential form indicated a good fit of the model to the data over time. This is based on the low level of Akaike Information Criterion and coefficient of determination (R-square). The result showed that 86.6% of variation in Foreign Direct Investment (FDI) is explained by the trend model. The result revealed that the coefficient of FDI was positive (0.164) and significant at 1% probability level. The instantaneous and compound growth rates were found to be 16.4% and 17.3% respectively, this implies there is acceleration in the growth of FDI over time.

The government should continue with policies that can attract and sustain FDI into Nigeria. This result is in variance with findings of Ukpe *et al.* (2018) who found that decrease in FDI could be as a result of inability of the government to regulate the inflow and outflow of FDI. The result further showed that exchange rate has R-square of 0.889 which implies that 88.9% variation in exchange rate is explained by the trend model. The result showed that the instantaneous and compound growth was found to be positive and significant with value 17.1% and 18.65% respectively. This is in harmony with the work of Ammani (2012) who found positive growth in domestic production of selected crops which showed acceleration in growth rate of selected crops in Nigeria.

The equilibrium relationship between the variables in the long run was motivated the construction of the Error Correction Mechanism (ECM). The application of ECM was necessary because of the existence of co-integration among variables. The result of ECM is presented in Table 8. Results show the long run influence of foreign direct investment (FDI) and exchange rate on fisheries, the coefficient of determination ($R^2$) of the model was 0.825 indicating that 82.5% variation in fisheries was explained by fisheries,

**Table 5:** Unrestricted Co-integration Rank Tests.

| Trace | | | | |
|---|---|---|---|---|
| **Hypothesized No of (ECS)** | **Eigen Value** | **Trace Statistic** | **0.05 Critical value** | **Probability** |
| None | 0.7189** | 85.4350 | 54.0790 | 0.0000 |
| At most 1 | 0.4768 | 38.4674 | 39.2310 | 0.3216 |
| At most 2 | 0.2265 | 14.4972 | 20.2618 | 0.2566 |
| At most 3 | 0.1262 | 4.9912 | 9.1655 | 0.2849 |
| **Maximum Eigenvalue** | | | | |
| None | 0.7190** | 46.9679 | 28.5880 | 0.0000 |
| At most 1 | 0.4768 | 23.9700 | 23.9920 | 0.1123 |
| At most 2 | 0.2266 | 9.5059 | 15.8990 | 0.3815 |
| At most 3 | 0.1261 | 4.9912 | 9.1651 | 0.2849 |

** denote rejection of null hypothesis at 5% significant level.
Sources: own composition

**Table 6:** Growth rate and direction of growth (Instantaneous and Compound Growth Rate).

| Variable | Instantaneous % | Compound growth % |
|---|---|---|
| Fisheries | 5.4 | 6.5 |
| FDI | 16.4 | 17.3 |
| Exchange Rate | 17.1 | 18.6 |

Sources: own composition

FDI, exchange rate and labour in the previous year. Results further showed that in the long run, FDI and exchange rate significantly affected fisheries. Specifically, the coefficient of FDI (0.02) is positive and significant at 1% level of probability and this is in line with the *a priori* expectations. This implies that a unit increase in FDI will increase fisheries by 0.02. This increase in fisheries could be due to an attractive macroeconomic policy of the government that encourages production through FDI, and it is advisable that such a policy be strengthened. The Federal Government can also take policy measures that encourage local production as well as protect infant industries. This is in line with the findings of Adeleke *et al*. (2014) who found that an increase in FDI increases agricultural output in Nigeria.

The coefficient on exchange rate is negative (-0.027) and significant at 5% probability level. This means a unit increase in exchange rate will decrease fisheries by 0.027. Most people import fisheries and their inputs which in turn affects the country substantial domestic production. This is due to the monetary policy of government, which has made the naira weak against the US dollar. While the government is encouraged to make efforts to strengthen the naira, research and development should be encouraged so that inputs needed for fisheries can be developed and produced locally, so as to reduce the high cost of inputs that are imported and also boost local production to meet the country's expected demand. This is different from findings of Aliyu (2011) who claimed to have shown that appreciation of the country's exchange rate exerted a positive impact on real economic growth in Nigeria.

The short run result from the Error Correction Model (ECM) is presented in the Table 9 below. The Error Correction Term (ECT) is -0.192 is statistically significant and negative which indicates a moderate speed of adjustment of variable towards equilibrium. This implies that previous year's error is corrected within the current year at a convergence speed of 19.2%. The coefficient of determination R square is 0.826 indicating that 82.6% of the variation in fisheries was explained by fisheries, FDI, exchange rate and labour in previous year. Change in coefficient of FDI is negative (0.018) and significant at 1% probability level. This means that an increase in FDI leads to acceleration in fisheries output by 0.081 in short run. The result shows that FDI is very beneficial to the fisheries subsector and as such government must continually work and make attractive policies for investors in Nigeria. Change in coefficient of exchange rate is negative (-0.022) and not significant. This result does not agree with the study of Oyakhilomen *et al*. (2014) who found that exchange is detrimental to the gross domestic product in Nigeria.

**Table 7:** Trend Regression Based on Growth.

| Variables | Model | Determinant | Coefficient | T-value | Prob. | Adj $R^2$ | AIC |
|---|---|---|---|---|---|---|---|
| Fisheries | Linear | Trend<br>Constant | 27596.4200<br>21552.9000 | 23.6400<br>0.8400 | 0.0000<br>0.4080 | 0.9630 | 25.5200 |
| | Quadratic | Trend<br>At Trend^2<br>Constant | 3106.1430<br>644.4800<br>172576 | 1.6400<br>10.0400<br>11.5700 | 0.1090<br>0.0000<br>0.0000 | 0.9880 | 23.9100 |
| | Exponential | Trend<br>Constant | 0.0540<br>28.3378 | 71.9000<br>655.1700 | 0.0000<br>0.0000 | 0.9920 | -2.9500 |
| FDI | Linear | Trend<br>Constant | -1.05E+09<br>-1.060E+10 | 4.6700<br>-2.1300 | 0.0000<br>0.0400 | 0.3500 | 49.8600 |
| | Quadratic | Trend<br>At Trend^2<br>Constant | -1.56E+09<br>68738113<br>5.50E+09 | -2.0100<br>3.4900<br>0.8800 | 0.0510<br>0.0000<br>0.3920 | 0.5040 | 49.6200 |
| | Exponential | Trend<br>Constant | 0.1640<br>17.8967 | 15.2400<br>75.3100 | 0.0000<br>0.0000 | 0.8620 | 2.3300 |
| Exchange Rate | Linear | Trend<br>Constant | 7.0760<br>-48.1610 | 14.9200<br>-4.6000 | 0.0000<br>0.0000 | 0.8570 | 9.9000 |
| | Quadratic | Trend<br>At Trend^2<br>Constant | -0.3250<br>0.0194<br>-2.5750 | -0.2400<br>5.5400<br>-0.2200 | 0.8140<br>0.0000<br>0.8250 | 0.9200 | 9.3300 |
| | Exponential | Trend<br>Constant | 0.1710<br>0.0816 | 17.4900<br>0.3800 | 0.0000<br>0.7060 | 0.8890 | 2.2200 |

Source: own composition

**Table 8:** Long Run Influence of FDI on Fisheries using VECM.

| Variables | Coefficient | Standard Error | t-Statistics |
|---|---|---|---|
| Fisheries | - | - | - |
| FDI | 0.0206 | 0.0598 | -2.9039 |
| Exchange rate | -0.0276 | 0.0535 | -1.9370 |
| Labour constant | -1.9249 | 0.2638 | -7.2969 |

Source: own composition

**Table 9:** Short Run Influence of FDI on Fisheries using VECM.

| | D(Fisheries) | D(FDI) | D(Exch rate) | D(Labour) |
|---|---|---|---|---|
| CointEq1 | -0.19222<br>(0.3910)<br>[-2.0341] | 0.1387<br>(0.9210)<br>[0.1507] | 1.7610<br>(0.3982)<br>[4.4226] | 0.2722<br>(0.0716)<br>[3.8024] |
| D(Fisheries(-1)) | -0.0826<br>(0.1560)<br>[-1.8886] | -0.4730<br>(1.9975)<br>[-0.2368] | -1.5306<br>(0.8636)<br>[-1.7723] | -0.4191<br>(0.1552)<br>[-2.6994] |
| D(FDI(-1)) | 0.0181<br>(0.0051)<br>[2.7780] | 0.3229<br>(0.1774)<br>[1.8197] | -0.0651<br>(0.0767)<br>[-0.8487] | 0.0161<br>(0.0138)<br>[1.1666] |
| D(Exchange Rate(-1)) | -0.0225<br>(0.0281)<br>[-0.8005] | 0.1383<br>(0.0274)<br>[0.5052] | 0.10112<br>(0.1184)<br>[0.8543] | -0.0057<br>(0.0213)<br>[-0.2687] |
| D(Labour(-1)) | -0.2820<br>(0.2009)<br>[-1.4038] | -0.3137<br>(1.9581)<br>[-0.1602] | 4.7669<br>(0.8466)<br>[5.6308] | -0.3624<br>(0.1522)<br>[-2.3813] |
| C | 0.0659<br>(0.0167)<br>[3.9525] | 0.1149<br>(0.1625)<br>[0.7073] | 0.12055<br>(0.0703)<br>[1.7158] | 0.0552<br>(0.0126)<br>[4.3660] |
| $R^2$ | 0.8270 | 0.1032 | 0.5970 | 0.4982 |
| F-statistics | 1.3859 | 0.7135 | 9.1832 | 6.1553 |

Source: own composition

# Conclusions

The study investigated the influence of Foreign Direct Investment (FDI) and exchange rate movements on the fisheries subsector in Nigeria. With the same order of stationarity, a cointegration test was carried out confirming a long run relationship among all the variables that were useful as descriptors of future behaviour in the fisheries subsector.

The study revealed a positive growth in the fisheries sector. All the variables were found to affect output of the fisheries subsector in the long run - only FDI was found to positively affect the output of fisheries in the short run. The positive impact of FDI on fisheries sector both in the short and the long run suggests that Nigerian government should revisit sustainable policies that can lead to increased inflow of FDI to the fisheries subsector, so that demand for fish can better match other local production in the agricultural sector.

Better macroeconomic policies to strengthen the Nigerian currency (Naira) are also advised as exchange rate movements were found to affect the fisheries subsector in the long run. The study has some limitations, which include the availability of data for fisheries output as well as the lumping together of industrial, aquaculture and artisanal production. Future research could exploit this limitation and further narrow down the analysis to consider these different approaches to cultivating fish that potentially attract agricultural FDI, while at the same time considering the effect of exchange rates on the fisheries subsector.

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# Short communication

**Marcel VAN ASSELDONK*, David MUWONGE**, Immaculate MUSUYA** and Moses ABUCE****

# Adoption and preferences for coffee drought index-based insurance in Uganda

Micro-insurance can be an effective approach to smoothening income in adverse times and potentially a way to contribute to the financial inclusion of vulnerable populations. However, direct sales to individual smallholders remains a challenging task without an easily scalable solution. The current research seeks to find the determinants of adoption of a stand-alone coffee index-based insurance product in Uganda marketed by a farmer cooperative, and elicited preferences for improving the design and delivery model. A stratified household survey was conducted among 614 farmers, of which 40% adopted insurance and 62% were member of a farmer cooperative. In odds ratio terms, adopters perceived themselves to be 3.09 times more likely to receive a pay-out than non-adopters (P<0.01), and those having better access to extension services were 2.47 times more likely to adopt a policy (P<0.01). Yet farmers perceiving the design as complex were approximately half as likely to adopt (P<0.05). Farmers preferred the option of premium payments proceeds on delivery, mobile premium payments and delivering insurance through cooperatives/associations. Deepening insurance uptake among coffee farmers will therefore require a strong focus on communication and information sharing facilitated by cooperatives/associations (e.g. farmer cooperates, village and saving associations, or women's associations).

**Keywords:** crop insurance, index-based, adoption, preference

**JEL classifications:** Q13, Q14

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## Introduction

Micro-insurance can be an effective approach to smoothening income in adverse times and potentially a way to contribute to the financial inclusion of vulnerable populations. As such, adopting a climate insurance coverage aims to adapt in reducing the vulnerability associated with anticipated negative impacts of climate change. Moreover, giving smallholders access to micro-insurance enables them to invest in improved agricultural inputs to enhance farm production and ultimately household income (Karlan *et al*., 2014; Marr *et al*., 2016). Key to success with this is to streamline claim handling and marketing efforts in order to minimise transaction costs (i.e. delivering a solution to a low-cost and at a large-scale). Emerging index-based insurance across Africa has proven to enable efficient claim handling. However, direct sales to individual smallholders remains a challenging task without an easily scalable solution (Carter *et al*., 2014).

Adoption studies in the field of crop (index-based) insurance often focus on one-off field experiments ignoring often the insurance delivery channel (see for example a systematic review by Marr *et al*., 2016). Yet those insurance programmes that are currently running are frequently marketed via aggregators. To reach the necessary scale it is essential to cooperate with aggregators in the agricultural value chain that have an extensive outreach and shared interests. Such organisations include the financial service industry (e.g. insurers, brokers, banks and micro-finance institutions), input providers (e.g. seeds and fertilisers), traders, the processing industry, and farmer-based organisations.

The current research seeks to find the determinants of adoption of a stand-alone coffee index-based insurance product in Uganda marketed by a farmer cooperative, and to elicit preferences for improving the index-based design and delivery model. Uganda is proving a particularly interesting context in which to develop the agricultural insurance market since recently public policy has begun supporting crop insurance by providing a premium subsidy (Van Asseldonk *et al*., 2019). Moreover, droughts are the main cause of crop failure in rain-fed production in Uganda and climate change is exacerbating the impact of drought events (Platform for Agricultural Risk Management, 2015). The findings can be valuable to guide the scale up phase by enhancing the design and delivery model.

## Methodology

### Index-based insurance design

Index-based insurance enables low-cost insurance since there is no need for on-site loss assessment. It simplifies and speeds up underwriting and claim handling through pre-underwritten index products and real-time satellite-based loss monitoring. In Uganda, the index-based insurance under research here is based on Relative Evapotranspiration (RE). Since evapotranspiration is proportional to $CO_2$ uptake, and consequently to plant growth and crop yield, RE is an accurate measure of drought and a suitable index for agricultural drought insurance (Von Negenborn

*et al*., 2018). RE index insurance designs allow flexibility in commodity, season and level of coverage. Design options include target premium rates, frequency of small and large pay-outs and different possible levels of spatial aggregation. These features aim to support low prices and to simplify sales and policy administration, whilst maintaining a sufficient pay-out level in dry years as has been rolled-out in for example Mali (Duchoslav and van Asseldonk, 2018).

The Ugandan government has made funds available to subsidise 30% of the premium for commercial farms and 50% for small-scale farms, and even up to 80% in 33 of the most disaster-prone districts of the country, where higher premium rates are needed to provide adequate coverage. Basic premium rates on all subsidised products are limited at 5% (10% in the disaster-prone areas). Whilst this ensures affordable prices and adequate coverage, it is a consequence of actual climatic risks that farmers in more high-risk areas still have to bear part of the drought risk themselves (Van Asseldonk *et al*., 2019). Public support with a view to increasing the uptake of insurance in agriculture is a very important driver in the upscaling success. By subsidising insurance premiums, the Ugandan government is providing an effective incentive for farmers to address weather risks and climate change-related disasters such as droughts, ultimately to help build a more sustainable and resilient agricultural sector.

Since 2014, several RE based products have been developed and marketed in Uganda. Currently, crop specific (Arabica and Robusta coffee, beans and maize) as well as a generic drought coverage is marketed. Crop specific coverage is based on a crop's specific growing season characteristics and drought sensitivity, whereas generic drought coverage aims to provide general protection during the rainy seasons and is for example suited to intercropped smallholder gardens. These products are delivered through several distribution channels of insurers, banks, brokers and aggregators such as the National Union of Coffee Agribusinesses and Farm Enterprises (NUCAFE). In 2017, sales of index-based insurance, being either credit-linked or stand-alone, reached approximately 45,700 smallholders. The largest scale has been achieved with the generic drought index, distributed as a compulsory element in the bundle for obtaining seasonal agricultural credit. Because it is compulsory and sold via large banks with a large portfolio, the credit-linked sales scale very well (Van Asseldonk *et al*., 2019). In the current study we focus on the niche coffee index-based insurance product sold via NUCAFE. Since it is a stand-alone product, not mandatory bundled with credit, we are able to study demand for the insurance product, rather than for the credit-insurance bundle as a whole. Coffee is a valuable cash crop and the sector is relatively organised. NUCAFE is a farmer owned organisation and is committed to leveraging its organisational infrastructure and existing transactional relationship with its members to provide drought coverage to its members. Selling voluntary stand-alone insurance in this manner requires the active engagement of hub managers and field staff in promotion, awareness raising and sales. To overcome liquidity constraints affecting smallholders at the onset of the growing season, the option to pay a premium in kind at the moment of harvest is a valuable solution. The premiums are paid through NUCAFE and then remitted to the insurance company. Any insurance pay-outs are balanced out with the reimbursement for the processed coffee beans after they have been sold by NUCAFE on behalf of the farmers. This approach is only an option in more organised value chains, where aggregators are closely linked to the producers and can leverage their organisational capacity and existing trust relationships.

## Sampling design

A household survey among coffee farmers was conducted in July and August 2018. Respondents were selected in three districts of Central Uganda (namely, Buikwe, Masaka and Rakai) because in these locations the highest number of coffee farmers under the NUCAFE insurance scheme were present. In each district, five sub counties and subsequently 15 parishes were selected to randomly identify respondents. The study involved 614 respondents of which 245 (40%) purchased insurance, while 369 (60%) were not insured. Moreover, 383 (62%) were member of NUCAFE, while 230 (38%) were not. For obvious reasons, following the targeted sampling design, insurance participation was low for non-members (8%).

## Household survey design and estimation

The household survey included both demand and preference indicators. Demand is hypothesised to be influenced by numerous explanatory variables including household characteristics, coffee production and annual income indicators, perceived customer value of insurance, risk experience and perceptions, preferences, insurance literacy and extension, coping strategies and credit access. Household characteristics include age of the household head (years), gender, education (years) and number of household members. Agricultural production in the previous season and annual income indicators encompassed land ownership (acre), area coffee (acre), coffee yield (kg/acre), total coffee production (kg), total coffee sales (US$), total other crop sales (US$), total livestock sales (US$) and other sources of income (US$). Binary perceived customer value of insurance indicators included complexity (0 if product is simple to understand versus 1 if complex to understand), perceived basis risk (0 if product appropriately indemnify losses versus 1 if not), and trust in the institution offering insurance (1 if trustworthy versus 0 if not). Risk experience captured whether (1) or not (0) a respondent had faced a climate-related disasters threatening their assets in the past, while risk perceptions elicited the likelihood of crop losses and pay-out (both measured by means of a three point scale from low up to high). Preferences were elicited based on a series of hypothetical lotteries to deduct risk aversion, ambiguity aversion and time preferences. Insurance literacy and extension captured whether respondents had access to extension (1) or not (0). Finally, respondents rated their ability for self-protection from shocks by means of for example savings, assets, other sources of income (measured by means of a three-point scale ranging from low up to high), and access to credit (1) or not (0).

By means of a stepwise logistic regression analysis, we obtain the significant determinants of adoption of aforementioned set of independent variables. Models were estimated for the sample as a whole as well as a sub-sample comprising only NUCAFE members to determine the robustness of the estimates. Furthermore, the key stated and inferred preferences to enhance insurance design are determined among NUCAFE members and those not a member, as well as insured and non-insured (and t-tests were applied to determine statistical difference between the sub-samples).

# Results

## Descriptive statistics

Overall, descriptive results indicated that the respondents were generally old (47 years) and this perhaps is related to the traditional way of coffee farming in Uganda (Table 1). The study comprised 59% males while 41% were females, and the respondents had attained on average 7 years of basic education. The average household comprised 6 members. Farmers grew coffee on 1.87 acres and produced 540 kg (average yield of 314 kg/acre) enabling a total sale of US$ 934. Other important sources of income were derived from sales of other crops such as beans, maize, banana and ground nuts ($1,525), other (non-farm) income ($390) and livestock sales ($70). The sample was most heterogeneous with respect to the total other crop sales as measured by the coefficient of variation.

Note that the average sum insured was less than average total sales and amounted $300 with corresponding average gross premiums of $18 per coffee farmer (and net premium rates before VAT averaging 5% after deducting eligible premium subsidy).

## Adoption analysis

By means of a stepwise multi-variate logistic regression, the odds ratios of insurance adoption were estimated (Table 2). In the total sample, adopters perceived themselves to be 3.09 more likely to receive a pay-out than non-adopters ($P<0.01$). Households with on average a better access to extension services than non-adopters were 2.47 more likely to adopt insurance ($P<0.01$). Those respondents perceiving the design as complex were approximately half as likely to adopt ($P<0.05$). These independent variables were also significant in the sub-sampling including only NUCAFE members. In the total sample also those participating in coffee drought indexed based insurance had relatively larger area under coffee production ($P<0.01$).

**Table 1:** Characteristics of respondents involved in the index-based insurance study.

| | Mean | Standard deviation | Coefficient of variation |
|---|---|---|---|
| Age (years) | 47 | 14 | 29 |
| Gender (male=0) | 0.41 | 0.49 | 120 |
| Education (years) | 7 | 4 | 57 |
| Family size (number) | 6 | 2 | 26 |
| Land ownership (acre) | 5.06 | 5.18 | 102 |
| Area coffee (acre) | 1.87 | 1.90 | 102 |
| Coffee yield (kg acre) | 314 | 235 | 75 |
| Total coffee production (kg) | 540 | 695 | 129 |
| Total coffee sales ($) | 934 | 3,328 | 356 |
| Total other crop sales ($) | 1,525 | 23,686 | 1,553 |
| Total livestock sales ($) | 70 | 129 | 182 |
| Other income ($) | 390 | 1,183 | 303 |

Source: own composition

**Table 2:** Regression analysis index-based insurance adoption.

| | Total | | | NUCAFE | | |
|---|---|---|---|---|---|---|
| | Odds ratio | Standard error | P-value | Odds ratio | Standard error | P-value |
| Likely pay-out | 3.09 | | <0.01*** | 2.64 | 0.76 | <0.01*** |
| Extension | 2.47 | | <0.01*** | 2.43 | 0.86 | <0.01*** |
| Complexity | 0.49 | | 0.03** | 0.40 | 0.17 | 0.04** |
| Area coffee | 1.20 | | <0.01*** | | | |
| | | | | | | |
| District 1 | 0.12 | 0.05 | <0.01*** | 0.12 | 0.06 | <0.01*** |
| District 2 | 0.14 | 0.05 | <0.01*** | 0.19 | 0.09 | <0.01*** |
| Constant | 0.51 | 0.19 | 0.07* | 1.71 | 0.82 | 0.26 |
| $R^2_{adj}$ | 0.17 | | | 0.14 | | |

* p<0.10, ** p<0.05, *** p<0.01.
Source: own composition

In the univariate analysis, interestingly all three customer values of insurance indicators (namely, perceived complexity, perceived basis risk and trust in institution offering insurance) were all significant (P<0.01). Respondents who perceived a higher degree of basis risk were 0.57 times less likely to adopt, while those with more trust were 2.81 times more likely to adopt. Because of a high correlation between these indicators, and problems with multi-collinearity, only the complexity indicator was included in the final model. Moreover, respondents who experienced a shock in the past were 1.62 times more likely to adopt (P<0.05).

### Preference analysis

Stated and inferred preferences are elicited among NUCAFE members and those not a member, as well as insured and non-insured (Table 3). Approximately half of all the respondents state that the existing design is fine because the fixed lump sum pay-out is easy and can be trusted. Yet the other half indicate that the existing design would need (some) modification should they be invited to represent the farmers in their area when contributing to the design of a better insurance product.

Both the option of premium payments proceeds on delivery coffee (as promoted by NUCAFE, whereby premiums are paid through coffee sales and then remitted to the insurance company) as well as mobile premium payments are preferred by the majority of the respondents. This also holds for delivering insurance through associations like NUCAFE and others (e.g. village and saving associations, or women associations). Approximately half of the respondents prefer that pay-out are cross-referenced with historical delivery volumes (which indirectly states that a hybrid insurance approach should include some kind of indemnity-based approach). The majority rejects a mandatory approach.

Preferences are also inferred from the reasons why respondents did not purchase insurance. The major reason advanced by the non-insured is lack of information or unavailability of a seller (67%), stressing the importance of awareness campaigns and further developing sales channels. The other major hindrance is the lack of understanding the insurance products currently on the market, stressing the importance of providing extension services to enhance financial literary. Furthermore, lack of cash hampers insurance uptake. Any innovation that would enable farmers pay for insurance without the need to pull cash would drive adoption. The approach of using farmers' products could drive premium payments for agricultural insurance in Uganda.

## Discussion and Conclusions

The major factors influencing purchase of insurance are linked to access and information availability with respect to the inherent pay-out characteristics of index-based insurance design. Farmers who purchased coffee drought index-based insurance under NUCAFE had better access to extension services, perceived more frequent pay-outs and perceived the index design as less complex than non-adopters.

Deepening insurance uptake among coffee farmers will therefore require a strong focus on communication and information sharing. This would involve well targeted messages that address fears of farmers and improve trust among beneficiaries. Furthermore, introducing innovative ways of charging for premiums on commodities supplied would improve premium payments. Large-scale insurance adoption hinges on the cooperation of participating aggregators and an effective outreach to the market. These aggregators are crucial as intermediaries in order to channel brokerage services to a vast number of farmers that are otherwise too difficult to reach individually. They allow scale in outreach and transactions (since they are well-ramified distribution network in the countryside), and provide much needed trust between all parties involved, from the index service provider to the insurance companies and smallholders. Nevertheless, value-chain actors have to convince farmers to purchase stand-alone insurance products. A major challenge, both for these aggregators and for the agricultural sector in general, is to increase awareness and understand-

**Table 3:** Preferences index-based insurance design.

| | Not member NUCAFE | Member NUCAFE |
|---|---|---|
| Needs improvements | 49% | 53% |
| Preferences improvements | | |
| Option mobile premium payment | 69% | 72% |
| Premium payments proceeds on delivery coffee | 66% | 61% |
| Offering index-based insurances through associations | 60% | 56% |
| Pay-out cross referenced with historical delivery volumes | 49% | 53% |
| Mandatory premiums for all members in the association | 25% | 25% |
| | **Not member NUCAFE not insured** | **Member NUCAFE not insured** |
| Reason not buying insurance | | |
| Insufficient information and/or no seller was available | 67% | 49%*** |
| Difficult to understand the insurance product | 31% | 24%* |
| Lack of cash/credit to pay the premium | 29% | 56%*** |
| Limited trust insurance providers | 6% | 6% |
| Fear of cumbersome administrative procedures during pay-out | 3% | 7% ** |

* p<0.10, ** p<0.05, *** p<0.01.
Source: own composition

ing among smallholders about their risk exposure and the possible ways to reduce it, transfer it via insurance, or otherwise cope with the risks they face. As a step forward, further upscaling would require use of, for example, insurance champions in rural communities to demonstrate added value in order to encourage farmers to appreciate the benefits of holding insurance. This will improve the trust levels of clients, and hence drive penetration levels among farmers.

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# Short communication

**Sefa IŞIK* and Fatih Cemil ÖZBUĞDAY***

# The role of tax cuts on agricultural input prices in Turkey

Agricultural input costs have a major impact on food prices in Turkey. In this context, a decrease in agricultural input costs can play a significant role in reducing food inflation. On January 1, 2016, the 18% Value Added Tax (VAT) rate in fertiliser was reduced to 1 percent with the Council of Ministers' decision numbered 2015/8353. Then, on February 10, 2016, fertiliser was included in the scope of the exception. As these tax reduction decisions exogenously affect fertiliser prices, there is an opportunity to conduct a natural experiment. Using the difference-in-differences (DID) method, this paper examines whether the decisions reduce fertiliser prices. The analysis results provide some hints that consumers received benefits from the tax reduction decisions.

**Keywords:** Difference-in-differences, agricultural input costs, taxation
**JEL classifications:** Q11, Q18

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## Introduction

Turkey is one of the countries that has suffered from food price inflation in recent years. Figure 1 indicates a negative divergence of the levels of Food Consumer Price Index (CPI) in Turkey from the world. The difference has become more evident lately. For instance, annual food inflation in Turkey reached 29.3 percent in October 2018, whereas annual food inflation in the world was only 2.7 percent. Many studies show that agricultural input costs lie behind these high food prices. For instance, Çıplak and Yücel (2004) indicate that increases in agricultural prices have a significant role in food price inflation and total CPI inflation in Turkey using a vector autoregressive (VAR) model. Balkan *et al*. (2015) find that fuel prices increase wholesale fresh fruit and vegetable prices through transportation costs using a difference-in-differences model. Eren *et al*. (2017) show that producer prices and the quantity of production are the main drivers of consumer food prices with a panel VAR model. Therefore, a decrease in agricultural input costs can play a significant role in reducing food inflation.

The paper aims to investigate the impact of tax cuts on agricultural input prices in Turkey with a natural experiment. The effect of taxation on market price has always been one of the issues under discussion in the literature. It has been investigated whether a reduction or increase in taxation has been passed on to consumers. According to the theoretical literature, the tax is passed through to prices depending on

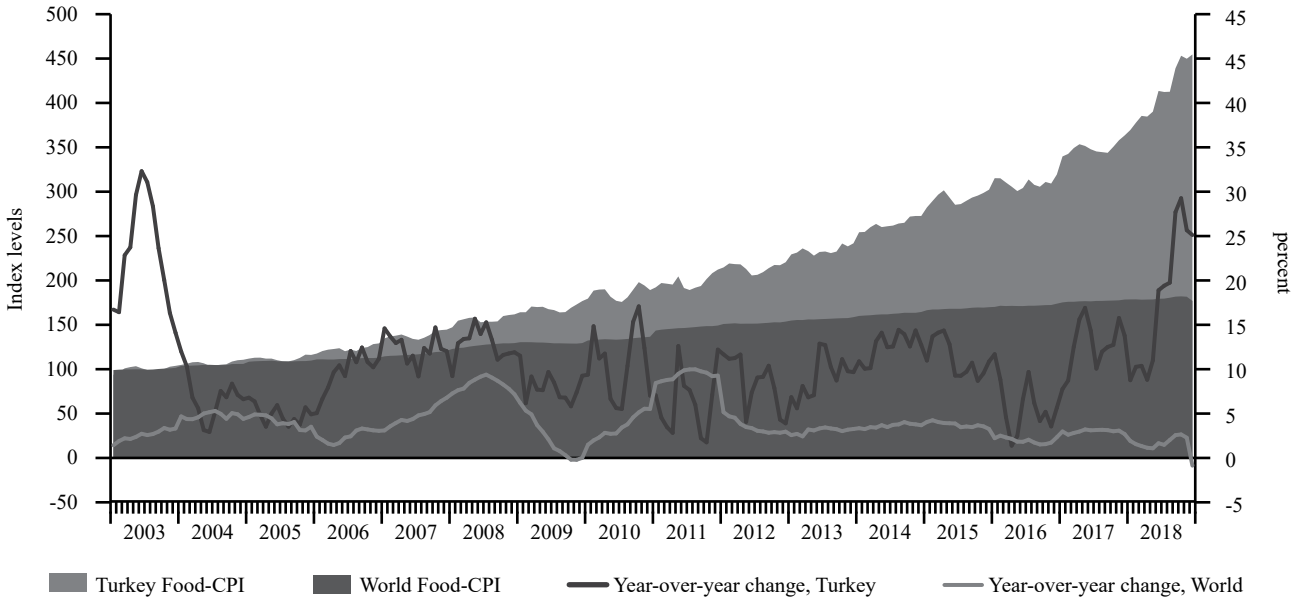


**Figure 1:** Food-CPI in the world and Turkey (2003=100).
Source: own composition based on FAO (2020) data
Note: Left vertical axis represents food-CPI levels; the right vertical axis shows the year-over-year percentage changes in the indices.

the relative elasticities of demand and supply (Berardi *et al*., 2016). If the supply curve is perfectly elastic or the demand curve is perfectly inelastic, the tax is fully passed through to prices (Fullerton and Metcalf, 2002). Studies investigating the impact of taxation on prices have found a wide range of results from under-shifting to over-shifting.

Besley and Rosen (1998) conduct a study examining the relationship between sales taxes and prices using quarterly data for 12 commodities (such as eggs, milk, soda, bananas, and shampoo) and 155 cities during 1982–1990. They estimate that taxes were entirely or under-shifted for some commodities, while commodity taxes were over-shifted for others. Kenkel (2005) assesses the impact of an alcohol tax hike on Alaska prices using primary data. The paper provides evidence that taxes were more than fully passed through to alcohol beverage prices. Doyle and Samphantharak (2008) investigate the impact of a gas tax on retail gasoline prices in Illinois and Indiana using daily prices at the gas-station level and a difference-in-differences approach. They estimate that 80–100 percent of the tax reinstatement was passed through to consumers, while 70 percent of the sales tax reduction was passed through to consumers. Hanson and Sullivan (2009) evaluate the effect of a tobacco tax on retail prices using an increase in Wisconsin's tobacco tax. They find that a $1 tobacco tax increase was over-shifted to Wisconsin consumers via a difference-in-differences approach. The consumers paid a premium of between 8-17 cents per pack of cigarettes as well as the full tax. Alm *et al*. (2009) investigate the incidence of state gasoline excise taxes using monthly data for all 50 U.S. states for the period 1984–1999. They find that gasoline taxes were entirely shifted to the final consumer. Chiou and Muehlegger (2010) examine the impact of cigarette excise taxes in the Chicago area. The paper finds that the tax was under-shifted to prices. They estimate price elasticities of approximately -0.4. Berardi *et al*. (2016) investigate the impact of the 'soda tax' introduced in January 2012 on consumer prices in France. Using a difference-in-differences approach, the study concludes that the tax gradually affected the prices of taxed beverages and entirely shifted to the prices after six months. They also state that the impact was heterogeneous across retail groups and brands.

The empirical literature on the impact of taxation on prices indicates that the impact varies depending on data sets from different tax applications. A reduction or increase in taxation is entirely or under-shifted to prices in some cases, while it is over-shifted in other cases. In this study, we contribute to the existing literature using a natural experiment in Turkey. The 18% VAT rate in fertiliser was reduced to 1 percent on January 1, 2016. Then, fertiliser was included in the scope of the exemption on February 10, 2016. In this context, this study investigates whether the decisions reduced fertiliser prices using the difference-in-differences approach. The analysis estimates that 83.7 percent of the tax reduction was passed through to prices in the first three months from the date of the tax cut decision on January 1, 2016.

The paper is structured as follows. In section 2, the empirical strategy and data are presented. Section 3 provides the main results and robustness checks. Finally, the conclusions are presented in Section 4.

## Methodology

The impact of tax cuts on fertiliser prices could be assessed in different ways. A standard econometric model consisting of a dummy variable for the taxation decision and other explanatory variables could be one way. The second way could be to obtain the impact of the tax reduction by subtracting the actual after-tax prices from the predicted after-tax prices. The predicted after-tax prices show what the prices would have been without the tax reduction decision. The third way could be a difference-in-differences (DID)

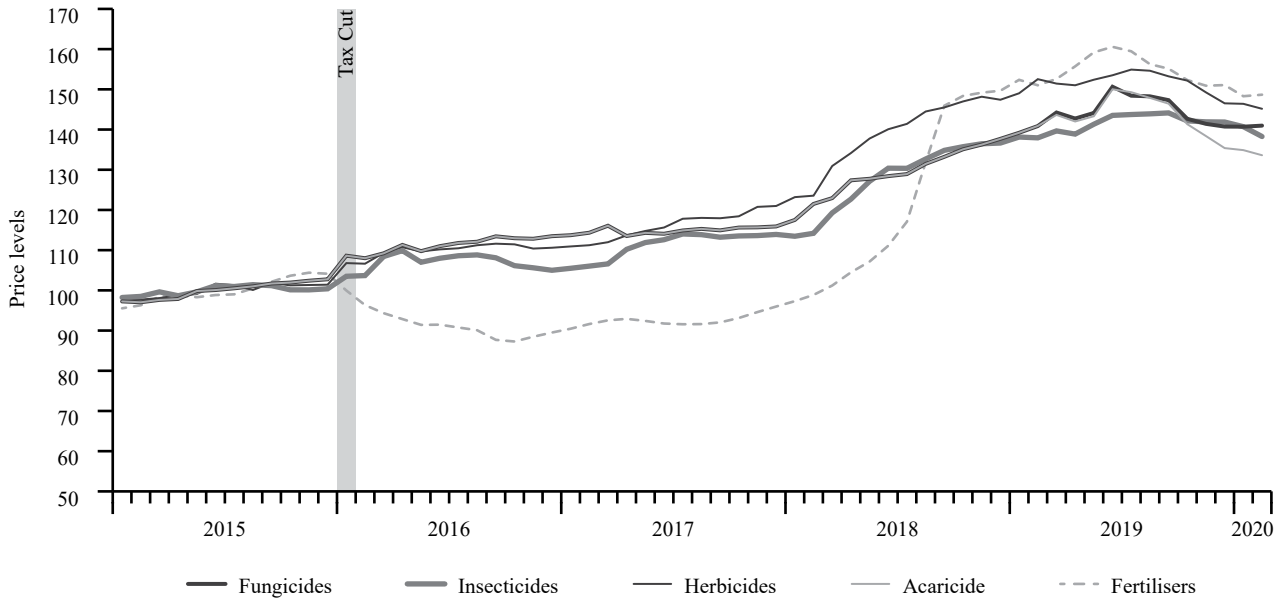


**Figure 2:** The movement of selected product prices in Turkey (2015=100).
Source: own composition based on TURKSTAT (2020) data

approach which is frequently used to examine the effects of taxation decisions on economic variables such as prices, and consumption (Berardi et al., 2016; Hanson and Sullivan, 2009; Doyle and Samphantharak, 2008).

In this paper, we employ the DID approach for two reasons. The first reason is that the fertiliser's tax reduction implementation is exogenous. Regulatory processes can be related to complex interactions between groups that lose or gain from regulations (Ozbugday and Nillesen, 2013). In other words, the main variable of interest (*TAXCUT*) might be correlated with the error term. Nevertheless, the tax cut decision in January 2016 is the realisation of one of the new government's promises for the November 2015 elections. In the process of the election campaigns, the main opposition party promised to decrease diesel prices for farmers if she were elected. In contrast, the ruling party announced that it would make the VAT reduction on fertiliser. After the election, the ruling party, namely the AK Party, was re-elected and reduced the VAT on fertilisers on January 1, 2016. So, the change in fertiliser's tax was not affected by interest groups.

The second reason we prefer to use the DID method is the existence of a control group unaffected by the decision. For a DID estimation, a satisfactory control group that has a similar trend with the treated group as much as possible is required. As candidates for a control group, we consider four pesticide prices (fungicides, insecticides, herbicides, and acaricide). Figure 2 plots the nationally-representative trends in the price indices for both fertilisers and pesticides in Turkey between January 2015 and February 2020. As shown in the figure, the treated group (fertilisers) and the candidate control groups (pesticides) exhibit a similar trend before the decision of the taxation in January 2016. Therefore, these four pesticides are chosen as control groups.

The DID estimates for the real differential impact of the tax cut decisions on fertiliser prices are shown in Table 1.

An alternative regression-based estimator yields the same result. More specifically, it can be shown that the estimate for $\delta$ in the regression equation below is equivalent to $\hat{\delta} = (P_{1,F} - P_{0,F}) - (P_{1,P} - P_{0,P})$:

$$\ln PRICE_{it} = \beta_0 + \beta_1 TAXCUT_t + \\ + \delta\,(TAXCUT_t \cdot TREATMENT_i) + \varepsilon_{i,t} \quad (1)$$

where *i* indexes items and *t* indexes the period of observation. The dependent variable ln*PRICE* is the natural logarithm of the price indices for items. The variable *TAXCUT* is a dummy variable indicating the post-tax cut period. The variable *TREATMENT* captures possible differences between fertilisers and four pesticides. The variable *TAXCUT · TREATMENT* is an interaction term between these two binary variables. In this case, the main parameter of interest is $\delta$.

For the data horizon in our main DID estimations, we focus on a two-month window, four-month window, and six-month window centred around the date of the tax cut, January 1, 2016. For instance, if the window size is two months, then the period of the analysis is December – January. We do not focus on larger window sizes due to the possibility of other exogenous factors that can affect fertiliser prices as the data window gets longer.

In order to test the robustness of the results, we perform the same DID approach as above, but with three different periods: (1) January 1, 2018, (2) January 1, 2019, and (3) January 1, 2020. In other words, we re-construct our baseline regressions as if the tax reduction decision took place on the same day at different years. This assumption is known as the parallel-trends assumption. If these alternative regressions concluded that estimated effects are statistically insignificant and very small, we could say that our main results are robust. This means that in the absence of the tax reduction decision, fertiliser prices (treatment group) and pesticides prices (control group) have a similar trend over time.

In the paper, fertiliser price was used as a treatment variable, and four pesticide prices (fungicides, insecticides, herbicides, and acaricide) were used as control variables. We employed sub-indices of the Agricultural Input Price Index collected and published for the first time in March 2020 at the national level by TurkStat. Moreover, all prices are monthly average prices and used in logarithmic forms. The summary statistics on these variables are presented in Table 2.

**Table 1:** The illustration of Difference-in-Differences Estimation.

| Prices | Fertilisers (F) | Pesticides (P) | Difference |
|---|---|---|---|
| $T_0$ = pre-tax cut period | $P_{0,F}$ | $P_{0,P}$ | $P_{0,F} - P_{0,P}$ |
| $T_1$ = post-tax cut period | $P_{1,F}$ | $P_{1,P}$ | $P_{1,F} - P_{1,P}$ |
| Change | $P_{1,F} - P_{0,F}$ | $P_{1,P} - P_{0,P}$ | $\hat{\delta} = (P_{1,F} - P_{0,F}) - (P_{1,P} - P_{0,P})$ |

Source: own composition

**Table 2:** Descriptive statistics of the variables analysed.

| | Pre-tax Cut Period (Three months) | | | | Post-tax Cut Period (Three months) | | | |
|---|---|---|---|---|---|---|---|---|
| **Variable*** | **Mean** | **Std. Dev.** | **Min** | **Max** | **Mean** | **Std. Dev.** | **Min** | **Max** |
| Fertiliser Prices | 4.645 | 0.004 | 4.641 | 4.648 | 4.573 | 0.029 | 4.547 | 4.605 |
| Pesticide Prices | | | | | | | | |
| fungicides | 4.629 | 0.004 | 4.624 | 4.632 | 4.688 | 0.006 | 4.682 | 4.693 |
| insecticides | 4.618 | 0.001 | 4.617 | 4.619 | 4.678 | 0.014 | 4.669 | 4.694 |
| herbicides | 4.607 | 0.002 | 4.606 | 4.609 | 4.656 | 0.026 | 4.640 | 4.686 |
| acaricide | 4.629 | 0.004 | 4.624 | 4.632 | 4.688 | 0.006 | 4.682 | 4.693 |

* All data are in logarithmic form.
Source: own composition

**Table 3:** The Results for the Difference-in-Differences Estimations.

| **Dependent Variable: LnPRICE** | | | | | | |
|---|---|---|---|---|---|---|
| | **2-month window** | | **4-month window** | | **6-month window** | |
| Variable | Coefficient | St. Error | Coefficient | St. Error | Coefficient | St. Error |
| Tax_cut | 0.048*** | 0.006 | 0.048*** | 0.005 | 0.057*** | 0.005 |
| TreatmentXtaxcut | -0.089*** | 0.013 | -0.109*** | 0.010 | -0.128*** | 0.012 |
| Constant | 4.628*** | 0.004 | 4.627*** | 0.003 | 4.626*** | 0.003 |
| Fixed Effect | Yes | | Yes | | Yes | |
| R-squared | 0.765 | | 0.735 | | 0.798 | |
| Observations | 10 | | 20 | | 30 | |

*** Refers to a 1% significance level. Standard errors are reported in parentheses. The window size describes the length of the period for the analysis. The starting day of policy implementation (January 1) is at the centre of the window. For example, if the window size is 2 months, then the period of the analysis is December – January.
Source: own composition

# Empirical results

The results seen in Table 3 display that the coefficient on TAXCUT X TREATMENT, which the parameter of interest, is negative and statistically significant at a 1 percent significance level in three different window sizes. For a 2-month window (the analysis period of December and January), fertiliser prices decrease by 8.9 percent at a 1 percent significance level. Moreover, it is observable that the fall in fertiliser prices accelerates for 4- and 6-month windows. We can say that fertiliser prices' inclusion in the VAT exemption announced on February 10 also has an effect on these decreases. Thus, the magnitude of the coefficient is between -8.9 percent and -12.8 percent for three different window sizes.

These results provide evidence that tax reduction decisions have a statistically significant effect on fertiliser prices. Also, the pass-through continues for three months from the date of the tax cut decision on January 1, 2016. However, a full pass-through rate was not observed as of the end of March 2016. A full pass-through of the tax reduction decisions would amount to a price decrease of 15.3 percent after the complete removal of the tax on fertiliser on February 10, 2016. Thus, the pass-through rate can be calculated as 83.7 percent for March 2016.

We focused on finding the short-term consequences of the tax cut decision because of the possibility of other exogenous factors that can affect our variables. For instance, if the analysis period were longer to cover the year 2018, the exchange rate shock resulting from the deterioration of Turkey-US relations would have been included in the analysis. In such a case, it would not be possible to see the effect of the tax reduction on fertiliser prices since the prices were also affected by the exchange rate shock. The impact of the exchange rate shock can be seen in Figure 2. As a result of the 41% deprecation of the Turkish Lira against the U.S. dollar, the price of fertilisers increased dramatically in the second half of 2018.

The actual tax cut date for the policy reform is January 1, 2016. As a robustness check, we re-constructed our DID estimates based on three different dates: (1) January 1, 2018, (2) January 1, 2019, and (3) January 1, 2020. Table 4 presents the results of our robustness-check exercise. Results suggest that the estimated effects are very small and statistically insignificant. Therefore, we conclude that our original results are robust to using treatment dates.

**Table 4:** Falsification tests for robustness checks.

| **Dependent Variable: Log Price** | | |
|---|---|---|
| | **4-month window** | |
| | **Coefficient** | **St. Error** |
| 2017-2018 | 0.008 | 0.014 |
| 2018-2019 | -0.004 | 0.008 |
| 2019-2020 | -0.004 | 0.009 |
| Fixed Effects | Yes | |
| Observations | 20 | |

***, **, and * refer to 1%, 5%, and 10% significance levels, respectively. Standard errors are reported in parentheses. The 4-month window represents that the period of the analysis is November – February of the corresponding year.
Source: own composition

# Conclusions

The study investigates the impact of a tax cut on agricultural input prices. On January 1, 2016, the Turkish government reduced the VAT of fertiliser from 18 percent to 1 percent. In addition, by adding fertiliser to the list of VAT-exempt products on February 10, 2016, the tax on fertilisers was removed entirely. In order to investigate the impact of the tax cut decisions on fertiliser prices, we use the difference-in-differences (DID) approach. Our findings indicate that the reduction in the tax was passed on to fertiliser prices. In the first month after the tax reduction, the fertiliser prices decreased by 8.9 percent. In the second and third months, the price decline reached 10.9 percent and 12.8 percent, respectively. If the fertiliser prices had dropped by 15.3 percent after the tax was removed entirely, a full pass-through would have been obtained. Consequently, the pass-through rate is calculated as 83.7 percent for the end of March. Although a full pass-through was not obtained, the simple DID estimations provide some hints that consumers benefited significantly from the tax reduction decisions.

The study indicates that the tax cut decision has decreased fertiliser prices in the short term in Turkey. It does not focus on a larger period due to the possibility of other exogenous factors that can affect fertiliser prices as the data period gets longer. Lately, the Turkish economy has faced a number of critical events such as elections, a failed coup attempt on July 15, 2016, and tensions between Turkey and the United States. Most of these events have caused the deterioration of many macroeconomic variables in Turkey, especially the depreciation of the Lira. Since agricultural inputs, including fertilisers and pesticides, are mostly imported from abroad, they are very sensitive to exchange rate shocks. For instance,

the detention of an American pastor in Turkey led to one of the gravest crises in the history of Turkey-US relations in 2018. The Turkish Lira depreciated by 41 percent in the first eight months of 2018 and the prices of fertilisers and pesticides increased significantly in 2018. Therefore, this paper has focused on the short term in order to avoid the contaminating effects of these events on prices.

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