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Contents

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Foreword

The European Research Area (ERA) is conceived as a unified research area, open to the world and based on the European Union's (EU) Internal Market. By making national research systems more open, inter-operable and inter-connected, fragmentation of research efforts and barriers to free circulation of researchers can be reduced. The EU's Horizon 2020 Research and Innovation programme for the period 2014-2020 is expected to help to further develop the ERA. However, in the first two years of the programme the 11 post-socialist EU Member States have secured just 3 per cent of the available funding[1].

There are several, legitimate, reasons for this apparent imbalance. Not least is that researchers from 'western' EU Member States have many more years of experience of the EU's international research programmes. Over time, they have established networks of collaborators that they know and trust, and may be reluctant to work with new and unknown partners. The reality is, however, that the very many, highly competent researchers in the 'eastern' Member States of the EU make specialist, even unique, contributions to the global pool of knowledge. This point is illustrated by this issue of *Studies in Agricultural Economics*, which includes papers from Czech, Hungarian, Polish and Slovenian contributors alongside those from Brazil, China, Ireland, the Russian Federation and the USA. Publishing in international journals can help researchers from the region to increase their participation in research networks, both at the European level and globally.

Continental climatic regions are expected to be severely affected by climate change. Jankó, Németh, Bertalan and Pappné Vancsó researched perceptions of climate change among farmers in Hungary and identified some significant factors such as the role of extreme weather events. Some farmers are seeking to adapt to climate change, but others seem unwilling to do so.

In the context of the removal of the EU milk quota regime, Emicha, Heanue, Hyland, Hennessy, Dillon and Buckley examined the economic, environmental and social sustainability of dairy farms in Ireland. Using sustainability indicators, they created a typology of farms, composed of three types, which could assist policy makers to formulate more targeted policies.

EU farmers are increasingly exposed to price volatility. Using the IACS database, Zgajnar studied the sustainability of farms in Croatia with respect to income risk and indemnification. The approach described can to be of use to policy makers when designing income risk mitigation measures and identifying potential beneficiary groups by either sector or economic farm size.

The topic of farming risk is taken up by Soliwoda, Špička, Vilhelm, Pawłowska-Tyszko and Gorzelak, who explored the relationship between the contrasting models of agriculture in the Czech Republic and Poland, and approaches to agricultural insurance schemes. In both countries, policy options should consider the balance between budget flexibility and the criterion of efficiency.

In the first of three papers related to trade, Sági and Nikulin assessed the effect of the food embargo imposed by Russia on its trade relations with the EU, using Hungary as an example. Hungary has failed to replace exports to Russia effectively and, in turn, Russia has not managed to replace the supply of most agricultural products.

A novel, network analysis based approach was used by Benedek, Bakucs, Fałkowski and Fertő to study changes in the structure of intra-EU milk product trade between 2001 and 2012. Integration of countries that joined the EU in 2004 or 2007 is only partial, and depends on the category of milk product considered.

Three major food scare events in the Chinese pork market, (porcine reproductive and respiratory syndrome, swine influenza and classical swine fever) were shown by Dai, Li and Wang, using monthly data from 2001 to 2014, to impact retail price and price transitions differentially. In addition, shocks from the same incident on price and price transmissions are significantly different.

Finally, Almeida and Bravo-Ureta applied three different types of matching algorithms (optimal, greedy and non-parametric) to the evaluation of the impact of the MARENA programme in Honduras. Optimal matching did not produce better-balanced matches than greedy matching, and programme impact calculated from nonparametric matching regressions, such as kernel or local linear regressions, yielded more consistent outcomes.

By publishing papers contributed by authors based in eastern central and south eastern Europe alongside contributions from other parts of the EU and the rest of the world, *Studies in Agricultural Economics* can contribute to the strengthening of the European Research Area.

Andrew Fieldsend
Budapest, July 2017

[1] see: https://ec.europa.eu/research/evaluations/pdf/h2020_2-years-on_brochure.pdf

JANKÓ Ferenc*‡, NÉMETH Nikoletta*, BERTALAN Laura* and PAPPNÉ VANCSÓ Judit*

Perceptions of climate change and adaptation in Hungarian agriculture: results of an interview study

In this paper, the results of an interview survey of farmers in Győr-Moson-Sopron, Fejér, Hajdú-Bihar, Jász-Nagykun-Szolnok, Pest and Zala (NUTS 3) counties of Hungary are used to demonstrate the major factors of climate change perception, such as the terms psychological climate, temporality and problem localisation. Adaptation strategies are also discussed. The interview results underline the subjectivity of temporality as well as the fact that the phenomenon of localisation and the narratives for place attachment differ when climate change is interpreted within the locality. Considering adaptation, it seems that Hungarian agriculture includes individuals who can be regarded as leaders or as people escaping ahead in terms of climatic adaptation, but the majority seems to be unable to follow them because they lack the necessary knowledge, technology or financial resources.

Keywords: interviews, temporality, localisation

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Introduction

The social issues pertaining to climate change range from the communication and reception of scientific results to the actual perception of the phenomenon and the adaptation to change, and these issues have been the subject of extensive research. In our study, we examine the latter questions – problem perception and adaptation – but place the emphasis on the perception of the problem, through which adaptation will be approached.

Why is the issue of problem perception important and what implications does it have in agriculture? Climate change – as with other natural phenomena – is experienced not only directly through own experiences; these are modified, biased by mass media and other people. Communication is a discursive process of reality making and thus the subject matter of discourse analyses, which examines the scientific or policy practice therein, or the presence of such questions in different media (press, technical press etc.). The social and scientific reception of an issue such as climate change may have an impact on the individual and, in our case, on farmers' prior knowledge, attitude and attention; belief in climate change is an important factor of experiencing it on the field (Howe and Leiserowitz, 2013; Niles and Mueller, 2016). Thus, personal perception of climate change cannot be separated from prior knowledge and expectations, and similarly from other emotional and cognitive biases, such as imagination based on personal factors including personality, education, cultural background (Moser, 2010; Yusoff and Gabrys, 2011; Clayton *et al*., 2015).

This is a crucial point in the case of climate change as from the perspective of problem communication an important question is whether climate change can be perceived visually. For a city dweller it is far from being obvious. In this respect, extreme weather and the relating discourse are of major importance. It has often been asked whether a particular extreme weather event is regarded as the consequence of climate change, or it would have occurred even without climate change (Moser, 2010; Weber, 2010; Hulme, 2014; Stoknes, 2014). There is no evident answer, as acknowledged by the Intergovermental Panel on Climate Change, even if between their two latest reports there has been some shift towards the view that the probability of anthropogenic causes of certain extreme weather events has increased (IPCC, 2007, 2013). However, according to a more realistic and acceptable explanation, warming of the Earth's climate may lead to more frequent natural disasters and extreme weather events. Nevertheless, this dubious reading also explains the significant number of people who are doubtful about the issue.

Consequently, for a city dweller – as often happens in climate change communication aiming to affect people's attitudes – it has to be explained that the most recent extreme weather events are a consequence of human-made climate change, and it is no coincidence that some kind of iconography of climate change has emerged by now with regard to polar bears, melting glaciers, shrinking icebergs and hurricanes (Manzo, 2010).

Nevertheless, many disasters are happening far from Europe. Problems should be hurting enough for us to change our established customs significantly. If they are not doing so, problems should be localised: they should be explained in the local context, attached to local issues and adapted to national or regional conditions (Brace and Geoghegan, 2010). Studying farmers and others who are engaged in agriculture is an obvious and appropriate way of examining the issue because in their case both factors may be significant (Weber, 2010). For those who live from the land, the transformation of climatic patterns and local problem perception are apparent, and therefore if problems are perceived, responses to such changes, i.e. adaptation, necessarily happens faster.

Therefore, our study examines how climate change appears in the everyday thinking, observations and activities of people living from agriculture: how they perceive the problem, how they react, what knowledge they have, and how they localise climate change in their own local context, influenced by personal factors.

Methodology

Firstly, to establish a comprehensive basis to the discourse analysis of the interviews, we delineate the theoretical background of the issue. Then we analyse the results of structured interviews conducted in 2013 and 2015 with 40 farmers (including eight women) in Győr-Moson-Sopron, Fejér, Hajdú-Bihar, Jász-Nagykun-Szolnok, Pest and Zala (NUTS 3) counties of Hungary. The interviewees were chosen randomly through contacts from local agricultural advisors, and by snowball sampling to get further contacts from interviewees. The interviews were documented by taking notes by hand or with voice recording. Half of the interviews were conducted by methodologically trained BA and MA students using an interview schedule. A number of questions were posed concerning the sources of climate change-related information, the respondent's opinion, experiences and memories about climate change and how these changes affected his/her farming practice or adaptation strategies. The interviewees included primary producers, grape growers and winemakers, fruit growers and large-scale farmers with wide product ranges. The youngest farmer was 25, the oldest 80 years old.

The interviews were intended to provide qualitative information and material for text (discursive) analysis and representativeness was not our goal. Discourse analysis is a qualitative method: quantitative information is not in the focal point. The method might have different objectives; our aim was to identify the narratives of climate change: the stories and memories around it, the metaphors, attributes and rhetoric used, relations between cognition and imagination. These features are demonstrated with quotations from the interviews.

Theoretical background

Climate as a social construction

In this paper, climate change is not regarded as a term that starts from the positivist and scientific perspective which has a lopsided and deterministic impact on the ecosystem, on different regions or on human society, and which provides a deterministic explanation for many things in our lives (extreme weather events, risks, threats etc.). Instead, we take it as a term which may mean something different for everyone, and which has to be understood and explained (Hulme, 2009). Similarly, landscape is not only a mediator which models global climate change in the same form for everybody, but it also offers a framework for interpretation for local people who perceive the phenomenon in their own lives, in their space and time (Brace and Geoghegan, 2010). However, as Hulme (2010) puts it, climate change makes everyone somewhat cosmopolitan, because it transcends boundaries and connect places with each other. We regard the term 'climate' as a term that forms part of the culture, which also has social components. In dominant scientific discourse, the term 'global climate' is used; however, it is easy to understand that this is a mere construction, a statistically created figure which has little to say to ordinary people. For the lay public it is very important to attach climate change to something specific, to localise and connect it to their own climate concept, i.e. to the psychological climate, otherwise it will remain an invisible or distant problem. IPCC (2013) also raised the question: when would the human influence on local climates be seen as evident?

The term 'climate' has several components. The lay public may have some understanding of the statistical concept of climate as some average weather pattern, the ordinary course of weather and the relating data (temperature, rainfall etc.), but this is complemented by psychological and cultural concepts. The former is to be understood in the individual's own time scale and life, which is based on individual experiences, memories and the construction process that stems from them: the individual's own climate concept is constructed several times through different itineraries based on the weather conditions experienced during the past weeks, months or years. In addition to this, the concept of cultural climate is also very important, which may also be interpreted in spatial dimensions, therefore we can talk about an ordinary climate for a particular country or region that is based on collective remembrance and is also attached to folk traditions (Brace and Geoghegan, 2010; Hulme *et al.*, 2009). However, this might also be deceiving since we all know that even little children are taught that in winter there is snow, and Christmas should be always white.

Similarly, we regard the concept of landscape as something that is socially constructed; not as a scientific term but rather in the sense of a cultural landscape, where the importance of individual perception is emphasised. Landscape is a subjective construction based on experience, partly on the level of the individual and of the community, which provides a framework for interpretation for several natural-social phenomena. Thus, landscapes give an opportunity to understand climate change spatially and to locate it to our everyday life. The subjectivity of time perception may not require further explanation, and the perceived rate of the lapse of time, the length of the time elapsed and the different perceptions of the future are also very important factors in the individual reception of climate change. Together with landscapes, temporality provides a relational context to the investigation and understanding climate change (Brace and Geoghegan, 2010; Hulme, 2010; Stoknes, 2014).

Agricultural adaptation and climate change

Climate change is one of the environmental stress factors of agriculture. Extreme weather has always contributed to yield variability. Globally, one problem affects another, which means that yields or production performance has an impact on the world market value of agricultural or food products, and in the medium or longer term the changes in climatic conditions in certain regions may have a significant impact on the world market position of certain food products.

Among the interwoven problems of agriculture, global food security seems to be the most significant today, seeing that the growth rate of the Earth's population – though it now represents a decreasing tendency for over four decades – has exceeded the annual growth rate of global crop production since the mid-1990s. Satisfying the growing need for sufficient and healthy food products, environmentally-friendly technologies, biodiversity and soil protection, and the growing raw material requirements for biofuels, biochemistry and bioenergetics, all place further burdens and expectations on agriculture. In this respect, climate change may not only affect daily farming practices but might also result in the transformation of existing farming systems and regions (Vermeulen *et al.*, 2012; Howden *et al.*, 2013).

Another important perspective is the issue of water. Globally, many of the regions with the fastest growing population experience water scarcity, and increasing water demand is not solely induced by climate change. Clarke (1999) forecasted that 25 African countries will face severe water scarcity by 2025. So-called rainfall-fed agriculture supplies just 60 per cent of the world's food production and, if the forecasts for unfavourable climate change prove correct, this figure may even fall in the future (Cooper *et al.*, 2008).

In the case of historic agricultural societies, successful adaptation to changing environmental conditions basically depended on agriculture (Pappné Vancsó, 2014). Today's societies are much more complex, both in terms of construction and operation; however, if adaptation in agriculture is inappropriate, the occasional success of the other sectors will also be futile. Accordingly, the adaptation of agriculture to climate change is one of the most researched fields within adaptation research.

The theoretical frames of such research are provided by the terms exposure, sensitivity, adaptation capacity and vulnerability-flexibility as summarised by Chen *et al.* (2010) or Preston *et al.* (2013) in the context of agriculture. Every area or production region has its typical climatic risks such as the fluctuations in precipitation or temperature, early or late frosts, hail etc. The agricultural ecosystem of the region is formulated accordingly with its distinctive variety of species, technological-technical culture including the farming methods, mechanisation, the use of fertiliser and pesticides and daily-yearly routines. Exposure arising from the risks is also formulated depending on such factors and vulnerability is born when the social-economic environment is added (labour costs, market value of the products, marketing channels, costs of agricultural resources, agricultural insurance systems). Adaptation capacity depends on the macroeconomic environment and the micro-economic conditions of farming (objectives, division of work, financial position, governance structure, social capital etc.) in the broader sense, and on the abilities and knowledge of the human resources, on the available financial resources, lands, technologies and alternative livelihoods in the narrower term. Basically, these factors in a condensed form determine the vulnerability or flexibility of a particular region or a farmer. Individual farmers, where possible, make their decisions by taking into consideration the perception of the problem, the risks perceived and their vulnerability, and the success of such decisions influences their planning and future activities. In this respect, the decision-making environment, the source and quality of the information, and analysing the reasons for success or failure are significant factors.

Adaptation research became more dominant after the turn of the millennium (Preston *et al.*, 2013), but in the US detailed farm-level studies focused on adaptation strategies even at the beginning of the 1990s. These studies were focused on what actual measures could help to protect against negative environmental influences on the one hand, and on simulating crop yields by using model calculations with different-level adaptation strategies introduced on the other (Easterling, 1996; Kaiser, 1999). In this research, the main focus is on developing countries, which are regarded as the most vulnerable, and the emphasis is placed on the development of institutional environment, technological transfer and competencies (Cooper *et al.*, 2008; Chen *et al.*, 2010; Chhetri *et al.*, 2012; Lybbert and Sumner, 2012). Such research also offers promising fields for studying the development of traditional and local knowledge in, for example, African countries as it is gradually adapting to changing environmental and climatic conditions (Newsham and Thomas, 2011).

For the purposes of our paper, studies of farm-level adaptation in developed countries that are focused on its social-ecological factors as opposed to technological developments, plant biological experiments, plant breeding etc. (e.g. Geoghegan and Leyshon, 2012; Lereboullet *et al.*, 2013; Niles and Mueller, 2016) are more important. On the one hand, they illustrate the wide range of adaptation strategies – choice and supplement of varieties, changes in natural farming methods, moisture conservation, diversification of farming structures, diversification of land use, improvement of water management, protection of water-base, promoting diversification within and outside the sector. Compared to the above, in the Second National Climate Change Strategy of Hungary (NÉS, 2013), wider and higher-level objectives were formulated. On the other hand, they identify the factors that determine the success of adaptation including the place of farming in the lifecycle, the scope of available technologies, the size of the farms, traditions, institutional environment, the availability of information, the community nature of the parties involved and the regulatory environment (Nicholas and Durham, 2012; Raymond and Robinson, 2013).

Results

Perception of the changing climate

All the interviewees perceived changes in the climate recently, reporting that climate change was evident in changes in the natural order of the seasons, the blurred boundaries between the seasons, in gradually warmer and dryer summers, unpredictable and changeable weather, uneven precipitation, reduced rainfall, problems with rainfall patterns or in reduced duration of snow cover in winter.

Temporality takes shape in different forms in the responses received. Some of the respondents regard the weather patterns and climate perceived in the past few years as unprecedented. Others – representatives of the older generations – remember experiencing similar periods before. One of the respondents, who cultivates 20 hectares of land with his son, was considering the relativity of remembrance, i.e. the psychological climate, which made him rather uncertain when answering the question "Is our climate changing?":

> "Well, yes. If I can [recall] my childhood, because I was a peasant's child, […] there used to be [changes in the climate] and at that time we said what kind of weather we had. We did not know anything about temperatures. We had no thermometers. […] But about the temperature – no, probably not. Perhaps those winters were colder, we had more snow, and perhaps more rain

too. I can remember […] that back at primary school I think we learnt that the distribution of rainfall was around 700 mm here in West Transdanubia, but in the Great Plains it was 4-500 and so on. And this has changed by now. I recorded rainfall figures for ten years, how much rain we had a month, so there were times when we had only 400 mm of rain a year. […] About the temperature? Well, I don't know. Whether this global warming has any impact, I don't know. I don't know much about it. Where I see the changes in the weather that seasons are blurred, there are no four seasons distinctly separated any more. Spring, we used to have nice springs, and summers – warm ones, and autumns – and something, and then winters – cold ones. Now somehow we typically have summer very early in the spring, but I don't know what these things were like a long time ago. We used to have cold winters because plants were also frozen sometimes if it was colder a long time ago. […] Something has changed. It is rather that the four seasons are not so distinctly separated, I guess. […] Was the situation similar a long time ago? Well, we cannot be sure. Because there were no weather forecasts, and people were making predictions. […] These somehow came true, but I don't know if something has changed. Something must have changed, but not very much." [man over 80, Zala].

The perception of time, similarly to remembering the climate or earlier weather phenomena, is naturally a subjective factor. Some people see the beginning of the changes at the distance of three or four years while others, looking back to ten years before, feel that the climate has been changing as a trend. At the same time, some older people claim that the borderline was in the 1980s and 1990s, however younger farmers can sometimes only reference to narratives of older farmers not having exact climate memories from their childhood. The different perceptions can also be observed in the nature of the changes perceived, and the role of the locality as a reference point is also a factor in rhetoric:

"How long have we been experiencing great changes; how long have we been saying that the order of nature has changed? There occurred such a thing once ten years ago back in 2003. At that time, we experienced the very first deviation from usual weather patterns. Well, here we usually have 800 mm of rain a year, and if I can remember well, we only had 450-600 mm. It was a problem because we did not choose other varieties or ripening periods but used the usual ones. So in 2003, we closed the whole season with a deficit." [man over 50, Zala]

"I worked at the collective farm, there are such periods, I can remember that our maize production was rather disturbed due to the dry period, so because of the drought. Thus, this year seems to be similar. The only exception is sunflower, a miraculous plant, because it yielded three tonnes or above in last year's weather, and it has yielded three tonnes again this year. In this extreme place, where we are, in this part of the Great Plain, in this part of Hajú-Bihar, where we have hard ground that is meadow clay soil, so we should have very good maize yield, but now stability is provided by sunflower. […] Two years ago we had 1,200 mm of rain here on the Great Plain where the yearly average is 5-600 mm – isn't it? – so, we had as much rain as in the Alpokalja region. And it turned everything upside down. […] We had a similar period about 15 years ago when we had drier or rainier weather, and that was natural, but now it changes every year." [man over 40, Hajdú-Bihar]

Our interviews were conducted in years with particularly extreme weather patterns (2013 and 2015). In many cases we felt that, despite our request, the respondents were not able to disassociate themselves from the weather conditions perceived during the actual year.

Understanding climate change

The respondents mentioned the media, the events organised by the Chamber of Agriculture, professional magazines and their own interest as their source of information on climate change. Climate change is an important issue for the farmers because "[we] usually consult one another and the farmers as well to decide who should do what and in what ways. No one knows the right answer as we can see. But others also regard it in the same way." [man over 30, Hajdú-Bihar].

As for the major cause of climate change, the respondents mentioned anthropogenic environmental pollution most frequently, including the iconic car use, industry, deforestation, consumer society, urbanisation and globalisation, which suggest the respondents' perception of more complex relationships. Responses which mentioned acid rain, ozone layer depletion, earthquakes or tsunamis in connection with climate change suggest the entanglement of environmental problems. However, six respondents regarded, at least partly, natural processes as the major cause for climate change. One of our respondents engaged in plant production summarised the gravity of the problem in the following way by localising and combining distant climatic phenomena in the Carpathian Basin:

"Unfortunately, mankind interfered with nature a long time ago […] And now, […] we are digging our own graves, also in a global context. […] Mankind lives a self-destructive way of life. […] It is important to develop an environmental protection system or such a technology that will not make the present situation any worse so that it may become even more serious. Because the more destruction we make, and the more frequently we interfere with the order of nature, the more likely it is that nature will 'take revenge'; that is why we have these cyclones and hurricanes in the Carpathian Basin, which we did not have before. We have such phenomena in our basin which were not typical here before. And this is all because of the above I think." [man over 40, Hajdú-Bihar]

Naturally, there are such respondents – with similar discursive strategies – who are uncertain about the extent of the predicted changes – "Many exaggerate global warming, but I do not believe that we will chase desert fox in the Carpathian

Basin" [man over 55, Győr-Moson-Sopron] – or about the role of mankind, which only fosters the naturally induced changes. Interestingly, one of them doubted climate change by localising the problem and using his own experiences, but expressed a different opinion with regard to arctic climate change learnt from the media. This quotation underlines the problem of visibility as well:

> "Basically, I do not really believe in this climate change, because we might as well make statistics about certain periods. But as I see in nature programmes, these are cycles, and it is not sure that the climate is actually changing. Perhaps it is changing, and it can be measured when compared to periods 10 or 100 years before, and in this regard it is not really significant. However, I would not exclude the impact of human activities on the climate. So, when I look beyond my own environment, to the arctic region for instance, that really appeals to me as well. At that level, and considering what is happening there, I can see the connection with climate change and the emission of greenhouse gases, but when I look at my own environment, climate change does not seem to be apparent." [man over 50, Hajdú-Bihar]

However, in other responses relating to the question of problem perception and searching for responsible actors, localisation was very important. This is also supported by the interesting responses received. Several respondents referred to the practice of cloud seeding by their 'neighbours', which might result in droughts in certain regions or produce precipitation in others. In this case, it might be the technology of hail protection which has been included in local folklore, and become a scapegoat in local discourse, as one of the factors representing unauthorised human interference with nature. However, the responses also included regional and micro-level localisation narratives:

> "Some people say and it is also supported by observations that since the Yugoslav Wars aeroplanes have been using different air routes, so they are flying above us, which has also changed our climate slightly, or pushed our cloud zone into another direction. Thus, the distribution of our rainfall has changed accordingly." [man over 50, Zala]

> "Back to the amount of rain, rainfall and water balance are closely linked to the existing sewage system in the neighbourhood of our family house. Since we had the sewage system installed, groundwater has receded to lower layers in the soil. Perhaps it is not connected to climate change, but to the former problem. I usually associate climate change with water and water management. The amount of water or rain we have in the area. I do not want to drain water around the house, I would rather want to preserve it there." [man over 50, Hajdú-Bihar]

Adaptation to climate change

In the interviews, the options of adaptation to climate change also appeared. It can be generally stated that large-scale farmers have usually more detailed knowledge about the features of adaptation, while small scale farmers better refer to traditional knowledge, or consider only watering possibilities. In the responses, four focus points were mentioned: irrigation, the choice of technologies (precision agriculture, mulching, modern cultivation and tillage methods) and varieties, and the factor of abilities, aptitude and knowledge. The latter have been attached by our oldest respondent to the issue of diversification:

> "If you grow different plant varieties, you can survive, and there is no disaster. You have to grow three different species at least. Another form of diversification is that you raise animals as well." [man over 80, Zala]

To reach even higher yields, many respondents are open to testing and implementing the newest technologies: soil melioration with bacterial or water retainer technology, high-tech machines etc. but some respondents emphasised the importance of old, traditional knowledge, which could be a solution to new challenges as well: "The knowledge of the elders is needed here […] The old knowledge should be sought!" [man over 55, Győr-Moson-Sopron]. Interestingly, two of our respondents farming over 1,000 hectares – one of them from Zala and the other from Hajdú-Bihar – both presented their farm as exemplary in terms of adaptation, however some respondents tend to be inactive even if they know the solutions to the problems induced by climate change.

> "So, for three or four years I have not grown early or mid-season maturing species. One of the reasons is that early-season varieties yield several decitonnes less, that is ten decitonnes fewer per hectare. […] If you walk around the fields you can see that smallholder farmers [planted] early-maturing varieties or they do not reconsider what type of varieties to plant now. They plant FAO 380 variety, for example. If you walk around the fields, you can see that those varieties get burnt, they are ripe. Actually, they are not ripe but they are forced ripe. But you can see our maize that we grow on a large scale, so if you walk around the fields you can see that our maize is still green, or was green until the early frost this morning. […] After the change of the regime, […] I planted and harvested maize, and no additional knowledge was required. I did not have to apply rotation; maize could be grown as a monoculture. But now we have moths and maize rootworms. So, basically maize is an expensive plant to grow. And if I fail to pay attention to the details, there is no harvest at all." [man over 50, Zala]

> "What we did is to push April planting season until the end of May or sometimes until the beginning of June if the varieties required so. […] You plant the maize in April, but you have to face drought throughout April and May until the end of June, a serious problem that tends to be typical these days. The problem is that maize needs rain during the ripening period that is after the pollination period. If it does not get rain at that time, and there is no grain formation, it makes no difference when the next rainfall comes, if grain formation itself does not start, it does not matter what you do later on. This is what we

have observed, and it works, thank God, this year we can see that it really works. Others planted maize earlier – we planted it in the middle or at the end of May. In some areas, we planted it even at the beginning of June. And it was in the summer that we had the first excessive rain. And our maize started to ripen, while others' maize was over the ripening period and started to get burnt." [man over 30, Hajdú-Bihar]

During our interviews, the issue of climate change was mentioned among other day-to-day problems the villages have to face – unemployment, migration, ageing – or among the personal problems of the respondents – diseases, family, earning a living etc. – and similarly to such problems it appeared as a problem which many of them are puzzled by. They regard climate change as a problem against which individuals' wills and activities make little difference. With this mentality, people cannot help perceiving the problem in search for mitigation, and trying to answer the question "What can we do to stop it?" Here, the individual's opportunities or responsibilities are dwarfed many times, however, some people emphasise that everybody has to do something based on his/her abilities. Nevertheless, those who regard climate change as the question "how should I adapt to it?" are considering adaptation, and the management of the problem. For such respondents, climate change appeared as a factor – similarly to market conditions or legislation – which rendered farming more difficult. In this respect, individuals' leeway is different: some respondents claim that the success of adaptation lies in individual opportunities, people's own knowledge or aptitude, while others think that it depends on legislation and the introduction of coercive and influencing measures.

Our respondent growing wheat, maize and sunflower by the river Körös expressed his opinion in the following way:

"It is negative for those who are unable to adapt, and positive for those who are capable of adaptation. You can always find a better market. Now I think that if you have your market, and you can grow your crops in sufficient quantities while others who cannot adapt, cannot produce sufficient quantities, then practically you will also get a better price." [man over 30, Hajdú-Bihar]

Discussion

Our study focused on farmer's narratives, how they understand and explain perceived changes in local climatic patterns. Using quotations from interviews we demonstrated the significance of the term psychological climate, temporality and localisation in experience and perception of climate change; our results are thus consistent with similar approaches such as Geoghegan and Leyshon, (2012) or Lereboullet *et al*. (2013). Particularly in the developed world, several studies examined other aspects in perception such as personal beliefs, political views, and local factors including place attachment or existing adaptation infrastructure, e.g. irrigation (Arbuckle *et al*., 2013; Howe and Leiserowitz, 2013; Prokopy *et al.,* 2015; Niles and Mueller, 2016). These results show that perception of climate change could be much more contested in different countries and contexts; however, our results underlined some significant factors, e.g. the role of extreme weather events and knowledge, highlighted also in the existing Hungarian literature (e.g. Csatári *et al.*, 2015; Vántus *et al.*, 2015). Lereboullet *et al*. (2013) pointed out also further aspects in successful adaptation: for example, system characteristics, economic health and social background. Thus, further research is needed in Hungary to understand the complex environment of adaptation planning.

Adaptation is an issue to consider to all, but also differently: traditional knowledge is sometimes in contrast with innovative knowledge; it seems that Hungarian agriculture includes individuals who can be regarded as leaders or as people escaping ahead in terms of climatic adaptation, but others seems to be unable or unwilling to follow them because they lack the necessary knowledge, technology or financial resources (cf. for example, Barnes and Toma, 2012). However, further research has to be carried out to reveal the adaptation capacity of Hungarian agriculture, as well as to study the different factors of the adaptation environment from national to local levels. Moreover, comprehensive research in the Carpathian Basin could show the diverse circumstances of climate change perception and adaptation behaviour and capacity in agriculture.

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Sustainability levels in Irish dairy farming: a farm typology according to sustainable performance indicators

Feeding the world's population in a sustainable manner is one of the key challenges facing the future of global agriculture. The recent removal of the milk quota regime in the European Union has prompted an expansionary phase in dairy farming, especially in Ireland. Achieving this expansion in a sustainable manner is crucial to the long-term survival and success of the Irish dairy sector. In this paper we examine the sustainability of Irish dairy farming, defining 'sustainability' as economically profitable, environmentally friendly and socially efficient. A typology of Irish dairy farms has been created using data on profitability, environmental efficiency and social integration derived from the Teagasc National Farm Survey. Economic, social and environmental performance indicators were determined and aggregated and then used in a multivariate analysis for the identification and classification of farm clusters. The purpose of this study to classify Irish dairy farms using performance indicators, thereby, assisting policy makers in identifying patterns in farm performance with a view to formulating more targeted policies. Two of the three clusters elicited from the analysis were similar in regards to their respective indicator scores. However, the remaining cluster was found to perform poorly in comparison. The results indicate a clear distinction between 'good' and 'weak' performers, and the positive relationship between the economic, environmental and social performance of Irish dairy farms is evident.

Keywords: economic, environment, social, less favoured areas, policy, multivariate analysis

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Introduction

Irish milk production expanded dramatically in the 1970s and early 1980s. However, a milk quota system was introduced in the European Union (EU) in 1984 and restricted growth in Irish milk production until April 2015. The removal of the milk quota regime in April 2015 has presented a significant opportunity for many EU Member States to increase milk production. The Republic of Ireland (hereafter referred to as Ireland) seems set to exploit its natural advantages associated with dairy production in a no-quota environment. Recent Irish Government strategies such as Food Harvest 2020 (DAFM, 2014) set a target to increase milk production volume by 50 per cent in the first five years following milk quota removal (against a base period of 2007-2009).

The sustainable intensification of the Irish dairy sector is a key challenge, particularly in light of the mounting pressure to increase food production in both a socially responsible and sustainable way. The sustainable performance of farms has been the subject of growing research attention in recent years. One approach to measuring farm performance is the construction of indicators that can measure the overall performance of farms. Indicators are synthetic variables describing complex systems and can measure various aspects of sustainability (Castoldi and Bechini, 2010). In this context, sustainable performance evaluation covers, in most cases, three pillars of sustainability: economic, social and environmental. Indicators have been developed by several evaluation programmes across Europe and studies that use this approach provide a holistic evaluation of sustainable performance at farm level (Firbank *et al.*, 2013). Indicators can be used to quantify farm performance through variables that can be derived from easily accessible datasets (Donnelly *et al.*, 2007; Bockstaller *et al.*, 2009). In an Irish context, several researchers have used indicators to quantify farm performance using qualitative and quantitative methodologies and indicators that best reflect the main aim of their research (Newman and Matthews, 2007; Mauchline *et al.*, 2012; Dillon *et al.*, 2014; Ryan *et al.*, 2014).

Until now, most of the work on the sustainable performance of Irish farms has focused on the performance of each farming sector. However, differences can be identified between farms within a sector. In view of this heterogeneity, it might be beneficial to classify farms into types of sustainable performers (Happe *et al.*, 2006; Valbuena *et al.*, 2008). Such classification allows for the identification of differences between farms within a sector and can assist our understanding of how farming may evolve. The process can inform the design of targeted farm policies and enable policy solutions that address the problems of different farming groups (Morgan-Davies *et al.*, 2012). Farm typologies have been widely used to assess policy impacts and decision-making processes (e.g. O'Rourke *et al.*, 2012; Micha *et al.*, 2015).

This study develops a typology of Irish dairy farms based on farm performance using multivariate statistical analysis and Teagasc National Farm Survey (NFS) data. While there are many studies of sustainability, this study which uses the NFS indicators is novel as only a few studies have used nationally representative datasets (see Dillon *et al.*, 2014 and O' Brien *et al.*, 2015 for a review of the literature in this area).

Methodology

To classify farms into clusters of sustainable performers, multivariate analysis was performed as suggested by Köbrich *et al.* (2003), which identifies farm groups based on performance indicators that have been normalised and weighted according to importance (Nardo *et al.*, 2005). The

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sustainability of farm groups is evaluated by comparing performances relative to a frontier value of the top performers in the sample.

Data

This study uses performance indicators (Table 1) that express the economic, environmental and social sustainable performance of Irish dairy[5] farms as classified by the NFS (Hennessy *et al*., 2013). The NFS, which is part of the EU's Farm Accountancy Data Network (FADN), has collected data from a nationally-representative sample of farms in Ireland annually for over 40 years. Economic, agronomic, demographic and farm infrastructure data are collected from approximately 1,000 randomly-selected, nationally-representative farms by means of a detailed farm management questionnaire that is administered through face-to-face interviews.

Farm classification

The approaches proposed by Koebrich *et al*. (2003) and Nardo *et al*. (2005) were combined and used to guide the methodology applied. Development of the theoretical framework was followed by correlation testing, quantification and optimum scaling, data normalisation, weighting, principal component analysis and cluster analysis (Figure 1). Initially, potential outliers were identified and eliminated. Outliers were identified using z-scores; observations that have an absolute value of modified z-score greater than |3.5| were eliminated. The process was not applied to categorical variables. The selected indicators were first tested for correlation using a Pearson correlation matrix to examine their validity as variables to be used in the multivariate analysis. If two or more variables had a Pearson correlation coefficient ≥ 0.8, only one would be retained in the analysis (Field, 2009). However, no such correlation coefficients were observed.

As part of the multivariate analysis, principal component analysis (PCA) was used (Pallant, 2010). However, Linting *et al*. (2007) suggest that binary categorical variables cannot effectively be used in PCA. Hence, categorical variables had to be transformed into numeric ones using optimum scaling (Takane, 2014). The SPSS 18 CATPCA package (IBM, Armonk, North Castle NY) is a tool that can perform a non-linear PCA that uses optimum scaling to transform nominal variables into numeric values through non-linear regressions. Optimum scaling can also be used to address the problem emerging in multivariate analysis of variables that range within only very small intervals (Gómez-Limón *et al*., 2012).

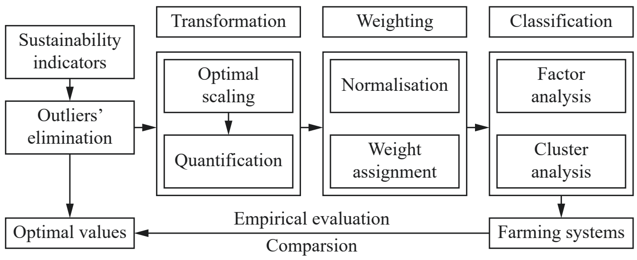

Figure 1: Conceptual framework of the methodology applied in this paper.

Source: own composition

[5] Dairy farms are those where the dominant enterprise is milk production, meaning that the largest share of their agricultural output comes from this activity.

Table 1: Teagasc National Farm Survey economic, environmental and social indicators used in the study and their optimum values.

Indicator	Measure	Unit	Optimum value
Economic			
Productivity of land	Gross output per hectare	EUR / hectare	The maximum value in the dataset. The performance rate for these indicators is calculated by dividing the cluster average by the optimum value. The latter is the highest in the dataset.
Profitability	Market based gross margin per ha	EUR / hectare	
Productivity of labour	Income per unpaid labour unit	EUR / labour unit	
Market orientation	Output derived from the market	Per cent of total output*	
Viability of investment	Farm business is economically viable**	1 = viable, 0 = not viable	The cluster average is compared to the optimum value, which is assumed at 100 per cent.
Environmental			
Greenhouse gas emissions / EUR 1000	IPCC estimate / EUR 1000 gross output	tonnes CO_2 equivalent / EUR 1000 gross output	The minimum value in the dataset. The performance rate for these indicators is calculated by dividing the optimum value by the cluster average. The former is the lowest in the dataset.
Greenhouse gas emissions from fuel and electricity / EUR 1000	IPCC estimate / EUR 1000 gross output	kg CO_2 equivalent / EUR 1000 gross output	
Nitrogen balance / farm	Risk to water quality	kg N surplus / farm	
Social			
Household vulnerability	Household income sustainability (1 = Farm business is not viable/no household off-farm employment)	Per cent of total sample	100 per cent. Performance rates are the percentage of viable household and educated farmers in each cluster.
Education level	Agricultural educational attainment (0 = N, 1 = Y)	Per cent of total sample	
Household viability	Age profile: household has a member < 45 years old (binary, 1 = yes)	Per cent of total sample	0 per cent. Performance rates are the percentages of households that are not vulnerable and do not face isolation risk for each cluster.
Isolation risk	Farmer lives alone (binary, 1 = yes)	Per cent of total sample	
Work-life balance	Work load of farmer	Number of hours worked on farm	The minimum value in the dataset. The minimum value of hours worked on farm for work-life balance.

* Total output includes subsidies

** An economically viable farm is one that has the capacity to remunerate family labour used on the farm at the average agricultural wage and the capacity to provide an additional 5 per cent return on non-land assets

Source: own composition; see Hennessy *et al.* (2013) for a full description of the indicators

To facilitate the interpretation of results, the scaled indicators were normalised to a (0-1) scale (Nardo *et al*., 2005). The non-linear PCA regressions used for optimum scaling in the previous step produced principal components, a number of which were retained following the Kaiser criterion (eigenvalue > 1). The loadings of the retained components were used to assign weights to the indicators using the same method as Nardo *et al*. (2005), and Gómez-Limón and Riesgo (2009). Weighting is an important step as it ensures the robustness of the variables that will be aggregated.

A linear PCA was applied to the dataset of normalised weighted indicators. The number of components to be retained follows the Kaiser Criterion (eigenvalue > 1) and only the component loadings with a value higher than 0.35 were accounted for in the analysis (Field, 2009). Hierarchical cluster analysis (Ward's method) was used to identify the number of clusters and this was followed by K-mean cluster analysis to indicate the cluster centres and the number of farms in each cluster.

To evaluate the emerging clusters according to performance, the average value of the indicator for each cluster was compared to the optimum indicator. The level of sustainability performance was calculated as a percentage of the optimum performance of the entire sample. Optimum values are the values of the indicators for the best performing farms of the whole dataset (Table 1)[6].

[6] We acknowledge that this method of establishing the optimum value is data-driven and is one of the many methods that can be considered for this purpose.

Table 2: Teagasc National Farm Survey socio-demographic variables used in the study.

Variable	Measure	Unit
Full-time farming	1 = yes, 0 = no	Categorical
Utilised agricultural area	Area of agricultural land used	ha
Parcels	Number of parcels on the farm	Numeric
Dairy livestock units	Dairy units in farm	Numeric
Household members	Family size	Number of individuals in the household
Less favoured areas (LFA)	1 = in LFA, 2 = not in LFA	Per cent of sample
Gender	1 = male, 2 = female	Per cent of sample

Source: own composition

Table 3: Calculated indicator weights based on non-linear PCA component loadings.

Indicator	CATPCA component			
	1	2	3	4
Productivity of land	0.13			
Profitability	0.16			
Productivity of labour	0.14			
Market orientation		0.19		
Viability of investment		0.13		
Greenhouse gas emissions/EUR 1000				0.38
Emissions from fuel and electricity/EUR 1000	0.14			
Nitrogen balance/farm		0.24		
Household vulnerability		0.15		
Education level			0.29	
Household viability			0.37	
Isolation risk				0.08
Work-life balance				0.24

See Table 1 for units of measurement
Source: own calculations

The elicited clusters were linked to selected socio-demographic variables from the original NFS dataset that included demographics and farm structure, subsidies, and variables related to certain management decisions such as the use of advisory services, stocking rates and the grazing season length (Table 2). To determine statistical significance, one-way ANOVA tests and least significant difference (LSD) post-hoc tests were used for continuous variables. Contingency analysis Chi-square tests were applied to discrete variables.

Results

After the elimination of eight outliers, 250 farm records remained from the 2012 NFS dataset. The Pearson correlation matrix showed that all 13 indicators were valid for analysis. The optimum scaling process produced an intermediate dataset of scaled variables that were normalised. Using the component loading of the yielded components the weights to be assigned to each normalised indicator were calculated (Table 3).

The linear varimax rotated[7] PCA performed on the dataset of weighted indicators yielded four principal components, explaining 67.4 per cent of the original variance (Kaiser-Meyer-Olkin = 0.76). The component loadings for each indicator are presented in Table 4 and detailed results of the cluster analysis and a comparison to the entire sample are presented in Annex 1 and Annex 2.

Performance of farms is presented as a percentage of that optimum value for each cluster. A similar comparison was made to evaluate the performance of the entire sample. Table 5 expresses performance (efficiency) rates for the entire sample and for each cluster, when compared to the related optimum value. These clusters were further analysed for identification of their socio-demographic characteristics (Table 5 and 6).

[7] Varimax rotation is performed following the methodology of Field (2009), as it helps generate more robust correlation coefficients between the principal components and the initial variables.

Table 4: Principal component loadings resulting from linear PCA.

Indicator	Component			
	1	2	3	4
Productivity of land		0.89		
Profitability		0.73		
Productivity of labour	0.81			
Market orientation		0.78		
Viability of investment	0.93			
Greenhouse gas emissions/EUR 1000				-0.61
Emissions from fuel and electricity/EUR 1000	-0.67			
Nitrogen balance/farm		0.79		
Household vulnerability	-0.92			
Education level			0.64	
Household viability			0.76	
Isolation risk				-0.43
Work-life balance				0.68

See Table 1 for units of measurement
Source: own calculations

Table 5: Performance rates (%) through comparison of the mean with the optimum indicator for three clusters of dairy farms and for the entire sample, and statistical differences between them.

Indicator	Optimum value (i.e. 100%)	All farms	Cluster A	Cluster B	Cluster C	Sig.
Representation		100	53.6	30.8	15.6	
Efficiency						
Productivity of land	6,404	48.3*	53.1[a]	43.2[b]	41.5[b]	0.00
Profitability	3,558	41.1	46.5[a]	34.9[b]	34.6[b]	0.00
Productivity of labour	141,725	28.7	33.5[a]	24.8[b]	19.8[b]	0.00
Market orientation	0.96	89.7	90.5[a]	89.5[a]	87.6[a]	n/s
Viability of investment	100%	73.2	79.1[a]	74.0[a]	51.3[b]	0.00
Greenhouse gas emissions/EUR 1000	60.8	63.1	67.7[a]	55.2[b]	66.1[a]	0.00
Emissions from fuel and electricity/EUR 1000	0.00	12.7	17.1[a]	10.7[b]	8.41[b]	0.00
Nitrogen balance/farm	24.6	16.9	16.4[a]	16.1[a]	21.8[b]	0.00
Household vulnerability	0.00	76.0	79.9[a]	79.2[a]	56.4[b]	0.00
Education level	1.00	74.4	85.8[a]	80.5[a]	23.1[b]	0.00
Household viability	1.00	9.60	0.75[a]	1.30[a]	56.4[b]	0.00
Isolation risk	0.00	94.0	98.5[a]	88.3[b]	89.7[b]	0.005
Work-life balance	300	12.1	11.0[a]	13.6[b]	14.2[b]	0.00

See Table 1 for units of measurement
* The mean values used for these calculations can be found in Annex 1 and Annex 2.
Different superscripts within a row indicate statistically significant differences among types ($p<0.05$)
Source: own calculations

Table 6: Demographics of the three clusters of dairy farms.

Socio-demographic variable	Sample	Cluster A	Cluster B	Cluster C	Sig.
Full-time farming	96.4	98.5[a]	96.1[a]	89.8[b]	0.04
Utilised agricultural area	61.2	65.0[a]	59.9[a]	50.6[b]	0.03
Parcels	3.36	3.40[a]	3.28[a]	3.51[a]	0.83
Dairy livestock units	73.3	80.0[a]	71.7[a]	53.4[b]	0.00
Household members	3.64	3.96[a]	3.57[a]	2.60[b]	0.00
Less favoured areas	61.6	54.5[a]	68.8[b]	71.8[b]	0.04
Gender					0.04
Male	98.8	100[a]	98.7[a]	94.9[b]	
Female	1.2	0.0	1.3	5.1	

See Table 2 for units of measurement
Different superscripts within a row indicate statistically significant differences among types ($p<0.05$)
Source: own calculations

Farm typology

The key characteristics of each cluster of farms are as follows.

Cluster A (53.6 per cent of farms in the sample)

The average farm size is 65 ha; divided into 3.35 land parcels and comprising of 80 livestock units. Farms of this cluster show the highest performance rates. Indeed, the productivity of land performance of farms of Type A exceeds the average performance across the NFS dairy farm sample and farms of this type are highly market oriented (90.5 per cent) and viable (79.1 per cent). The cluster sustainability performance score for productivity of labour and profitability are 33.5 and 46.5 per cent respectively. This cluster is quite efficient in terms of sustainable greenhouse gas (GHG) emissions but scores low in GHG from fuel and electricity and nitrogen (N) balance. The performance score for household vulnerability is 79.9 per cent, meaning that such farms have a sustainable source of income from the farm and/or from an off-farm source. Almost all of the farmers (98.5 per cent) are full-time farmers (Table 6). The work-life balance performance score is low, indicative of the significant amount of labour that is required to operate this type of farm (Table 6). There is a low risk of isolation with farm households comprising, on average, 3.96 members. However, farms show extremely low performance in terms of household viability (0.75 per cent).

Farms of this cluster are significantly more productive (land and labour) and profitable than the other two clusters. This is combined with significant differences in household composition as few farmers live alone and their households have the most members (Tables 5 and 6). Conversely, farms are least efficient in terms of work-life balance.

Cluster B (30.8 per cent of farms in the sample)

In this cluster the average farm size is 59.9 ha, the average herd size is 71.7 livestock units, and 68.8 per cent farms are located in a less favoured area (LFA). Farms performed relatively well on most aspects examined, with performance scores close to the sample average. Land productivity is below average but farms are highly market oriented. Profitability and labour productivity are lower than the sample average but viability is quite high. Farms have an average GHG emissions performance score of 55 per cent and performance scores for GHG emissions from fuel and electricity and N balance are low. In terms of social performance, household viability is only 1.3 per cent, indicative of an ageing farming population. However, farmers do not face isolation risk and the average household is comprised of 3.57 members. Similar to Cluster A, education level is high and work-life balance is below the sample average. The farm household appear to have sustainable income sources (household vulnerability efficiency = 79.2 per cent) although 96 per cent are full-time farmers.

Farms share similarities with Cluster A farms in terms of certain social indicators such as high household vulnerability (off-farm income), education level, household viability and off-farm employment. However, Cluster B farms are less efficient in terms of isolation risk and there is a significant difference in work-life balance. The performance of Cluster A and Cluster B farms with respect to the viability of investment is statistically indistinguishable. Nevertheless, Cluster B farms have a statistically lower performance score for the productivity and profitability indicators. There is no significant difference in N balance between Cluster A and Cluster B. However, there is a significant difference in GHG emissions efficiency between both clusters, with Cluster B farms scoring a significantly lower climatic impact. Cluster A and Cluster B have very similar farm and household characteristics; Cluster B farms are, however, on average smaller in terms of land area farmed and herd size: they also have smaller households on average.

Cluster C (15.6 per cent of farms in the sample)

Mean farm size is 79.9 ha, divided into 3.51 parcels with an average herd size of 53.4 units. Most farms within this cluster (71.8 per cent) are located in LFAs. Land productivity is below the average and profitability and labour productivity are also relatively low. Farms are highly market oriented (87.6 per cent), but only 51 per cent are viable investments. Farms are also quite environmentally efficient with GHG emissions performance score at 66.2 per cent. Farms are the most efficient in terms of N balance (rate = 21.8 per cent). Only just over half the households appear to have sustainable income sources, and 89.7 per cent are full-time farmers. The cluster is comprised of mostly young households, as 56.4 per cent have low age profiles, and small households (2.64 members). Farms are more efficient in work-life balance that the rest of the sample. The percentage of female farmers in this cluster is 5.13 per cent.

Farms score relatively poorly on most economic indicators and certain social ones. Cluster C farms also differ from other clusters in structural characteristics. There are fewer full-time farms, more small farms and more households with a female presence. Regarding social performance, Cluster C farms score significantly lower for off-farm employment and education level in comparison to Cluster B, but there are more young farmers.

Discussion and conclusion

Our findings indicate that, in order to meet the goals set for Irish dairy farming in the context of sustainable intensification, there is a need for a range of policy solutions to address the heterogeneity present within the sector. Given these caveats, certain policy suggestions arise from these analyses that address the issues of each system separately.

Interestingly, no cluster has a high score for productivity of labour. This, combined with very low scores across clusters on work-life balance, could lead to the conclusion of overall labour inefficiency in the sector. Intense labour combined with low labour productivity has been highlighted in studies in Ireland (O'Brien *et al*., 2006) and in the dairy sectors of other nations (e.g. Ruiz *et al*., 2009). One of the reasons advanced is the lack of hired labour, as Irish farms tend to be family farms. Hurley and Murphy (2015) found that the higher the profitability, the lower the workload of the farmer as extra labour can be hired. However, our typology shows that more profitable farms are less efficient in terms of work-life balance. It is also worth noting that farmers in Cluster A and Cluster B have attained higher levels of education in comparison to Cluster C.

GHG emissions from Cluster C are lower than the other clusters elicited (Table A1). Clusters A and B share social and structural characteristics but differences in GHG efficiency are observed. Studies suggest that a relationship exists between good economic and GHG emissions performances (Ryan *et al*., 2015; Dillon *et al*., 2014). Cluster C is almost as efficient in overall GHG emissions as Cluster A, although its economic performance is similar to Cluster B. However, the social performance and the structure of Cluster C farms are very different. The similarities in environmental performance between 'good' and 'weak' economic performers could be explained by differences in farm size (Crosson *et al*., 2011; Adler *et al*., 2015).

We observe a similar N use sustainability score for Clusters A and B but it is much higher for Cluster C. Higher N surpluses (hence, lower efficiency) are consistent with productivity and intensity (Dillon *et al*., 2016). However, we find that despite land productivity differences between clusters A and B, N use performance scores are similar.

Cluster A performed best in terms of sustainability. As this cluster is highly market oriented, the creation of new, or maintenance of existing market channels, is essential. Also, a policy towards reducing dependence on subsidies would help these farms invest in becoming entirely self-sustained. An example of how this could be achieved would be the gradual reduction of direct land subsidies and the creation of a subsidy framework that rewards market orientation, in accordance with the rural development targets of the EU's Common Agricultural Policy. This farm cluster has lower rates of overall GHG emissions but indicated higher N surpluses per hectare, which is to be expected as they are operating at higher levels of intensity. Therefore, improvement of the N balance could be achieved through farmers' further environmental education and, therefore, the provision of information would be an appropriate policy goal (Buckley *et al*., 2015). Policy makers could take advantage of the fact that a high percentage of farmers in this system are educated and design the appropriate measures to help improve environmental performance (Ondersteijn *et al*., 2003). The cluster has a quite low efficiency in labour allocation which could be a negative driver. Incentives towards hired labour in agriculture could improve the work-life balance and at the same time create a better environment for a variety of social groups in rural areas.

Cluster C is smallest in terms of its membership and performed poorly against many of the indicators assessed. A strictly economic approach would demand farms of this cluster eventually to be taken over by farmers of the two other clusters and be run more efficiently. However, Irish social structures and issues such as attachment to land and cultural identities create barriers to such forms of land exchange (Cassidy and McGrath, 2014). A policy framework addressing the problems of the sustainable development of these farms could include the encouragement of farm diversification and multifunctionality (Feehan and O'Connor, 2009). Farm diversification allows for the optimum allocation of land to farm functions that are useful to agriculture but can include diversified activities (van der Ploeg and Roep, 2003). Farms in cluster C were characterised by being located in LFAs and evidence has shown that farm multifunctionality (diversification) as a strategy is being increasingly accepted and successfully implemented in LFAs in various countries (López-i-Gelats *et al*., 2011; Fleskens *et al*., 2009).

The nature of farms in Cluster B allows for more flexible policy targets, as we believe the main aim of these farmers is to switch to the best performing cluster. Policies towards the sustainable development of these farms could focus on encouraging the engagement of younger farmers and enhancing environmental sustainability through education and best management practice promotion (through extension activities such as discussion groups). Also, the large proportion of LFA farms, the relatively low levels of land profitability, combined with the high scores of off-farm income and market orientation, suggest the need for further measures such as diversification or initiatives encouraging farm co-operation and other joint ventures that could help these farmers reach the levels of Cluster A.

To conclude, the classification of farms into types based on their sustainability performance is essential for understanding how sustainably intensive dairy farms can be developed in Ireland. This paper limits itself in the quantitative aspects of sustainable performance scores using the Teagasc NFS indicators. Further research could explain the reasons behind these scores and explore the social implications. The typology created in this study confirms that we cannot expect farmers with different characteristics to adjust to similar policies, and for policies to be effective it is necessary to target distinct groups (Brodt *et al*., 2006). As the demands for a more intensified dairy sector are likely to increase dramatically in the near future, it is essential to know that a unified policy for the entire sector might not be feasible, but a more targeted policy that would help each group to react positively to potential changes.

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Annex

Annex 1: Descriptive statistics of qualitative indicators for the three clusters of dairy farms and representation of farms per cluster.

Indicator	Sample		Cluster A		Cluster B		Cluster C	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Productivity of land	3,090	978	3,401	939	2,768	846	2,660	1003
Profitability	1,462	599	1,655	595	1,243	502	1,231	568
Productivity of labour	40,689	28,925	47,501	30,908	35,199	24,033	28,119	24,433
Market orientation	0.86	0.05	0.87	0.05	0.86	0.05	0.84	0.07
Greenhouse gas emissions/EUR 1000	2.63	0.43	2.45	0.27	3.00	0.48	2.50	0.30
Greenhouse gas emissions from fuel and electricity/EUR 1000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitrogen balance/farm	145	57.7	150.3	58.6	181	56.1	113	47.4
Work-life balance	2,470	534	2,731	361	2,203	509	2,106	612

See Table 1 for units of measurement
Source: own calculations

Annex 2: Descriptive statistics for the quantitative indicators for the three clusters of dairy farms (per cent).

Indicator	Sample	Cluster A	Cluster B	Cluster C
Viability of investment	73.2 (N=183)	79.1 (N=106)	74.0 (N=57)	51.3 (N=20)
Household vulnerability	24.0 (N=60)	20.1 (N=27)	20.1 (N=16)	43.6 (N=17)
Education level	74.4 (N=186)	85.8 (N=115)	80.5 (N=62)	23.1 (N=9)
Household viability	9.6 (N=226)	99.3 (N=133)	98.7 (N=76)	43.6 (N=17)
Isolation risk	6.0 (N=15)	1.5 (N=2)	11.7 (N=9)	10.3 (N=4)
Total		53.6	30.8	15.6

See Table 1 for units of measurement
Source: own calculations

Jaka ZGAJNAR*

Analysis of indemnification of income risk at sector level: the case of Slovenia

Using Monte Carlo simulations, the impact of different levels of risks on indemnification through an income stabilisation tool is investigated at the sector level. The presented approach, using the IACS database, allows analyses of differences across farms with respect to farm type and farm size, applying average-based approaches. Such preliminary information is useful for policy makers responsible for the design and introduction of measures to tackle income risk issues and to identify potential beneficiary groups among farmers. The analysis shows that on average 25 per cent of farms would be indemnified annually, the majority in fruit production, the dairy sector and hop production. Mixed farm types, with a share of 34 per cent, receive only 15 per cent of the total sum of indemnity. However, if EUR 12,000 of average income is set as the threshold for participation in such a tool, only 6 per cent of farms participate and only 13.3 per cent of them would be indemnified. Indemnity at farm level would range between EUR 82 and 40,870. Taking into account all farms in the sector, the average indemnity is EUR 918 per farm and almost EUR 13,500 for the second case.

Keywords: income risk, indemnification, income stabilisation tool, IACS

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Introduction

In recent years, the concept of income stabilisation has received a great deal of attention from policy makers in the European Union (EU) (Meuwissen *et al*., 2008a). Owing to increased liberalisation and globalisation, EU farmers are increasingly exposed to competition and price volatility on agricultural markets that are causing losses in income. To help farmers cope with increased income volatility and other risks, income stabilisation mechanisms are gradually being introduced in the EU. One such attempt is the European Commission's (EC) proposal for an income stabilisation tool (IST) that could be implemented by Member States in order to provide support to farmers experiencing a severe income drop (El Benni *et al*., 2016). However, El Benni *et al*. (2016) also see the possibility of the IST becoming a new transfer instrument hampering structural changes in farming. This consideration raises the need for more empirical research to improve our understanding of the mechanisms of farm income volatility and possible indemnification for income risk.

In the launch phase of a new risk management tool, it is necessary to assess its possible effects at the aggregate sector level from different viewpoints. When evaluating ISTs from a policy maker perspective, particular emphasis is usually laid on actuarial evaluations, government costs, impacts on optimal farm programmes, and on the identification of potential beneficiary groups of farmers (Finger and El Benni, 2014a).

Three main methodological streams to analysing ISTs and risk management tools can be found in the literature. The first is the mathematical programming (MP) approach. For example, Liesivaara *et al*. (2012) applied linear programming as a part of IST analysis in Finland to explain farmers' actions. Turvey (2012) used discrete-state stochastic programming, minimising the second moment (variance). Mary *et al.* (2013a) applied dynamic stochastic programming. There are also studies utilising positive mathematical programming (e.g. Cortignani and Severini, 2012) and the quadratic programming paradigm (e.g. van Asseldonk *et al*., 2008). In most cases, optimisation is performed at the level of a whole-farm model in order to investigate how an IST affects a specific farm, representative farm or farm type (van Asseldonk *et al*., 2008; El Benni *et al*., 2016). The second most common and also most widely applied approach is stochastic simulation modelling based on Monte Carlo simulations (MCS) (e.g. Majewski *et al*., 2008; Kimura and Anton, 2011; Finger and El Benni, 2014a). The third approach is to analyse data series with regression-based econometric approaches (e.g. Pigeon *et al*., 2014; El Benni *et al*., 2016). Long enough data series are essential for this type of analysis.

The main difference between studies analysing risk issues and those dealing with indemnification is their focus. The purpose of the first group is to test an insurance programme at the level of a farm or farm type (e.g. Turvey, 2012), while the second is to analyse the efficiency of potential income stabilisation tools at the sector level (e.g. El Benni *et al*., 2016); this also determines what kind of data are applied.

Bookkeeping data for large sets of agricultural holdings and years are commonly used for specifying potential indemnification within ISTs (El Benni *et al*., 2016). However, farm-level data are clearly needed to study or calculate indemnities at the farm level, and most studies in the EU (e.g. Meuwissen *et al*., 2008a; Vrolijk and Poppe, 2008; dell' Aquila and Camino 2012; Liesivaara *et al*., 2012; Mary *et al*., 2013a; Pigeon *et al*., 2014) use Farm Accountancy Data Network (FADN) data for analyses of ISTs at the farm and sector level. The aim is normally not to analyse income losses at a particular farm as an insurance product, but to analyse the situation on a sample of farms. This approach allows investigation of the differences across farming types, sizes and other factors that may influence indemnification of the farmer through the IST (El Benni *et al*., 2016).

Janowicz-Lomott and Lyskawa (2014) stress that the FADN tool is not directly applicable in insurance schemes due to its selective application, as well as some technical obstacles. They argue that either a comprehensive accounting system or a reference income system needs to be implemented at farm level. Meuwissen *et al*. (2008b) stressed the need for enhancements of the FADN system that would enable better analyses and responses to farm-level risk management concerns. Liesivaara *et al*. (2012) noted the two-year time delay between current and readily calculated FADN results, which is also a drawback of the Canadian scheme (Kimura and Anton, 2011). But these points are important when the approach is supposed to be a baseline for indemnification on a particular farm, which is not the case in this study.

The approach of analysing income risks faced by groups of agricultural holdings differs significantly from that of estimating actual losses of income and calculating indemnities for a specific holding. In the latter case, farm-level bookkeeping data are necessary. An important aspect of calculating indemnities is of course the baseline for indemnification. Reference – baseline income is used to identify whether and to what extent a farmer will be indemnified from such a scheme. Finger and El Benni (2014a) analysed in detail the influence of different reference incomes on costs and the distribution of potential government support in such an income stabilisation scheme.

In this paper, an alternative approach to income loss and indemnification analysis is proposed that is based on the Integrated Administration and Control System (IACS) database. Zgajnar (2016) used this approach to investigate the level of income risk and riskiness of different farm production types. A similar approach was applied by Zgajnar (2013) in order to analyse income risks in the Slovenian pig sector. In this paper, the focus is on the probability and amount of indemnification for different farm production types and sizes. Which production types would be the main beneficiaries of such an IST in Slovenia are explored, as is the amount of indemnification at both the farm group and sector level, taking into account different levels of probability of severe income loss. The soundness of the approach of using IACS data to study indemnification is also tested.

In the next section of this paper, the modelling approach is briefly presented, and this is followed by a detailed description of how potential indemnities are estimated for each group of beneficiary farms. Then, aggregated results regarding the probability of income loss and indemnities at the farm level are presented. A rough estimation of potential indemnities is also given, indicating the main beneficiary groups in the sector. The paper concludes with an assessment of the results obtained and the approach applied.

Data description and conceptual approach

The analysis reported here focuses on indemnification through the potential IST, the primary interest being in the extent and probability of indemnification for each beneficiary group of farms. It addresses the farm, sector and national levels, and emphasis is put on severe income losses, greater than 30 per cent of average income, and potential indemnification.

On the supply side, very simple logic is applied. No additional costs of participating in such an IST are considered, since they play no role in the current 'modelling logic'. To compensate for this simplification, additional logic simulating farmers' decisions was incorporated into the model. Namely, the decision to buy an instrument for risk 'sharing' is strongly connected to risk aversion. This is a rather complex process that demands an estimation of the coefficient of risk aversion at the farm level. Mary *et al*. (2013b) solved this issue by using the average relative risk aversion coefficient but, owing to the lack of information and fundamentally different modelling paradigm in this case, such an approach was not applicable. However, the model does enable the threshold income to be selected, this being an important indirect factor influencing the decision of whether or not to buy a risk management tool.

Table 1: Farm economic size class ranges by standard output adopted in this study.

	Economic size class (SO, EUR 1,000)													
	up to 2	2-4	4-8	8-15	15-25	25-50	50-100	100-250	250-500	500-750	750-1000	1000-1500	1500-3000	3000+
Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Source: own construction

The simulation model is based on the Slovenian IACS database for the period 2010-2011 and includes 59,629 farms that applied for Common Agricultural Policy (CAP) Pillar 1 payments and payments for less favoured areas (LFA) in that period. In this way, information was acquired regarding the farms' main production activities and the extent to which they were conducted on a particular farm. Precise information regarding revenues from subsidies and extent of arable and grass land was also obtained. From these data it is possible to infer on the farming type and approximately estimate production volumes, yielding some information about all agricultural holdings in a particular agricultural sector. This classification and reconstruction of farms was done for the study by Rednak (2012) based on estimated standard outputs[1] (SO) methodology. Farms were divided into 21 farm types and 14 economic size classes (Table 1). Most are small farms with a diversified enterprise composition (Zgajnar, 2016).

For the purpose of this study, SOs for each activity at the farm level were calculated based on average data for the period 2005-2009, derived from internal data sources prepared by the Agricultural Institute of Slovenia (KiS). These data include information of input and output prices on monthly bases and are applied for model calculations (KiS, 2013). Forty-two basic production activities that could enter farms' production plans were defined. Using the methodology proposed by the EC (Rednak, 2012), and considering the extent of each activity, further SOs at the level of agricultural holding were calculated. An important assumption in the analysis was that the production choice remains fixed and that farmers cannot add additional production activities to the production plan in a particular year (state of nature). In that respect, it is a static stochastic analysis.

[1] The SO of agricultural production means the monetary value of output corresponding to the average situation (average values over a reference period).

Simulation model

Before analysing indemnification through an IST, the income of each farm in the sample had to be estimated. Income refers to the sum of revenues the farmer receives from the market, including any form of public support, deducting input costs (EC, 2011). The first step was to generate simulated data regarding revenues and variable costs from distributions consistent with observed prices, costs and yield dynamics, based on data prepared by the KiS (KiS, 2013), national statistics (www.stat.si) and expert estimates, while taking into account the pitfalls of data aggregation outlined by Finger (2012).

To simulate income realisation (I_{fj}) at the farm level (f) in different situations (j), e.g. different combinations of risks, a static simulation model based on the Monte Carlo simulation paradigm was used. This relies on random sampling of values for uncertain variables included in the model, based on Latin Hypercube sampling. Analytic Solver® Platform (Frontline Systems Inc., Incline Village NV, USA) was used to run the model in Microsoft™ Excel™.

Achieved income (I_{fj}) on each agricultural holding was calculated as:

$$I_{fj} = GM_{fj} - FC_f * g_f$$

where FC_f represents fixed costs per farm (f), assumed to be constant within simulations of risk. They were estimated at the level of each activity in the model as a relative share ($FC_A = SO * P_{FC}$) of an activity's standard output (SO) and summed up at farm level (FC_f). Additionally, special calibrating coefficients g_f were added to adjust the fixed costs for each farm within a particular farming type to reflect the total tillage area. This has to be done, since the same relative share was considered for particular activity (e.g. dairy) and was in that respect calibrated with regard to the size of production at each farm.

The crucial part, where risk consequences enter the model, is gross margin (GM_{fj}) achieved at the farm level:

$$GM_{fj} = \sum_{i=1}^{n} GM_{ij} + SUB$$

It is the sum of the gross margins (GM_{ij}) of all n production activities on a holding, with different values between states of nature (j). The gross margin was also increased by eligible subsidies (SUB) from Pillars 1 (including also historical payments) and 2 (LFA) of the CAP. The amounts of subsidies by which the gross margin (GM_{fj}) was increased for each farm were based on information retrieved from the IACS dataset. An important premise was that all subsidies remain constant during the simulation process.

The gross margin at the activity level (GM_{ij}) was calculated as the difference between estimated revenues (R_{ij}) and variable costs (VC_{ij}) that vary across different states of nature (j):

$$GM_{ij} = R_{ij} - VC_{ij}$$

Since most subsidies are decoupled, it was not possible to estimate revenues directly at the level of a particular activity (R_{ij}) in the farm production plan, but at the farm-level gross margin (GM_{fj}). The same approach was used for all activities in the model, meaning that the SOs for each activity were taken as the baseline for calculating revenues (R_{ij}):

$$R_{ij} = SO_i e_i a_{i,j}$$

where the calculated SO_i for each activity (i) was adjusted with an index generated from the triangular distribution ($a_{i,}$) for each state of nature j (i.e. specific combinations and probabilities of possible outcomes at activity level) reflecting the selected scenario . Based on the binomial distribution (s_1, s_2, s_3; p_{s1}, p_{s2}, p_{s3}), the model considers three different scenarios representing different levels and types of risk. The first scenario (s_1) includes 'normal risk' which means that minimum and maximum values are in the range of the 'normal' of a few years' average. The second scenario (s_2) includes greater possibilities for extremes (positive correlation between risks) than the first scenario, and the range of possible outcomes (minimum and maximum) is widened. The third scenario (s_3) anticipates catastrophic – extreme events, with significantly higher frequencies of very bad, as well as very good outcomes. e_i is a static coefficient included in order to adjust the average SO_i of each activity to each farm's characteristics, mainly with regards to economy of scale (see Zgajnar, 2016). Less emphasis is put on technological change or technological progress. Minor corrections for some technologies (e_i) were included, but it was otherwise assumed that technologies are the same for all analysed farms engaged in a certain activity.

Variable costs (VC_{ij}) were simulated at the activity level using a similar approach:

$$VC_{ij} = SO_i * P * b_{i,s,j}$$

They are defined as a percentage share (P) of SO_i. To adjust the variable costs for each state of nature (j) and each selected scenario (ss), an index generated from the triangular distribution ($b_{i,s,j}$) was included, defined by minimum, maximum and most likely values. Also for variable costs, two different scenarios (ss) were considered. They are based on the binominal distribution (ss_1, ss_2; p_{ss1}, p_{ss2}). In this case the first scenario includes 'normal risk' where minimum and maximum values are in the range of the normal few years' average. The second scenario (ss_2), as for the third revenues scenario (s_3), anticipates catastrophic events.

Evaluation of potential indemnities

Analysing potential income losses, one is interested in the likelihood of a holding's actual income falling below a certain threshold level. In the current analysis, two aspects were considered: (a) if income loss is greater or equal to 30 per cent of reference income (I_T), indemnification is triggered; (b) in such a case losses could be indemnified for no more than 70 per cent of total income loss.

Even though the EC's proposal of an income stabilisation tool (EC, 2011) states that support may be granted only when the loss of income exceeds 30 per cent of the average annual income of the individual farmer in the preceding three-year period or a three-year average based on the preceding five-year period excluding the highest and lowest entry, the average value derived from all iterations of the simulation was used. Namely, from the incomes calculated for different states of nature (I_{fi}), the reference average (expected) income (EI_f) was calculated for each farm. This value serves as a baseline for calculating the threshold level (I_T) for triggering indemnification ($Indemnity_j$):

$$I_T = EI_f * (1 - 0.3)$$

$$Indemnity_j = \begin{cases} 0; if\ I_T \leq I_{fi} \\ 0.7(EI_f - I_{fi}); if\ I_T > I_{fi} \end{cases}$$

So indemnification ($Indemnity_j$) for each analysed farm is only triggered when the observed income in a particular state of nature I_{fi} falls below this level. In such a case, 70 per cent of total income loss ($EI_f - I_{fi}$) in that particular year is compensated.

The manner in which the reference income level is calculated or estimated influences the indemnification significantly. Finger and El Benni (2014a) showed that not considering income trends when specifying reference income levels in such an IST may cause biases.

One of the results of this analysis is the number of cases in which farmers would be entitled to indemnification. However, it should be noted that only those farms that meet certain conditions are entitled for compensation. In practice, this means purchasing such an instrument or paying a premium. In the model, this assumption was relaxed and only farms exceeding the threshold level of average income (EI_f) were considered to participate.

A special approach was developed to assess income losses and potential indemnities. The reference income level (I_T) serves as a baseline to identify whether and by how much a farmer is indemnified in a specific (average) year. In the first step of assessing the probability of income loss and the potential indemnification concept of the IST, the model simulates income losses in 5,000 iterations for each farm in the database (59,629 in total). In the next step, which losses[2] should be considered are defined, with respect to the probability of their occurrence (percentiles). Thus, when calculating the average loss and, consequently, the average compensation, only those losses are considered that occur with a certain probability. For the purpose of this study, only those losses whose probability of occurring is greater than 20 per cent were considered. This was an arbitrarily set assumption. Such an approach reduces the expected loss of income, but the obtained solution is more stable. Namely, with this approach, events with a very low probability of occurrence and with a large impact on the expected compensations are omitted. A possible approach would be also to conduct sensitivity parametric analysis, allowing for the analysis of different scenarios in order to explore the spectrum of possible events (e.g. optimistic, average and pessimistic). In this study, the 20th percentile was used, indicating an average situation.

Using the presented approach, indemnities were estimated for each farm in the group. However, as the core purpose of this study was to analyse the characteristics of indemnification at the level of groups of farms with similar production types or economic sizes, these results were further aggregated accordingly. Thus, besides deviations for individual parameters at the farm level, differences within the analysed group of farms were also considered in the analysis.

Scenario analysis for farms participating in an IST

In addition, the difference of the average level of indemnification in different situations was outlined for illustrative purposes. A simple rule was applied regarding the participation of a particular farm in such a scheme, as well as regarding the conditions under which it would be indemnified. To show the robustness of the applied approach, two scenarios are presented with different assumptions regarding farm participation: (A) all farms achieving at least positive average income would participate, and (B) average annual realisation of income should be greater or equal to EUR 12,000 for the farm to be eligible for participation. Assumption (A) is supported by the fact that farms with negative incomes are usually treated differently, as is stressed by Liesivaara *et al*. (2012) and Finger and El Benni (2014b); thus they were omitted also from this analysis. The EUR 12,000 threshold level for scenario B was arbitrary and regarding the calculations in this paper these farms are serious business holdings employing at least one full-time person.

Results and discussion

The results relating to income losses and participation in the potential income stabilisation scheme for the Slovenian agricultural sector are presented in Table 2. Aggregate results for all 21 production types are also shown, with further division into economic size classes (Table 3). The results include both scenarios' threshold levels of average income (A and B) regarding the participation of farms in such a tool.

Almost 98 per cent of farms achieve a positive average income (Table 2) and would therefore participate in such a scheme. In that context, it should be recalled that direct payments, a major component of incomes (Severini *et al.*, 2016), are assumed to be fixed, which is also important reason for such a result. Since direct payments are considered as part of farm income, it is important to stress the finding of El Benni *et al*. (2016), which is that an area-based direct payment has a U-shaped effect. This means that such payments at first reduce and later increase the probability of a severe income drop.

Under the assumption that only income losses greater than 30 per cent of average income are considered, almost 25 per cent of farms would be eligible for indemnification. This analysis does not consider off-farm income, but it is interesting to note that El Benni *et al*. (2016) found that in the case of Swiss farms the probability of indemnification those without any off-farm income is 19 per cent and increases to 29 per cent if the share of off-farm income increases.

The largest share of farms eligible for indemnification comes from groups of farms with permanent crops (exclud-

[2] In this exercise only losses greater than 30 per cent of average income are considered.

Table 2: Farms participating in income insurance scheme and estimated indemnities for different sectors, classified according to different threshold levels A and B.

Production type	No. farms	Threshold to participate in the scheme	Sum of total indemnity (>80%)	Entitled farms	Average indemnity	Sum of total indemnity (>80%)	Entitled farms	Average indemnity
		A | B	Threshold A			Threshold B		
		%	EUR 1,000	Number	EUR	EUR 1,000	Number	EUR
11-Agriculture	4,327	0.99 | 0.03	540.68	2,015	268	90.09	11	8,190
12-Hop	90	1.00 | 0.73	1,335.92	89	15,010	1,306.57	66	19,797
13-Agriculture mixed	1,026	0.97 | 0.01	29.70	190	156	0.00	0	
14-Forage production	5,910	0.99 | 0.01	74.74	566	132	0.00	0	
P2-Vegetables	284	1.00 | 0.07	531.67	281	1,892	197.81	19	10,411
31-Vineyards	1,581	0.99 | 0.01	1,301.34	1,552	838	337.40	13	25,954
32-Fruits	1,140	1.00 | 0.10	3,029.87	1,080	2,805	1,820.11	117	15,556
33-Olive plantations	173	1.00 | 0.01	7.95	28	284	0.00	0	
34-Permanent crop mixed	584	1.00 | 0.02	613.99	470	1,306	286.12	7	40,875
41-Dairy production	5,909	0.94 | 0.33	1,771.49	1,564	1,133	106.71	22	4,850
421-Suckler cows	2,391	1.00 | 0.01	0.25	3	82	0.00	0	
422-Beef	7,436	0.99 | 0.02	187.12	520	360	18.89	4	4,723
43-Cattle mixed	5,795	0.98 | 0.02	147.37	615	240	3.74	1	3,740
44-Small ruminants	2,389	1.00 | 0.02	14.23	76	187	0.00	0	
45-Grazing animals mixed	2,169	0.99 | 0.02	24.06	168	143	0.00	0	
51-Pigs	498	0.90 | 0.10	1,109.36	445	2,493	585.14	45	13,003
52-Poultry	240	0.96 | 0.45	971.77	197	4,933	692.37	87	7,958
53-Granivores mixed	88	1.00 | 0.14	78.31	78	1,004	31.73	5	6,345
P6-Crop mixed	4,977	0.99 | 0.01	614.86	1,936	318	107.38	16	6,711
P7-Livestock mixed	3,564	0.99 | 0.03	311.40	603	516	30.26	7	4,323
P8-Mixed farming	9,058	0.99 | 0.03	1,133.87	2,587	438	359.82	26	13,839
Total	59,629		13,829.93	15,063		5,974.14	446	

Threshold A: to participate in IST, average farm income must be positive; Threshold B: to participate in IST, average farm income must be equal to or greater than EUR 12,000
Source: own data

Table 3: Sum of total indemnities (EUR 000, bold text) and share of entitled farms (per cent, italics) by farming type and economic size class under scenario A.

Type	1		2		3		4		5		6		7		8		9		10		11		12		13		14	
11	**79**	*66*	**121**	*51*	**103**	*29*	**49**	*17*	**37**	*13*	**75**	*19*	**60**	*28*	**16**	*17*	**0**	*0*	**0**	*0*			**0**	*0*	**0**	*0*		
12							**2**	*100*	**5**	*100*	**29**	*100*	**80**	*100*	**532**	*100*	**415**	*94*					**124**	*100*	**149**	*100*		
13	**6**	*22*	**11**	*18*	**7**	*12*	**5**	*22*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*												
14	**17**	*12*	**20**	*7*	**17**	*7*	**8**	*9*	**10**	*16*	**2**	*2*	**0**	*0*	**0**	*0*	**0**	*0*										
P2	**1**	*100*	**8**	*100*	**16**	*100*	**50**	*98*	**51**	*95*	**137**	*100*	**79**	*100*	**165**	*100*	**25**	*100*										
31	**8**	*92*	**48**	*98*	**135**	*99*	**196**	*99*	**236**	*100*	**228**	*100*	**96**	*96*	**47**	*100*	**34**	*100*	**36**	*100*	**55**	*100*	**74**	*100*	**110**	*100*		
32	**3**	*90*	**21**	*85*	**85**	*92*	**190**	*97*	**243**	*98*	**403**	*99*	**660**	*100*	**540**	*100*	**216**	*100*	**53**	*100*	**65**	*100*	**109**	*100*	**442**	*100*		
33	**0**	*100*	**2**	*41*	**2**	*13*	**2**	*8*	**0**	*0*	**1**	*13*																
34	**1**	*89*	**7**	*76*	**30**	*77*	**61**	*77*	**72**	*88*	**115**	*91*	**48**	*78*	**13**	*67*									**92**	*100*	**175**	*100*
41			**0**	*9*	**5**	*28*	**50**	*28*	**221**	*33*	**681**	*29*	**559**	*20*	**236**	*13*	**20**	*11*	**0**	*0*					**0**	*0*	**0**	*0*
421	**89**	*1*	**0**	*0*	**157**	*0*	**0**	*0*	**0**	*0*	**0**	*0*	**0**	*0*														
422	**3**	*17*	**10**	*7*	**25**	*5*	**40**	*6*	**35**	*9*	**40**	*12*	**19**	*12*	**17**	*20*			**0**	*0*								
43	**2**	*31*	**10**	*16*	**31**	*10*	**38**	*8*	**27**	*8*	**24**	*10*	**16**	*11*	**0**	*0*	**0**	*0*										
44	**2**	*8*	**3**	*3*	**4**	*2*	**2**	*1*	**1**	*2*	**2**	*2*	**0**	*0*	**0**	*0*												
45	**2**	*20*	**6**	*11*	**8**	*6*	**5**	*4*	**1**	*1*	**2**	*4*	**0**	*0*	**0**	*0*												
51	**0**	*71*	**2**	*69*	**6**	*77*	**26**	*96*	**60**	*93*	**241**	*90*	**353**	*92*	**280**	*88*	**71**	*100*							**69**	*100*	**0**	*0*
52	**0**	*0*	**1**	*88*	**2**	*80*	**1**	*100*	**4**	*75*	**17**	*73*	**105**	*86*	**456**	*87*	**169**	*75*	**105**	*71*			**42**	*100*	**70**	*50*	**0**	*0*
53	**1**	*94*	**2**	*82*	**4**	*100*	**4**	*90*	**3**	*100*	**5**	*100*	**4**	*50*	**39**	*88*	**16**	*67*										
P6	**28**	*44*	**86**	*35*	**118**	*38*	**72**	*39*	**50**	*56*	**91**	*57*	**108**	*70*	**36**	*71*	**26**	*100*										
P7	**1**	*25*	**10**	*19*	**22**	*11*	**41**	*16*	**43**	*25*	**61**	*26*	**65**	*41*	**51**	*37*	**0**	*0*	**17**	*100*								
P8	**24**	*66*	**73**	*39*	**160**	*24*	**170**	*21*	**102**	*20*	**137**	*20*	**123**	*24*	**118**	*36*	**22**	*40*			**38**	*100*	**0**	*0*			**169**	*100*

For definitions of economic size classes 1-14 see Table 1; for definitions of farm types see Table 2

ing olives) and granivores (Table 2). The trend is practically parallel to the average frequency of occurrence of income loss greater than 30 per cent, which is expected, as only losses greater than 30 per cent justify their consideration. The trend is similar in other production types, with some discrepancies in the groups with forage production and grazing animals without dairy.

Almost 74 per cent of these farms are classified into economic size class lower or equal to EUR 15 thousand of annual SO (EC 1 – EC 4; Table 2). These small farms receive, under scenario A, 17.4 per cent of estimated total indemnity. However, something less than EUR 5.5 million (40 per cent) of total indemnity goes to economic size classes greater than 7 (SO greater then EUR 50,000), which are larger holdings in Slovenia and account for less than 2 per cent of farms from the sample.

In scenario A, the annual total sum of average indemnities would be on average almost EUR 14 million. The average indemnity payment per farm would range between EUR 82 and 15,000, with significant differences between economic size classes within each production type (Table 3). Although these values could be much higher in a worst-case scenario, in general the average indemnity calculated at the sector level is relatively low (EUR 918) as a consequence of the large number of small farms entitled to low indemnities, as well as the very low probability (less than 20th percentile) of severe income losses (30 per cent). Even though only the sum of total indemnity per group of farms is presented in Table 3, based on the share of entitled farms from the group, the average indemnity for each group (economic size class) can be inferred. Similar results were obtained by Finger and El Benni (2014b), who found that expected indemnities are rather low compared to the average level of incomes in Switzerland and only a small number of farms would actually be indemnified in the case of an IST. Even though they applied a different approach, the findings of El Benni *et al*. (2016) are also interesting in this context. They found that farm size has no effect on the probability of indemnification, while it does have a non-linear effect on its level. The analysis reported here showed that a larger share of indemnities goes to farms within higher economic size classes.

When less likely events are taken into consideration (in the tails of the income distribution for each farm), for example lower values of percentiles, the amounts of indemnities increase rapidly. An extreme example is dairy, where the difference increases exponentially. By considering events that happen with a probability of 5 per cent or more (under assumption A), the total indemnity would increase only for dairy farms up to EUR 4.8 million.

As regards the share of total indemnity (Table 2), the majority of indemnity payments (almost 45 per cent) would go to fruit production, the dairy sector and hop production (A), which represent 18 per cent of eligible farms. On the other hand, mixed farm types (P6, P7 and P8) represent 34 per cent of entitled farms but would receive only 15 per cent of the total amount. However, this share of entitled farms drops significantly if the threshold level is increased (B). In this case, less than 6 per cent of farms exceed the threshold level and, in an average situation, fewer than 450 holdings (13.3 per cent) would be entitled annually. These farms are from the sixth or higher economic size class, which means that the annual SO is higher than 50 thousand EUR in 99 per cent of cases and higher than EUR 100 thousand in 16 per cent. Fifty-four per cent of these farms are in the seventh economic size class (EC 7) with SO between EUR 50 and 100 thousand (data available from the author upon request).

Seventy per cent of farms achieving the threshold level of income (EUR 12,000) are engaged in livestock grazing, with dairy representing more than 80 per cent of these holdings. However, the figures are very different when it comes to indemnification. Only 2.2 per cent of total payments go to farms from this group, which represent 6 per cent of entitled farms (446). In scenario B, the majority of indemnities would go to hop and fruit producers (52 per cent) and an important share (21.4 per cent) would go to granivores (pigs and poultry). In six production types, no farms are indemnified (B). This represents over 1,000 agricultural holdings, which receive 1 per cent of total indemnities under scenario A (in all these cases average indemnities are very low). The sum of total annual indemnity would decrease under scenario B (EUR 6 million), but average indemnity per farm would increase significantly, in some cases by more than thirty times (11, 31 and 34). Calculated at the sector level, the average indemnity would be about EUR 13,500. This is a consequence of the fact that farms in lower size classes do not meet the EUR 12,000 threshold and are therefore not considered.

Conclusions

The novel contribution of the approach presented in this paper is that it is based on the IACS database and therefore enables agricultural sector level analysis. Accounting data at the farm level are not needed, and a preliminary analysis of income risks and indemnification for the sector as a whole is possible. Notwithstanding that the simulations are done at the level of individual activities and aggregated at the holding level, the model is not suitable for analyses of income risks at farm level. For a detailed analysis of an individual farm's risk, it is necessary to have much more detailed data (bookkeeping records) for each farm than those used here.

Despite these strong assumptions in the current version of the model, it is suggested that the described approach gives a sufficiently reliable estimate of income risks and levels of indemnification for a group of agricultural holdings, either at the sector level or within an economic size class. The usefulness of using simulations and analysing the results lies in the improved understanding of income issues at the sector level. This approach yields information regarding the possible magnitude of potential indemnities and beneficiary groups for different sizes and sources of risk.

Even though the current EC proposal calculating expected income suggests a three-year average or a five-year Olympic average to specify the farm-level reference income, the approach adopted here is based on the averages calculated from 5,000 simulation iterations. It would therefore be interesting to analyse in further research how the figures would change if a three- or five-year average was used in the approach using the IACS database.

The results show that there are big differences in indemnities for income losses for different farm types, as well as economic size classes. On average, indemnities are relatively low. This is to some extent due to the direct payments that stabilise farm incomes as shown by Severini *et al*. (2016). Similar results were also obtained by dell'Aquila and Camino (2012), who found that the majority of farmers would receive a few thousand euro. The average indemnity is highly dependent on assumptions regarding farm participation. The average indemnity calculated at the sector level would be EUR 918 in the first case (A), and almost EUR 13,500 when only farms achieving at least EUR 12,000 of average income participate (B). A significant part of income losses is not considered in such a case due to the large share of small agricultural holdings. This finding is in line with El Benni *et al*. (2016), who found that particularly low-income farmers would be indemnified under an IST.

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Is there a relationship between the prevailing model of agriculture and the structure of the crop and livestock insurance markets?

A comparison between the Czech Republic and Poland

Given the strong dependence of its economic results on natural factors, agriculture is characterised by high exposure to risk. This paper explores the relationship between the prevailing 'model of agriculture' in a country and methods of risk management (in particular, insurance schemes). The Czech Republic and Poland are post-socialist countries which are characterised by different models of agricultural development. While agriculture in the Czech Republic is oriented to industrial farming with large farms, Polish agriculture has a bipolar structure that includes both small, family-owned farms and large agricultural holdings. Various approaches to agricultural insurance schemes may arise from the contrasting models of agriculture, and substantial differences in both the demand and supply sides of the crop and livestock insurance markets indicate different policy approaches to the role of agriculture in the economies of the two countries. In both the Czech Republic and Poland, policy options for farm risk management should consider the balance between budget flexibility and the criterion of efficiency (from the perspective of insurers).

Keywords: risk management, agricultural insurance, agricultural finance

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Introduction

Given the strong dependence of its economic results on natural factors (for example, weather-related factors), agriculture is characterised by high exposure to risk. Farmers face both weather and disease risks, of which the former, especially drought, have been more significant in recent years (Potop *et al.,* 2010). Moreover, shifts in agricultural commodity demand and supply have led to relatively strong volatility of agricultural/agrifood prices. This shows that there is a real need to develop new or modify existing risk management tools (Meuwissen *et al.,* 2001; Meuwissen *et al.*, 2006). Insurance is one of the few financial management tools that can mitigate risks in agriculture (Šturcová, 2013).

The topic of agricultural insurance is complex from three perspectives: the state, the insurance sector and farmers. This paper explores the relationship between the prevailing 'model of agriculture' in a country and the methods of risk management (in particular insurance schemes) adopted. It compares the situation in the Czech Republic, where agriculture is oriented to large-sized industrial farming, with that of Poland, where it has a bipolar structure that includes both small, family-owned farms and large agricultural holdings. Various approaches to agricultural insurance schemes may arise from the different models of agriculture that prevail. In this paper, particular attention is paid to the perspective of agricultural policy in both countries.

Following a brief introduction to crop and livestock insurance, we compare, using Farm Accountancy Data Network (FADN) data from 2009 and 2015, the income and financial situation of agricultural holdings in the Czech Republic and Poland. Then, we consider different models of agricultural insurance. We compare the situations in the crop and livestock insurance markets (both from the perspective of demand and supply side), with particular attention to the issue of subsidisation. In-depth analysis has been conducted at the sectoral level on the basis of statistical data from 2009 to 2015 provided by supervision authorities and/or ministries of agriculture. We conclude with political recommendations and suggestions for future research.

Crop and livestock insurance

Crop and livestock insurance are purchased by farmers as forms of financial loss protection. State-subsidised crop insurance programmes strengthen existing components of farming safety nets (Shields, 2015). There is a growing body of literature on subsidised crop and livestock insurance, particularly in the United States and Canada where developed systems of agricultural insurance with a relatively high degree of subsidisation exist. For example, the demand for crop insurance in the United States has been explored by Glauber *et al*., (2002), Sherrick *et al.* (2004) and Goodwin and Smith (2013). Some European countries (such as Spain, Italy and France) have also adopted various solutions (partly subsidised) for risk management in agriculture. Empirical studies dealing with determinants of crop insurance in Europe include Enjolras and Sentis, 2011; Špička and Vilhelm, 2012; Pawłowska-Tyszko *et al*., 2015 and Santeramo *et al*., 2016.

As Santeramo *et al*. (2016, p.640) observed, policy makers, irrespective of the country, "often act to encourage participation in crop insurance programmes, most often through

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the use of large subsidies". The question of subsidising agricultural (crop and or/livestock) insurance systems depends on various factors, including the share of agriculture in GDP and the percentage of the citizens in a country that live in rural areas (Du *et al*., 2016). Santeramo *et al.* (2016, p.653) noted that "although subsidised crop insurance programmes continue to proliferate around the world, participation remains sporadic and not well understood in many cases". They added (p.653) that a significant increase in subsidised crop insurance may be stimulated by "the factors that lead a farmer to adopt insurance and to remain insured". An entrepreneur's receptiveness to agricultural insurance is influenced, among other factors, by his/her attitude towards risk (Ginder *et al.*, 2009). Significant risk aversion may lead to the loss of competitive ability and subsequent withdrawal from the market.

Enjolras and Sentis (2011) identified the following key groups of determinants of demand for crop insurance: (a) environmental variables; (b) financial variables (related to capital structure, financial liquidity); (c) variables related to farm organisation and management; and (d) variables related to options of agricultural policies (including the impact of subsidies on premiums for/of crop and livestock insurance). In particular, a change in subsidising a crop insurance system may increase the number of farmers who are able to buy multi-peril crop insurance (MPCI). Only a few empirical studies evaluate the impact of farm size as a determinant of participation in insurance markets. In Italy there are regional differences (northern vs. southern regions) in demand for crop insurance products (Santeramo *et al*., 2016). This may be explained by the fact that insurance premium rates are different and 'the typical loss ratio' is closer to unity. Several research papers on the issue of mainly crop (less commonly livestock) insurance have focused on the demand side. Goodwin *et al*. (2004), Goodwin and Smith (2013) and Yu *et al*. (2016) looked at dependencies between premium subsides and crop area insured. Some empirical studies (e.g. Goodwin *et al*., 2004; Goodwin and Smith 2013; Weber *et al*., 2015) referred to key insurance issues such as risk aversion, information asymmetry and credit market imperfection.

Agriculture in the Czech Republic and Poland

The agricultural sectors in the Czech Republic and Poland differ as a consequence of their contrasting models of development, as well as due to socio-demographic determinants (greater preference for quasi-social farming in Poland). The basic characteristics of the agricultural holdings indicate higher-level intensification in the Czech Republic (Table 1). Moreover, the average economic size of a farm is around ten times larger in the Czech Republic, the total labour input per farm is more than four times greater, and the average farm land area in the Czech Republic is more than ten times higher. This may indicate not only higher capital intensity and larger scale of agricultural production. In the Czech Republic more than 75 per cent of agricultural land (mainly utilised agricultural area) was rented, which is also associated with the dominance of agricultural holdings in the form of legal entities.

Table 2 presents the overall income and financial situation of agricultural holdings in the Czech Republic and Poland. The gross farm income of Polish agricultural holdings was on average only one tenth of that in the Czech Republic. Moreover, the average value of farm assets in Poland amounted to around EUR 170,000 in 2015, whereas in the Czech Republic it was about four times higher. The subsidy rate (expressed as the ratio of total subsidies to total output) was higher in Czech Republic. However, a significant decrease was noted in both countries over the period 2009-2015. This may be explained by differences in price scissors that lead to different dynamics of total output (Seremak-Bulge, 2016). It should be noted that self-financing has played a significant role in the case of averaged farm household in Poland. The debt-to-assets ratio of Czech agricultural holdings (mainly corporates) exceeded 10 per cent both in 2009 and 2015.

Table 1: Economic situation of agricultural holdings in the Czech Republic and Poland, 2009 and 2015.

	2009		2015	
	CZ	PL	CZ	PL
No. farms represented [SYS02]	14,860	725,670	17,210	735,170
Economic size [SE005] (EUR 000)	242	24	251	28
Total labour input [SE010] (AWU)	6.74	1.70	5.62	1.64
Rented UAA [SE030] / Total UAA [SE025] (%)	84.6	29.3	77.3	25.6
Total UAA [SE025] (ha)	226.1	18.4	204.4	18.5
Total output: crops and crop production [SE135] (EUR)	122,369	11,215	164,244	15,065
Total output: livestock and livestock products [SE206] (EUR)	91,519	10,413	107,215	12,673
Total livestock output / LU [SE207]	887.7	780.1	1170.9	1042.3
Gross farm income [SE410] (EUR)	106,329	12,073	151,053	14,800

AWU: annual work unit; LU: livestock unit; UAA: utilised agricultural area; data from 2015 are preliminary
Data source: Farm Accountancy Data Network

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Gross farm income [SE410] (EUR)	106,329	12,073	151,053	14,800
Farm net income / FWU [SE430]	11,230	4,279	16,365	5,709
Total assets [SE436] (EUR)	739,401	134,133	670,476	169,937
Debt-to-assets ratio (%)	15.0	4.9	30.2	5.7
Total subsidies excluding on investments [SE605] (EUR)	76,336	5,164	83,951	5,136
Subsidy rate: total subsides-to-total output-ratio (%)	15.4	9.8	27.6	18.2

FWU: family working unit
Data source: Farm Accountancy Data Network

Models of agricultural insurance

Table 3 provides a comparison of the insurance schemes in the Czech Republic and Poland. Trends in the agricultural insurance markets in these countries are enumerated with short explanations. Selected areas related to the demand and supply sides of agricultural insurance are highlighted.

In the Czech Republic, agricultural insurance has been

Table 3: Agricultural insurance systems in the Czech Republic and Poland – comparison and trends

Topic	Czech Republic	Poland
Risk factors	Crop insurance: hail, fire, storm, flood, landslide, winter frost damage, and/or for some crops spring frost damage, and/or for vine frost damage; drought and rains during harvest are excluded. Livestock insurance: contagious diseases, other mass diseases, injury or death caused by electrical injury or caused by an electricity outage, loss, death or abstraction of farm animals as a consequence of flooding, poisoning, overheating of animal organism, individual losses.	Crop insurance: As in the Czech Republic (similarities due to very similar climates), but the risk of drought is increasingly perceptible. Livestock insurance: contagious diseases and selected illnesses, hurricane, flood, lighting strike, avalanche, landslide, a sudden fatal accident, robbery during transport.
Legal basis of subsidisation	Crop/livestock insurance compulsory until 1990 but since 1991 voluntary on a contract-to-contract basis. Since 2001 there has been increasing interest in purchasing crop/livestock insurance. State subsidies for insurance schemes have existed since 2004.	Subsidies for crop and livestock insurance premiums (Law of 7 July 2005). Contracts are implemented in accordance with the state budget set out in the Budget Act, Part 32 – Agriculture.
Degree of subsidisation (from the perspective of farmers)	Fifty per cent of the premium paid for livestock insurance as well as for crop insurance. Special crops (e.g. grape, hop, fruit, vegetable, ornamental plants) are eligible for higher rates of subsidy (up to 70 per cent).	Maximum 65 per cent of premiums paid by farmers. Additionally, the amount of subsidies to premiums strictly depends on the sum insured (the upper limit is set by the Executive Acts).
Eligibility criteria for obtaining subsidies	• Fulfilling strict requirements as for SME, consequently family farms may receive subsidies relatively easily. • The amount of the premium is determined by the yield of insured crops per hectare, the insured price chosen, the area of the insured crop, the type of insurance chosen and the agreed amount of farmer's contribution. It will also be affected by the amount of the bonus. • Premium rates vary according to crop type and type of insurance. The premium is always calculated for the entire calendar year and its amount is not changed. The premium for the insurance contract is the sum of the premium for the individual. In insurance for individual crops, rates are increased by 50 per cent, i.e. the basic rate is multiplied by 1.5. The client can also choose to participate in percentages (0, 10 or 25 per cent).	• Contract with insurance companies that entered into an agreement with Ministry of Agricultural and Rural Development. • Subsidies to insurance premiums cannot exceed 65 per cent of the amount of premiums. The upper limit depends on the sum insured (currently 3.5 or 5 per cent depending on the type of plant). • This subsidy represents 60 per cent of the difference between the total amount of claims paid in respect of drought and the amount representing 90 per cent of the silent contributions in the case of damage caused by drought. In the case of non-use, the amount can be used to increase the funds earmarked for subsidies to insurance premiums for crops and livestock.
Supply side: the structure of the insurance market	Similar to oligopolistic competition: Česká pojišťovna; Generali Pojišťovna; Agra pojišťovna; Hasičská vzájemná pojišťovna.	Similar to oligopolistic competition, although some firms have a relatively small share of the market: PZU (dominant, state-owned insurance firm); Towarzystwo Ubezpieczeń Wzajemnych; Concordia Polska Towarzystwo Ubezpieczeń Wzajemnych; Pocztowe Towarzystwo Ubezpieczeń Wzajemnych; InterRisk Towarzystwo Ubezpieczeń SA Vienna Insurance Group.
Transfer of subsidy from the state to farmers	• Agricultural producers must submit an electronic application on the website of the Support and Guarantee Fund for Farmers and Forestry (PGRLF), the operating body for public subsidies for agri-food and forestry economy.	• Direct transfers of subsidies to insurance companies (on the basis of Executive Acts) are based on the bilateral farmer-to-insurer agreement. • Subsidies to an insurer paid once per quarter, on the basis of a request made by the insurance company. • Insurance companies which have concluded an agreement on subsidies and/or contracts of compulsory insurance of crops and entered into a co-insurance agreement are entitled to a special purpose subsidy to cover part of the compensation paid to farmers for losses caused by drought.
Stimulants / constraints on a farmer's decision to buy insurance	• The structure of the insurance market decides on prices and quality of crop/livestock insurance. • Bonus system offered by insurance firms. • Taking into account the dominance of farms that are legal entities, active attitude to risk management (as is typical for non-agricultural business) is preferred. • Discount on insurance premiums in the form of a refund of part of the premium paid.	• Obligation on the farmer to insure a minimum of 50 per cent of the crop comes from the regulations on direct payments. • In the case of very low penalties (EUR 2 for each uninsured hectare) there would be a lower risk aversion towards this type of insurance.
Future perspectives	• A need for setting up a fund for covering catastrophic risks which cannot be managed by farmers or insurance companies – that may be explained by a strong need to reduce budget expenditures on ad hoc payments. • Crop and/or livestock insurance in the packages for farmers: financial and insurance conglomerates offers packages that include both financial and insurance service (cross-selling), moreover, agricultural insurance products are not a significant part of portfolio of insurance and financial firms.	• Higher amount of public subsidy to premium – reasons explored by political economy (in Poland farmers are relatively important in election process). • Including risk of drought in MPCI. However, inclusion of this risk results in a significant increase of the insurance rate (even MPCI insurance companies have been reluctant to offer crop insurance against drought, implementing new regulations has changed this situation).

Source: own compilation

voluntary since 1991 on a contract-to-contract basis. There is market competition on prices and quality of services among the four main insurance companies offering agricultural insurance (Česká pojišťovna, Generali Pojišťovna, Agra pojišťovna, Hasičská vzájemná pojišťovna). Altogether there were six insurance companies, five of which are joint stock companies and one is the organisational unit of the Austrian Hail Insurance company, offering crop or livestock insurance on the Czech agricultural insurance market in 2015, but there is no independent body that fixes tariffs in the Czech market. Agricultural insurance has become more popular since 2001 due to the introduction of a new state support subsidy for insurance programmes. The national subsidies have been processed by the Support and Guarantee Fund for Farmers and Forestry. Support is granted to agricultural businesses complying with the parameters of an SME. Crop insurance is a more significant part of the Czech agricultural insurance market than livestock insurance, because both the share of crop compensation payments and the share of crop premiums written exceeded the figures for farm animals. Nevertheless, agricultural insurance is not a significant source of income for insurance companies. In recent years, agricultural insurance has often been sold in a complex package of financial products.

In Poland, according to the Law of 7 July 2005 on subsidies to crop and livestock insurance premiums, contracts are implemented in accordance with the Budget Act, Part 32 – Agriculture. The state has also provided for the possibility of granting specific subsidy to cover part of the compensation for the damage caused by drought (Figure 1). These expenses are covered from the Budget Act, Part 83 – Provisions. The number of insurance contracts concluded by farmers is limited by the amount of subsidies allocated to the insurance company. The conclusion of the bilateral farmer-to-insurer agreement is followed by the payment of the contribution paid by the farmer to the insurer and the payment of subsidies by the minister responsible for agriculture. Subsidies are therefore part of insurance premiums owed to the insurance companies.

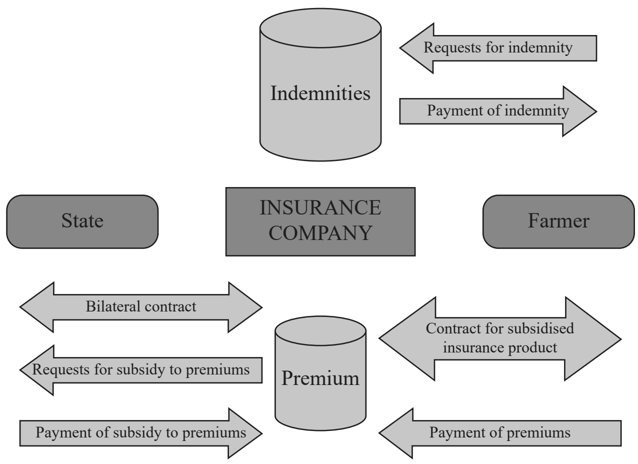

Figure 1: Flow of premium subsidies for crop and livestock insurance in Poland.

Source: own composition based on the Law on insurance of agricultural crops and livestock of 2005

Table 4: Crop and livestock insurance in the Czech Republic and Poland from the perspective of the sector (EUR), 2009-2015.

Description	2009	2010	2011	2012	2013	2014	2015	Change 2015/2009
Czech Republic								
No. crop insurance contracts	3,564	3,836	4,127	4,128	4 246	4,304	4,693	1.32
Sum insured (EUR million)				no data				
Amount of insurance premiums receivables for insurance firms (EUR million)	29.6	34.4	39.8	40.4	39.8	37.4	37.2	1.26
therein: the sum of subsidy to premiums (EUR million)	13.5	15.4	17.1	8.9	9.0	8.8	16.1	1.19
No. livestock insurance contracts	2,210	2,165	2,290	2,172	2,146	2,172	2,150	0.97
Sum insured (EUR million)				no data				
Amount of insurance premiums receivables for insurance firms (EUR million)	10.1	10.0	10.1	9.5	9.2	8.8	8.9	0.88
therein: the sum of subsidy to premiums (EUR million)	3.3	3.3	3.2	2.4	2.9	2.8	3.3	0.99
Area of insured crops (000 ha)	1,412	1,495	1,501	1,500	1,600	1,600	n.d.	
Poland								
No. crop insurance contracts	144,080	134,986	138,425	135,707	151,101	142,492	139,108	0.97
Sum insured (EUR million)	1,501	1,964	2,485	2,888	3,391	3,184	3,273	2.18
Amount of insurance premiums receivables for insurance firms (EUR million)	40.6	51.2	66.0	84.8	89.3	84.9	89.5	2.21
therein: the sum of subsidy to premiums (EUR million)	18.4	24.1	30.7	38.0	39.1	38.5	41.7	2.25
No. livestock insurance contracts	248	279	290	292	307	426	477	1.92
Sum insured (EUR million)	8,782	12,243	13,710	18,891	24,581	57,705	57,260	6.52
Amount of insurance premiums receivables for insurance firms (EUR million)	29.6	39.8	48. 6	59.9	78.1	166.2	164.0	5.55
therein: the sum of subsidy to premiums (EUR million)	13.8	19.4	22.8	29.4	38.5	83.0	81.6	5.92
Area of insured crops (000 ha)	2,808	2,846	3,033	2,751	3,399	3,270	2,824	1.01
No. insured livestock units	235,005	689,200	1,245,670	2,079,000	4,073,830	13,300,000	13,115,432	55.81

Data sources: CZ: reports of Czech agriculture, ČAP (Czech Insurance Association), Agra pojišťovna, PGRLF (Support and guarantee fund for agriculture and forestry); PL: Ministry of Agriculture and Rural Development (based on reports of insurers)

There are no simple regulations in either country concerning the maximum rate that makes farmers eligible to receive public aid. For example, in Poland the maximum amount of subsidy is limited by the percentage of sum insured. A special fund that operates payments of subsidies to premiums is a key feature of the Czech agricultural insurance system.

Subsidised crop and livestock insurance systems

Quantitative data on the level of crop and livestock insurance activity in the Czech Republic and Poland are presented in Table 4. Monetary values (e.g. the sum insured) are expressed in EUR, with exchange rates shown in Annex 1.

Both the number of crop insurance contracts and the amount of insurance premiums receivables for insurance companies have been increasing over a long period in the Czech Republic. According to Land Parcel Information System (LPIS) data, in 2015 the share of insured area to utilised agricultural land was 59 per cent. Approximately 1,500,000 hectares of crops were insured. Crop insurance has been subsidised in the Czech Republic. The loss ratio is much more volatile in the crop production sector than in livestock production because the crop yields and quality are directly affected by adverse weather condition (Ashenbrenner, 2010). The public subsidy for insured farmers has changed in recent years, and was 50 per cent of the premium in 2015 (MZ, 2016). Unlike the crop insurance market, the livestock insurance market has been relatively stable in recent years. There were 2,146 livestock insurance contracts in 2009 and 2,290 in 2015. The highest insurance penetration rate (over 80 per cent) is recorded in cattle insurance; the penetration rate in insurance of pigs and poultry is lower. The public subsidy for insured farmers in 2015 was 50 per cent of premium paid for livestock insurance in the Czech Republic as well as for crop insurance (MZ, 2016). Regarding the risk of livestock disease in the Czech Republic, the share of livestock insured has been around 80 per cent in recent years.

In Poland in the period 2009-2015 the number of 'quasi-voluntary' crop insurance policies (i.e. Polish farmers are obliged to insure a minimum of 50 per cent of the area sown; this results from the directives on direct payments, but in practice is only rarely enforced) averaged approximately 141,000 per year (Table 4). The number of crop insurance policies and the total sum insured peaked in 2013. Moreover, there was a more than two-fold increase in gross premiums collected from policyholders in the period 2009-2015. That resulted in a nearly two-fold increase in the amount paid in premiums and the share of subsidies to crop insurance premiums averaged 45.6 per cent, which practically corresponds to the statutory subsidising level for such instruments. The average share of subsidies for livestock insurance premiums in the analysed period amounted to 48.6 per cent. In the period 2009-2015, approximately 3 million hectares of crops were insured, representing around 20 per cent of the sown area. A notable drop in insured area was reported in 2015 which may be the result of a lack of foresight by the farmers not treating insurance as a risk management tool. The favourable weather conditions for agriculture in 2013-2014 may have made farmers complacent about buying insurance. This fall in crop insurance occurred alongside an increase in the number of insured animals. In the period 2009-2015 the total received insurance premiums in the agricultural sector (voluntary and mandatory) amounted to approximately EUR 152 million, including voluntary contributions accounting for approximately 24 per cent (EUR 37 million). A similar trend can be seen in the voluntary insurance market. The largest annual sums of compensation for compulsory insurance and voluntary (EUR 102-154 million) were paid in the years 2010-2012. In the 2013-2015 period, the value of these claims amounted to approximately EUR 62.0-65.5 million. The largest sum of compensation, EUR 112.9 million, was

Table 5: Premium, indemnities and loss ratio for crop and livestock insurance in the Czech Republic and Poland (EUR), 2009-2015.

Description	2009	2010	2011	2012	2013	2014	2015	Change 2015/2009 or 2015-2009
Czech Republic								
Sum of premium collected – all crop and livestock insurance (EUR million)	39.7	44.4	49.9	49.9	49.1	46.2	46.1	1.16
Total sum of indemnities paid - all crop and livestock insurance (EUR million)	51.0	29.1	26.0	46.1	38.9	27.1	16.8	0.33
Total loss ratio (%)	128.3	65.4	52.0	92.4	79.2	58.6	36.3	-92.0
Poland								
Sum of premium collected – all agricultural business insurance (EUR million)	120.6	138.3	155.6	156.2	156.2	159.8	176.5	1.46
therein: voluntary crop and livestock insurance	21.8	28.3	40.1	43.4	39.0	39.2	44.5	2.04
Total sum of indemnities paid - all agricultural business insurance (EUR million)	51.4	150.6	102.6	154.5	61.9	65.1	65.5	1.27
therein: voluntary crop and livestock insurance	17.9	16.3	49.1	112.9	20.0	27.6	19.0	1.06
Total loss ratio (%)	42.6	108.9	66.0	98.9	39.6	40.8	37.1	-5.5
Loss ratio for voluntary crop and livestock insurance (%)	82.2	57.5	122.3	260.0	51.2	70.4	42.8	-39.4

Note: the total loss ratio (%) is the ratio of *the total sum of indemnities paid – all agricultural business insurance* to *the sum of premium collected – all agricultural business insurance*; the loss ratio for voluntary crop and livestock insurance (%) refers respectively to this aggregated group of insurance
Data sources: CZ: see Table 4; PL: reports of the Polish Financial Supervision Authority, Ministry of Agriculture and Rural Development

paid in 2012. This situation significantly impacted the gross damage ratio.

At 108.9 per cent, i.e. a 66.3 percentage point deterioration from the previous year, the total loss ratio in the market of agricultural insurance in Poland was the highest in 2010 (Table 5). This change did not occur due to the increase in the damage ratio of subsidised voluntary insurance, because a substantial increase in subsidised insurance damage ratio was noted in 2011-2012. A similar trend occurred in Hungary (Kemény *et al*., 2012). The situation in the crop and livestock insurance market is very unstable, which affected a strong fluctuation in the gross damage ratio. In the period 2009-2015, compensation paid by insurers (EUR 262 million) exceeded premiums collected (EUR 256 million). The biggest impact on the overall result was seen in 2012, due to the large number of compensation payments throughout the severe winter. It should be noted that the problem of spring frosts is important, particularly in Polish horticulture (Kaczała and Wisniewska, 2015).

In both countries, strong fluctuations in the gross loss ratios (the Czech Republic from 36.3 to 128.3 per cent; in Poland 39.6 to 108.9 per cent) indicate the need for periodic 'monitoring' of regulations on agricultural insurance and, if necessary, changes to the subsidy system.

Discussion

Accession to the European Union (EU) has meant making some changes to agricultural risk management tools in Poland and the Czech Republic. In both countries, there has been an improvement in the economic and financial situations of farmers (Pawlas, 2015). The Common Agricultural Policy (CAP) has underlined the link between rural economies and the environment. That resulted in the transfer of innovations to the region (Jedlička *et al*., 2014). Agricultural insurance is a very important part of the risk management scheme in the Czech Republic. The system has two functions: it is socially beneficial through reducing the risks associated with agricultural production, ensuring more stable incomes for farmers, and thus contributes to the stability of rural areas (Vávrová, 2010). The demand for private risk management instruments depends strongly on several variables, and the degree of public support (subsidies to premiums) still seems to be crucial (EP, 2016). The system of crop and livestock insurance in Poland is strongly subsidised and covers only 30 per cent of the area sown, whereas the situation in the Czech Republic seems to be quite the opposite.

The crop and livestock markets in both countries (regardless of differences in the scale of production of the agricultural sector or microeconomic intensity and efficiency) strongly depended on public support in the form of subsidies. It should be noted that the issue of subsidised premiums to crop and livestock insurance at country level is affected by determinants related to the competitiveness of the agricultural sector at both the international and EU levels. Risk management schemes have been a policy issue and recipients of public support for a long time: the maximum tariffs were fixed after the WTO Uruguay Round Agreement on agriculture in 1995 (Špička, 2010). The importance of risk management tools (inter alia, crop and livestock insurance products) will increase in the near future. Given the fiscal sustainability at EU and Member State level, after 2020 the role of income support from Pillar I of the CAP may be weakened. This means that crop and livestock insurance will receive special attention from policy makers. Given the criticism of the CAP budget in terms of its function of redistribution, national agricultural policy measures would more actively be engaged by the Czech Republic and Poland. Despite significant differences both in the demand and supply sides of the crop and livestock insurance markets, subsidised crop insurance products in particular, accompanied by ad hoc payments (if necessary), are regarded as an important component of the farming safety net in both countries. However, taking into account the necessity of balancing the budget, excessive support for these two risk management tools (in particular ad hoc disaster payments) is questionable from the point of view of social justice. The United States experience (*vide:* The 2014 Farm Bill) shows that the elimination of direct payments resulted in a notable expansion of price risk management instruments, as well as subsidised crop insurance (Shields, 2015). Differences in models of agricultural development result in difficulties in the adoption of relatively uniform (with only a small number of alternative options) risk management tools.

Since, in the Czech Republic, significant power is held by large agricultural holdings and, compared to the agrarian structure in Poland, family farms are not so dominant, the risk exposure is not equal for all farms. Špička and Vilhelm (2012) found that there is a difference between categories between the yield risk character and price risk at farm level. The risk of price fluctuation has a generally more systematic character and is diversified in a more difficult way. On the other hand, the yield risk is more specific. Moreover, the efficiency of crop production insurance (measured by total loss ratios) is higher in small enterprises specialised in field production than in the largest enterprises. Small farms which are typical for specialised production generally face a higher risk of income variability than large farms with mixed type of farming. The insurance efficiency in the largest agricultural enterprises in the Czech Republic is low and insurance represents for these enterprises' costs rather than benefits due to the distribution of risk over a large and diverse territory. As for livestock production, the negative trend in insurance premiums written for farm animals has been caused by the long-term decline in the number of farm animals. This decline surpassed the fall in the insurance premiums written, which corresponds to a stable proportion of livestock insured. An important issue in livestock insurance in the Czech Republic is the extent to which it can influence farm behaviour. Meuwissen *et al*. (2006) considered incentives for risk management when designing epidemic insurance. They concluded that classifying farms based on their epidemic disease risk and use of deductibles was an important step in aligning incentives with policy goals.

In Poland, falls in purchases of crop insurance (e.g. since 2013 there has been a significant decrease in the purchase of crop insurance policies) is especially alarming. This situation may have occurred due to the high prices of this type of policy (Pawłowska-Tyszko, 2015). The problem currently faced both by the insurance companies and farmers is still the high cost of a single policy. One of consequences of increased subsidised insurance claims is a limited risk exposure of insurance companies.

As Shields (2015, p.23) stated, "premium subsidies are too generous for farmers, particularly high-income farmers, and expect that farmers would maintain crop insurance coverage at lower subsidy rates", and this viewpoint can refer to the situation in Poland. In both the Czech Republic and Poland, policy options for farm risk management should consider the balance between budget flexibility and the criterion of efficiency (from the perspective of insurers). This also refers to identifying potential paths for development of insurance markets (Soliwoda, 2016). The risk management support in the Czech Republic after 2014 does not use EU funds from the Rural Development Programme; it depends on national financial sources, either in the form of direct support (premium subsidies, ad hoc aids) or indirect support of prevention (disease fund, recovery fund). In order to eliminate any unexpected need for ad hoc aid, it is highly desirable to establish and contribute continuously to a fund for covering catastrophic risks which cannot be managed by farmers or insurance companies (Vilhelm *et al*., 2015). The problem of how to subsidise risk management tools is also important in the agricultural sectors in some other Central and Eastern European countries, for example Bulgaria (Lefebvre *et al*., 2014) and Serbia (Zarkovic *et al*., 2014).

Avenues for further research should include empirical studies at micro level (based on geographical data, GIS, survey-based research). However, utilisation of more complex methods (more example, regression based on GIS data) depends on the quality of databases provided by national FADN liaison agencies.

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Annex

Annex 1: Currency exchange rates 2009-2015.

Exchange rate	2009	2010	2011	2012	2013	2014	2015
PLN/EUR	4.33	3.99	4.12	4.19	4.20	4.19	4.18
CZK/EUR	26.45	25.29	24.59	25.14	25.97	27.53	27.28

Data source: annual averaged data of national banks

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The economic effect of Russia imposing a food embargo on the European Union with Hungary as an example

In the summer of 2014, Russia imposed a food embargo on most agricultural products from countries that supported the anti-Russian sanctions. In this study we use vector autoregression and neural network modelling to assess the effect of the embargo on the bilateral trade relations between the European Union (EU) (using the example of Hungary as an EU Member State) and Russia. In particular, the changes in the dynamics of Hungary's aggregate agricultural exports in response to the shock of the embargo, as well as to Russia's imports of products banned under the embargo, are analysed. The work also looks at the effectiveness of the introduction of the embargo with the aim of implementing import substitution policies and supporting domestic producers. Our results show the ineffectiveness of the Russian import substitution policy and the negative effects on both Russian and Hungarian parties.

Keywords: Russian embargo, Hungarian economy, shock analysis, artificial neural networks, vector autoregression

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Introduction

On 7 August 2014, Russia introduced an embargo on a number of agricultural products from Australia, Canada, the European Union (EU), Norway and the United States (US)[2]. The list of banned products included all meat, milk and dairy products, fruits, vegetables, fish and crustaceans. The embargo was introduced as a response to economic, technological and financial sanctions against Russia.

There is no agreed opinion among economists regarding the effect of imposing sanctions on the optimal allocation of resources, as well as the magnitude of losses incurred by both the exporters and the importers of products falling under the embargo. Moreover, a food embargo can have a significant effect on the distribution channels of both the country that imposes sanctions and the countries against which these measures are directed (McGillivray and Smith, 2005; Kaempfer and Lowenberg, 2007). In this case, the final impact on prices and the number of products produced will depend on the demand for imports and the elasticity of supply, the production volume affected by the restrictions, and the degree of substitution of imports by domestic production and the possibilities of imports from other sources (Caruso, 2003; Marinov, 2005; Eyler, 2007).

The literature on economic sanctions shows that they can be ineffective tools to achieve the desired goals since they have a limited effect on the welfare of the country on which sanctions are imposed. This becomes especially notable when an import embargo is imposed since the exporting country can redirect exports to other countries effectively, or resell products through countries that did not fall under these sanctions. In particular, the EU, despite the reduction in exports of agricultural commodities, food and beverages to Russia by 2 per cent in value terms in 2016, has increased food exports to China, Japan, Switzerland and the US[3].

It should also be noted that, according to some authors (for example, Kutlina-Dimitrova, 2015), the countermeasures introduced by Russia have had a rather ambivalent effect on the EU economy. In particular, the embargo led to a decrease of only 0.02 per cent in total EU exports, which indicates a strong mitigating effect of the EU internal market. At the same time, the general changes in exports are strongly limited by the boundaries of individual countries and products. Dairy products, and vegetables and fruits are the sectors in which the EU's exports experienced a significant decline, in particular from Lithuania, Finland and Poland. In the short term, the EU can replace about one fifth of the lost trade in banned goods with Russia by expanding exports to other markets, particularly to Asia. Although Russia can replace the imports of certain banned products, alternative sources are limited. Regions with increasing exports to Russia include Turkey and the Commonwealth of Independent States (CIS) countries (dairy products, and fruits and vegetables), and South America (meat) (Van Acoleyen, 2015; Boulanger *et al.*, 2016; Firanchuk, 2017).

For Russia, the embargo led to a change in the commodity and geographical structure of its imports. The ban on the importing of certain food products led to a sharp restriction of competition in the Russian market, which in turn led to an increase in the prices of substitute products for sanctioned products. There are two effects of the embargo on the domestic Russian market: consumer and production. The consumer effect was expressed in the decrease in the level of the welfare of citizens, due to the rise in prices. The production effect is the result of the growth of profits of agricultural producers, caused by the restriction of import competition.

The imposed prohibitions enforced the search for alternative import channels for products through countries that were not on the ban list. For individual goods, for instance, cheese, importing of products continues to be carried out under the guise of a de-lactose. At the same time, the quality of the products produced, due to a ban on imports of milk,

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2 Decree No. 778 of the Government of the Russian Federation of 7 August 2014 'On Measures for the Implementation of the Decrees of the President of the Russian Federation of 6 August 2014 No. 560, 24 June 2015 No. 320 and 30 June 2016 No. 305' (Collected Legislation of the Russian Federation, 2014, No. 32, Article 4543, 2015, No. 26, Article 3913, No. 33, Article 4856, No. 39, Article 5402, 2016, No. 10, Article 1426, No. 23, Article 3320, No. 28, Article 4733, No. 38, Article 5546, No. 44, Article 6142).

3 See http://ec.europa.eu/trade/policy/eu-position-in-world-trade/statistics/ and https://www.vedomosti.ru/business/news/2017/01/18/673513-evrosoyuz-eksport-prodovolstviya.

has significantly deteriorated, which has led to the spread of falsified and counterfeit products.

Ponomareva and Magomedov (2017) assessed consumer losses as a measure of compensated variation in income when Russia imposed an embargo on certain types of goods from the EU and the US. Estimates were made on the basis of a comparison of actual and forecasted price indices for goods. It was assumed that, in the absence of a product embargo, the dynamics of prices for consumer goods can be described by the standard ARIMA model (Contreras *et al.*, 2003; Al-Zeaud, 2011; Uko and Nkoro, 2012). To take into account the peculiarities of certain types of goods, they were divided into groups of analogue goods to sanctioned ones and non-sanctioned goods. The results of the analysis showed negative consequences for both the consumer and the domestic producer. The assessment of consumer losses which resulted from the embargo showed that, in the absence of restrictions, the prices of the sanctioned goods would be lower than current values by about 3 per cent, and the prices of the non-sanctioned goods by 2.9 per cent. The monetary losses of consumers in annual terms for the period 2014-2016 amount to RUR 4,380 per year per consumer. From the manufacturer's point of view, the greatest benefit of imposing sanctions came in the first 6-12 months; the increase in prices and the drop in consumption volumes are the result of a reduction in commodity markets. This fact confirms the negative effect of the introduction of Russia's retaliatory sanctions for the manufacturer: the imposition of an embargo gives advantages to producers only in the short term, thereby having a positive effect on import substitution, but in the long term the effect of the embargo on market indicators is reduced.

Our paper adopts a novel approach in analysing the dynamics of agricultural trade, concerning the effect of the embargo. The research published in the literature has been of limited scope, being mostly in the form of depictive statistics about the embargo or estimations of the geopolitical risks (see Bond *et al*., 2015). In contrast to papers by, for example, Antimiani *et al*. (2014) and Kutlina-Dimitrova (2015), who modelled simulations of calibration of the prohibitive tariff rates, with results on the equilibrium, our paper assesses the effects of export/import shocks. The novelty of our research is how the dynamics of possible exports/ imports can be analysed, with propositions to that case, if the embargo had not been introduced.

We study the effect of introducing Russia's embargo on the EU using the example of Hungary. According to Hungarian Central Statistical Office data, Russia has been the fifth to the twelfth largest trading partner of Hungary during the period of our research. The country's share of trade peaked eighteen months before the start of the embargo.[4,5]

Within the framework of the study, a vector autoregressive model was constructed to analyse the dynamics of Hungary's agricultural exports before and after the introduction of the embargo. We also employed artificial neural network for the modelling of the scenario, in which no embargo would be imposed. The main objectives of the study were the following: (a) analysis of the impact of the Russian embargo on Hungary's total exports; (b) analysis of the dynamics of Russian imports of agricultural products after the introduction of the product embargo; and (c) analysis of the effectiveness of import substitution policies.

Methodology

Data sets

As a methodological basis for the embargo analysis, we employed the indicators listed in Table 1. These indicators were implemented for the groups of goods listed in Table 2. By the targeting of the Russian import substitution policy, the most relevant goods were chosen. Consequently, this scope of (Hungarian exports/Russian imports) goods reflects the most significant changes in export/import relations.

Table 1: Indicators used for the embargo analysis.

Hungary	Russia
• Statistics of total exports from August 2014 to December 2015; • Neural network forecasts (the statistics for the neural network learning are from January 2011 to July 2014), which allows analysing the dynamics of possible exports, provided that the embargo would not have been introduced; • Responses to the export shock (we use the statistics of Hungary's total exports and exports to Russia, it is important in terms of the analysis of the results to note that exports to Russia are included in total exports).	• Statistics of imports from CIS countries from August 2014 to December 2015; • Statistics of production of sanctioned goods from 2011 to 2016 (only yearly statistics are available); • Neural network forecasts (the statistics for the neural network learning are from January 2011 to July 2014); • Reaction to the import shock (there are significant differences from Hungary, as the data on the CIS and on the import from the other world are presented separately).

Data sources: Hungary: Hungarian Central Statistical Office (http://statinfo.ksh.hu/Statinfo/); Russia: Russian Federal Service of State Statistics (http://www.gks.ru/) Both these data providers apply the Standard International Trade Classification

Table 2: Groups of Hungarian export goods and Russian import goods used in the analysis.

Hungarian export goods	Russian import goods
Meat • ts1: Pork, fresh, chilled or frozen; • ts2: Meat and edible offal of poultry of heading, fresh, chilled or frozen; • ts3: Salted meat, in brine, dried or smoked; • ts4: Sausages and similar meat products, meat offal or blood; Ready-made food products made on their basis. ***Fruits and vegetables*** • ts5: Vegetables, edible root vegetables and tubers (excluding seed potatoes, onion, maize sugar for seeding, peas for sowing); • ts6: Fruits and nuts. ***Cheese*** • ts7: Food or ready-made products manufactured using cheese manufacturing techniques and containing 1.5 per cent by weight or more of milk fat.	***Meat*** • ts1: Fresh and frozen meat; • ts2: Fresh and frozen poultry. ***Fish*** • ts3: Fresh and frozen fish. ***Milk and dairy products*** • ts4: Milk and cream; • ts5: Butter and other dairy fats. ***Fruits*** • ts6: Citrus fruits.

[4] 2011: 2.8 per cent, 2012: 5.7 per cent, 2013: 3.4 per cent, 2014: 3 per cent, 2015: 2.3 per cent.

[5] The importance of trade is even higher for some agricultural goods. For example, in 2013 Russia took 12 per cent of Hungary's pork exports, being the fourth most important destination for the country, while Hungary supplied 2.5 per cent of all Russian pork imports, which ranked the country in twelfth place.

Vector autoregression

Vector autoregression (VAR) has the following form:

$$y_t = a_0 + A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + \varepsilon_t = a_0 + \sum_{n=1}^{p} A_n y_{t-n} + \varepsilon_t \quad (1)$$

where a_0: constant vector; $A_1 \ldots A_p$: matrices of model parameters (autoregression coefficients); y_t: the vector of time series; y_{t-p}: the vector of previous values of time series; and ε_t: the vector of random errors.

Model fitting

We used Akaike Information Criterion (AIC) (Akaike, 1973) and Bayesian Information Criterion (BIC) (Adkison *et al.*, 1996) to determine the optimal lag order in terms of model accuracy. We chose the minimal lag from both criteria which is 2. We applied root mean squared error for estimation of the model. After fitting VAR, we were able to provide shock analysis. For this purpose, we employed impulse response function analysis (Pesaran and Shin, 1998), we used exports to Russia as a shock for Hungary and imports from sanctioned countries as a shock for Russia. The value of the shock is one standard deviation of time series.

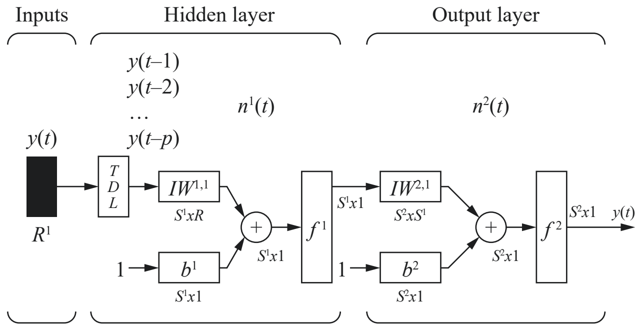

Figure 1: Nonlinear autoregressive neural network architecture.
Source: Leontaritis and Billings (1985)

Neural network

As a neural network, we employed nonlinear autoregressive neural network (NAR) (Leontaritis and Billings, 1985; Figure 1). NAR is defined by the following expression:

$$y_t = F(y_{t-1}, y_{t-2}, \ldots, y_{t-p}) + \varepsilon_t \quad (2)$$

where $F(\cdot)$: nonlinear function, approximated by neural network; y_t: the vector of time series; y_{t-p}: the vector of previous values of time series; and ε_t: the vector of random errors.

In order to train the neural network, we divided the raw data into three groups: Train: 70 per cent; validation: 15 per cent; and test: 15 per cent. We chose a mean squared error as a parameter for neural network performance estimation and levenberg-marquardt algorithm for training. All the data were standardised before the neural network processing.

Results

From the modelling, we provided an analysis of the impact of the embargo shock on the change in the dynamics of Hungary's aggregate exports to all countries for agricultural products banned from import into Russia. In addition, we assessed the changes in the dynamics of the production of banned agricultural products and, as a consequence, the evaluation of the effectiveness of import substitution policy.

Analysis of Hungarian exports

To a large extent, the embargo affected the change in Hungary's total exports of meat, as well as fruits and vegetables (Figures 2 and 3). Among meat products the embargo has had the most negative impact on sausage exports. The reaction to the shock of the embargo showed a 5 per cent drop in Hungary's total exports to all countries. At the same time, the stabilisation of exports occurred only five months after the shock, which exceeds the average value for the rest of meat products for a month.

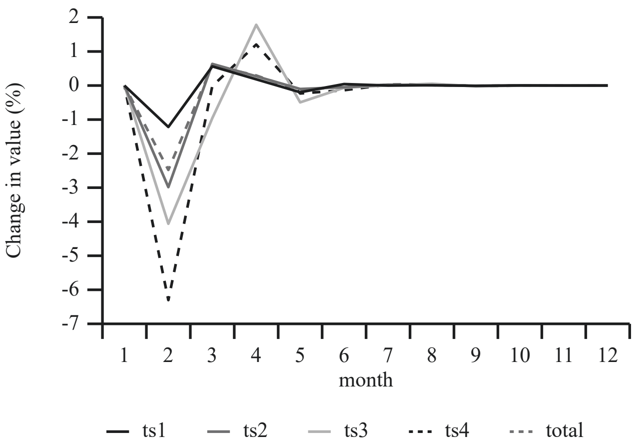

Figure 2: Monthly percentage change in the value of meat exports from Hungary following the imposition of the Russian embargo, 1 August 2014 to 1 July 2015.
See Table 2 for groups of goods
Source: own data

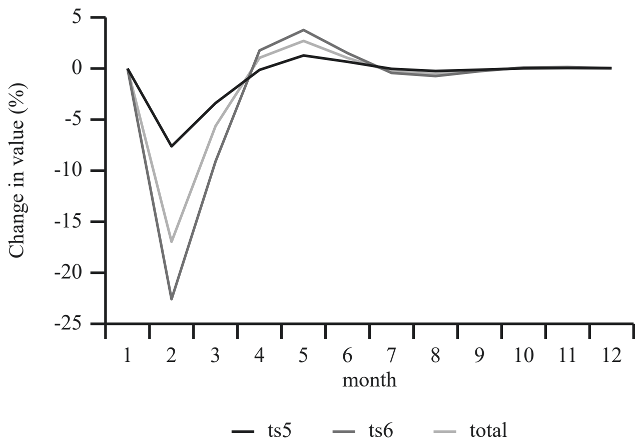

Figure 3: Monthly percentage change in the value of fruit and vegetable exports from Hungary following the imposition of the Russian embargo, 1 August 2014 to 1 July 2015.
See Table 2 for groups of goods
Source: own data

The forecast of the NAR model showed an improvement in the exports of meat products over the same period of time (Table 3). This can be explained by the fact that the NAR forecast was built on the basis of normal economic relations between the two countries, i.e. the 'no embargo' scenario. At the same time, the real dynamics of Hungary's total exports of meat products remained on average unchanged. Thus, the agricultural embargo led to a reduction of the possible positive dynamics of exports which, ultimately, reflects the absence of changes in the real dynamics of the total exports of meat products by Hungary.

The dynamics of Hungary's exports of vegetables and fruits are also strongly negative. The impulse responses from this analysis reveal the ineffectiveness of the redistribution of banned goods intended for export from Hungary to Russia. In particular, as regards fruit exports, the reaction of the model to shock is an 18 per cent drop in export dynamics. Stabilisation comes seven months after the introduction of the embargo. The NAR shows mixed forecasted dynamics over a period of six months after the introduction of the embargo in fruit and positive dynamics in vegetables. The

Table 3: Nonlinear autoregressive neural network forecasting for Hungarian exports, August-December 2014 (per cent).

	Meat	Fruits	Vegetables	Cheese
August	3	7	4	-1
September	10	6	2	-3
October	8	-1	-3	5
November	-8	-10	9	-1
December	2	3	5	2

Source: own data

real dynamics of Hungary's exports to all countries over the same period is negative. Comparison of the real dynamics with the dynamics of both models showed that exports of fruits and vegetables were the most sensitive to the embargo. At the same time, Hungary failed effectively to redirect the former Russian exports of fruits and vegetables to other countries, which eventually led to a coincidence of the results of embargo shock modelling and real export dynamics.

Concerning cheese exports, the models did not show any significant change; nonetheless, the results correlate with the real dynamics (Figure 4). We conclude that cheese is not an indicative parameter for the analysis of the embargo effect since there are no significant movements from all the models and in real dynamics.

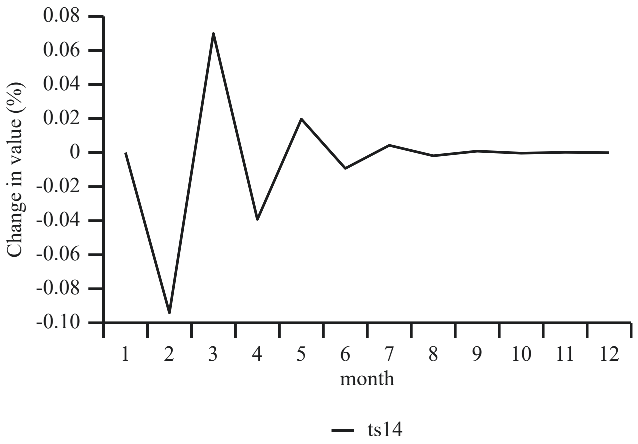

Figure 4: Monthly percentage change in the value of cheese exports from Hungary following the imposition of the Russian embargo, 1 August 2014 to 1 July 2015.

Source: own data

Analysis of Russian imports and production

The shock of the embargo has led to a regional transformation of import flows. In this case, for different groups of goods, substitution is not homogenous. In particular, the impulse responses show that the imposition of the embargo causes a sharp increase in imports of meat products from the CIS (Figure 5), but a sharp drop in imports is observed for fish and citrus fruits (Figure 6). In particular, imports of citrus fruits fell by 11 per cent, although the dynamics of the decline in imports is significantly reduced, it can be viewed as impossible to substitute imports of this agricultural product with supplies from the CIS countries.

The forecast of the NAR also confirms the reorientation of Russia's imports to the CIS countries after the imposition

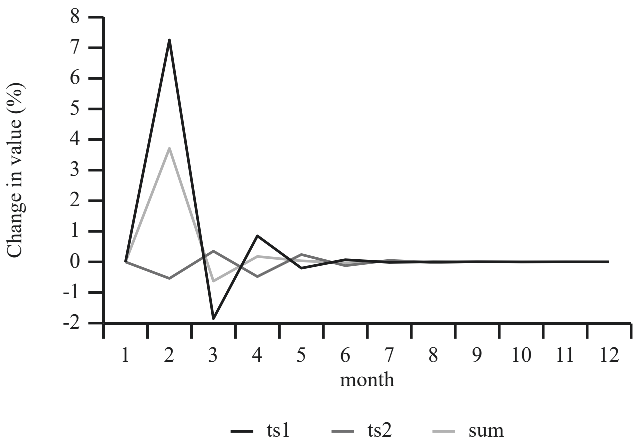

Figure 5: Monthly percentage change in the value of Russian meat imports from CIS countries following the imposition of the Russian embargo, 1 August 2014 to 1 July 2015.

See Table 2 for groups of goods

Source: own data

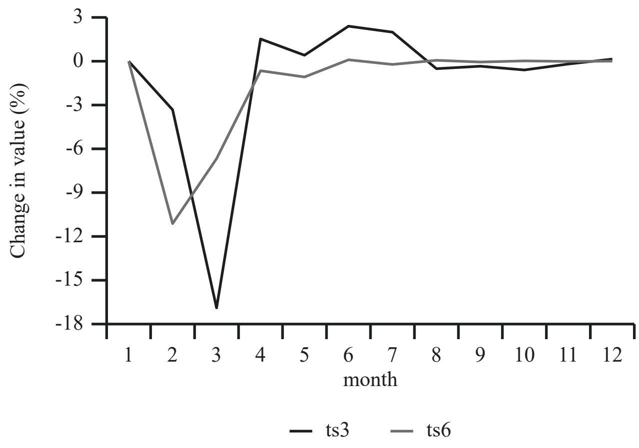

Figure 6: Monthly percentage change in the value of Russian citrus fruit imports from CIS countries following the imposition of the Russian embargo, 1 August 2014 to 1 July 2015.

See Table 2 for groups of goods

Source: own data

of the embargo. The decline in imports from the whole world leads to a simultaneous increase in imports from the CIS countries (Table 4). Nevertheless, the real dynamics for the period of September-December 2014 confirm the model data only in terms of fish imports. In particular, there was a 17 per cent decrease in fish imports during the first six months of the embargo. The most significant decrease in real dynamics, 34 per cent, occurred for cattle meat. As regards imports of vegetables and fruits (Figure 6), which for the same period fell by no more than 15 per cent, Russia succeeded in coping with the consequences of the embargo relatively effectively.

Thus, the introduction of the food embargo did not change significantly the annual indicators of agricultural production. (Table 5). This shows that the effectiveness of the import substitution policy is limited and brings no significant positive effect of the embargo on domestic producers in a long-term perspective.

Table 4: Nonlinear autoregressive neural network forecasting for Russian imports from all countries and from CIS, August-December 2014 (per cent).

	All countries				CIS			
	Meat	**Fish**	**Milk**	**Fruits**	**Meat**	**Fish**	**Milk**	**Fruits**
August	3	-5	0	-4	-4	10	5	-2
September	10	-10	-7	0	5	3	15	-6
October	8	1	3	-1	18	2	1	13
November	-8	-2	-2	-8	3	-3	-2	-7
December	2	-4	7	-17	1	1	10	-11

Source: own data

Table 5: Agricultural production growth in Russia, 2011-2015, per cent.

	2011	2012	2013	2014	2015
Meat	4	6	5	6	4
Fish	-1	0	-4	1	0
Milk	55	-10	2	4	7
Vegetables	21	0	0	5	4
Fruits	17	6	10	2	-3

Source: own data

Discussion

In this paper, an econometric analysis of the food embargo imposed by Russia since August 2014 was conducted. The analysis was carried out using the vector autoregressive model, which allowed the effect of the product embargo on the dynamics of Hungary's aggregate agricultural exports to be simulated and the responses of export-dynamics to the embargo shock to be analysed. The NAR was implemented to assess the forecast of the dynamics of Hungary's exports and imports of Russia in the absence of an embargo and in the normal bilateral trade turnover of the countries.

The study examines the influence of the embargo policy on the development of the Russian agricultural sector. The results confirm the negative effect of the introduction of the embargo for both countries, in particular, for most of the general exports. Hungary has failed to replace exports to Russia effectively. In turn, Russia has managed to replace the supply of agricultural products effectively only for vegetables and fruits, reorienting imports to the CIS countries, but has failed in other directions. Thus, contrary to the opinion that the Russian embargo has had an insignificant impact on the EU economy and the changes in exports of certain countries are very limited (Kutlina-Dimitrova, 2015), our results show that the embargo has had a negative effect on Hungary. However, the effect of the embargo on Russia is negative too, because of the limited possibilities of redirection of the imports as shown by Van Acoleyen (2015). Also, the results of the modelling reveal the ineffectiveness of the Russian import substitution policy, aimed to maintain domestic producers. Thus, it is minus-minus game, which brings no profit for both parties of international trade.

The production of domestic agricultural products in Russia, despite the introduction of the food embargo, has remained predominantly at the level of 2012-2013, continuing the trend to reduce production growth rates after the active overheating of the food market in 2011. Thus, the advantage for the domestic producer was exhausted in the first six months of import stabilisation after the embargo was imposed. Thereafter, the growth in prices for domestic and imported products and, as a consequence, the decline in the level of the welfare of people caused a reduction in the demand for domestic agricultural products.

Our work emphasises the problem of assessment of embargo policy effectiveness, which is reflected in the methodology. However, most existing models employ principles which were initially developed for scenario analysis and could not provide any estimation of policy effectiveness. Thus, the proposed model includes the following output signals for the analysis: statistics of imports/exports, statistics of production of banned goods, neural network forecasts, and responses to the shock from the food ban. We would like to extend the implementation of the neural network forecasts and response to shock from the VAR model. Neural network forecasts allowed the dynamics of possible exports/imports to be analysed as if the embargo had not been introduced. Responses to the shock illustrated the course of events if there was no regulation targeted to stabilise the situation. This approach employs mathematical modelling for the analysis itself, but not for the hypotheses confirmation, thus the model allows deeper analysis of the effectiveness of the embargo policy.

The Russian embargo has caused great concern for the Hungarian dairy and pork industry. It has pushed down the purchase prices for farms, causing them severe operating losses. This deterioration of profitability has contributed to delays in planned investments and capital expenditure. As our results show, the shock has been asymmetric: the Hungarian economy (with its smaller market size and absorption capacity) has suffered for more than the Russian economy since the introduction of the embargo. The ban runs until 31 December 2018, and a major policy question is what kind of fiscal initiatives are to be introduced in the meantime in favour of Hungarian agricultural producers (e.g. assistance with exports to Russia). This question goes beyond the scope of our study, and can be a subject of further research.

Concerning the limitations of the study and possible development of this research, the proposed model is based on machine learning techniques, which are rather universal. On the one hand, it gives significant benefits in model estimation and specification, since it is unstructured by its nature and can be adjusted to any data patterns. On the other hand, it brings limitations to the research, because such models serve as 'black boxes' and do not provide the ability for analysis of intermediate states of cash flows and goods.

In the continuation of this work, it would be interesting to develop a model with a strict structure, such as DSGE or system dynamic models. We would like to implement this model for the scenario analysis and use artificial neural networks for the probability estimation of each scenario. Thus, we will obtain a model which can provide detailed, structural analysis.

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Intra-European Union trade of dairy products: insights from network analysis

In this paper, we employ a novel, network analysis based approach to gain new insights with respect to the changes in the structure of intra-European Union (EU) milk product trade between 2001 and 2012. Several network indices are computed to assess the relative importance of the countries from a number of perspectives. The results emphasise that the trade network has become denser, yet its overall centralisation slightly decreased during the period. While the impacts of the 2004 EU enlargement are clearly visible, the effects of the 2008 financial crisis are less evident. Integration of countries that joined the EU in 2004 or 2007 (the so-called New Member States, NMS) is only partial, and depends on the category of milk product considered. Although the number of NMS trade relations increased constantly between 2001 and 2012, the relative importance of most of them did not change. A significant exception is Poland, which became one of the most important exporting countries.

Keywords: EU-27, enlargement, dairy quota, export, weighted trade network, centrality

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Introduction

It is difficult to overestimate the importance of the dairy sector in the European Union (EU). Dairy products are the second most important source of animal protein; the yearly average per capita consumption in the EU is equivalent to approximately 300 kg milk (Westhoek *et al.*, 2011). Further, milk is the EU's number one single product sector in terms of value, accounting for 15 per cent of agricultural output in 2013 according to Eurostat data. In addition, not only are dairy products of many EU Member States competitive on global markets (Bojnec and Fertő, 2014), but the intra-EU milk trade is also very significant (EDA, 2014). In fact, over the period 2001-2012, some 90 per cent of all cow milk produced in Europe was commercialised and consumed within the EU.[4] More importantly however, these trade relations involve rich and complex network patterns. This calls for a network analysis (NA) approach to evaluate and understand the structure and dynamics of international relationships within the EU dairy sector. In this paper, we provide a first step in this wider area. Using NA, we study the dynamics of intra-EU milk trade in the period 2001-2012. By doing so, we are able to analyse the stability of the network across time and assess the extent to which it has been affected by two important events, the EU enlargement in 2004 and the global financial crisis starting in 2008. In particular, we aim to see whether the time series of the international relations exhibit any (rapid) shifts with different structures at the beginning and at the end of the period under study. This will allow us to draw conclusions on how the trading relations and the relative position of EU Member States – reflected in bilateral trade flows – changed over time.

Applications of NA in empirical economic research (e.g. Snyder and Kick, 1979, focusing on World-System/Dependency theories of differential economic growth between countries) or in mapping trade patterns (see, for instance, Nemeth and Smith, 1985 with respect to international relations, or Smith and White, 1992 for a quantitative analysis of trade) date back almost four decades. But it was the recent advances in computing power, empirical econometrics and new network methods that brought NA back into the limelight. Some more recent examples of the possibilities offered by NA include Büttner *et al.*, 2013 (trade network analysis of the pork supply chain in order to assess the spread of infectious diseases between holdings) or the methodological paper by Cranmer *et al.,* 2017 (assessment of NA as a statistical tool, concluding that models rooted in this approach can easily outperform traditional regression based models such as Logit or Probit). As regards economics of trade, Chaney (2014) uses French exporter data to analyse the network structure of international trade, while Arpino *et al*. (2017) apply impact analysis methods to show that neglecting network properties results in "considerably higher estimates of the effect of the GATT[5] on bilateral trade" (p.16). Perhaps more importantly, the authors conclude that a balanced sample based on cofounding variables – required for Propensity Score Matching – cannot be obtained unless network centrality measures are included in the analysis.

By using the NA approach in this particular context, our study contributes to the broader literature that adopts a similar perspective to discuss world trade patterns (e.g. Bhattacharya *et al.*, 2008; De Benedictis and Tajoli, 2011; Fagiolo *et al.*, 2013). Closest to our research is the paper of Gephart and Pace (2015). The authors apply similar techniques but focus on the structure and evolution of the global seafood trade network. Thus, to the best of our knowledge, agricultural commodity trade data, especially in an EU context, has not yet been analysed in this way. The main benefit of this approach is that the behaviour of the whole system (European milk trade) can be regarded (on a quantitative

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4 These calculations use World Integrated Trade Solution data for HS0402 and HS0401 milk taken together. In addition, it is estimated that export outside the EU accounts for about 10 per cent of all cow milk produced in Europe (EDA, 2014).

5 General Agreement on Tariffs and Trade – the predecessor of the World Trade Organization.

basis), while taking into account potential indirect effects that are usually given much smaller emphasis. The point is, bilateral trade relations are embedded in a broader network of relationships and the structure of this network is likely to affect the outcome of these relations. Thus, the application we propose may complement other empirical analyses of the intra-EU trade usually revolving around bilateral relations.

Methodology

Network analysis

In NA, nodes represent countries and links represent trade relationships. Binary links show the existence of partnerships. A directed graph (digraph) represents directional relations, where links have an origin (exporting country) and a destination (importing country). Furthermore, it is possible to add values (weights) to the links representing traded volumes, thus asymmetric relationships are acknowledged. A *weighted digraph* consists of three sets of information: a set of nodes $N=\{n_1, n_2, \dots n_k\}$, set of links $L=\{l_1, l_2, \dots l_L\}$ and set of values (weights) $W=\{w_1, w_2, \dots w_L\}$. The link from n_i to n_j is not necessarily the same as the link from n_j to n_i (two distinct weights might exist).

Several indices are calculated to quantify the relative importance of the Member States from various perspectives. Some of them are dependent only on the local characteristics of the focal node, while others regard wider network features. The most local index, degree (D_i) gives the number of nodes connected directly to node *i*. For directed networks out-degree ($D_{out,i}$) corresponds to the number of links that originate from node *i* (Wasserman and Faust, 1994). For trade networks, out-degree represents the number of trade partners to which a given country exports its products (De Benedictis and Tajoli, 2011). Similarly, in-degree ($D_{in,i}$) gives the number of links terminating at node *i* (thus the number of partners from which country *i* imports). However, degree is not a useful measure for weighted networks. There are two ways to give a meaningful generalisation. Firstly, the average of the values of all links connected to a node can be calculated (weighted degree, (D_i^w). Consequently, *weighted out-degree* ($D_{out,i}^w$) gives the average export volume per trade partner, while *weighted in-degree* ($D_{in,i}^w$) represents the average import volume per trade partner (based on Wasserman and Faust, 1994). Secondly, the *strength* of a node (S_i) can be calculated that describes the total volume of annual trade associated with a node (Bhattacharya *et al.*, 2008):

$$S_i = \sum_j w_{ij} \tag{1}$$

Out-strength ($S_{out,i}$) of a node summarises the weights of links that originate from node *i*, thus the overall export from country *i*. Similarly, *in-strength* ($S_{in,i}$) denotes the overall import to country *i*.

Betweenness centrality (BC_i) is used very often in social network analysis (Wasserman and Faust, 1994). It describes the extent to which a node lies on the shortest geodesic (i.e. with the minimum number of edges) paths between other nodes (Freeman, 1977):

$$BC_i = \frac{2 \times \sum_{j<k} g_{jk}(i)/g_{jk}}{(N-1)(N-2)} \tag{2}$$

where g_{jk} is the proportion of all geodesics linking node *j* and node *k* which pass through node *i*; $i \neq j \neq k$, *N* is the number of nodes in the network. Division in equation 2 is needed, otherwise *BC* would increase with the number of pairs of nodes (network size). However, *BC* is defined for binary graphs, and also the stress on the shortest path in many cases seems to be a too strong assumption. These drawbacks are eliminated by the measure of flow betweenness centrality of Freeman *et al.* (1991):

$$fBC(n_i) = \sum_{j<k}^{p} \sum^{p} m_{jk}(n_i) \tag{3}$$

where m_{jk} is the amount of flow between node *j* and node *k* which passes through node *i* for any maximum flow. fBC_i is the sum of all m_{jk} where $i \neq j \neq k$ are distinct and $j<k$. The flow betweenness is thus the extent to which the maximum flow between all unordered pairs of points depends on node *i*.

Eigenvector centrality (EC_i) is based on the idea that an actor is more central if it is in relation with actors that are themselves central (Ruhnau, 2000). According to Bonacich (1972), the centrality *c*(*i*) of node *i* is:

$$\lambda c(i) = \sum_{j=1}^{m} a_{ij} c(j) \tag{4}$$

$a_{ij}=1$ if nodes *i* and *j* are connected; and $a_{ij}=0$ if they are not. Density is a global network index that shows the number of actual links relative to the number of all possibilities that could potentially exist. Density is a useful measure of structural cohesion especially in case of the lack of subgroups. As density corresponds to different level of cohesion in networks of different size (Friedkin, 1981), the measure is meaningful in time series analysis, when network size (the number of nodes) remains constant.

Data

Aggregate bilateral export volume data (expressed in 100 kg), as reported by the exporting country in World Integrated Trade Solution (WITS), are used for two milk product groups. In the Harmonised System classification these are: HS0401: *Milk and cream, not concentrated nor containing added sugar or other sweetening matter*, and HS0402: *Milk and cream, concentrated or containing added sugar or other sweetening matter*, representing around 30 per cent of the (milk product) value traded intra EU. These are the most homogenous milk product categories, roughly be equivalent with raw (unprocessed) and processed fluid milk. The natural logarithms of volume data are used in the calculations. To address system dynamics, data range from 2001 to 2012; hence the effect of EU enlargements (2004 and 2007), 'soft landing' (the start of gradual milk quota removal in 2008) and the financial crisis (starting in 2008) can be considered. WITS data are analysed with Ucinet 6 software (Borgatti *et al.*, 2002).

Results

Figures 1a and 1b depict the intra-EU trade networks of HS0401 milk in 2001 and 2012 respectively, while Figures 1c and 1d display the same for HS0402 milk. The intra-EU trade of HS0401 milk intensified in terms of the number of trading partners per country in the last decade. Especially peripheral (less connected) countries diversified their trading relationships. The comparison of the HS0401 and HS0402 milk sectors reveals that the trade of HS0402 milk was much more intensive between 2001 and 2012 than that of HS0401 milk. This difference is especially remarkable in the beginning of the period. A more detailed analysis of general network indices is discussed below to support these visual observations.

Table 1 details the network structure evolution through the changes of some general network statistics[6] and the average values of the network indices. Although for HS0401 milk the number of trading partners per country increased 1.6 times, the volume traded, showed by S_{out}, increased even

[6] Figures A1 and A2 provide some additional insights.

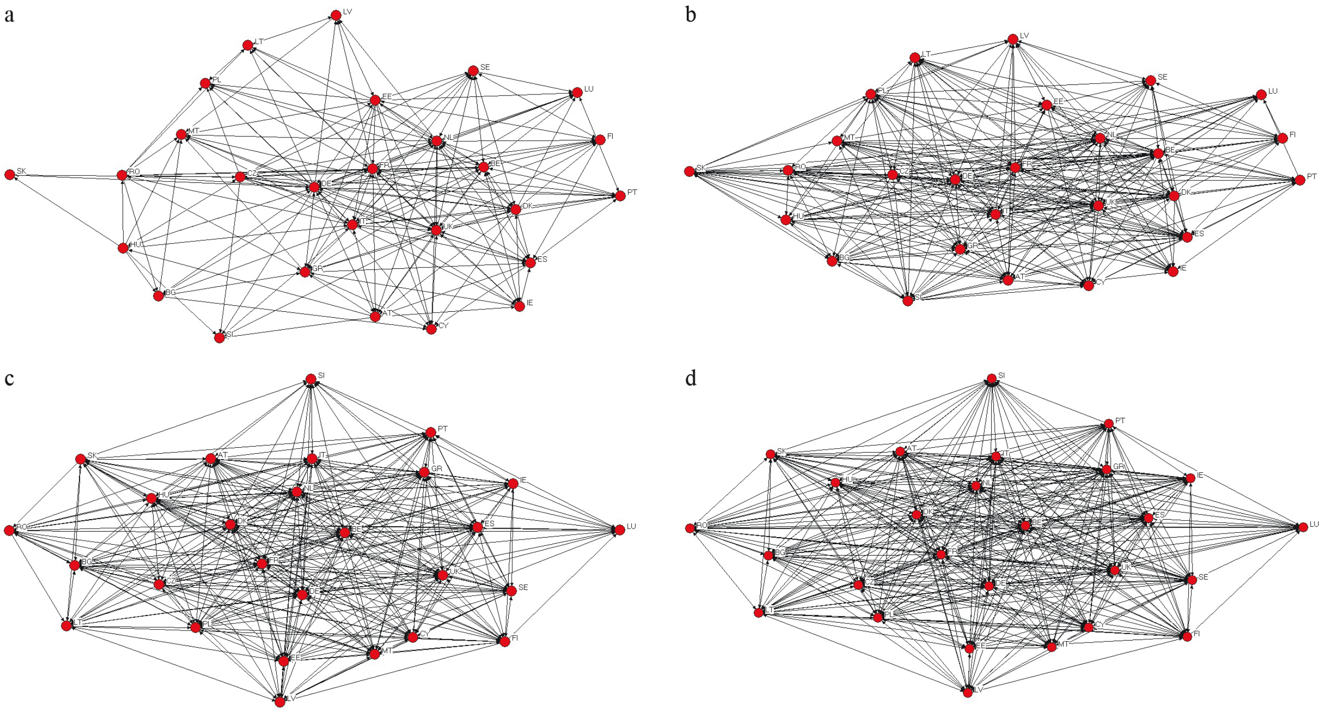

Figure 1: a: The intra-EU trade network of HS0401 milk in 2001; b: The intra-EU trade network of HS0401 milk in 2012; c: The intra-EU trade network of HS0402 milk in 2001; d: The intra-EU trade network of HS0402 milk in 2012. (All EU-27 Member States are included; weights are not shown).

The networks were dHS0401n with netdHS0401, Ucinet (Borgatti *et al.*, 2002)
Source: own compilation

Table 1: Trade network indices over time and their changes between the three-year (or two-year) periods.

	2001	2004	2007	2010	2012	Change				
						2004/2001	2007/2004	2010/2007	2012/2010	2012/2001
HS0401 milk										
No. of countries	27	27	27	27	27	1.00	1.00	1.00	1.00	1.00
No. of links	255	318	342	376	399	1.25	1.08	1.10	1.06	1.565
Density	0.363	0.453	0.487	0.536	0.568	1.25	1.08	1.10	1.06	1.565
D^w_{out} (average)	10.7	11.5	11.8	12	12	1.08	1.02	1.02	1.00	1.128
S_{out} (average)*	103.7	138.1	152.2	171.3	181.9	1.33	1.10	1.13	1.06	1.754
fBC (average)	25.8	23.5	24.6	24.5	24.4	0.91	1.05	1.00	1.00	0.946
EC (average)	0.172	0.181	0.182	0.183	0.185	1.05	1.00	1.01	1.01	1.071
HS0402 milk										
No. of countries	27	27	27	27	27	1.00	1.00	1.00	1.00	1.00
No. of links	484	504	568	574	589	1.04	1.12	1.01	1.02	1.217
Density	0.689	0.718	0.809	0.818	0.839	1.04	1.12	1.01	1.02	1.217
D^w_{out} (average)	12.6	12.7	13	13	13	1.01	1.02	1.00	1.00	1.031
S_{out} (average)*	233.1	262.3	283	288.3	293.7	1.12	1.08	1.02	1.02	1.26
fBC (average)	25.3	25.2	25	24.9	25	0.99	0.99	0.99	1.01	0.99
EC (average)	0.187	0.189	0.189	0.19	0.19	1.01	1.00	1.01	1.00	1.014

Baseline: value in the first year of the period. (All EU-27 Member States included)
*: export, expressed as the natural logarithm of volumes
Source: own calculations

more. This EU-level pattern (also considering the rates of changes) might be explained by the enlargement process (providing a bigger market and more stable economic environment) supplemented by a gradual increase of 1 per cent per year in the milk quotas (initiated in 2008 to prepare a 'soft landing' in 2015 when the quotas expired).

A slight, 5.4 per cent decrease in *fBC* implies a decrease in the extent to which the network has been dominated by key countries. There are further notable changes: (a) the rate of change in the average EC was the highest before 2004, implying that connection to central nodes (important trading countries) was the most intensive before the 2004 enlargement, and (b) the change in the average EC was less than the change in density over the 2001-2012 period. In other words, the relative advantage (as an increase in the relative importance) that can be gained by connecting to a well-connected partner decreased.

However, a closer look at flow betweenness centrality – depicting separately the pre-2004 EU Member States (the so-called EU-15) and those that joined the EU in 2004 or 2007 (the so-called New Member States, NMS) – (Figures 2a and 2b), reveals that the decreasing differences of importance may be attributed to the decreasing importance of Germany among the EU-15. With the exclusion of Germany, it becomes clear that the other EU-15 Member States increased their importance (2.5 per cent of increase in *fBC*, compared to the 3.2 per cent decrease on average, when only NMS are studied).

In a similar fashion, Figure 3 depicting the ranks of EC emphasises the integration of NMS into the trade network. This is especially evident for HS0401 milk (Figure 3a), where all NMS except Estonia greatly increased their EC values between 2001 and 2012, emphasising an intensive relationship with the core (most prominently Slovakia, Slovenia, Lithuania and certainly Poland). Furthermore, according to the 2012 ranking of EC, a number of NMS rank higher (better integrated) than EU-15 Member States.

While for HS0401 milk changes were the greatest during the pre-enlargement period (2001-2004, see Table 1), the pattern is not that clear when HS0402 milk is considered: the number of partners (and consequently, density) changed the most between 2004 and 2007 (but not later). For the other measures the pattern resembles that of HS0401 milk. Owing to the originally more intensive relationships and higher volumes traded, changes were less pronounced for HS0402 milk than they were for HS0401 milk. In this case, the increase in the average out-strength (overall exports) goes together with the increasing number of partners (comparatively, the change in the export volume of HS0401 milk greatly exceeded the change in the number of partners).

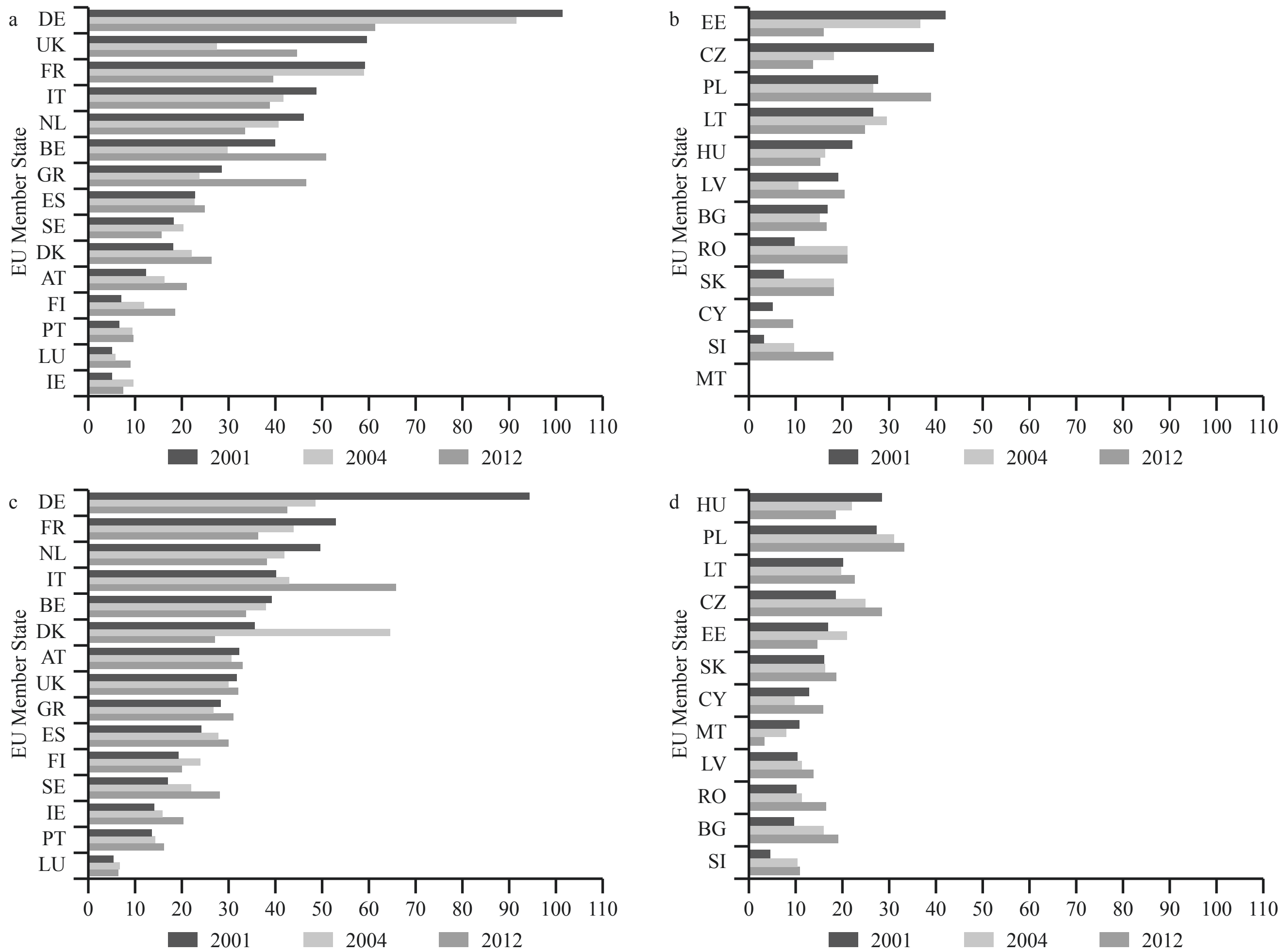

Figure 2: Flow betweenness centrality (a) EU-15 for HS0401 milk; (b) NMS for HS0401 milk; (c) EU-15 for HS0402 milk; (d) NMS for HS0402 milk.

Source: own calculations

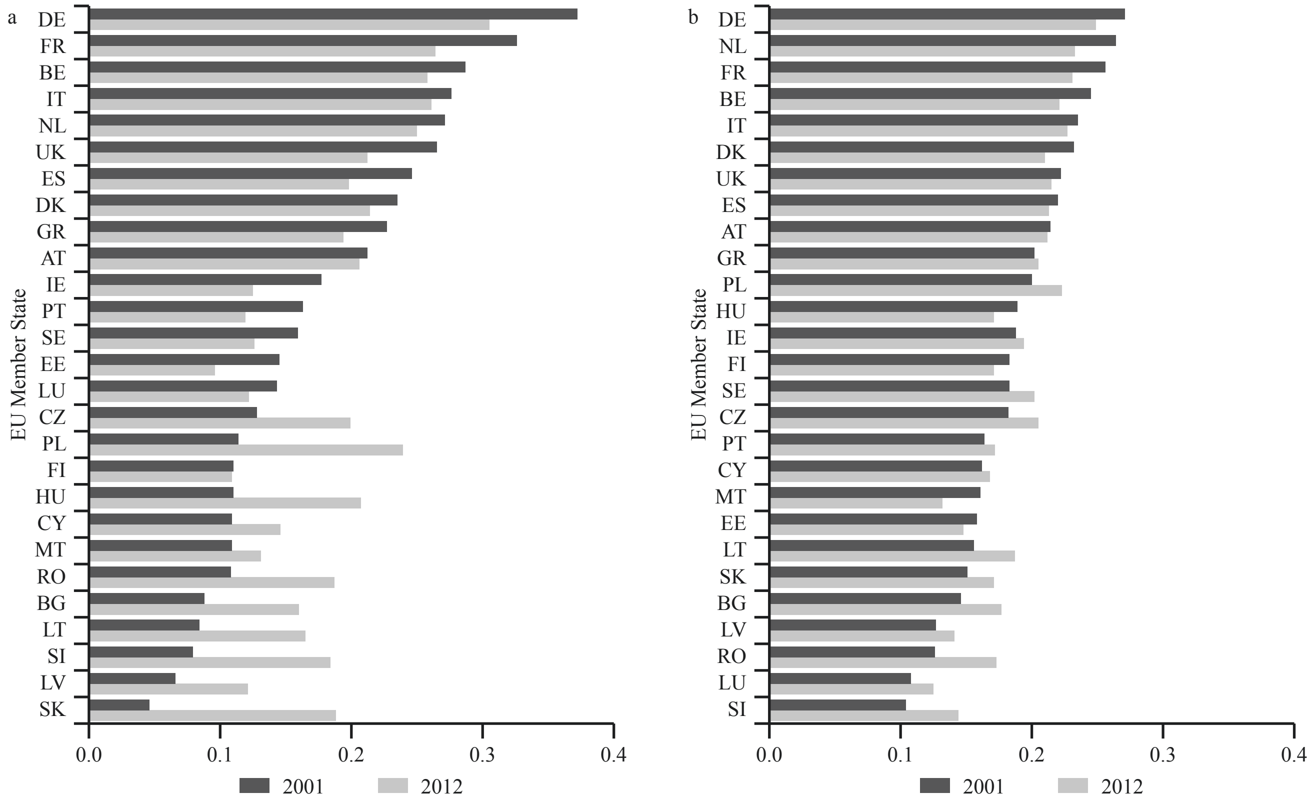

Figure 3: Ranks of Eigenvector Centrality. High *EC* shows intensive relationship with central nodes. a: HS0401 milk, b: HS0402 milk.
Source: own calculations

The performance (integration) of the NMS seems to be more complete for HS0402 milk. Figures 2c and 2d show the evolution of the *fBC* measure for the EU-15 and NMS respectively. Again, the decrease in the average *fBC* can be attributed mostly to the pattern observed for Germany. Its exclusion shows that the increase of *fBC* among the rest of the EU-15 Member States was 3.7 per cent on average, compared to the 16 per cent increase among the NMS. Thus, the trade network of HS0402 milk became less centralised in this period.

Some more general findings can also be drawn. The most important exporting countries of both HS0401 and HS0402 milk are Germany and France, in 2001 and also in 2012 (Figures A1-A2). For most indices (both product groups) the difference between the average index values of the EU-15 and NMS decreased in the studied period, which implies integration; though country ranks (relative importance) varied only to a minor extent. The exception seems to be the position of Poland which evolved to be the best performing NMS by 2012.

Discussion

In summary, milk trade intensified, especially for HS0401 milk. Differences in the average performance of the EU-15 and NMS decreased; though the relative importance of the countries did not change remarkably (with the exception of Poland). Centralisation of the dairy trade network at the EU level slightly decreased. Integration seems to be more complete for HS0402 milk; in the other product group the seeming decrease in differences can be attributed to the decline in the importance of Germany. In general, over the period 2001-2012, the 2004 enlargement caused bigger changes in the trade network structure than the financial crisis. Our results seem to indicate the following: denser connections between the EU-15 and NMS can be observed, as indicated by trends in *EC* for both groups of countries. Interestingly, this process is more clearly visible for transactions in HS0401 milk. This in turn is consistent with observations suggesting increasing internationalisation of the European dairy supply chain. We can conclude that the integration of NMS into the intra-European milk trade network was a successful process. The question with respect to the distribution of rents within these input-output linkages remains however an open one.

Indeed, while the centrality of NMS in the dairy trade network generally improved over the years, it is not that certain that it helped them to increase their share in the total value added. Note that the increase in unprocessed milk trade that we document is consistent with a growing process of international disintegration of production processes characterised by a noticeable expansion in input trade (Antras, 2016). It could be argued therefore that the changes in trade patterns which we observe result from the fact that countries vertically specialise in various stages of the production processes. In this context one may wonder whether NMS have started to specialise in producing raw materials (processed further abroad) which are typically associated with a relatively small value added. While this issue seems to be of high policy relevance it is relatively unexplored in the existing literature.

The picture emerging from this paper also suggests several other interesting directions for future research. Firstly, it may provide the reference for analysing the evolution of trade patterns in dairy sector following the milk quota removal. Given our focus, it is useful to note that the propagation of shocks (including those triggered by policy reforms) through trade networks might be an important driver of macroeconomic fluctuations. In this context, investigating to which extent the distribution of costs and benefits resulting from milk quota removal do or do not depend on the structure of the European milk trade network is an interesting (future) research topic. In other words, one may ask to what extent the overall impact of quota removal in a given country will be dependent on the outcomes observed in its trading partners. A further interesting research direction is to investigate factors responsible for network formation, e.g. whether exporting to/importing from a country *a* increases the chances of also trading with country *b* if countries *a* and *b* trade with each other, all else being equal.

A related and equally important question for our understanding of economics of trade is what specific mechanism is likely to transmit this impact. Does the evolution of trade networks follow the patterns of international workflow migration or is it rather an outcome of the presence of multinationals? Both these factors have been identified as exerting strong impacts on international trade. The EU enlargements that we cover in our analysis were marked by a sharp increase in migrant flows from NMS to the EU-15 as well as by huge investments made by EU-15-based companies in both the dairy sector and supermarkets in NMS. The relative importance of these and other factors in affecting the evolution of trade networks seems to be a fruitful area for future investigation.

Acknowledgments

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Annex

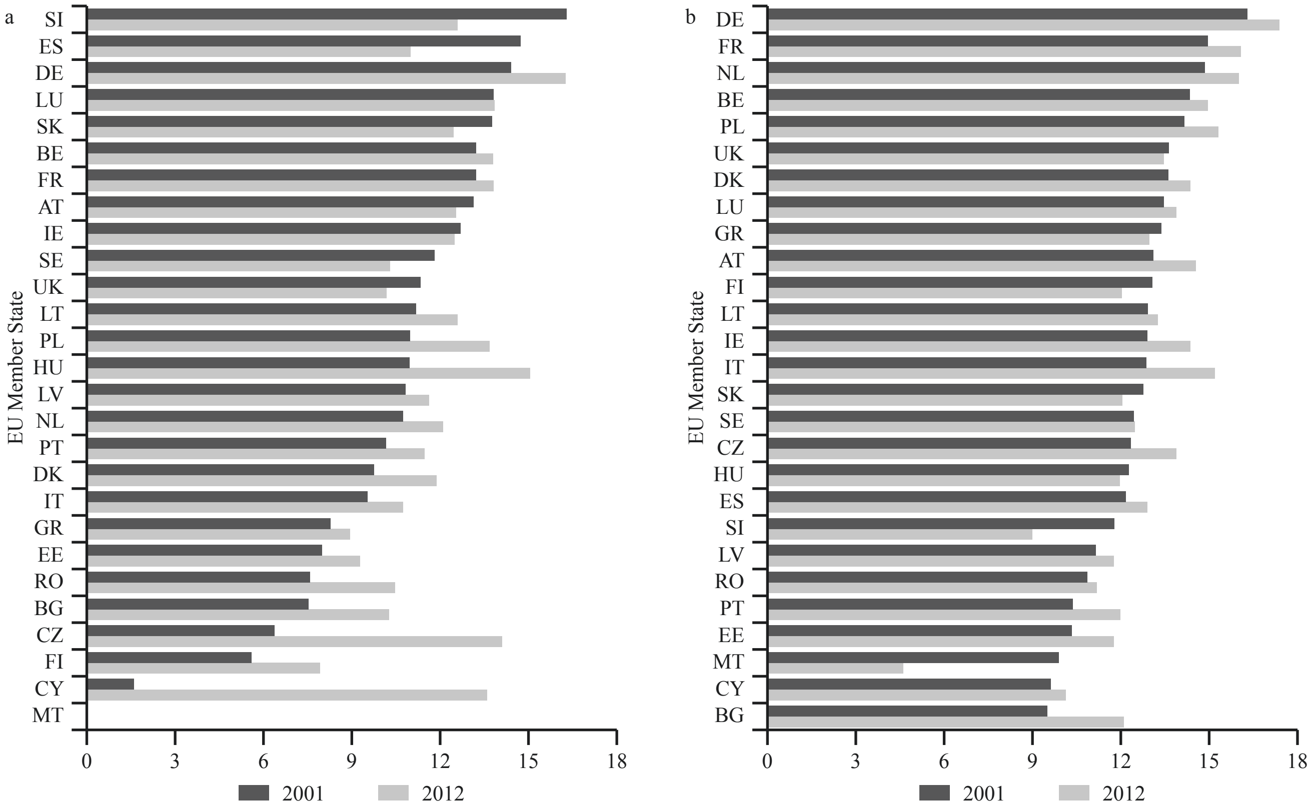

Figure A1: Ranks of weighted out-degree (the average export volume per partner). a: HS0401 milk, b: HS0402 milk.

Source: own calculations

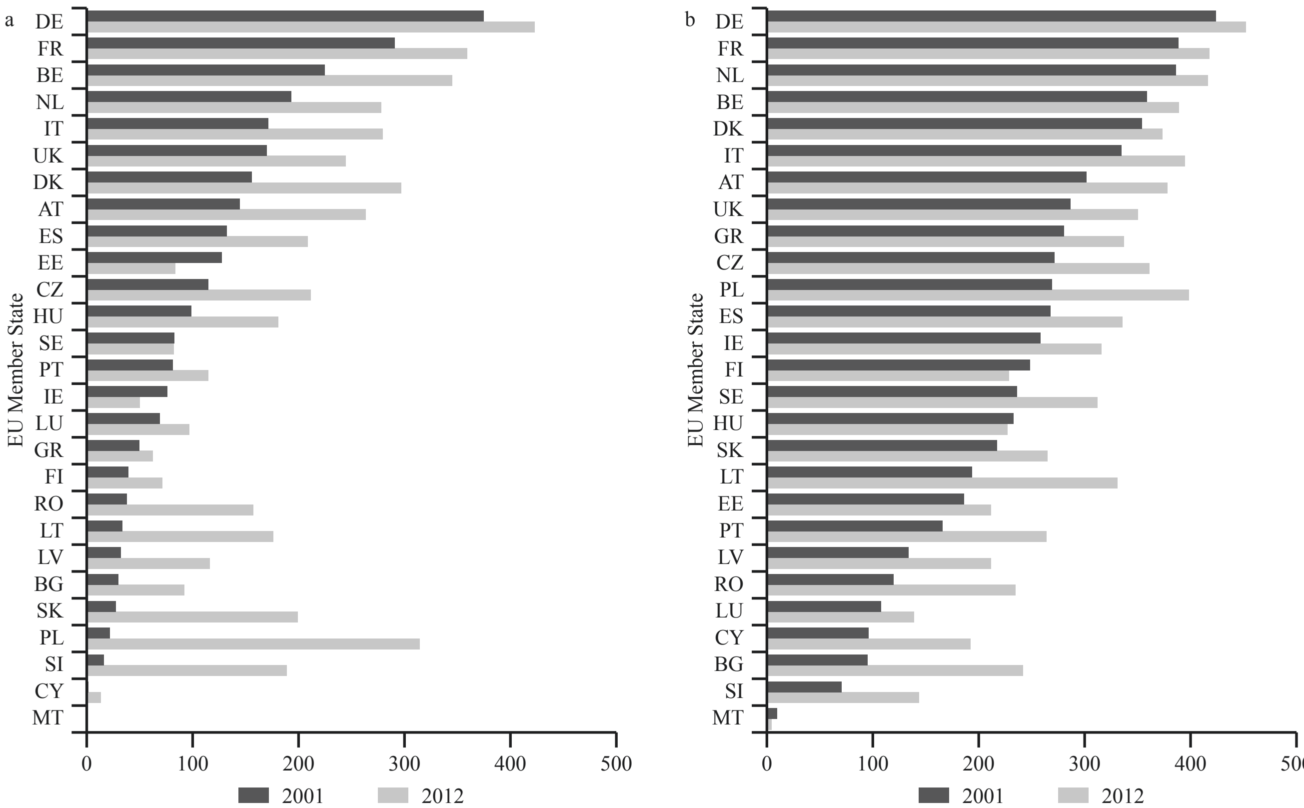

Figure A2: Ranks of out-strength (overall export volume). a: HS0401 milk, b: HS0402 milk.

Source: own calculations

Jiawu DAI*, Xun LI and Xiuqing WANG*****

Food scares and asymmetric price transmission: the case of the pork market in China

This paper investigates the symmetry of impact from three main food scare events on both the upstream and downstream price transmissions in the Chinese pork market through monthly data from 2001 to 2014. Based on a theoretical model, we firstly estimate the VAR systems for pork retail price and price transmissions in different links, and then plot the impulse response function and dynamic multiplier function respectively for endogenous substitute good price and exogenous food scare events. Empirical results indicate the asymmetry of price transmission in the Chinese pork market, and demand and supply shocks from three food scare incidents are found to impact retail price and price transmissions differentially. In addition, shocks from the same incident on price and price transmissions are significantly different. This research provides implications for farmers, business managers and policy makers to make strategies in response to food scare events[1].

Keywords: porcine reproductive and respiratory syndrome, swine influenza, classical swine fever, price transmission

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Introduction

China is the biggest pork producer in the world with, according to National Bureau of Statistics of China data, a record output of 54.93 million tonnes in 2013, accounting for about 48 per cent of the world pork products. On the other side, pork is the most heavily consumed meat in China. According to USDA World Agricultural Supply and Demand Estimates, the consumption of pork is on average four times as high as that of chicken and nearly eight times as high as that of beef.

The Chinese pork industry is frequently exposed to food scare events such as porcine reproductive and respiratory syndrome (PRRS), swine influenza (SI) and classical swine fever (CSF), which are documented as being the three main porcine diseases in China (Cai, 2002; Yang, 2010; Li and Yang, 2014) and result in an economic loss of RMB 10 billion annually (Ding, 2011). These food scare events directly affect the supply of pork.

PRRS occurs in most major pig-producing areas throughout the world and is characterised by reproductive failure of sows and respiratory problems of piglets and growing pigs. This reproductive failure includes infertility, late foetal mummification, abortions, stillbirths, and birth of weak piglets that often die soon after birth from respiratory disease and secondary infections. Older pigs may demonstrate mild signs of respiratory disease, usually complicated by secondary infections. The Ministry of Agriculture of the People's Republic of China (MAPRC) forbids the slaughter, transportation and transactions of hogs infected with or died from the PRRS virus (MAPRC, 2007).

SI is a highly contagious viral infection of pigs. The disease usually spreads very quickly within swine units, even though all infected pigs might not show clinical signs of infection, followed by a rapid recovery of the infected animals. Morbidity rates can reach 100 per cent with SI infections, while mortality rates are generally low. The MAPRC requires farmers to kill and destroy all hogs infected with or died from the SI virus (MAPAC, 2009a).

CSF, formerly known as hog cholera, is a fatal disease in the pig industry. It is among the diseases included in List A of the Office International des Epizooties with mortality up to 80-90 per cent. Similarly, the MAPRC requires farmers to kill and destroy any hogs infected with or died from CSF virus (MAPAC, 2009b).

These food scare events are also deemed as risks for consumers to different extents and usually affect pork consumption. The least risky disease is PRRS as its virus can be killed under high temperature. Though SI is not a real threat for human health in veterinary medicine, for the virus is not easily transmitted from swine to human beings, it does result in scares on pork consumption at the beginning of an outbreak due to ignorance. Conversely, CSF is a substantial threat for pork consumption because pork infected with the CSF virus is inevitably harmful for human health in terms of salmonella food poisoning. In general, outbreaks of porcine diseases are reported simultaneously on websites, television, newspapers and magazines, and consumers could be exposed to this information and aware of the potential risk, thus decreasing pork consumption.

Shocks to supply and demand can cause a volatile market price and price transmission in different links, undermining the profits of farmers and entrepreneurs, as well as the social welfare of consumers. As the biggest pork producer and consumer in the world, China has been perplexed by the frequently-occurring hog diseases and corresponding economic losses. As a consequence, it is of both academic and policy significance to study this phenomenon.

Literature review

Price transmission in food industries has been analysed extensively, but few studies have been conducted on the pork market. Abdulai (2002) applies threshold cointegration tests to examine the relationship between producer and retail pork prices in Switzerland and verifies an asymmetric price transmission between these two links. Using the endogenous break date estimation procedures, Adachi and Liu (2009) identify four breaks in the retail-farm price relationship in the Japanese pork market. Similar empirical results are

[1] An earlier, unreviewed version of this paper was presented at the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Annual Meeting, San Francisco CA, 26-28 July 2015.

demonstrated in the U.S. pork market (Boetel and Liu, 2010; Gervais, 2011). Farm-retail price transmission in the Hungarian pork market is found to be symmetric in the long term (Bakucs and Fertő, 2005), but asymmetric in the short term (Bakucs and Fertő, 2009).

Market power is regarded as one of the most important factors inducing asymmetric price transmission in pork markets. For example, Cechura and Sobrova (2008) confirm that oligopsony power in the processing stage is a main cause of asymmetric price transmission in the Czech pork meat agri-food chain. Asymmetric price transmission in the long term in the Swedish pork industry is also deemed to be caused to a great extent by market power (Karantininis *et al*., 2011). Other factors found to be correlated with asymmetric price transmission include menu costs, inflation, government intervention and stock management; see Bakucs *et al.* (2014) for a review.

Although price transmission is empirically tested widely, only a few studies evaluate the effect of food scare events on price transmission, especially in the pork market. Several classic works shed light on examining the cases in beef markets (e.g. Sanjuan and Dawson, 2003; Piggott and Marsh, 2004; Leeming and Turner, 2004; Lloyd *et al.*, 2006; Saghaian, 2007; Marsh *et al.*, 2008; Schlenker and Villas-Boas, 2009; Hassouneh *et al*., 2010). Nevertheless, research on the effects of food scare events such as PRRS, SI and CSF on price transmission in the pork market is still lacking. In addition, almost all of the existing empirical studies paid attention to only one stage between the farm gate and the retailer, or the upstream stage between the purchase of inputs and the sale of agricultural products (e.g. Ward, 1982; Carlton 1986; Kinnucan and Forker, 1987; Hannan and Berger, 1991; Neumark and Sharpe, 1992; Griffith and Piggott, 1994; v. Cramon-Taubadel, 1998; Borenstein *et al*. 1997; Goodwin and Holt, 1999; Abdulai 2000; Peltzman, 2000; Goodwin and Piggott, 2001; Miller and Hayenga, 2001; Chavas and Mehta, 2004; Acharya *et al*. 2011; Shrinivas and Gómez, 2016). It is significant both in theory and policy to calculate the price transmission in the upstream and downstream simultaneously through a systematic framework.

Following Capps *et al*. (2013), the analysis of potential effects of food scare events on the Chinese pork supply chain requires the consideration of certain aspects. Firstly, because outbreaks of PRRS, SI and CSF may occur simultaneously, it is important to isolate the effects of them when assessing their impacts on the marketing channel. Secondly, as adjustments in the pork market are not necessarily instantaneous after a food scare event (Schlenker and Villas-Boas, 2009), understanding the time periods lagged of the effects is important for both policymakers and business managers. So here we account for immediate and delayed effects of food scare events on price transmissions. We explore different model specifications and identify the optimal lagged effects with values of Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC).

Several contributions emanate from this work. Firstly, we assess in detail the impact of three food scare events on the pork market, which is closely connected to the production and consumption of the most important red meat in China. Secondly, we jointly model these three food scare events and disentangle their effects on price transmission. Previous studies only centre their attention on some specific food scare event, ignoring that they might occur and affect the market simultaneously and differentially, which could lead to a biased estimation. Thirdly, we attempt to test the price transmissions in both the upstream and downstream of China's pork industry via a systematic framework. Overall, given changes in price transmission may reflect changes in the efficiency and equity of the market system, this study provides valuable information to policymakers about responding to food scare events, to maintain the stability of the market and to minimise welfare loss of consumers.

Methodology

Theoretical and econometric methods

In order to build a theoretical framework for testing price transmission, we firstly assume a pork retail price equation as follows:

$$RP_t = I(X_t) + F(M_t) + N_{Rt} + \epsilon_t \tag{1}$$

where RP_t is pork retail price, $I(X_t)$ represents endogenous variables affecting pork retail price, $F(M_t)$ represents marketing costs such as transportation and wage for processing link, and N_{Rt} represents impact from exogenous demand and supply shocks on pork retail price.

Similarly, the hog price equation is assumed as follows:

$$PP_t = G(X_t) + N_{Pt} + \xi_t \tag{2}$$

where PP_t is hog price, $G(X_t)$ represents endogenous variables affecting hog price, and N_{Pt} represents impact from exogenous demand and supply shocks on hog price.

Subtract equation (2) from (1), we have:

$$RP_t - PP_t = \alpha_H[I(X_t) - G(X_t)] + \alpha_F F(M_t) + \alpha_N(N_{Rt} - N_{Pt}) + \varepsilon_t \tag{3}$$

If $N_{Rt} = N_{Pt}$, then exogenous shocks would exert the same impact on pork retail price and hog price, i.e. the pork-hog price transmission is symmetric under the shock of exogenous shifters.[2] Conversely, if the coefficient of N is significant in equation (3), then asymmetry of price transmission may exist. The deductions are similar for the upstream price transmission equations between hog and piglet prices, and we omit the details.

A vector autoregressive (VAR) framework is applied in the empirical analysis. Consider a VAR(p) model:

$$X_t = \Phi_1 X_{t-1} + \Phi_2 X_{t-2} + \cdots + \Phi_p X_{t-p} + \Psi_0 w_t + \Psi_1 w_{t-1} + \cdots + \Psi_q w_{t-q} + \epsilon_t \tag{4}$$

where X_t is a $n \times 1$ vector of endogenous variables, including pork retail price RP_t, chicken retail price RC_t representing the price of substitute good, and price margin in two different

[2] As implied by the right hand side of equation (3), the significance of endogenous $[I(X_t) - G(X_t)]$, and exogenous $F(M)$ may also indicate the asymmetry of pork-hog price transmission. However, this is not the main point of this study, as we are more interested in the food scares.

links, i.e. the downstream $RPP_t = RP_t - PP_t$ (margin between pork retail price RP_t and hog price PP_t) and the upstream $PPL_t = PP_t - LP_t$ (margin between hog price PP_t and piglet price LP_t). w_t is a $k \times 1$ vector of exogenous variables, which include marketing cost such as oil price O_t, wage W_t, and exogenous demand shocks such as information about porcine diseases (D_PRRS_t, D_SI_t and D_SF_t), supply shocks such as the slaughter and died volume of hogs infected by PRRS (S_PRRS_t) and SCF (S_CSF_t)[3] and net export EXP_t. $\Phi_i (i=1, \ldots, p)$ and $\Psi_j (i=0, \ldots, q)$ are $(m \times n)$ and $(m \times k)$ matrices of coefficients to be estimated. ϵ_t is a $(m \times 1)$ vector of disturbances with zero mean and non-diagonal covariance matrix, Σ.

Price margin in two different links are represented as measurement of price transmission. As mentioned above, price margin could not be significantly affected by any other variables except marketing costs, such as wage and transportation, in the intermediate stage. In other words, price transmission would be asymmetric if its explanatory variables except marketing costs are statistically significant.

Prior to estimating the empirical model, we test the orders of integration for these variables to guarantee the stationary. In addition, the numbers of lags p and q are selected to achieve the minimum values of AIC and BIC. The stationary of the model system is confirmed with unit roots. Residuals should be serially uncorrelated.

Data

All data sets used in this study are monthly data from January 2001 to July 2014, a total of 163 months. The retail prices of pork and chicken, price of live hogs, and export data of pork and hogs are from the MAPRC website. Oil prices are obtained from the Wind database, which is the monthly price of crude oil at Daqing oilfield. Wage rates for employees in the manufacturing industry are smoothed monthly using NBSC seasonal wage rate data.

Information on diseases such as PRRS, SI and CSF are collected from the www.baidu.com, from which news and information originating from newspapers, websites and television etc. can be gathered. Volumes of information about food scare events are collected as a proxy for consumers' exposure to the negative information. In general, the volumes of news and reports online increase dramatically to a peak at the outbreak of diseases and decay as the diseases are brought under control. In this study, we create the index for the negative information shocks by taking logarithms of the numbers of news. On the contrary, quantities of slaughter and died infected hogs induced from PRRS and CSF are collected from the MAPRC *Official Veterinary Bulletin*, representing the supply shocks of PRRS and CSF respectively.

[3] There were no hogs slaughtered and died in the case of SI, for SI is only a common, mild disease for pigs.

Table 1: Summary statistics of the main variables used in this study (n=163).

Variable	Mean	Std. dev.	Minimum	Maximum
RP	14.64	3.48	9.80	22.70
PP	9.09	2.48	5.62	14.55
LP	17.84	8.92	6.84	38.24
RC	10.70	1.25	8.35	13.30
FP	1.97	0.29	1.54	2.43
W	1,933.17	780.97	778.63	3,808.86
O	397.85	131.18	147.27	766.67
D_PRRS	1.64	2.47	0.00	8.75
D_SI	1.91	2.64	0.00	11.27
D_CSF	2.00	2.15	0.00	6.35
S_PRRS	40,336.20	142,136.40	0.00	1,116,780.00
S_CSF	97,730.80	112,992.70	0.00	608,820.00
LNEXP	9.65	0.46	7.05	10.34

Source: own calculations

Table 1 presents the summary statistics of the main variables in this study. The mean of *D_SCF*, on average, is higher than that of *D_PRRS* and *D_SI*, indicating consumers are exposed to much more negative information on SCF than of the other two diseases.

Figure 1 shows the incidences of three porcine diseases. PRRS outbreaks mainly in 2007 and stays active for nearly three years. SI outbreaks mainly in 2009 and continues in the following years, while CSF outbreaks almost every year since 2004. Figure 2 shows the trends of pork retail price and pork-hog price transmission, corresponding to the outbreaks of PRRS and SI. Both pork retail price and price transmis-

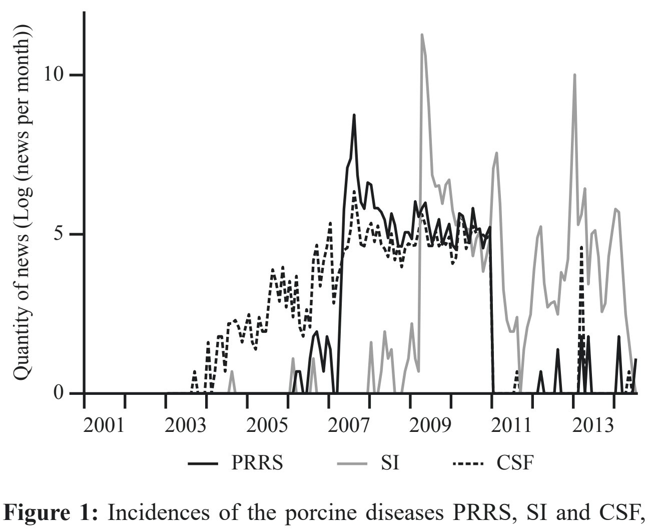

Figure 1: Incidences of the porcine diseases PRRS, SI and CSF, 2001-2014.

Source: own composition

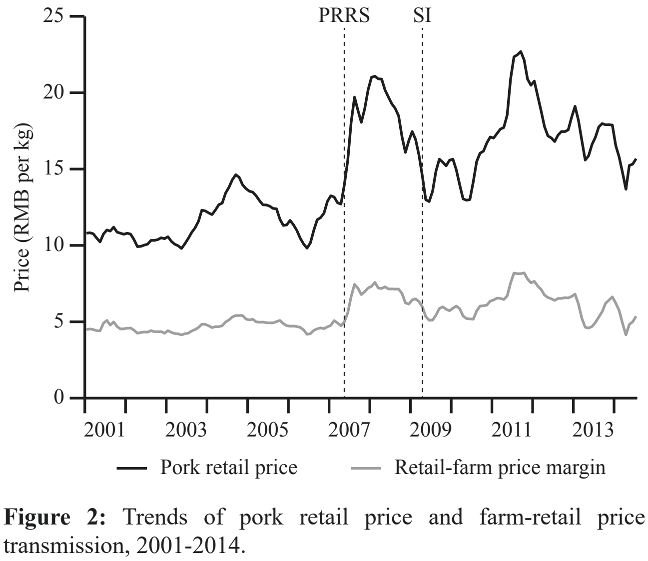

Figure 2: Trends of pork retail price and farm-retail price transmission, 2001-2014.

Source: own composition

sion show an upward trend after the outbreak of PRRS, and a downward trend after that of SI. Note that CSF is not marked in Figure 2, given that it breaks out almost every year.

Results and discussion

Prior to the estimation, variables are tested for the order of integration. Table 2 gives augmented Dickey-Fuller test statistics for all variables, which are all stationary after taking the first-order difference. The lags for endogenous and exogenous variables are selected based on AIC and BIC.

Pork retail price

Pork retail price is directly impacted by exogenous shocks, and selected as the benchmark to distinguish differential effects on different links. For the equation of pork retail price, we find that the values of AIC and BIC reach the minimum and no serial correlation is found for the residuals at the 5 per cent significant level if four lags for both endogenous and exogenous variables are taken. In addition, all the unit roots are located in the unit circle, implying that the VAR (4) system is stationary. Test results for serial correlation and stationary are given in the Annex for simplicity.

Empirical results of the VAR system for pork retail price are reported in Table 3, from which the differential effects from food scares on pork retail price are evident. The coefficients of *D_PRRS* are positive and highly significant in current period and one period lagged, implying that PRRS incidents stimulate the rise of pork retail price. The reason could be that the outbreak of PRRS was not regarded as a serious threat for people's health. On the contrary, the expectation of pork shortage resulting from PRRS would prompt consumers to purchase more pork. In addition, both *D_SI* and *D_CSF* negatively affect retail price significantly in current and one period lagged. As mentioned above, the possible explanation is that SI and CSF could decrease demand as a type of negative information, resulting in a decline of pork retail price.

Table 2: Augmented Dickey-Fuller test statistics of the main variables used in this study.

Variable	Levels (lag)	Differences (lag)	Inference
RP	-2.468 (2)	-8.083*** (1)	*RP* ~ I (1)
PP	-2.564 (2)	-8.097*** (1)	*PP* ~ I (1)
LP	-2.709 (4)	-4.152*** (4)	*LP* ~ I (1)
RC	-1.624 (6)	-2.639* (11)	*RC* ~ I (1)
FP	-2.749 (1)	-5.160*** (4)	*FP* ~ I (1)
W	-1.539 (12)	-4.635*** (11)	*W* ~ I (1)
O	-2.610 (1)*	-7.136*** (1)	*O* ~ I (1)
D_PRRS	-1.911 (1)	-9.406*** (1)	*D_PRRS* ~ I (1)
D_SI	-1.446 (10)	-10.908*** (1)	*D_SI* ~ I (1)
D_CSF	-1.836 (1)	-12.360*** (1)	*D_CSF* ~ I (1)
S_PRRS	-1.658 (10)	-11.992*** (1)	*S_PRRS* ~ I (1)
S_CSF	-1.117 (11)	-4.772*** (12)	*S_CSF* ~ I (1)
LNEXP	-1.514 (12)	-11.241*** (11)	*LNEXP* ~ I (1)

Lag length of the ADF regression was selected according to the SC (Schwarz Criterion) and AIC (Akaike Information Criterion) and is reported in parentheses adjacent to test statistics; ***/**/*: statistically significant at the 1%, 5%, and 10% levels respectively
Source: own calculations

Similarly, the supply shock from PRRS at current and one period lagged positively and significantly impact pork retail price, while supply shock from CSF at current term negatively and significantly impacts the retail price. These empirical results accord with the reality well, because the PRRS would significantly lead to reproductive failure, i.e. reduction of pork supply, and thus raise pork prices, while the death and slaughter resulting from CSF as well as the gloomy expectation would aggravate farmers' and retailers' scares and push them to undersell inventory.

As for the other exogenous variables, wage rate positively affects pork retail price in two and three periods lagged, and negatively affects pork retail price in four periods lagged. The effect from oil price shock is around 0.003 and highly significant in the current period, but -0.002 in the two periods lagged. Exports in all the four periods affect pork retail price positively and significantly, where the effect in three periods lagged is largest.

For the endogenous variables, pork retail price in one and three periods lagged have a positive and significant effect on current price, while that in two and four periods lagged negatively impacts current pork retail price. The chicken retail price has a significantly negative effect on pork retail price in one and four periods lagged, and a positive but insignificant effect on pork retail price in two and three periods lagged.

Price transmission

Two links of price transmission will be tested in this study. According to the AIC criterion, VAR(4) is appropriate on testing the pork-hog price transmission. All of the other variables apart from wage and oil price are significant in current and/or lagged periods (Table 4). It means that the pork-

Table 3: Estimation results for pork retail price.

	Current	Lag(1)	Lag(2)	Lag(3)	Lag(4)
Endogenous					
RP	—	0.7741***	-0.2037**	0.1975*	-0.1523*
	—	(0.0857)	(0.1043)	(0.1078)	(0.0847)
RC	—	-0.3739***	0.0959	0.1293	-0.2522**
	—	(0.1225)	(0.1212)	(0.1259)	(0.1239)
Exogenous					
W	-0.0002	-0.0001	0.0007**	0.0008*	-0.0009**
	(0.0003)	(0.0003)	(0.0003)	(0.0005)	(0.0004)
O	0.0030***	-0.0019*	-0.0001	0.0011	-0.0015
	(0.0012)	(0.0012)	(0.0012)	(0.0011)	(0.0011)
D_PRRS	0.1980***	0.1096*	0.0119	0.0625	0.0096
	(0.0574)	(0.0636)	(0.0658)	(0.0634)	(0.0564)
D_SI	-0.0402*	-0.0860**	-0.0012	0.0380	0.0300
	(0.0278)	(0.0294)	(0.0317)	(0.0317)	(0.0308)
D_CSF	-0.1994***	-0.2365***	-0.0969	-0.0423	0.0083
	(0.0561)	(0.0658)	(0.0682)	(0.0651)	(0.0540)
S_PRRS	7.76E-07***	7.87E-07**	-1.86E-07	2.08E-08	1.53E-07
	(2.88E-07)	(3.37E-07)	(3.52E-07)	(3.56E-07)	(3.06E-07)
S_CSF	-7.73E-07*	-2.12E-08	2.17E-07	-4.45E-07	-3.54E-07
	(4.06E-07)	(4.42E-07)	(4.31E-07)	(4.32E-07)	(3.99E-07)
LNEXP	0.2384**	0.4306***	0.5328***	0.3940***	0.1359*
	(0.0985)	(0.1509)	(0.1714)	(0.1475)	(0.0810)
Constant	0.0146	—	—	—	—
	(0.0302)	—	—	—	—

Only the results for equation of pork retail price are reported here, i.e. the dependent variable is pork retail price; standard errors are reported in parentheses
***/**/*: statistically significant at the 1%, 5%, and 10% levels respectively
Source: own calculations

Table 4: Estimation results for pork-hog price transmission.

	Current	Lag(1)	Lag(2)	Lag(3)	Lag(4)
Endogenous					
RP–PP	—	0.2450***	-0.1981**	0.0627	-0.1945**
	—	(0.0923)	(0.0927)	(0.0972)	(0.0829)
RC	—	0.0808	0.1241**	0.1138*	-0.0308
	—	(0.0589)	(0.0576)	(0.0599)	(0.0586)
Exogenous					
W	0.0002*	-0.0003*	0.0003**	0.0006**	-0.0002
	(0.0001)	(0.0002)	(0.0001)	(0.0002)	(0.0002)
O	0.0021***	-0.0002	0.0003	0.0008*	-0.0002
	(0.0006)	(0.0006)	(0.0006)	(0.0005)	(0.0005)
D_PRRS	0.0791***	0.0710**	0.0527*	0.0660**	0.0213
	(0.0269)	(0.0300)	(0.0311)	(0.0302)	(0.0266)
D_SI	-0.0083	-0.0655***	-0.0567***	-0.0158	-0.0065
	(0.0129)	(0.0133)	(0.0148)	(0.0152)	(0.0147)
D_CSF	-0.1017***	-0.1090***	-0.0664**	-0.0543*	-0.0207
	(0.0264)	(0.0315)	(0.0329)	(0.0324)	(0.0259)
S_PRRS	1.810E-07	3.490E-07**	6.130E-08	-2.250E-07	-1.360E-07
	(1.370E-07)	(1.590E-07)	(1.670E-07)	(1.670E-07)	(1.420E-07)
S_CSF	-4.430E-07**	-1.220E-07	-2.560E-07	-3.900E-07	-1.320E-07
	(1.940E-07)	(2.110E-07)	(2.060E-07)	(2.060E-07)	(1.890E-07)
LNEXP	0.0566	0.1267*	0.1756**	0.1269*	0.0336
	(0.0468)	(0.0714)	(0.0807)	(0.0685)	(0.0374)
Constant	-0.0061	—	—	—	—
	(0.0143)	—	—	—	—

Only the results for equation of farm-retail price transmission are reported here, i.e. the dependent variable is price transmission; Standard errors in parentheses
***/**/*: statistically significant at the 1%, 5%, and 10% levels respectively
Source: own calculations

hog price margin and then welfare distribution are affected not only by marketing costs, but also by some other factors such as price of substitute good, food incidents and export, verifying the obvious asymmetry of pork-hog price transmission in China's pork market.

Coefficients of three demand shocks are almost significant. *D_PRRS* affects pork-hog price transmission significantly lasting for four periods (i.e. from three periods lagged to current period), indicating that outbreaks of PRRS widens pork-hog price margin, which means pork retailers will be more profitable under the PRRS shock.[4] In contrast, both SI and CSF narrow the price margin. Specifically, SI negatively affects price transmission in one and two periods lagged, and CSF has a negative effect on price transmission in the first four periods. In addition, the effect of CSF is more enduring and powerful than that of SI. This is because CSF is a much more severe animal disease compared to SI. These estimated results also imply the porcine diseases have a differential impact on retailers and producers.

Meanwhile, shocks of diseases from supply side are less significant. Only the one period lagged of *S_PRRS* is significant and similar situation also exists in the supply shock of CSF. Not surprisingly, pork export and two kinds of marketing costs tend to enlarge the price margin (except in two periods lagged of wage). In other words, it means these variables increase pork retail price more than hog price.

The VAR(2) are selected on testing the upstream hog-piglet price transmission (PPL_t) based on the AIC criterion. Compared to the pork-hog price transmission, coefficients in the hog-piglet system are less significant (Table 5). In three food scares, only the demand shock of SI in one period lagged is significant and positive. While in two supply shocks resulted from food incidents, only PRRS in one period lagged is significant and negative.

Table 5: Estimation results for hog-piglet price transmission.

	Current	Lag(1)	Lag(2)
Endogenous			
RP–PP	—	0.6137***	-0.0487
	—	(0.0840)	(0.0811)
RC	—	-0.0880	-0.2112
	—	(0.1840)	(0.1852)
Exogenous			
W	0.0018***	0.0003	-0.0005
	(0.0004)	(0.0005)	(0.0004)
O	-0.0045**	0.0006	0.0004
	(0.0021)	(0.0021)	(0.0020)
D_PRRS	-0.0891	-0.0100	0.1452
	(0.1018)	(0.1079)	(0.0987)
D_SI	0.0365	0.1689***	0.0080
	(0.0501)	(0.0501)	(0.0540)
D_CSF	0.0861	0.1309	-0.0530
	(0.0970)	(0.1070)	(0.0944)
S_PRRS	2.260E-07	-1.230E-06**	-4.590E-07
	(4.970E-07)	(5.660E-07)	(5.140E-07)
S_CSF	3.550E-07	-2.690E-07	-4.300E-07
	(7.250E-07)	(7.760E-07)	(7.100E-07)
LNEXP	-0.3661***	0.0331	0.1500
	(0.1295)	(0.1655)	(0.1237)
Constant	-0.0458	—	—
	(0.0565)	—	—

According to the AIC criterion, VAR (2) is the best choice; only the results for equation of farm-retail price transmission are reported here, i.e. the dependent variable is price transmission; standard errors in parentheses
***/**/*: statistically significant at the 1%, 5%, and 10% levels respectively
Source: own calculations

Furthermore, only current period of the other three exogenous variables are significant, of which wage is positive but oil price and export are negative. The endogenous chicken price is insignificant in all periods. These results indicate that price transmission from hog to piglet market cannot be easily

[4] The authors consulted several Chinese butchers who experienced the 2007 PRRS crisis and get conclusions that are completely consistent with our empirical results.

impacted by food incidents, especially by PRRS and CSF. In other words, the pork-hog price transmission is more asymmetric than the hog-piglet one, which means more attention should be paid to the former facing porcine disease shocks.

Dynamic simulations

The impulse response function (IRF) proposed by Koop *et al*. (1996) and Pesaran and Shin (1997) is applied to observe the dynamic effects from endogenous variables on pork price and price transmissions. Figure 3 illustrates the IRF as there is an endogenous shock from chicken retail price. The minimum negative effect on pork retail price and two upstream price transmissions happen at one or two periods lagged, followed with fluctuations to zero until period 8. On the other side, the effect on pork-hog price transmission reaches the peak after the first three periods, declines from period 3 to period 7, then returns to zero gradually.

Unlike Lloyd *et al.* (2006), we use the Dynamic Multiplier Function (DMF) to test the impact of a unit increase in exogenous shocks on the endogenous price transmission, which is recognised to be more appropriate (Lütkepohl, 2005).

Figure 4 illustrates the effects of *D_PRRS* on pork retail price and price transmissions, which follow very similar patterns. All the three kinds of effects of *D_PRRS* rise at the beginning periods, and then decline dramatically until period 5, followed with fluctuations and decay to zero. The difference is that effects of *D_PRRS* on hog-piglet price transmission at the first two periods are negative, while effects on others are always positive, which is very meaningful for policy implications.

The effect processes of *D_SI* on pork retail price and pork-hog price transmissions are very analogous, i.e. drop to a minimum negative value at the first period, and then bounce back to horizon (Figure 5). Although patterns of them are similar, the impact on pork retail price is larger than those on price transmissions, suggesting that the pork retailer is more profitless than swineherds under the shock of SI. On the contrary, the effect on hog-piglet price transmission reaches a maximum positive value at the first period, followed with continuous decrease to zero. It means an amplifying hog-piglet price transmission existing in the upstream under the shock of SI. Therefore, it is not difficult to conclude that in the case of SI shock, swineherds in the middle of the chain

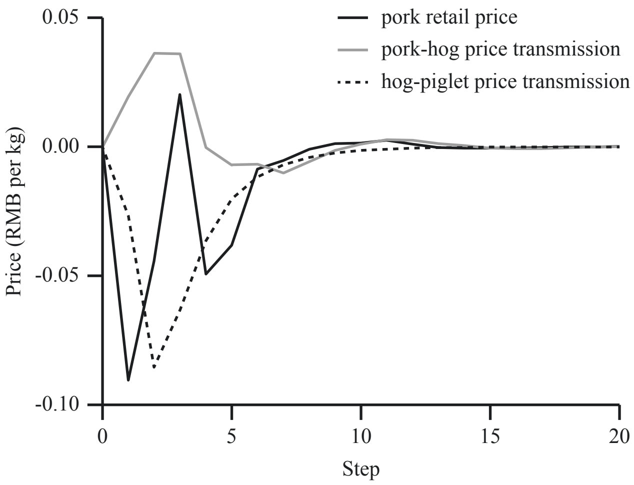

Figure 3: The simulated dynamic effect of a (one standard error) shock from chicken retail price (impulse response function).
Source: own composition

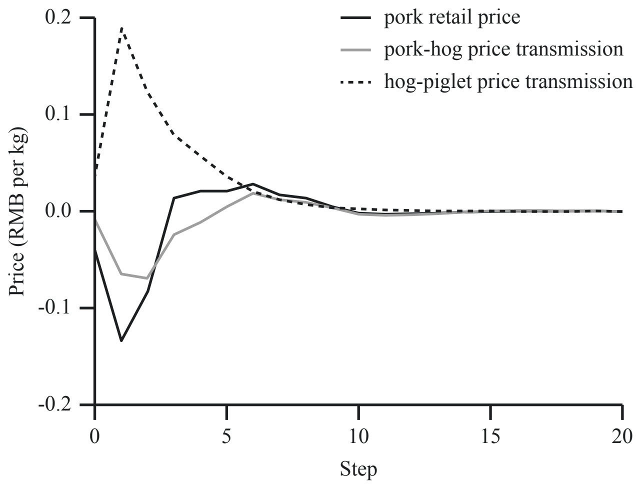

Figure 5: The simulated dynamic effect of a (one standard error) shock from SI (dynamic multiplier function).
Source: own composition

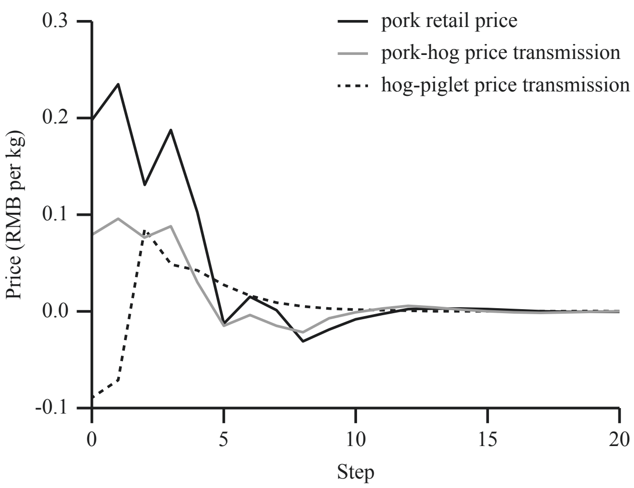

Figure 4: The simulated dynamic effect of a (one standard error) shock from PRRS (dynamic multiplier function).
Source: own composition

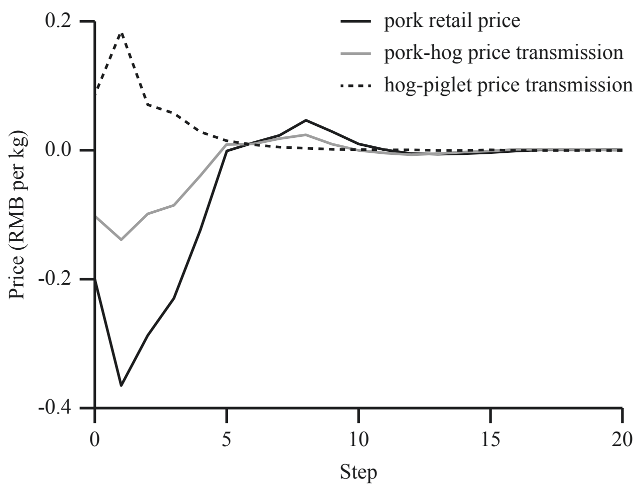

Figure 6: The simulated dynamic effect of a (one standard error) shock from CSF (dynamic multiplier function).
Source: own composition

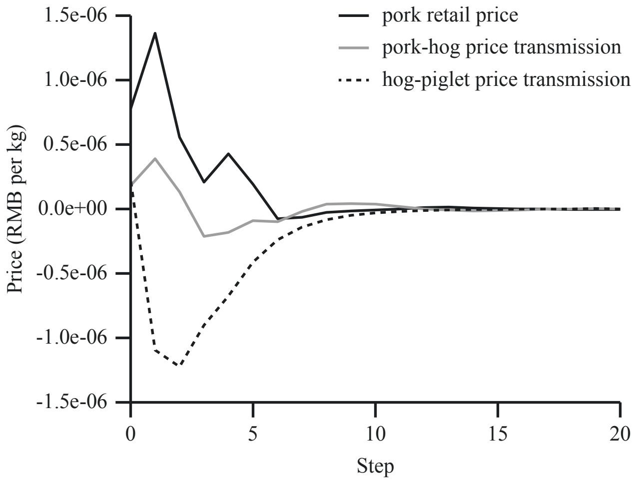

Figure 7: The simulated dynamic effect of a (one standard error) shock from S_PRRS (dynamic multiplier function)

Source: own composition

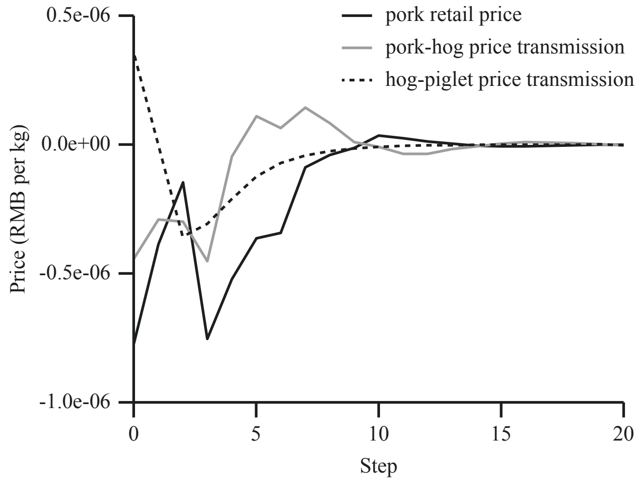

Figure 8: The simulated dynamic effect of a (one standard error) shock from S_CSF (dynamic multiplier function).

Source: own composition

are profitable as they can get a positive margin, while piglet farmers and pork retailers are very likely loss-making.

Figure 6 describes the impacts of *D_CSF* on pork retail price and price transmissions. Similarly, the impacts on pork price and pork-hog price transmission bottom out during the first period, and then recover to zero quickly. It is notable that the negative shock on pork retail price is much deeper than that on the pork-hog price transmissions. In addition, the effect process of *D_CSF* on hog-piglet price transmission tends to be totally opposite, which peaks at the first period and then drops quickly. Its implications are very similar with those for SI.

The effects of two exogenous supply shocks from PRRS and CSF are described in Figures 7 and 8. The increase of slaughter and death resulting from PRRS would push up the pork price and pork-hog price transmission to the maximum values at the first period, and then pull them down to zero gradually (Figure 7). The positive effect on pork price is significantly larger than that on pork-hog price transmission. On the contrary, impact on hog-piglet price transmission is negative and bottoms out at the second period and finally goes back to zero. Apparently, in the case of supply shock of PRRS, swineherds are loss-making, while both piglet farmers and pork retailers are winners with price margins. In comparison, the dynamic effects from the supply shock of CSF are more complicated and irregular (Figure 8).

Conclusions

This paper investigates the symmetry of impact of three main food scare events on farm and retail prices in the Chinese pork market, with national monthly data from 2001 to 2014. Based on a simple theoretical model, we estimate the VAR systems for pork retail price and price transmissions in different links, as well as plot the impulse response function and dynamic multiplier function respectively for endogenous substitute good price and exogenous food scare events.

Compared with previous studies, this paper jointly models three main food scare events and disentangles their effects on price transmission between both the upstream and downstream stages in the Chinese pork market. Empirical results correspond well with the reality and provide implications for farmers, business managers and policy makers to make strategies in response to food scare events. The biggest enlightenment is to respond differentially and flexibly for different market participants under different shocks. Future research can be fruitful in two ways. The first is obtaining higher quality data, for example, data for a longer time period. The second is to improve theoretical models and empirical procedures.

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Annex

Test for equation of pork retail price

Table A1: Lagrange-multiplier test for serial correlation for the equation of pork retail price.

lag	chi²	df	Prob > chi²
1	0.405	4	0.982
2	1.861	4	0.761
3	3.776	4	0.437
4	2.324	4	0.676
5	6.817	4	0.146

H0: no autocorrelation at lag order.
Source: own calculations

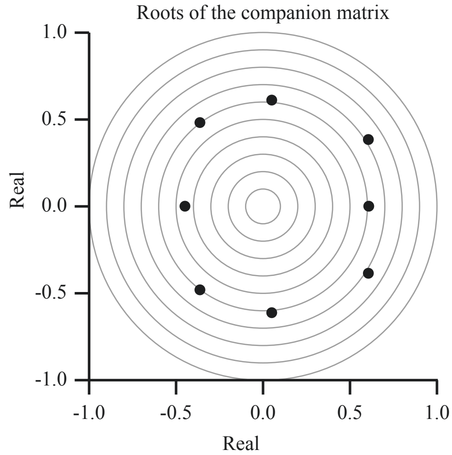

Figure A1: Test for stationary of VAR system of pork retail price.
Source: own composition

Test for equation of pork-hog price transmission

Table A2: Lagrange-multiplier test for serial correlation.

lag	chi²	df	Prob > chi²
1	7.110	4	0.130
2	0.440	4	0.979
3	1.286	4	0.864
4	4.707	4	0.319
5	6.969	4	0.138

H0: no autocorrelation at lag order
Source: own calculations

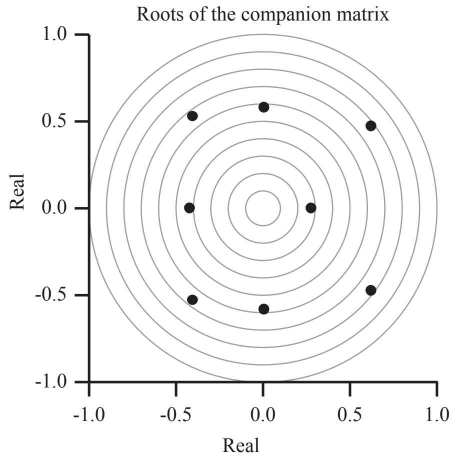

Figure A2: Test for stationary of VAR system.
Source: own composition

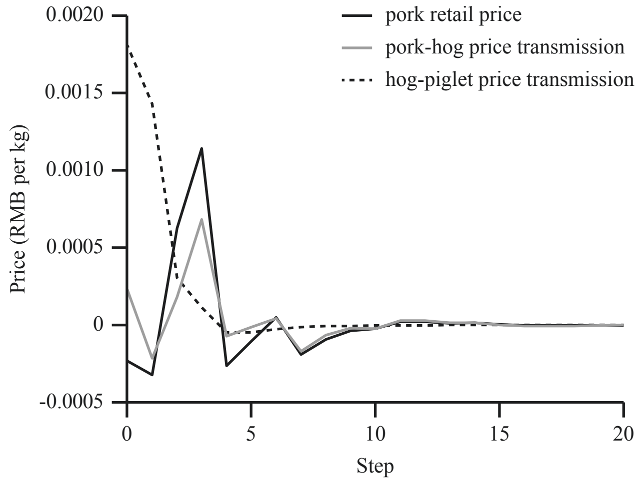

Figure A3: The simulated dynamic effect of a (one standard error) shock from wage (dynamic multiplier function).
Source: own composition

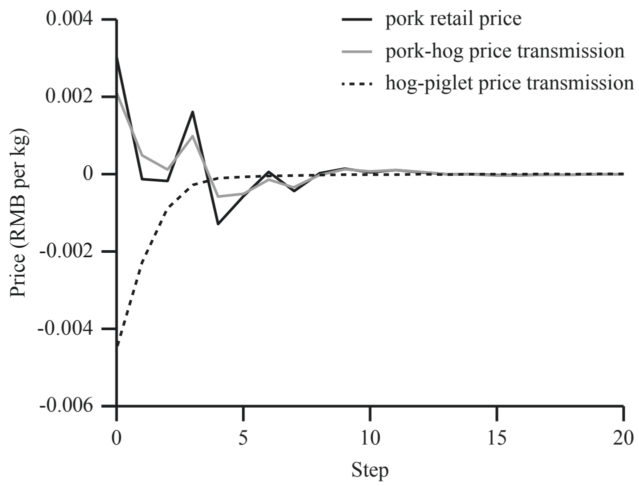

Figure A4: The simulated dynamic effect of a (one standard error) shock from oil price (dynamic multiplier function).
Source: own composition

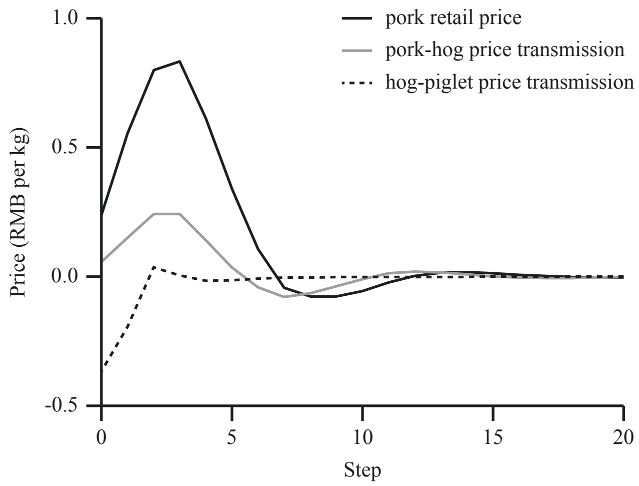

Figure A5: The simulated dynamic effect of a (one standard error) shock from LNEXP (dynamic multiplier function).
Source: own composition

Alexandre N. ALMEIDA*[1] and Boris E. BRAVO-URETA**

Assessing the sensitivity of matching algorithms: The case of a natural resource management programme in Honduras

A fundamental challenge in impact evaluations that rely on a quasi-experimental design is to define a control group that accurately reflects the counterfactual situation. Our aim is to evaluate empirically the performance of a range of approaches that are widely used in economic research. In particular, we compared three different types of matching algorithms (optimal, greedy and nonparametric). These techniques were applied in the evaluation of the impact of the MARENA programme (*Manejo de Recursos Naturales en Cuencas Prioritarias*), a natural resource management programme implemented in Honduras between 2004 and 2008. The key findings are: (a) optimal matching did not produce better-balanced matches than greedy matching; and (b) programme impact calculated from nonparametric matching regressions, such as kernel or local linear regressions, yielded more consistent outcomes. Our impact results are similar to those previously reported in the literature, and we can conclude that the MARENA programme had a significant, positive impact on beneficiaries.

Keywords: impact evaluation, propensity scores, semiparametric models

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Introduction

Similar to many Central American countries, the Honduran rural sector is characterised by low levels of production and income, which are attributed to a large proportion of landless or near landless rural workers, and low levels of farm family education (López and Valdés, 2000; Bravo-Ureta *et al*., 2011). In 2014, the Honduran agricultural sector contributed only 13.8 per cent to total GDP (WB, 2016). However, a significant part of the total population (44 per cent) lived in rural areas and 82 per cent were below the poverty line (ECLAC, 2009). Moreover, GEF-IFAD (2002) indicated that Honduran rural poverty is largely a consequence of unsustainable land use, which has led to environmental degradation, productivity losses, food insecurity and growing climatic vulnerability.

Recognising these major challenges, the international community has begun to re-adopt the old idea (Johnston and Mellor, 1961) that agricultural productivity growth is an essential component of any development strategy (WB, 2008). Moreover, it is now believed that policy efforts that focus on agricultural development can make a significant contribution to the Millennium Development Goals established by the United Nations in 2000, and to the more recent Sustainable Development Goals (SDSN, 2013; Sachs, 2015).

A key strategy to increase agricultural production and thereby income is the provision of agricultural extension services (Birkhaeuser *et al*., 1991; Anderson and Feder, 2007; WB, 2008). An effective diffusion of knowledge not only reduces the gap between laboratory experiments and farmers' fields, but also develops the skills necessary for good farm management practices and sustainable development (Winters *et al*., 2010).

Although the literature focusing on the evaluation of agricultural programmes in developing countries is growing, there are still very few quantitative studies assessing programme interventions for poverty in Central America (Bravo-Ureta *et al*., 2011). Rigorous measures of the impact of agricultural development programmes that target poor people are necessary not only to contribute to an emerging literature but they can also help donors and government agencies document the impact of their financial contributions and thus improve resource allocation (Heinrich *et al*., 2010; Petrikova, 2014).

Initially applied in medical sciences, treatment evaluation tools have become increasingly popular for analysing policy interventions across disciplines, particularly in economics. A central challenge of all these tools is how to define the counterfactual situation adequately (Ravallion, 2008). Ideally, one would have the outcome of interest for a group of individuals that has been treated and the outcome for the same group without treatment. Yet it is impossible to observe the same group with and without treatment at the same time. When the outcome of non-participants is used as a control, there is a real risk of selection bias that can overestimate or underestimate the impact of the treatment (Duflo *et al*., 2008). A well-executed randomised approach guarantees that, on average, there is no difference between treated and untreated subjects with respect to observable and unobservable characteristics (Ravallion, 2008). However, for technical and ethical reasons, randomised experimental studies in resource economics are difficult to implement (Ravallion, 2008; Heinrich *et al*., 2010). Thus, much of the evaluation work has relied on quasi-experimental designs, often incorporating propensity score matching (PSM) methodologies (WB, 2011).

The purpose of this study is to evaluate the impact of the MARENA (***Ma****nejo de* ***Re****cursos* ***Na****turales en Cuencas Prioritarias*) programme implemented in Honduras between 2004 and 2008. For this purpose, we conduct a detailed comparison of impact measures obtained from a range of propensity score functions and matching algorithms currently used in economic research. Overall, no single statistical method has emerged as the principal dominant or superior choice, and the number of applied studies that compares the performance of different matching techniques is very limited (Austin, 2013). In practice, researchers should select methods based on data characteristics to try to optimise the

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trade-off between the bias and variance of the estimators (Augurzky and Kluve, 2007; Austin, 2013). As a result, it is desirable to assess a variety of matching approaches to examine their robustness when evaluating a given intervention (Caliendo and Kopeinig, 2008; Ravallion, 2008; Imbens and Wooldridge, 2008).

Our analysis focuses on the MARENA programme, which financed activities designed to enhance agricultural production, productivity and the sustainable management of natural resources in predominantly poor rural agricultural areas in Honduras. Details of the programme can be found in Bravo-Ureta (2009) and Bravo-Ureta *et al*. (2011). The ultimate goal of MARENA was to reduce rural poverty while enhancing environmental sustainability. This paper extends the work reported by Bravo-Ureta *et al*. (2011), who relied on quasi-experimental data and traditional matching approaches along with difference-in-difference (DID) techniques, and showed that MARENA had a positive impact on its beneficiaries. An important attribute of MARENA, compared to other natural resource management projects, is that "… the collection of farm-level data to monitor and evaluate the programme was a priority from the beginning" (Bravo-Ureta *et al*., 2011, p.432). This feature offers high quality data assembled on a timely fashion, which makes it possible to conduct a robust evaluation that can then provide useful policy implications. Our goal here is to go beyond this earlier study by conducting an exhaustive analysis of robustness and performance for a variety of matching algorithms with different kinds of propensity scores that are not commonly applied in empirical studies (Khandker *et al*., 2009; Bravo-Ureta, 2014).

In summary, our main results corroborate the findings reported in Bravo-Ureta *et al*. (2011) who, using only two traditional matching techniques (one-to-one nearest neighbour (NN) and kernel regression), found impact estimates ranging from HNL[2] 16,425 to 25,575 in favour of the beneficiaries of the MARENA programme. In addition, based on balancing tests and the stability (i.e. similar of magnitudes) of impact estimates, we find that: (a) propensity scores coming from semiparametric estimation do not produce more robust impact estimates than propensity scores coming from logit or probit models; and (b) optimal matching does not lead to more robust impact estimates than the widely used greedy algorithm. These latter findings are consistent with what is expected based on conceptual grounds (Gu and Rosenbaum, 1993).

Methodology

Matching and quasi-experimental data

For evaluations where the objective is to measure the Average Treatment Effect on the Treated (ATET) and only quasi-experimental data are available, as in our case, it is necessary to generate a control group with observable characteristics for individuals that are as close as possible to those of the treated group (Khandker *et al*., 2009). To satisfy this requirement, the use of PSM has become a useful method of selecting controls to serve as 'perfect clones' of the treated subjects (Gertler *et al*., 2011). This selection is based on a set of observable characteristics (covariates) that are not affected by the treatment (Caliendo and Kopeinig 2008). In this manner, the model satisfies the conditional independence assumption and the common support assumption, as stated by Rosenbaum and Rubin (1983).[3] According to the latter authors, one of the advantages of using the PSM method is computational in nature, particularly when sample sizes are large and matching is time-consuming.

The goal of PSM consists essentially of finding the minimum distance between treated and untreated subjects given by the probability of an individual receiving treatment or not in a 'one dimensional vector' rather than relying on the whole set of observable characteristics (covariates) (Caliendo and Kopeinig, 2008). This minimum distance can be defined in various ways. The most straightforward used matching algorithm is the one-to-one NN method that can be executed with or without replacement of the treated and untreated observations based on the minimisation of the Euclidean distance (Caliendo and Kopeinig, 2008). Earlier, the one-to-one NN matching approaches were based on covariate means (known as Covariate Matching – CM), and were performed based on the Mahalanobis distance metric, a technique that is computationally cumbersome if the number of covariates is large (D´Agostino, 1998).

The NN algorithm, with and without caliper, has been widely implemented in impact evaluation studies and has been called 'greedy'. The main idea is that the odds of a treated unit finding its best match from a reservoir of controls are best for the 'early' units in the search; in other words, first come, first served as described by Rosenbaum (1989). Augurzky and Kluve (2007) explain that a greedy algorithm works by a random selection between treated and untreated units in terms of a specified distance. Once a treated unit finds its control, both are removed from the original sample, and the matching process continues. As a consequence, finding 'good' controls for treated units becomes increasingly difficult as the process unfolds. To overcome this problem, optimal matching has been proposed. This technique "works backwards and rearranges already matched units if some specific treated unit turns out to be a better (closer) match with a control unit previously matched to another treated unit" (Augurzky and Kluve, 2007, p.540). The idea is to attain the optimal minimum distance between treated and untreated units. To date, an empirical study of this matching approach that aims to analyse the impact of development interventions in the context of agriculture does not appear to exist.

In theory, optimal matching should overcome the shortcomings of greedy matching, such as the creation of bad 'late' matches. Gu and Rosenbaum (1993) evaluated the performance of optimal versus greedy matching programmes and found that optimal matching is superior to greedy matching only when the goal is to minimise the average Mahalanobis distance within pairs among covariates. Yet, optimal matching is no better at minimising propensity scores' distances or at producing balanced matched samples. Augurzky and Kluve (2007) tested the relative efficiency of greedy and optimal matching, along with different types

[2] HNL (Honduran Lempiras) 19.50 = USD 1.00 in 2012.

[3] Formal proofs of these assumptions can be found in Rosenbaum and Rubin (1983) and Imbens (2000).

of distance measures, to evaluate the time it takes for high school graduates to complete a bachelor's degree and found that the greedy choice produced a more favourable balancing of covariates than the optimal matching. More recently, Austin (2013) compared several matching algorithms using Monte Carlo simulations, with results very similar to those of Gu and Rosenbaum (1993). Austin (2013) found that if optimal matching resulted in samples in which the mean difference in the propensity scores is less between treated and control units compared to greedy matching, then balancing of covariates was not improved under optimal matching.

As far as we are aware, a good deal of discussion remains but no clear conclusions about the relative performance of the matching algorithms that are commonly used empirically, particularly the optimal matching. Moreover, both greedy and optimal matching systems share a limitation when the common support assumption is imposed (as it should be). In this case, some observations from the treated and/or untreated groups will be dropped, which can be a problem if the sample size is small. Heckman *et al*. (1997) proposed a partial solution to this problem that relied on estimating the treatment effect by comparing the outcome of interest of all treated individuals to a weighted average of the outcomes of all untreated individuals. This comparison is made using a standard nonparametric Nadaraya-Watson regression in which the propensity scores are used as weights.[4]

Regardless of the choice of the matching approach, it is imperative to verify if the balancing property holds. A simple and efficient way is to check the similarities between treated and untreated subjects using two different types of statistics widely used currently: standardised bias and p-values from a standard t-test between the means (D'Agostino, 1998; Lee, 2013).[5] The rule of thumb in such cases is that the standardised bias should not be higher than 20 per cent in absolute value, and p-values should be no lower than the 10 per cent level of statistical significance (Rosenbaum and Rubin, 1985). Moreover, a likelihood-ratio test of the joint significance of all the regressors and the pseudo R^2 after matching are also useful to check the balancing condition (Leuven and Sianesi, 2003; Sianesi, 2004; Caliendo and Kopeinig, 2008). In any case, if the matched sample does not turn out to be balanced, a new specification of the covariates should be considered (Heinrich *et al*., 2010).

Combining PSM and difference-in-difference

As already pointed out, a robust and accurate evaluation of the intervention is possible only if individual characteristics for non-participants are well matched with those of participants. Although matching can eliminate or substantially mitigate biases stemming from observed characteristics, it is possible that biases from unobserved time invariant characteristics, such as managerial skills and motivation of farmers, still remain (Gertler *et al*., 2011; Maffioli *et al*., 2013). As panel data are available for this study, we can combine the DID estimator with alternative propensity scores and the various matching algorithms (Khandker *et al*., 2009; Bravo-Ureta, 2014). The DID approach, as initially suggested by Heckman *et al*. (1998), measures the difference between the expected outcome of treated and control groups at the baseline (in our case 2003-2004) and the difference in the outcome at a point typically close to the end of the intervention (in our case 2007-2008), often referred to as the endline (Ravallion, 2008). The average treatment effect for the treated individual *i* using DID and combining PSM can be expressed as:

Table 1: Definition of variables used in the analysis.

Variable	Unit	Definition
TVAO	HNL	Total value of agricultural output
BENEF	Dummy	1 if the household is a beneficiary of MARENA
NEIGHBOR	Dummy	1 if the household is not a beneficiary of MARENA and lives within its area of influence
AGLAND	Hectares	Total land devoted to agricultural production
DIVER	Dummy	1 if household produces crops in addition to maize and beans
CAFEECO	Dummy	1 if the household produces coffee using ecological practices
ALTITUD	Dummy	1 if the farm is located at an altitude higher than the mean
AGE	Years	Age of household head
EDUC	Years	Years of schooling of the household head
NUMBER	Number	Number of people in the household
ORGA	Dummy	1 if the household head participates in farmer organisations
ASSIST	Dummy	1 if the household receives technical assistance
YEAR	Dummy	0=2004, 1=2008

Source: own compilation

$$DID_i = (Y_{i,t}^T - Y_{i,t-1}^T) - \sum_{j \epsilon c} \omega(i,j)(Y_{i,t}^C - Y_{i,t-1}^C) \quad (1)$$

where $\omega(i,j)$ is the weight (using PSM) given to the *j*th control individual matched to treated individual *i*, *t* is the endline, $t-1$ is the baseline, and *T* and *C* stand for treated and control respectively (Khandker *et al*., 2009).

Implementation of the empirical analysis for the MARENA intervention

The implementation of the empirical analysis is as follows:

Step 1. Estimate a binary choice model to calculate the probability (propensity score) that the farmer is a beneficiary of MARENA, using data for the 2003-2004 baseline year. The function to be estimated can be written in general terms as:

$$BENEF=f(AGLAND, CAFEECO, NUMBER, ALTITUD, AGE, EDUC, ORGA, ASSIST, DIVER) \quad (2)$$

where *BENEF*=1 if beneficiary and 0 if non-beneficiary. The covariates are defined in Table 1.

Step 2. Using the propensity score vectors from step 1, matched samples are constructed based on Euclidean distance using different algorithms without replacement.[6] Fig-

[4] Local linear matching is also a version of kernel matching and is implemented in the same fashion as the Heckman approach (see Caliendo and Kopeinig, 2008).

[5] The standardised bias is the size of the difference in the means of covariates between treated and untreated units, scaled by the square root of the average of their sample variances (Heinrich *et al*., 2010).

[6] Austin (2013) discourages the use of matching with replacement, because it seems to induce a higher mean square error (higher variance) of the estimated impact than matching without replacement.

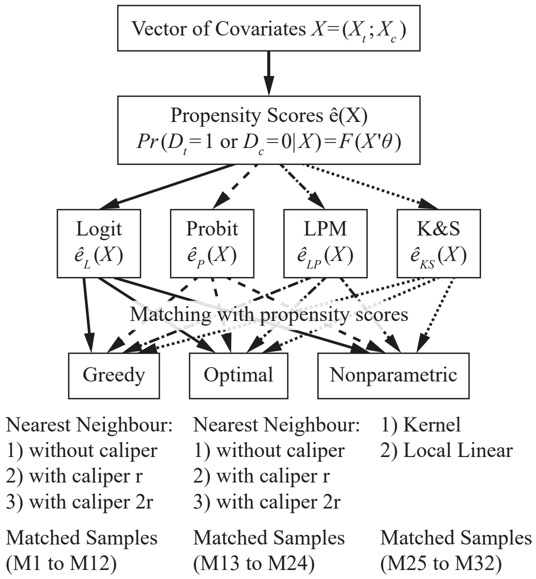

Figure 1: Matched sample generation process using propensity score vectors from the estimation of logit, probit, linear probability and Klein and Spady models.

Source: own composition

ure 1 shows all the combinations considered among matching algorithms and propensity scores generating a total of 32 matched samples. The common support condition is imposed in all cases.

Step 3. Check whether the covariates of treated and untreated units are balanced. If they are not, a new specification of the score function regarding covariates should be tested.

Step 4. Calculate the ATET by combining PSM from the 32 matched samples and DID method (equation 1). See Caliendo and Kopeinig (2008) for a detailed review on ATET.

Data

The data used in this research are from a two-round panel covering 366 households, of which 109 were beneficiaries of the MARENA programme, while the remaining 257 constitute the untreated or control group. Of the untreated group, 143 households (neighbours) are located within MARENA's area of intervention, and 114 households are located outside of that area (non-neighbours).[7] Data were collected during the 2003-2004 agricultural year (baseline) and then four years later, for the 2007-2008 production cycle (endline). The dataset includes information on socioeconomic and demographic household characteristics, alternative sources of income, and a detailed description of farm inputs, outputs, expenses and revenues. Table 2 reports the means and standard deviations of the MARENA programme for the agricultural year 2003-2004 (baseline) for beneficiaries versus non-beneficiaries. The key outcome of interest for the evaluation is the total value of agricultural output

[7] Similar to Bravo-Ureta *et al*. (2011), the spillover effect (indirect effect) of the MARENA programme between neighbours and non-neighbours was also investigated. Our estimates show that the spillover effect (on neighbour), although positive, was not statistically significant in any of our simulations. According to Bravo-Ureta *et al*. (2011), if the skills or incentives required to implement the farming practices by the programme are sufficiently complex, it is not unexpected that the knowledge diffusion between beneficiaries and non-participants neighbours might be inefficient.

Table 2: Group comparisons prior to matching (beneficiaries vs. control, baseline 2004).

Covariate	Treatment		Control		Two-sample t-statistic	Standardised difference (%)
	Mean	SD	Mean	SD		
AGLAND	1.80	1.26	2.25	2.29	1.91**	-24.07
CAFFECO	0.02	0.13	0.00	0.06	-1.40	13.76
NUMBER	6.20	2.68	5.96	2.52	-0.81	9.11
ALTITUD	0.47	0.50	0.53	0.50	1.00	-11.46
AGE	46.61	14.45	48.14	14.10	0.95	-10.78
EDUC	3.50	2.74	3.24	2.97	-0.77	8.91
ORGA	0.74	0.44	0.26	0.44	-9.60***	109.79
ASSIST	0.44	0.50	0.25	0.43	-3.78***	41.89
DIVER	0.52	0.50	0.44	0.50	-1.46	16.66
Observations	109		257			

For definitions of the variables see Table 1
***, **, * Significant at the 1%, 5% and 10% levels respectively
Source: own calculations

(TVAO). TVAO includes revenues from the production of maize, beans, coffee and horticultural crops and the value of any farm products consumed by the household. Before the programme, the TVAO (not shown) was much larger for the control group (around HNL 45,000) than for the treatment group (HNL 27,786).

The last two columns of Table 2 contain statistics (t-test and the standardised bias difference in per cent) that were used to compare the treated and untreated groups with regard to observable characteristics before the matching at the baseline. As stated, large statistical differences among observable characteristics can lead to biased estimates of the real impact of the intervention. We observed that only three variables have shown such distortion in our sample. They are: (1) total land devoted to agricultural production (AGLAND); (2) participation in farmer organisations (ORGA); and (3) technical assistance (ASSIST). Therefore, special attention is given to these three variables below.

Results

Estimating propensity scores

In practice, discrete choice models, such as logit and probit, have been widely used to estimate propensity scores before matching (Cameron and Trivedi, 2005). On the other hand, Smith (1997) and Caliendo and Kopeinig (2008) argue that because propensity score models are used only for classification, a simple linear probability model (LPM) could also be used. However, one of the drawbacks of the LPM is that it is likely to yield predicted outcomes that lie outside of the common support condition, resulting in a loss of information (observations), thereby compromising the quality of the matching (Zhao, 2007). For our study, we also use the model developed by Klein and Spady (1993) that has the major advantage of relaxing the assumption that the error term follows a logistic (logit) or normal (probit) distribution, which can be restrictive and can produce inconsistent estimates in practice (Li and Racine, 2007). The coefficients of the semiparametric K&S model, logit, probit, and LP models are displayed in Table 3.

The next step is to calculate the predicted probabilities (propensity scores). A simple Q-Q plot method[8], which compares the quantiles of these scores for the four models, indicate that there is no statistical difference between them. However, we find that propensity scores coming from different models do affect the magnitude of the final impact of the intervention after matching, as shown below.

The impact of the MARENA programme and robustness checking

Table 4 reports the impact of MARENA in HNL on the TVAO between 2003-2004 and 2007-2008 for 32 samples matched using different matching algorithms and distance measures. Matching is combined with the DID estimator and is applied in all cases. The ATET estimates are identified in Table 4 by a superscript with the capital letter M along with a number from 1 to 32 for each matched sample (See Figure 1 for a review of the matched sample generation process). The ATET results constructed using a one-dimensional vector are shown; that is, matching is performed only using the predicted propensity scores estimated from logit, probit, linear probability and K&S functions. We used these vectors of propensity scores to perform the matching based on the following algorithms: (1) greedy and optimal one-to-one NN with no caliper; (2) greedy and optimal one-to-one NN with caliper r, where r is one quarter of a standard deviation of the propensity score (Rosenbaum and Rubin, 1983); (3) greedy and optimal one-to-one NN with caliper 2r; (4) kernel regression; and (5) local linear regression.

The greedy matching, nonparametric kernel, and local linear were performed in a STATA do-file procedure (*psmatch2.ado*) published by Leuven and Sianesi (2003).[9] Another STATA do-file procedure (*optmatch2.ado*) developed by Mark Lunt at the University of Manchester was used for optimal matching.[10]

As mentioned above, three variables in our unmatched sample (Table 2) for the baseline year were unbalanced: AGLAND, ORGA and ASSIST. Of the total 32 matched samples constructed, eight (matched samples 1 to 4; 13 to 15) did not yield balance for one of the covariates (AGLAND or ORGA) and one matched sample (M16) exhibited two unbalanced covariates (ORGA and ASSIST), i.e., they did not pass the balancing tests (p-value < 0.10 and standardised bias < 20 per cent) after matching. Therefore, all the ATET estimates from these eight matched samples were omitted in the analysis in Table 4; The indicators of covariate balancing for these eight matched samples are shown in Annex 1.

Firstly, all statistically significant ATET estimates for matched data were higher than for the unmatched data (HNL 13,886, not shown). Secondly, based on the balancing tests and stability of coefficients (i.e. quite similar on magnitude values), we found more consistent matching results of the impact of the programme (1) under non-parametric matching approaches, whether kernel or local linear, and (2) under the greedy algorithms, particularly when a caliper is imposed.

Table 3: Logit, probit, LPM, and K&S results for participation in the MARENA programme using baseline data (2004) (N=366).

Covariate	Logit	Probit	LPM	K&S (1993)
	Coefficient			
AGLAND	-0.375*** (0.094)	-0.215*** (0.056)	-0.048*** (0.011)	-0.380*** (0.061)
CAFFECO	4.035*** (1.034)	2.346** (1.114)	0.578** (0.243)	4.604*** (0.732)
NUMBER	0.038 (0.050)	0.025 (0.031)	0.006 (0.008)	0.042*** (0.008)
ALTITUD	-0.474* (0.281)	-0.259* (0.160)	-0.076* (0.043)	-0.607*** (0.097)
AGE	-0.013 (0.010)	-0.008 (0.006)	-0.002 (0.002)	-0.036*** (0.006)
EDUC	-0.035 (0.050)	-0.015 (0.029)	-0.006 (0.008)	-0.089*** (0.013)
ORGA	2.296*** (0.295)	1.340*** (0.163)	0.418*** (0.044)	3.423*** (0.535)
ASSIST	0.673** (0.290)	0.403** (0.168)	0.117** (0.047)	0.524*** (0.086)
DIVER	0.523* (0.299)	0.280* (0.167)	0.068 (0.045)	0.721*** (0.116)
CONSTANT	-1.056* (0.624)	-0.635 (0.404)	0.270** (0.108)	-
LR $chi^2(9)$	78.95***	105.36***	14.42***	
Wald $chi^2(9)$				46.19***
Pseudo R^2	0.242	0.236	0.248	0.221
Log likelihood	-169.947	-170.21		-158.307

For definitions of the variables see Table 1
***, **, * Significant at the 1%, 5%, and 10% levels respectively; SE are shown in parentheses
Source: own calculations

Table 4: The impact of the MARENA programme on total value of agricultural output in HNL constructed from matched samples using propensity score (PS) vectors from the estimation of logit, probit, linear probability and K&S models.

Outcome: $TVAO = TVAO_t - TVAO_{t-1}$	PS (Logit)	PS (Probit)	PS (LPM)	PS (K&S)
(1)	(3)	(4)	(5)	(6)
Greedy matching				
NN with no caliper£	FBT^{M1}	FBT^{M2}	FBT^{M3}	FBT^{M4}
NN with caliper (0.06)†£	18,629^{M5} (10,072)**	18,153^{M6} (10,034)*	20,594^{M7} (9,710)**	18,390^{M8} (9,877)*
NN with caliper (2x0.06)†£	20,408^{M9} (9,860)**	18,948^{M10} (9,813)*	20,427^{M11} (9,534)**	17,120^{M12} (9,895)*
Optimal matching				
NN with no caliper£	FBT^{M13}	FBT^{M14}	FBT^{M15}	FBT^{M16}
NN with caliper (0.06)†£	23,126^{M17} (11,313)*	8,594^{M18} (1,068)	16,091^{M19} (9,404)*	18,188^{M20} (11,224)*
NN with caliper (2x0.06)†£	19,963^{M21} (10,770)*	12,548^{M22} (10,893)	24,263^{M23} (10,278)**	22,649^{M24} (11,558)*
Nonparametric matching				
Kernel€	19,845^{M25} (9,852)**	18,977^{M26} (9,811)*	20,661^{M27} (9,519)**	17,000^{M28} (9,822)*
Local linear€	17,882^{M29} (9,933)*	17,231^{M30} (9,886)*	18,414^{M31} (9,855)*	17,736^{M32} (9,970)*

The DID estimator is combined with PSM; SE are shown in parenthesis and superscripts identify the matched samples; FBT stands for failed balancing tests
***, **, * Significant at the 1%, 5% and 10% levels respectively
Notes: £ One-to-one matching; †Size of the caliper used is a quarter of a standard deviation of the propensity score as suggested by Rosenbaum and Rubin (1983). For the four models, the standard deviation ranged from 0.2315 to 0.2426; € The optimal bandwidths (Logit = 0.067; Probit = 0.066; LPM = 0.065; K&S = 0.081) were calculated based on the rule of thumb of Silverman (1986)
Source: own calculations

[8] Not reported here but available from the authors upon request.

[9] Stata v.13 has introduced a new *teffects* command for estimating ATE and ATET with the advantage compared to *psmatch2* for which standard errors take into account that propensity scores are estimated rather than known (http://www.ssc.wisc.edu/sscc/pubs/stata_psmatch.htm). One limitation, however, is that the procedure does not allow the use of propensity scores different from those estimated using logit or probit models. Moreover, the non-replacement option is also not allowed.

[10] http://personalpages.manchester.ac.uk/staff/mark.lunt

Discussion

In this paper, we extended the study by Bravo-Ureta *et al*. (2011) who found that the MARENA programme had a significant positive impact on beneficiaries. To corroborate those earlier results, and given that there is no agreed-upon best approach, we used several matching approaches designed specifically for quasi-experimental data (Caliendo and Kopeinig, 2008). We also tried to extend our analysis by relaxing the major assumptions imposed in the logit and probit models that are widely used to calculate propensity scores, and also by comparing different algorithms (e.g. greedy versus optimal). We observed that the use of propensity scores from a semiparametric estimation (Klein and Spady), for example, might provide estimated coefficients that are quite similar to those obtained using the logit, probit or linear probability models. Nevertheless, as stated by Smith (1997), and Caliendo and Kopeinig (2008), because the goal of propensity scores is only classification, the choice of the model to be estimated might not be crucial. Overall, our evaluation lends support to the positive impacts reported in the literature for a family of natural resource management interventions that have been implemented in recent years in Latin America (Solís *et al*., 2009, Cavatassi *et al*., 2011) and to similar programmes that are currently under preparation.

We did not corroborate the hypothesis, coming from the theoretical literature, that optimal matching produces 'better-balanced' matched samples and consequently more stable results than the greedy matching. We found that the balancing property holds equally well for both the greedy and optimal algorithms, particularly when calipers are imposed. However, based on the stability of the various impact estimates, we did find significant differences in terms of ATET values when propensity scores are compared, particularly in the same optimal matching approach. Moreover, the ATET calculated from nonparametric regressions, such as kernel or local linear, not only presented very consistent outcomes but also satisfied the balancing property for all selected covariates.

One of the potential reasons that optimal matching has no advantage over greedy matching in producing balanced matched samples is because both methods select more or less the same controls (Gu and Rosenbaum, 1993). We also find the optimal matching generates unstable results across differently estimated propensity scores than greedy matching even while they have equally better-matched samples. That being said, our findings support the view that the way propensity scores are estimated, whether parametrically or semiparametrically (K&S model), matters, particularly when these scores are used to execute the optimal matching. For example, by comparing the same impact from different propensity scores based on the same matching algorithm, it is clear that there is greater variability across the estimates from one-to-one optimal matching with caliper r (from HNL 8,594 (M18) to HNL 23,126 (M17)) and one-to-one optimal matching with caliper 2r (from HNL12,548 (M22) to HNL 24,263 (M23)) than the estimates from the greedy algorithms with caliper r and 2r (ATET estimates between HNL 17,120 (M12) and HNL 20,594(M7). Such lower variability was also reported by Bravo-Ureta *et al*. (2011) who, testing a greedy NN matching technique with a caliper arbitrarily chosen at 0.05, found impact estimates ranging from HNL 16,425 to HNL 20,654. Only a logit model based on the same covariate specification, as this study does, was used to generate their vector of propensity scores.

Moreover, in our dataset, two of the estimates (M18 and M22) from the optimal matched samples (NN with caliper of 0.06 and caliper of 0.12 using propensity scores from the probit model) are not statistically significant at the 10 per cent level, even though they have passed the balancing tests.

We also found that when the two non-parametric matching regressions, kernel and local linear, are tested and compared using different propensity scores, the impact estimates are similar in magnitude to greedy algorithms with calipers. The respective ATET non-parametric results (shown at the bottom of Table 4) on the TVAO are not only statistically significant and vary in value in a narrow range from 17,000 to 20,661.

Our results point out that analysts should not neglect the application of greedy algorithms and the use of a caliper during matching as also a way to impose common support and consequently avoiding bad matches (Gu and Rosenbaum, 1993; Caliendo and Kopeinig, 2008). Augurzky and Kluve (2007) and Austin (2013), using Monte Carlo simulations to examine different algorithms, found that when a caliper is used, it is possible to achieve balance, both for continuous and binary covariates, as we found for all matching approaches used. Note that the imposition of too narrow a caliper can result in the loss of observations and, consequently, an increased variance of the estimates so that non-parametric approaches (kernel or local linear) arise as an advantage because they avoid the loss of observations. In fact, based on our analysis, when the common support condition was imposed, between 8 and 14 of 109 treated observations needed to be discarded when performing the matching, depending on the propensity score vector used.

In practice, as seen in the applied literature, clearly some variability in the results are, to some extent, expected because matching techniques are implemented differently; and results depend on characteristics of the data under analysis (Caliendo and Kopeinig, 2008; Ravallion, 2008; Heinrich *et al*., 2010). Moreover, we should keep in mind that an estimator that works well in simulations does not necessarily behave in the same manner in applications with real data, which was the major motivation for this study.

To the best of our knowledge, comparisons of greedy versus optimal matching, although discussed in the literature, have not been well documented and, therefore, warrant further attention in both theoretical and applied work.

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Annex

Annex 1: Covariate balancing tests between treated and control farmers of the MARENA programme for eight matched samples which failed the balancing tests.

Matched sample	Comparisons	Covariates									Pseudo R^2	$Pr>\chi^2$
		AGLAND	CAFEECO	NUMBER	ALTITUD	AGE	EDUC	ORGA	ASSIST	DIVER		
M1	p-value (t-test)	0.55	0.00	0.68	0.67	0.80	0.18	0.07	0.47	0.89	0.029	0.432
	SB %	-6.40	0.00	5.80	-6.00	3.60	-20.00	27.30	10.70	2.00		
M2	p-value (t-test)	0.44	0.00	0.35	1.00	0.75	0.30	0.07	0.39	0.89	0.028	0.452
	SB %	-8.10	0.00	13.10	0.00	4.60	-15.10	27.30	12.90	-2.00		
M3	p-value (t-test)	0.08	0.32	0.41	0.68	0.94	0.42	0.17	0.31	0.78	0.037	0.249
	SB %	-29.60	-9.40	11.50	-5.90	1.00	-11.50	20.10	14.80	4.00		
M4	p-value (t-test)	0.05	0.32	0.57	0.89	0.48	0.34	0.44	0.13	0.67	0.032	0.390
	SB %	-27.20	-10.00	-8.50	-2.10	10.70	-13.60	12.00	22.60	-6.30		
M13	p-value (t-test)	0.82	0.16	0.60	0.59	0.80	0.44	0.00	0.22	0.69	0.011	0.946
	SB %	-3.02	19.25	7.18	-7.31	3.47	-10.46	39.06	16.84	5.48		
M14	p-value (t-test)	0.86	0.16	0.51	0.79	0.75	0.68	0.00	0.17	1.00	0.019	0.776
	SB %	-2.40	19.25	8.99	-3.66	4.40	-5.61	40.96	18.77	0.00		
M15	p-value (t-test)	0.12	0.56	0.39	0.50	0.83	0.93	0.02	0.34	0.59	0.020	0.736
	SB %	-20.44	7.84	11.71	-9.14	-2.92	-1.26	31.45	13.03	7.31		
M16	p-value (t-test)	0.15	0.56	0.40	0.59	0.93	0.77	0.01	0.02	0.59	0.011	0.946
	SB %	-19.73	7.84	-11.54	-7.31	1.22	-3.92	35.25	32.73	7.31		

SB: standardised bias (Rosenbaum and Rubin, 1985)
Source: own calculations

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