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Full Research Article

Climate change and variations in mountain pasture values in the central-eastern Italian Alps in the eighteenth and nineteenth centuries

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Abstract. This study investigates variations in pasture lease rents during the eighteenth and nineteenth centuries in a sector of the Italian Alps and how these correlate with climate changes. Analysis of the rents in the three data sets clearly demonstrates a sharp increase over the period considered, which can generally be ascribed to increased human pressure following population growth during the same period. Oscillations in the values obtained for fifty-year periods between the last half of the eighteenth century and the beginning of the twentieth suggest a strong connection with environmental and climatic factors. Increases or decreases in temperature seem to have a less marked and less direct effect on the values of grazing lands close to the upper limit of vegetation, while socio-economic and infrastructural signals impinge significantly on climate signals on the grazing lands at lower altitudes.

Keywords. Grazing lands, climate changes, Italian Alps.

JEL codes. Q54, Q15, Q51.

1. Introduction

1.1 Climate change and mountain agriculture

The consequences of ongoing climate change are the subject of an increasing number of scientific studies (IPCC, 2014). In particular, the interaction among climatic factors, agro-forestry systems and ecosystem productivity is currently being investigated using a variety of tools (Baglioni *et al.*, 2009; Bosello and Zhang, 2005; Roson, 2003; Solomon, 2007). The aim is generally to obtain an economic assessment of variations in well-being due to changes in the environments where agriculture is practiced (e.g., Palatnik and Nunes, 2010).

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In fact, in the Alps:

a) climate imposes very clear limitations on soil productivity[1];
b) the history of locations bears clear evidence of variations in climate[2];
c) for many centuries the development of communities has been strongly conditioned by agricultural productivity, which in turn is correlated with climate evolution (Mathieu, 2000, p.127).

In the southern Alps in particular, the traditional organisational structures of communities were such that private property was located near the villages and common pastures and meadows in the mountains (Raffaelli, 2005). This type of organisation reflected the fact that development of the local communities was to a large extent dependent on resources that could be generated locally. Unlike the fields close to the villages, pastures and woodlands could be exploited with low fixed investments and represented a reserve of resources that could be adjusted relatively quickly in the case of rapid increases or reductions in anthropic pressure.

From this perspective, the Alps are an ideal testing ground for measuring the economic consequences of climate change (Dearing 2006; Fraser 2009; Pfister and Brazdil 2006; Theurillat and Guisan, 2001).

Alpine pastures represent one of the most complex and interesting study cases. Forage productivity and quality in areas given over to pasture are closely linked to environmental factors, such as soil temperature, fertility and moisture (Baglioni, *et al.* 2009; Bosello and Zhang, 2005; Menzel and Fabian, 1999; Roson, 2003). Alpine pastures are characterized by a rapid growth in productivity in spring and summer followed by a period of gradual decline and decreasing quality. There is now an extensive body of scientific literature on the effects of temperature on productivity trends in Alpine pastures (Cavallero *et al.* 1992; Gusmeroli *et al.*, 2005; Orlandi *et al.*, 2004; Ziliotto and Scotton, 1993;), although there has not always been general consensus on the nature of the variability (Orlandi and Clementel, 2007). All of the studies agree, however, that pasture productivity is closely related to natural constraints and particularly to temperature variation, which, in the mountains more than anywhere else, has a direct effect on the vegetative cycle and the productivity of herbaceous vegetation. In other words, it seems to be clear that the productivity of mountain land varies over time in response to trends in temperature, with consequent fluctuations in its economic value.

In the Alps, spring temperature appears to be particularly important for total grass production. Indeed, it is well known that the growth of grass depends on accumulated temperature (day degrees); as a consequence, the spring temperature determines whether herds are taken up to the mountain pastures earlier or later (Gusmeroli et al, 2005). Summer temperature, on the other hand, appears to be less important in the Alps, so that the end of the grazing season, unlike the beginning, is traditionally set for a fixed date (20 September), at least in the area examined here (Bussolon, Martini, 2007). As far as precipitation is concerned, the climate regime in the entire Alpine area has a winter

[1] For example, the upper limit of tree growth (treeline) and the limit of cereal cultivation are usually defined by altitude. This is because, with the exception of specific local situations, average temperature and length of the growing season vary as a function of height above sea level.

[2] For example, toponomy still reflects situations arising as a consequence of the climate in the near or distant past. (Bussolon and Martini, 2007)

minimum (under the influence of the Russo-Siberian anticyclone in the cold months) followed by a maximum between spring and autumn. The study area in particular has a pre-Alpine type of climate regime with an autumnal maximum slightly higher than the spring maximum. Areas with a pre-Alpine climate are more influenced than others by their geographical proximity to the Po plain, which places few obstacles in the way of humid air masses. Spring precipitation in these areas is always abundant and, unlike in south-central Italy, no significant fluctuations are evident in the available historical series (Buffoni *et al.*, 2003). As a result, the precipitation regime has had less influence on the modifications in the seasonal productivity of pastures in these regions.

The mountains of the Italian pre-Alps studied here have been exploited at least since the sixteenth century. The pastures are part of a system based on vertical transhumance whereby livestock spend the summer on higher Alpine pastures (Salvador and Avanzini 2014). Against this background, the aim of this study is to investigate variations in pasture lease rents during the eighteenth and nineteenth centuries and how these correlate with climate changes. In analysing the relationship between climate variation and the value attributed to the pasture areas, account has been taken of natural and socio-economic factors, which may be summarised as follows: a) climate changes and, in particular, variations in spring temperatures; b) population evolution in pastoral communities.

Regarding the former issue, given that climate variability influences pasture productivity, as will be described later in greater detail, it may be considered a proxy for the potential volume of grass that the pastures produce. Regarding the latter issue, population evolution in an economic system that is closely dependent on local natural resources may be considered a proxy for anthropic pressure on the environment and hence for the demand for pasture with possible repercussions on the attributed value.

1.2 Climate and social well-being

As mountain areas have developed economically, especially in the periods prior to the industrial revolution and extensive migration, the link between resource availability and climate change has been crucial (Malanima, 2006), even though, as in other historical processes, altitude and environmental factors play a variable role (Mathieu, 2000, p.127). An increase or decrease in temperature of even a few tenths of a degree may result in an increase or decrease in resources, thereby contributing to capital gain or loss. Climate deterioration may lead to a shorter growing season with a consequent decrease in the value of pastures and radical changes in the exploitation of mountain areas, even over short periods of time (Bozhong, 1999). A decrease in temperature may give rise to a 10% reduction in calories per square centimetre of land, a shortening of the field pasture and forest vegetation growth period by three weeks, increased rainfall, changes in microbial activity in the soil and consequently its level of fertility, and a lowering by 150-200 metres of the altitude limit for growing cereals (Anfodillo, 2007).

According to some authors (e.g. Pfister, 2005), that contraction of pastureland in the European mountains at the height of the Little Ice Age (LIA - from the fourteenth to the late nineteenth century), restricted the prospects for pasturing animals. Lower forage yields also affected the quality and quantity of the milk produced. During the LIA weather and climate conditions were different from those prevailing in the preceding 'Medieval

Warm Period' (from about 900 to the fourteenth century) and in the 'warm twentieth century'. The LIA was a simultaneous, world-wide phenomenon, although there were considerable regional and local variations. That epoch was the longest period of glacial expansion in the Alps for at least 3000 years. However, it should be stressed that the six centuries between 1300 and 1900 were not continuously cold. The cold phases were repeatedly interrupted by phases of 'average climate'. In some periods, e.g. from 1718 to 1730, the summer half-year was even somewhat warmer than the 'warm twentieth century'. It is in this context that Heinz Wanner coined the expression "Little Ice Age type events" (LIATE) to designate the three extensive advances known.

Many historians assume that the productivity of agriculture in the medieval and early modern periods depended only on the relative scarcity of two prime production factors: land and labour. The fundamental fact that agricultural output also depends on weather and climate has simply been ruled out. The most difficult study regards impacts and consequences. Having reconstructed past climate in the area of concern, biophysical impact studies may be carried out to identify the direct effect of climate anomalies on plants, domestic animals and disease vectors through study of their sensitivity to climate. Social impact assessment studies can then examine how biophysical impacts - i.e. the effects of climate anomalies on biota - propagate into the social and political system. This type of integrated approach, which would include the potential of people to adapt and adjust to climatic stress, reflects historical reality far better than a simple impact model and raises more fruitful research questions.

Pfister (2005) developed a climate impact model tailored to food production in the agrarian economies within the mixed economies of southern central Europe, where grain was the staple crop cultivated according to a three-field system in combination with dairy or wine production. It was found that a given set of specific sequences of weather spells over the agricultural year was likely to affect all sources of food, at the same time leaving little margin for substitution. This yielded a model of worst-case crop failure and, conversely, a year of plenty.

Livestock in traditional agriculture did not serve only the currently exclusive purpose of providing animal protein for human nutrition; instead, its vital role consisted in the multiple function of providing muscular power, manure and milk. Livestock provided large part of the required labour and enabled the active management of plant nutrients. The milk yields of cows and goats depended on the amount of the daily food ration available per animal and its nutrient content, mainly raw proteins. The amount of the feed ration varied according to the duration of the winter snow cover and autumn and spring temperatures.

In a frosty spring, the animals ran out of feed, as happened in 1688 in the example provided by Einsiedeln (Pfister, 2007). The longer the famine lasted, the longer it took for the animals to recover and resume their usual level of milk production. A long wet spell during the hay harvest in July and early August could reduce the raw protein content of the hay by as much as two-thirds, causing the cows to cease producing milk during the subsequent winter.

Most importantly, the simultaneous occurrence of rainy autumns, cold springs and wet mid-summers in successive years had a cumulative impact on agricultural production. This combination of seasonal patterns contributed largely to triggering extensive advances of the glaciers. Chilly springs and rainy mid-summers have been shown to be the most common climatic elements during the Little Ice Age, even though they were not causally related.

This economically adverse combination of climatic patterns is labelled "Little Ice Age-type Impacts" (LIATIMP). The biophysical climate's impacts in terms of the duration of cold spells and wetness in particular phases of the year may be relatively similar without being fully identical. Human responses to such impacts, on the other hand, often differ over time; and these differences may form the basis of in-depth studies on changing vulnerabilities.

At the same time, complex interactions with environmental changes compounded by socio-economic factors may eventually lead to a loss or decrease in the value of the asset (Gellrich *et al.*, 2007; Irwin and Geoghegan, 2001; Paavola and Fraser, 2011) and the associated rental fee. An example found throughout the southern Trentino region in the Italian Alps is the contrast between changes in the value of privately-owned agricultural land over time and the large tracts of forest and pasture assets managed by local communities. The former were subject to extensive fragmentation with a gradual reduction and dispersion of agricultural land; but the latter, because they had a fixed land area (the pastures in particular), made long-term management of the resources possible.

2. Materials and methods

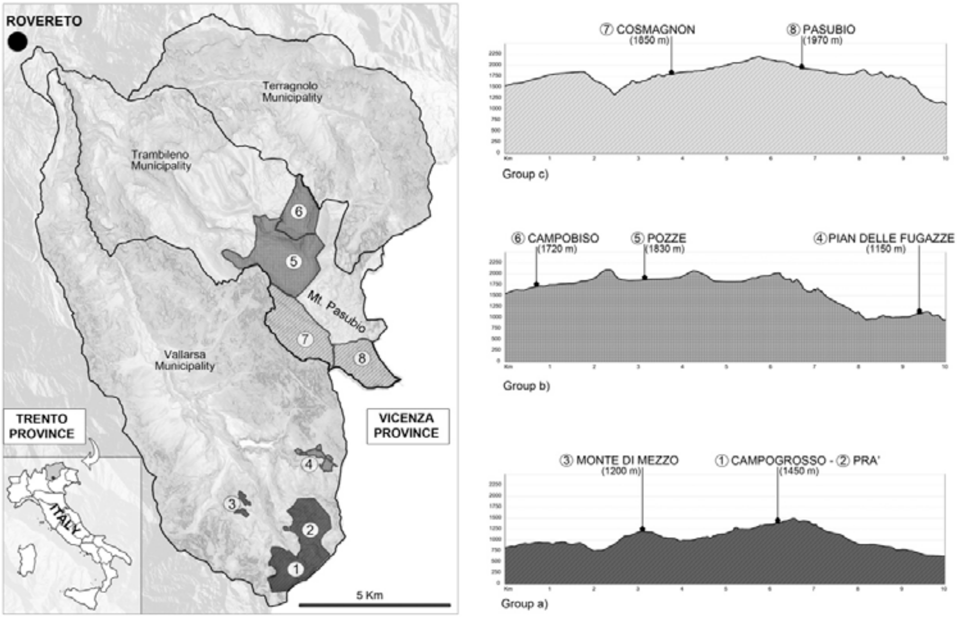
2.1 The study area

The pastures studied for this paper are located on the Pasubio massif and its surrounding areas (Fig. 1). The Pasubio is an extensive plateau in the southeast of the Trentino region (northern Italy) at a height of between 1500 m and 2000 m and confined by two deep valleys. The summit area is a wide plateau from which radiate a series of small valleys cutting deep into the slopes. The geological structure of the massif has given rise to the development of surface karst landforms where water drains deep into the mountain, leaving the summit land arid and feeding large springs at lower altitudes. In phytoclimatic terms the area is classifiable as pre-Alpine - moist temperate.

2.2 Temperature variability in the Alps

Very few quantitative reconstructions of climate variability in the Alps over the last millennium have been made. High-resolution reconstructions for the pre-instrumental period are based on documentary reports (Behringer, 2013; Lutherbacher *et al.*, 2004; Pflister, 2005, 2007), geochemical data (stable oxygen isotopes), physical data (annual growth rate of stalagmite laminae; Frisia *et al.*, 2007; Mangini *et al.*, 2005; Smith *et al.*, 2006), and temperature profiles measured along deep perforations (Pasquale *et al.*, 2003). Representative results can be expected from trees at the Alpine timberline, where the temperature during the short vegetative period controls the growth rate. Utilizing ring-width series measured with string instruments, several authors have developed a consistent, spatially-resolvable network of summer temperature-sensitive chronologies for high elevations in Central Europe for at least the last 500 years (Wilson *et al.*, 2005). A com-

Figure 1. The Pasubio area is in southern Trentino (Italy). The mountain pastures studied, higlighted in grey, occupy the central part of the Pasubio massif and the southermost part of the Vallarsa valley. (1 Campogrosso; 2 Pra; 3 Monte di Mezzo; 4 Pian delle Fugazze; 5 Pozze; 6 Campobiso; 7 Cosmagnon; 8 Pasubio).



mon temperature signal across the Alps has allowed regional reconstructions to be made of mean April–September temperatures (1650–1987) from ring-width (RW) and density (MXD) records using nested principal component regression models (Wilson *et al.* 2005).

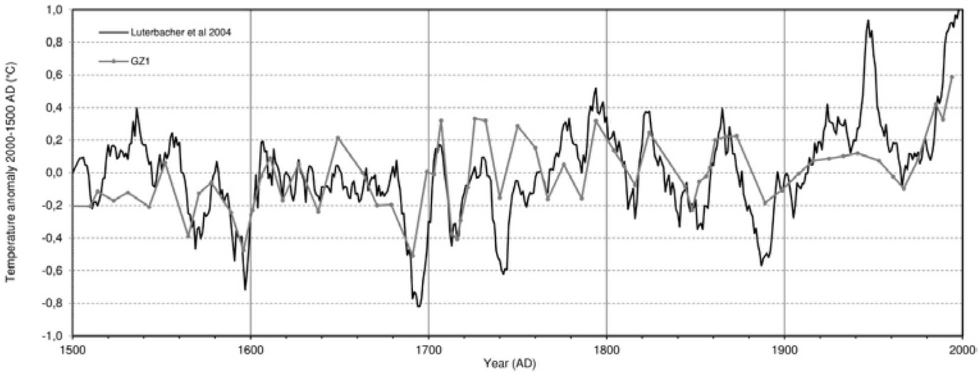
Calibration of paleo-climatic series with instrumental series is based on the assumption that the climate in the last millennium was characterized by modes of variability similar to those in the instrumental period. While this assumption may not be entirely correct, we can be reassured by the fact that all of the series now available display comparable low and high frequency variations. In fact, a comparison of temperature proxy reconstructions for the Alpine region highlights periods of synchronous warm and cold periods in the records (Mann *et al.* 2000; Pauling *et al.* 2003; Luterbacher *et al.* 2004, Wilson *et al.* 2004).

These variations can be adjusted to local contexts where the micro-climate or altimetric conditions diverge from the Alpine reference conditions.

2.3 The climate in the Pasubio massif in the last thousand years

Located at an altitude of 1025 m in the central Pasubio, the Cogola di Giazzera is a large cave with concretions that have been the subject of recent palaeo-climatic studies (Frisia *et al.*, 2007). Analysis of a stalagmite in this cave using the U/Th dating technique, micro-crystal analysis, and oxygen and carbon stable isotope ratios (284 samples) has made it possible to reconstruct the curve of local thermal anomaly over the last 4500 years.

Figure 2. Comparison of reconstructed temperature anomalies for the Pasubio (GZ1) (from Miorandi *et al.*, 2007) and for the Alps (from Lutherbacher *et al.*, 2004) over the past 500 years.



The isotopic series derived from the stalagmite's most recent concretions (U1), dated from 1060 ± 70 AD to today, had an average resolution of seven years. The isotopic series was synchronised with the Milan series (1750-1998) (Maugeri and Nanni, 1998) and with reconstruction of temperatures in Europe and the Alps from dendrocronological, instrumental and historical data (Mann and Jones, 2003; Lutherbacher *et al.*, 2004; Bohm et al 2001; Briffa et al 1998) (Fig. 2). The coefficient of correlation between the Giazzera and Luterbacher reconstructions of temperature anomalies was good ($r^2 = 0.77$).

For the purposes of the research reported in this article, we needed to be able to correlate the average temperature of the reference periods with those used to determine the rents for Alpine pastures in the study area. Because the leases were renewable every five years and the rent was correlated with this time frame, it was necessary to have temperature data on a scale of at least five years. The Giazzera dataset has a resolution of seven years, and Lutherbacher's (2004) series, having a resolution on an annual and seasonal scale, perfectly suited with the purposes of our analysis. Therefore, having confirmed the positive correlation between the temperature anomaly series reconstructed for the Pasubio and those available for Europe and the Alps (Frisia, 2007; Frisia *et al.*, 2007), Lutherbacher *et al.*'s (2004) annual thermometric data were adopted in the analysis.

2.4 Historical data

2.4.1 The social context: public good and private good

Except for the brief period of Napoleonic rule, from the second decade of the sixteenth century onwards few alterations were made to the political administration of the area, which was part of the Habsburgs' Tyrolean domains. With the demise of the feudal system in the eighteenth century, local communities gained possession of most of the mountain land and managed them by leasing pastures to local and non-local breeders (Salvador and Avanzini, 2014).

At the beginning of the eighteenth century, grazing land was the property of the community (now the district council) of Vallarsa, which every five years leased them by public auction to the highest bidder. The rental contracts contained clauses that remained substantially unchanged over time and were the same for all pastures in the same period. In this respect, changes in the rent values assigned to Alpine pastures are good indicators of climate changes. The fact that the extent of land[3] and its ownership do not change in part removes several socio-economic variables from the diachronic evaluation of their values.[4]

During the period considered, the population of the area increased in line with that of the entire Alpine region (Bussolon, Martini, 2007). In the area examined, between the eighteenth and nineteenth centuries the number of inhabitants grew, albeit more slowly than in the nearby plain. In order to increase food resources to feed the larger population there was a rise in the number of livestock raised and therefore an increased demand for pastures, with a consequent linear increase in their average value.

2.4.2 Source of economic data

The historical archives[5] of the administrative districts of the area under study contain the 'Auction Deeds' and the corresponding 'Auction Tenders' for grazing lands since the seventeenth century. They record the conditions on which the district council leased each grazing pasture, the price the tenant had to pay annually to the district council and any additional sums due, which in the eighteenth century would become a fixed fee for maintenance of the pastureland.

From the eighteenth century onwards (the first rental agreement examined here is dated 1719) the Vallarsa district council kept specific records of mountain leases with documentation of the costs and auction conditions. In the eighteenth century, the grazing lands were allocated in the autumn of the year preceding the start of grazing, although the auction for the five-year period 1774-1778 took place in the autumn two years previously (October 1772) and became the rule for successive decades. This gave the tenant who had won the auction sufficient time to procure cattle, hire a cheese maker and shepherds, procure all the cheese making equipment, ensure that the buildings (farmhouse and cheese-making outbuilding) and infrastructures (roads, watering holes) were in good condition and, if necessary, carry out repairs.

From 1810, the auction deed also specified the reserve price (usually the rent from the previous five years) and by how much each bidder was willing to raise the starting price. When the reserve price was considered too high for that year, the auction was cancelled and another took place with a lower starting price.

The year of the auction, regardless of whether it took place one or two years prior to the start of the lease, was therefore taken into consideration in analysing the comparison with the standard thermometric series.

The price from 1719 to 1773 is given in trons, and after that in florins (1 florin = 5

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[3] The actual extent of the pasturelands may well have varied as a result of tree clearance, or, in other periods, tree encroachment. However, while it is true that the areas cannot be measured with any certainty, it is also true that these changes to the grazing lands have no significant bearing on the analysis that follows.

[4] The Alpine pastures are not privately owned but are instead the property of the district council, which means no variables associated with land division and change of ownership need be considered. (Bussolon and Martini, 2007).

[5] The Trento State Archive, the Rovereto District Archive and the Vallarsa District Archive were consulted.

trons). In the nineteenth century, the price was given in various currencies: Tyrolean florins, Imperial florins and common florins (100 Viennese florins = 105 Tyrolean florins = 120 Imperial florins = 125 common florins). To overcome currency conversion problems, prices have been converted to silver equivalents, *i.e.* the actual amount of silver (in grams) contained in the coins in every year under study. Information regarding the various currencies is taken from Pribram (1938).[6]

It has been necessary to use silver as the numeric value because it is practically impossible to reconstruct a historical series of the prices of the products of livestock raising to which the analysis refers. The chosen indicator allows at least reduced instability, which happens to be rather substantial in some of the periods under study. A similar solution has already been adopted by other scholars (Allen, 2001). It goes without saying that such an indicator does not resolve the issue of silver's actual purchasing power. Nonetheless, no significant variation in silver's actual purchasing power has been recorded in the area under study (Bonoldi *et al.* 2018).

2.5 Analysis

2.5.1 Rents for pastures from the eighteenth to nineteenth centuries and the relationship with changes in climate.

Until the mid-twentieth century, land values and pasture rents were directly related to the productivity of the mountain. Therefore, to investigate the relationships between them, we compared the values of the pastures with environmental drivers in the study area.

This analysis took account only of those grazing lands for which there is a sufficient continuity of information on rents for the period 1719-1880. We also selected pastures used mainly for grazing cattle and which were not subject to any change of use during the period considered.[7] In addition, periods of evident socio-economic and/or political instability (such as the Napoleonic rule from 1800 to 1815) were excluded from the comparison, and any sums due in addition to the rents as a result of improvements to and work carried out on the buildings or pastures during the period under investigation were removed.

The grazing lands examined fell into three groups: a) Campogrosso/Monte di Mezzo/Pra, average altitude 1350-1400 m (low altitude); b) Pozze/Campobiso/Pian delle Fugazze, average altitude 1550-1600 m[8] (medium altitude); and c) Cosmagnon/Pasubio, average altitude 1900 m (high altitude).

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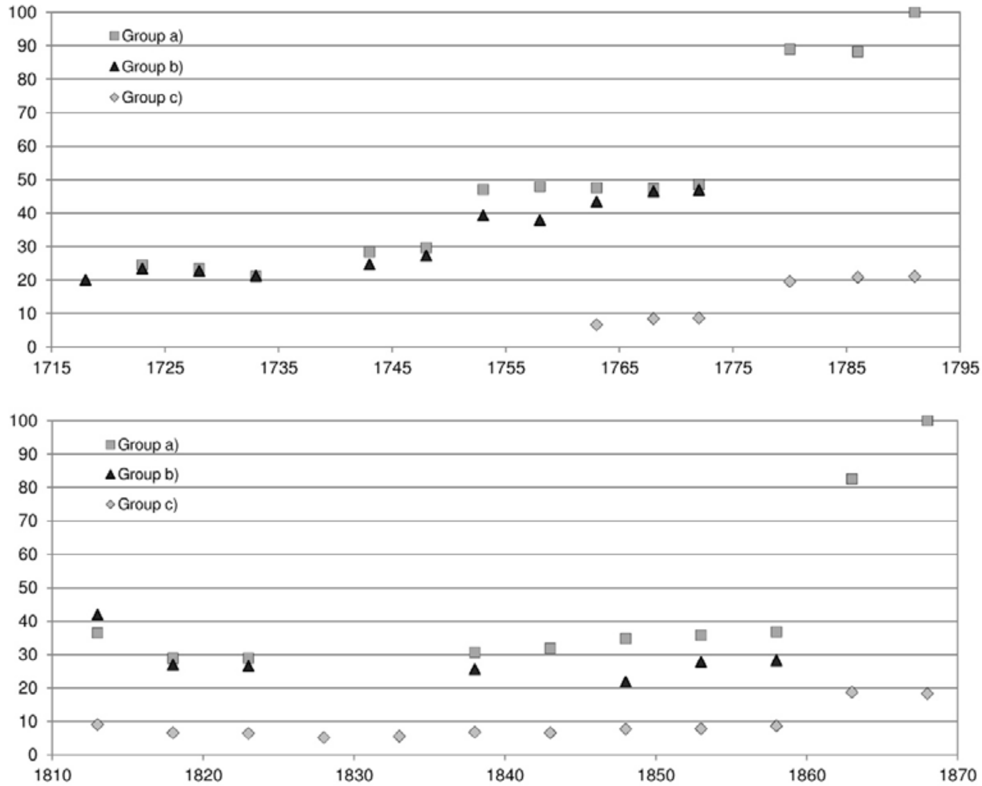
[6] Given the length of the period considered, use of a deflector in order to express the variables considered in terms of purchasing power would be desirable. Unfortunately, the available statistics do not allow even approximate estimates of this indicator to be made.

[7] Because of the scarcity of hay fields from the beginning of the twentieth century and the need for hay to feed livestock during winter, several pastures neighbouring Vallarsa were leased for haymaking and were only partly utilised for grazing. These were allocated directly (without public auction), although the contract was still for five years and the price in some cases did not change for as much as 30-35 years.

[8] We also had to consider the grazing lands at Passo Pian delle Fugazze (altitude 1100 m to 1300 m) as they were often leased together with those of Pozze/Campobiso. However, as they comprised only less than one fifth of the total area leased, these grazing lands should not greatly impinge on the following analysis. The Pozze/Campobiso pastures cover around 250 ha, those of Passo Pian delle Fugazze around 30 ha. The relationship between the sizes of the two areas remained more or less constant throughout the period considered.

Figure 3. Variations in rent values of the three groups of grazing lands between 1715 and 1850 normalised and expessed in silver grams.



Preliminary analysis of the variations in rent values (with all prices converted to florins) shows that they gradually increased over the course of the period studied as a consequence of the increase in demographic pressure, as can be seen from the following graph (Fig. 3).

Furthermore, comparison with the climate curve (Fig. 2) is highly consistent with the trend of rising average temperatures and hence with the presumed improvement in mountain weather conditions following the negative peak of the 1740s.

From the beginning of the period analysed, higher values were assigned to the grazing lands below 1500 metres, these being rich pastures at lower altitudes with relatively easy access, a reasonably assured supply of water and relatively speedy connections to the towns in the valley.[9] The grazing lands located at higher altitudes (group c) have poorer pastures and structural conditions that remained unchanged over time, and their rent values do not significantly increase.

At the turn of 1740, there was a drop in the value of the pastures for which data are available (a and b), possibly as a result of the marked fall in average temperatures over this

[9] A new road was constructed in 1823 giving better access to the area where all the grazing lands are located, which may have something to do with the greater value assigned to them between 1825 and 1839.

period (Fig. 2). A second, clear drop in the rent values of all the grazing lands (a, b and c) occurs between 1820 and 1845, followed by a marked rise in the next three five-year periods. This appears to coincide with the cold phase documented in the Alps between 1820 and 1840 (Büntgen *et al.*, 2006; Leonelli *et al.*, 2012; Rea *et al.* 2003), followed by a rapid rise in average temperatures from the 1850s onwards.

Differences in rent according to temperature and altitude may be understood in light of the differential rent concept defined by Ricardo (1821) and reinterpreted by, among others, Quadrio Curzio (1998).[10] Temperature and altitude are, in fact, the original natural factors influencing rents and therefore income.

In the case of grazing, as with many agricultural crops, productivity depends on natural factors and on permanent or temporary improvements resulting from human activities.

During the period considered, characterized by few technological innovations, temporary improvements linked to the use of production aids, such as fertilizers, seeds, etc., were almost non-existent. Even management organizational models remained more or less the same, as evidenced by the invariance of the conditions that applied to the tenant.

However, permanent improvements were effective, resulting in deforestation and clearing of the land occupied by the less steep woodlands. As a result of the increasing need for pastures, from the sixteenth and seventeenth centuries (Salvador and Avanzini, 2014) woods located at increasingly lower altitudes were ceded to grazing areas. The initial investment in deforestation increased, the lower the altitude.[11] These deforestation activities can be treated as investments and are considered fully amortized, given the period examined in this study.

Soils at lower altitudes are more productive and can be more easily associated with permanent housing.

In this framework, the annuity of a pasture in the period examined (i.e., in the absence of technological innovations and in an essentially closed market) will necessarily tend to increase in the presence of increasing human pressure. This will lead, as Ricardian theory suggests, to less fertile lands being cultivated and to an increase in the income from those already in use.[12]

2.5.2 Econometric analysis

To examine the available data in detail, a multiple regression analysis was conducted to identify the types of links between the variables that we considered important: the dependent variable being pastures' rent value[13] and the independent variables being temperature and population.[14] As already mentioned, to overcome problems resulting from the use of different currencies, we used silver equivalents of their values.[15]

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[10] The best-known reference is P. Sraffa (1925), but Keynes (1936) also worked on the problem.

[11] At lower altitudes, the forests are bushier with trees of larger diameter.

[12] Some pastures utilized in the nineteenth century were abandoned in a later period due to low fertility.

[13] During the period under examination the pastures' rent value in Campogrosso, Prà and Monte di Mezzo (Group a) varied between 25.258 and 8490.830 silver grams; pastures in Pozze, Campobiso, Pian delle Fugazze (Group b) yielded a rent between 24.175 and 3561.084 silver grams; Pasubio and Cosmagnon (Group c) between 7.998 and 1587.12 silver grams.

[14] In the period under study, population varied between 1394 and 3206 inhabitants.

[15] Other explanatory variables might be of some interest, e.g. the overall economic trend and farms' structure,

Population pressure was examined by taking information on the population residing in the Vallarsa district as a proxy.[16]

Regarding temperature, we decided to employ average values[17] for the spring immediately preceding the auction. As reported in the introduction, the spring/early summer temperature is crucial for grass growth and hence for determining the productivity of an Alpine pasture (Cavallero *et al.*, 1992). The nutrients contained in the soil are the most critical factors influencing the level of grass output and growth, although this also depends to some extent on precipitation patterns: too much precipitation, particularly during autumn and winter, reduces the content of calcium, phosphates and nitrogen in the soil.

Sequences of wet years had a cumulative impact, although temperature, according to results obtained by agronomists, has far more to do with mobilizing nitrogen from the soil than was previously believed (Bengston, 2004). Since temperature trends are spatially far more uniform than rainfall patterns, we may conclude that yields tend to react in a similar way within large regions.

Detailed analysis of the temperatures reconstructed by Lutherbacher *et al.* (2004) also reveals a high correlation between average spring temperature and average annual temperature (correlation coefficient 0.61) (Fig. 4). Furthermore, the use of constructed variables, such as moving averages and weighted moving averages of spring temperatures for the three years preceding the year of the auction, did not produce results significantly different to those obtained using simple average spring temperatures (c.c. 0.64 for moving averages, c.c. 0.82 for weighted moving averages).

The results of the preliminary analysis suggested using the average spring temperature of the year of auction, which has a greater influence than the average temperature of the previous years on the amount of grass in the pastures in the year of auction and ultimately on the bidding.

3. Results

3.1 Data elaboration.

An initial analysis was performed treating all the available information (59) as panel data (Greene, 2008). As the panel regression did not involve a significant increase in the explanatory capacity of the model, we estimated an ordinary least square regression on the entire set of available data. In this case, we used a double-log functional form of the following type[18]:

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but statistical information is not available to add such dimensions in the model. Given the specific situation we can nonetheless suggest that the effect of economic growth is to a certain extent captured by the population variable. In a closed economy, population growth is only possible when a larger amount of resources becomes available (Malthus 1798). The farms' structure does not change significantly in the period under examination (Bussolon and Martini, 2007). Given this specific context, we believe that, altogether, the lack of availability of further variables does not invalidate the main conclusions of the study.

[16] Missing observations for the years of interest were interpolated using linear regression.

[17] During the period under study, the average spring temperature was between 5.895 and 8.133 degrees Celsius (°C).

[18] We used a log-log formula to reduce the influence of the different rent values of the grazing lands. This functional form smooths the rent value differences.

Figure 4. Average annual temperature versus average spring temperature in the period analysed (from Lutherbacher et al. 2004).

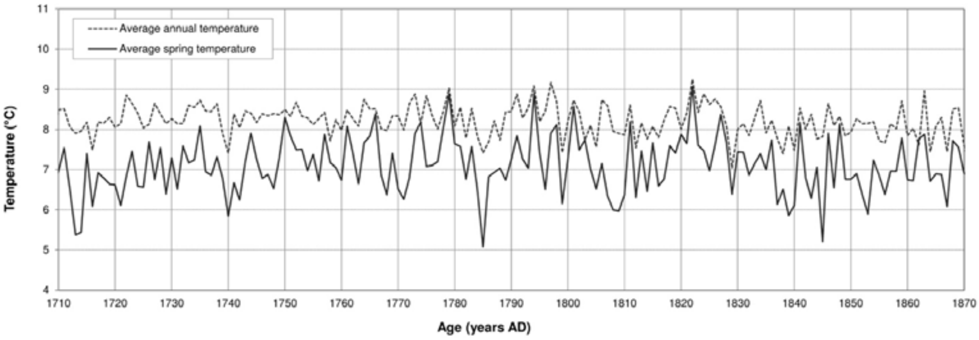

Table 1. Estimated results for all the mountain pastures

	Panel estimation
Population	+8.461 ***
Average spring temperature (degrees centigrade)	+2.783 **
Dummy variable for grazing lands at medium altitude	+1.634 ***
Dummy variable for grazing lands at lower altitude	+1.759 ***
Constant	-66.731 ***
r^2	0.896
adr^2	0.889
Number of observations	59

* Significant at 10% significance level, ** significant at 5% significance level, *** significant at 1% significance level.

LN(AR)[19] = f (LN(Pop), LN(S_temp), D_1, D_2

The estimated results are presented in Table 1.

We can note that all the estimates are significantly different from zero at least at the 0.05 value. Estimated coefficients confirm that average spring temperature and population positively affect the rent values of the grazing lands. Moreover, the lower the altitude of the grazing land, the higher is its rent value.

Given this relevant effect of altitude, we deemed useful to estimate separated functions for the three different groups of mountain pastures. Despite the small number of observations for each area examined, this exercise allows highlighting the role of population and temperature as a function of altitude.

In this case, it seems appropriate to introduce a new dummy variable for the grazing

[19] LN(AR) = logarithm of annual rent expressed in silver, LN(Pop) = logarithm of population, LN (S_temp) = logartihm of average spring temperature, D1 Dummy variable for grazing lands at medium altitude, D2 Dummy variable for grazing lands at lower altitude.

Table 2. Estimation results for three different groups of mountain pastures.

	Group (a) (low altitude)	Group (b) (medium altitude)	Group (c) (high altitude)
Population	+4.34 ***	+1.87 ***	+1.22 ***
Average spring temperature (degrees centigrade)	+798.21 **	+309.31	+199.43 *
Dummy variable for years after 1752	+1746.42 **		+418.86 **
Constant	-14554.24 ***	-5296.81 **	-4187.87 ***
r^2	0.80	0.77	0.82
adr^2	0.77	0.74	0.77
Number of observations	23	18	18

lands located on the border with the nearby Veneto region (group a, c), assuming a value of zero up to 1752 and one over the following years. This is to account for the fact that the borders were definitively fixed in 1752, thus putting an end to a series of incursions and acts of intimidation that had made the mountain unsafe for use in previous years.[20]

The estimated equations using the least squares method were as follows[21]:

AR[22] = f(Pop, S_temp, D)

Most estimates are significantly different from zero at least at the 0.10 value, except for average spring temperature for group (b). Estimated coefficients confirm a strong effect of human pressure due to population growth on rent values for each group of grazing lands. Interestingly, this effect is decreasing as moving from grazing lands at lower altitude towards grazing lands at higher altitudes, confirming the Ricardian assumptions. The same trend emerges for average spring temperature, which exerts the greatest effect on rent values for grazing land at lower altitudes, while for group (b) and group (c) the effect is lower.

In order to highlight the different sensitivity of rents to variations in spring temperature and changes in the size of the population we can calculate elasticities. The elasticity of rent to population indicates the average amount by which the rent varies as a response to a change in the population. The elasticity of rent with respect to temperature indicates the average amount by which the rent varies as a response to change of 1 degree Celsius in spring temperature. The elasticities of rent are presented in Table 3. Calculating these elasticities on regression results of Table 1 (all the grazing lands considered together) we obtain 0.70 for the elasticity with respect to population and 7.73 for the elasticity with

[20] The Campogrosso/Prà/Monte di Mezzo and Cosmagnon/Pasubio pastures are located on the border with the Veneto region. Until 1752 this border was not clearly defined and as a result animals might be found grazing in a neighbouring property, thus provoking punitive raids which included the animals' seizure, the burning of farmhouses and so on, and the beginning of lengthy controversies. With the Rovereto treaty (1752) the borders were precisely drawn and guarded, and there was a considerable increase in the rent values as a consequence of the greater security.

[21] Since there were no structural differences (e.g. in altitude) within the three groups identified for mountain pastures and their rents, we preferred to use a linear functional form.

[22] AR = annual rent

Table 3. Estimated rental price elasticities.

	Elasticity with respect to population	Elasticity with respect to temperature[a]
Overall elasticity	0.70	7.73
Group (a) (Campogrosso, Prà, Monte di Mezzo)	3.118	187.493
Group (b) (Pozze, Campobiso, Pian delle Fugazze)	0.830	36.735
Group (c) (Pasubio, Cosmagnon)	0.236	14.213

[a] In thousandths of a degree Celsius.

respect to temperature. This indicates that rents are inelastic with respect to an increase in population but are very elastic in response to an increase in average spring temperature.

The elasticities calculated for the three different groups confirm a different sensitivity of rents according to altitude. It appears as evident that changes in temperature have a much stronger impact on the amount of rent charged than changes in population.

The elasticity of rents with respect to population is high (3.118) for grazing lands located at low altitude but is inelastic for grazing land at medium (0.830) and higher altitude (0.236). We can therefore draw the conclusion that a change in human pressure has graver consequences for the grazing lands at low altitude than for those at higher altitudes. This is explained by the fact that it makes sense to make the best possible use of the lower grazing lands in the area under study given that they are, on the one hand, closer to the towns and villages and, on the other hand, adjacent to the tree line and can be "extended" by encroaching on the woods and forests. In contrast, there is no possibility of extending the pastures at the highest grazing lands, which in all probability are affected by the situation in the pastures at lower altitudes.[23]

The sensitivity of rent values to changes in spring temperature follows a similar pattern, even with a different order of magnitude.[24] The elasticity to spring temperature is very high for grazing lands at low altitude while it is lower for grazing lands at medium altitude and even lower for land located at higher altitude. This can be explained in part by the fact that even small increases in spring temperatures can give rise to longer pasturing periods in the low grazing lands, while the grazing period in the high pastures is much more constant.

4. Concluding remarks

Research conducted on the values of mountain pastures in the Pasubio estimated from the rents charged for them over a two-hundred-year period show that variations in these values are related to natural and anthropogenic drivers to varying extents depending on historical period and altitude.

[23] It should also be remembered that only pastures located above the tree line were at first utilised, and it was only later that pastures were created at lower altitudes by clearing the less steep woodland areas.

[24] The different ranges of variation of the two variables (low for temperature, high for population), rather than their different orders of magnitude should be taken into account when interpreting the high values for elasticity.

Oscillations in the values for 5-year periods between the last half of the eighteenth century and the beginning of the twentieth century suggest a strong connection with environmental and climatic factors.

Increases or decreases in temperature appear to have a less marked and less direct effect on the values of grazing lands close to the upper limit of vegetation, while, in addition to the climate signal, socio-economic and infrastructural signals impinge significantly on the grazing lands at lower altitudes.

If we consider that the value of the rent is an estimate of income and therefore of the utility of the "land productive factor" within the production process, we may draw some general considerations from this survey.

In particular, an interesting observation is that increasing population and temperature have the same influence in increasing the yield, independently of altitude.

For both the variables, the values of the rents for land located at a lower altitude - generally more fertile - have an elasticity approximately 13 times greater than that of land at a higher altitude. This means that human pressure and more favourable climatic conditions lead to significantly intensified pastoral activity in the fertile areas, while the income of marginal land is less affected by these changes. This finding is counterintuitive because people are generally inclined to believe that higher temperatures should favour pastures at high altitude because they should supposedly become more fertile. This apparent contradiction can nonetheless be explained with reference to the ricardian theory of rent. Our research supports what David Ricardo, at the dawn of economic science, had guessed. This contribution to the validity of the ricardian theory of rent is even more interesting given the long time interval considered and the relative small number of situations where this theory can actually be tested. Within agricultural production, only pastures have undergone no significant technological transformation over time.

The analysis partly suffers from the lack of consistent statistical data: given the length of the period under study, the elaboration could not always be conducted on homogeneous information. More precisely, the absence of a reliable indicator to convert the rent value into actual purchasing power can lead to a distortion in the estimates provided. Nonetheless, the elaboration carried out, if confirmed by other surveys, can provide a solid basis for appropriate measures of agricultural policy and land management adapted to ongoing climate changes.

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6. Conflict of Interest

The authors declare that they have no conflict of interest.

7. References

Allen, R.C. (2001). The Great Divergence in European Wages and Prices from the Middle Ages to the First World War. *Exploration in Economic History* 38: 411-447

Anfodillo, T. (2007). Cambiamenti Climatici e Dinamica di Popolazione al Limite Superiore del Bosco: Importanza delle Ricerche di Lungo Termine. Forest@ 4: 3-5.

Baglioni, M., Macagno, G., Nunes, P. and Travisi, C. (2009). Natura 2000 Network, Agricultural Pressures and Biodiversity Conservation: an Italian outlook: Analysing the potential of the Natura 2000 database in describing the linkages between agricultural pressures and biodiversity. Report of the EXIOPOL, Deliverable.II.3.b.1. part 2, Milan; Italy.

Behringer, W. (2013). Storia culturale del clima. Torino: Bollati Boringhieri.

Bonoldi A., Novi Inverardi P.L. and Salvador I. (2018). The Cereal Market in an Alpine Region at the End of the Ancient Regime: Tyrol (1761-1817). Working Paper, ESSHC Belfast.

Bosello, F. and Zhang, J. (2005). Assessing Climate Change Impacts: Agriculture. FEEM Working Paper, 94.

Bovolenta, S., Pasut, D. and Dovier, S. (2008). L'allevamento in Montagna: Sistemi Tradizionali e Tendenze Attuali. *Quaderni SoZooAlp*. 5: 22-29.

Bozhong, L. (1998). Changes in Climate, Land, and Human Efforts. The Production of Wetfield Rice in Jiangnan during the Ming and Qing Dynasties. In Elvin, M. and Ts'ui-jung, L. (eds.), Sediments of Time. Environment and Society in Chinese History, Cambridge: Cambridge University Press, 447-487.

Bohm, R., Auer, I., Brunetti, M., Maugeri, M., Nanni, T. and Schoner, W. (2001). Regional Temperature Variability in the European Alps 1760–1998 from Homogenized Instrumental Time Series. *International Journal of Climatology* 21: 1779–1801.

Briffa, K. R., Jones, P.D. and Schweingruber, F.H. (1988). Summer Temperature Patterns over Europe: a Reconstruction from 1750 A.D. Based on Maximum Latewood Density Indices of Conifers. *Quaternary Research* 30: 36–52.

Buffoni, L., Brunetti, M., Mangianti, F., Maugeri, M., Monti, F. and Nanni, T. (2003). Ricostruzione del Clima Italiano negli Ultimi 130 anni e Scenari per il XXI Secolo. Atti workshop "Climagri - cambiamenti climatici e agricoltura". Cagliari, 16-17 January 2003.

Bussolon, R. and Martini, A. (2007). La Vallarsa attraverso la Storia. Dalle origini alla Prima Guerra Mondiale. Mori (TN): La Grafica edizioni.

Büntgen, U., Frank, D.C., Nievergelt, D. and Esper, J. (2006). Summer temperature variations in the European Alps, A.D. 755-2004. *Journal of Climate* 19: 5606-5623.

Cavallero, A., Talamucci, P., Grignani, C., Reyneri, A., Ziliotto, U., Scotton, M. and Acutis, M. (1992). Caratterizzazione della Dinamica Produttiva di Pascoli Naturali Italiani. *Rivista di Agronomia* 26 (3): 325-343.

Dearing J.A. (2006). Climate – Human – Environment Interactions: Resolving Our Past. *Climate of the Past* 2: 187-203.

Fraser, E.D.G. (2009). Economic Crises, Land Use Vulnerabilities, Climate Variability, Food Security and Population Declines: Will History Repeat Itself or Will Our Society Adapt to Climate Change? In: Centre for Climate Change Economics and Policy Working paper No. 1, Leeds and London, UK.

Frisia, S. (2007). Sintesi delle Conoscenze sulla Variabilità Climatica nelle Alpi negli Ultimi 1000 Anni. *Studi Trent. Sci. Nat., Acta Geol.* 82: 65-69.

Frisia, S., Borsato, A., Richards, D.A., Miorandi, R. and Davanzo, S. (2007). Variazioni Climatiche ed Eventi Sismici negli Ultimi 4500 Anni nel Trentino Meridionale da una Stalagmite della Cogola Grande di Giazzera. *Studi Trent. Sci. Nat., Acta Geol.* 82: 205-223.

Gellrich, M., Baura, P., Koch, B. and Zimmermann, N.E. (2007). Agricultural Land Abandonment and Natural Forest Re-Growth in the Swiss Mountains: A Spatially Explicit Economic Analysis. *Agriculture, Ecosystems & Environment* 118: Issues 1–4: 93–108.

Gelman, A. and Hill. J. (2007). Data Analysis Using Regression and Multilevel/Hierarchical Models. New York: Cambridge University Press.

Greene, W.H. (2008). Econometric Analysis. Prentice Hall.

Gusmeroli, F., Corti, M., Orlandi, D., Pasut, D. and Bassignana, M. (2005). Produzione e Prerogative Qualitative dei Pascoli Alpini: Riflessi sul Comportamento al Pascolo e l'Ingestione. *Quaderni SoZooAlp*. 2: 7-27.

IPCC (2014). Summary for Policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 1-32.

Irwin, E.G. and Geoghegan, J. (2001). Theory, Data, Methods: Developing Spatially Explicit Economic Models of Land Use Change. *Agriculture, Ecosystems & Environment* 85: 7-24.

Keynes, J.M. (1991). Note Conclusive nella Filosofia Sociale Verso la quale La Teoria Generale Potrebbe Condurre. In: La Fine del Laissez-Faire e Altri Scritti. Torino: Bollati Boringhieri.

Leonelli, G., Coppola, A., Pelfini M., Salvatore, M.C., Cremaschi, M. and Baroni, C. (2012). Il Segnale Climatico e le sue Variazioni negli Anelli di Accrescimento degli Alberi da Siti Estremi al Contorno della Regione Mediterranea. *Rendiconti Online Società Geologica Italiana* 18: 24-28.

Lutherbacher, J., Dietrich, D., Xoplaki, E., Grosejan, M. and Wanner, H. (2004). European Seasonal and Annual Temperature Variability, Trends and Extremes since 1500. *Science* 3013: 1499-1503.

Malanima, P. (2006). Energy Crisis and Growth 1650-1850: The European Deviation in a Comparative Perspective. *Journal of Global History* 1: 101-121.

Mangini A., Spötl C. and Verdes P. (2005). Reconstruction of Temperature in the Central Alps During the Past 2000 Years from a δ18O Stalagmite Record. *Earth Plan. Sci. Lett*. 235: 741-751.

Mathieu, J. (2000). Storia delle Alpi 1500-1900: Ambiente, Sviluppo e Società (Vol. 4). Casagrande.

Malthus T.R. (1798). An Essay on the Principle of Population. London: J. Johnson.

Menzel, A. and Fabian, P. (1999). Growing Season Extended in Europe. *Nature* 39: 659-661.

Maugeri, M. and Nanni, T. (1998). Surface Air Temperature Variations in Italy. Recent Trends and Update to 1993. *Theor. Appl. Climatol.* (1998): 191-196.

Orlandi, D. and Clementel, F. (2007). Caratterizzazione Produttiva dei Pascoli Alpini. http://www.pianteofficinali.org/main/Alpicoltura/Alpicoltura.htm. Accessed 10 January 2017.

Orlandi, D., Clementel, F., Bovolenta, S. and Dovier, S. (2004). Caratterizzazione Chimica e Nutrizionale Delle Principali Specie Pascolive Alpine. *Quaderni SoZooAlp*. 1: 171-180.

Paavola J. and Fraser E. (2011). Ecological Economics and Environmental History. *Ecological Economics* 70: 1266-1268.

Palatnik, R. and Nunes, P. (2010). Valutazione delle Relazioni tra Cambiamenti Climatici, Biodiversità e Produttività dei Sistemi Agro-Forestali in Europa. *Agriregionieuropa* Special Issue on Climate Change and Agriculture: Adaptation, Mitigation and Food Security 6(21).

Pasquale V., Verdojya M., Chiozzi P. and Safanda J. (2000). Evidence of Climate Warming from Underground Temperatures in NW Italy. *Global Planetary Change* 25: 215-225.

Pfister, C (1995). Monthly Temperature and Precipitation in Central Europe from 1525–1979: Quantifying Documentary Evidence on Weather and Its Effects. In Bradley, R.S. and Jones, P.D. (eds.), Climate Since AD 1500, London: Routledge, 118–142.

Pfister, C. (2005). Weeping in the Snow. The Second Period of Little Ice Age-type Impacts, 1570-1630. In Behringer, W. (ed.), Kulturelle Konsequenzen der 'Kleinen Eiszeit', Göttingen, 31-86.

Pfister, C. (2007). Climatic Extremes, Recurrent Crises and Witch Hunts: Strategies of European Societies in Coping with Exogenous Shocks in the Late Sixteenth And Early Seventeenth Centuries. *The Medieval History Journal* 10, 1-2: 33–73

Pfister, C. and Bradzil R. (2006). Social Vulnerability to Climate in the "Little Ice Age": An Example from Central Europe in the Early 1770s. *Climate of the Past Discussions* 2: 123-155.

Pribram, A. F. (1938). Materialien zur Geschichte der Preise und Löhne in Österreich 1 (= Veröffentlichungen des Internationalen wiss. Komitees f. die Geschichte d. Preise u. Löhne 1), Wien, Ueberreuter.

Quadrio Curzio, A. (1998), Rendita. In Enciclopedia delle scienze sociali, Roma: Istituto dell'Enciclopedia Italiano.

Raffaelli, R. (2005). Sostenibilità e Multifunzionalità dell'Agricoltura di Montagna. Istituto Nazionale della Montagna, Bononia University Press.

Rea, R., Rampanelli, G. and Zardi, D. (2003). The Temperature Series of Trento: 1816-2002. Proceedings of the 27th International Conference on Alpine Meteorology and MAP-Meeting 2003, Vol. A. Brig, 483-486.

Ricardo, D. (1821). On the Principles of Political Economy and Taxation. 3rd edition, London: John Murray.

Roson, R. (2003). Modelling the Economic Impact of Climate Change, EEE Programme Working Papers Series.

Salvador, I. and Avanzini, M. (2014). Costruire il Paesaggio. L'Alpeggio dal Tardo Medioevo alle Soglie della Grande Guerra in un Settore del Trentino Meridionale. *Studi Trentini. Storia* 93: 79-114.

Smith, C.L., Baker, A., Fairchild, I.J. and Frisia S. (2006). Reconstructing Regional Climates from Multiple Stalagmite Records. *Int. Journal of Climatology* 26: 1417-1424.

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. and Miller, H.L. (eds) (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, NY, USA: Cambridge University Press.

Theurillat, J.P. and Guisan, A. (2001). Potential Impact of Climate Change on Vegetation in the European Alps: A Review. *Climatic change* 50 (1-2): 77-109.

Wilson, R., Frank, D., Topham, J., Nicolussi, K. and Esper, J. (2005). Spatial Reconstruction of Summer Temperatures in Central Europe for the Last 500 Years Using Annually Resolved Proxy Records: Problems and Opportunities. *Boreas* 34 (November): 490–497.

Ziliotto, U. and Scotton, M. (1993). Metodi di Rilevamento della Produttività dei Pascoli Alpini. Comunicazioni di ricerca ISAFA (TN), 93/1, 33-42.

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Full Research Article

Traditional poultry farmers' willingness to pay for using fly larvae meal as protein source to feed local chickens in Benin

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Abstract. This study estimated poultry farmers' willingness to pay (WTP) for fly larvae meal as animal protein source to feed local chickens in Benin. A double-bounded contingent valuation approach was used to collect data from 480 poultry farmers, and an interval regression model was performed. We found that 82.10% of poultry farmers are willing to pay for using fly larvae meal. The average WTP was estimated at FCFA/kg 225.10 (€/kg 0.34), indicating a potential and reliable demand in fly larvae meal. Our analysis suggests that public actions can sensitize poultry farmers and support innovative small companies to produce and market fly larvae meal.

Keywords. Animal feeding, Benin, Fly larvae, Poultry farmer, Willingness to pay.

JEL codes. Q120, Q160, Q180.

1. Introduction

Poultry farming plays an important role in traditional agricultural production systems in Africa. Poultry farming is ideal for all families, even the poorest (Bell, 1992), given the low individual needs of the animals involved and the low investment costs (Guèye, 2002). It provides a significant share in the supply of animal protein calories (Buldgen *et al.*, 1992) and of cash income. Therefore, poultry farming contributes to poverty reduction. Edible domestic poultry includes chickens, pigeons, geese, ducks, guinea fowls, quails, turkeys, etc. (Njue *et al.*, 2002). In developing countries, chicken (domestic fowl) is the most widely accepted and appreciated species (Ideris *et al.*, 1990) and makes up the bulk of the poultry industry (Spradbrow, 1997). Three traditional poultry production systems exist and have been studied: the scavenging system, the semi-scavenging system and, the confinement system (Gunaratne *et al.*, 1993).

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The most common system in rural Africa is based on scavenging poultry (Kitalyi, 1998). Although productivity is modest, even a few live poultry and eggs generate a net benefit for poultry farmers because of the very low production costs (Buza and Mwamuhehe, 2001). The deficit in poultry products in developing countries, particularly in sub-Saharan Africa, is mostly due to the low productivity of traditional poultry (Guèye, 1998) and other factors as well. As shown by Narrod *et al.* (2008) and Delgado *et al.* (2008) the production technology for exotic breeds of poultry meat is widely available and has in fact been used by farmers in developing countries. To overcome these deficiencies, many African countries have supported the development of short-cycle poultry species hoping to provide people cheap and with highly nutritive animal products. The constraints of traditional poultry farming include access to animal feed and healthcare, improving productivity as well as commercial issues. In particular, the dominant local breeds are of low productivity and the traditional chicken farming methods are prone to diseases, which sometimes decimate entire flocks.

Feed represents the major constraint to the development of small-scale poultry farming in Africa. Feed given to local poultry is often insufficient in quantity and quality because its protein content is low, especially during dry seasons (Goromela *et al.*, 2006). In particular, scanty provision of dietary protein by rural farmers to scavenging poultry does not optimize productivity and profitability of their enterprise. The use of unconventional food resources such as local legume seeds, leaves and tubers, and various animal by-products, which availability or cost is not a limiting factor, could be a solution. The interest in these resources in recent years has particularly increased with the grain crisis of 2007. The conventional protein sources such as soybean and peanut de-oiled cake (DOC) and fish meal are indeed rare and therefore expensive. The demand and the price of fish meal, which is used as protein in animal feeding, have particularly increased these recent years (FAO, 2014). Various studies attempted to use locally available animal and vegetable proteins to substitute some or all of the conventional proteins (Basak *et al.*, 2002; Amaefule and Osuagwu, 2005; FAO, 2014; Mutungi *et al.*, 2017). The introduction of snail flour or meat in animal diet has been explored (Barcelo and Barcelo, 1991; Farina *et al.*, 1991). The positive influence of the use of termites as a protein source on production parameters of guinea fowl in villages has been demonstrated (Chrysostome, 1997). Earthworms have been bred as a protein source for feeding chickens (Vorsters *et al.*, 1994). Broilers can receive 3.6% of earthworm flour to substitute 5% of meat meal without affecting their growth performance (Agbédé *et al.*, 1994). Also fly larvae, in particular house fly (*Musca domestica*) and black soldier fly (*Hermetia illucens*) proved to be an excellent source of protein, and can replace fish meal partly or entirely in animal diets (Kenis *et al.*, 2014; Makkar *et al.*, 2014). Pomalégni *et al.* (2016; 2017) indicated the use of fresh fly larvae by small poultry farmers in Benin, and most of them had a good perception of its use in poultry feeding. Pomalégni *et al.* (2017) showed that 5.6% of traditional poultry farmers in Benin use fly larvae at least occasionally to feed their poultry, with variations among regions. The use of fly larvae in animal feed is safe if the standards of production on substrates are respected (Charlton *et al.*, 2015; Nkegbe *et al.*, 2018). One of the current constraints in the widespread adoption of fly larvae in poultry farming is their unavailability on the market. Seeking an economic measure of fly larvae valorization is a prerequisite to generate relevant indicators needed for better decision-making.

This study explores the terms of use of fly larvae meal in traditional poultry farming diet that may offer new opportunities in terms of value creation, human health preservation and nutritional value improvement of local chickens. It uses the double-bounded contingent valuation procedure to analyze the possibility that traditional poultry farmers could accept to pay for fly larvae meal. The procedure considers nutritional value and contribution to the improvement of production performance of local chickens in Benin. If farmers are willing to pay, how much are they willing to pay? What are the factors affecting their willingness to pay (WTP)? The contingent valuation method is often used to reveal the monetary value of services, public goods, public dimensions of private goods and non-market assets (Roe *et al.*, 2004; Mogas *et al.*, 2006; Wu *et al.*, 2016). It is also used to reveal farmers' and consumers' preferences for new agricultural technologies or products (Wei *et al.*, 2016; Drichoutis *et al.*, 2016). It is based on the intentions of respondents, *i.e*, not on observed behavior (Vidogbéna *et al.*, 2015; Wu *et al.*, 2016).

This paper provides useful information to international Non-Governmental Organizations, international organizations, food policies-makers; and enterprises dealing with food and nutritional security, who intend to promote and/or produce fly larvae meal as a protein source on a large scale to poultry farmers in developing and developed countries.

2. Material and Methods

2.1 Sampling and data collection

This study was conducted in 12 provinces of Benin where traditional poultry farming is practiced. A pilot survey was first made to determine the importance of traditional poultry farming in the provinces, districts and villages of Benin (Pomalégni *et al.*, 2016). The result of that preliminary survey was used to test the validity of the levels of bids proposed for the contingent valuation procedure and to elaborate, test and validate the survey questionnaire. This preliminary survey allowed to select the districts and villages where the real study would be carried out.

Based on information provided by extension officers, one district was chosen in each province according to the relative number of poultry farmers, the genetic diversity, and the supply of poultry. In each district, two villages were selected according to the importance of livestock. Twenty-four villages were visited. The sample size was determined using a formula (Dagnelie 1998):

$$n = \frac{Pi(1-Pi)U_{1-\alpha/2}^{2}}{d^{2}} \tag{1}$$

Where Pi is the proportion of traditional poultry farmers considering the number of farmers at the national level and was estimated at 50.00 %. We used Pi =0.5 as it is not possible to make any assumption regarding the traditional poultry farmers coverage in Benin (Lwanga and Lemeshow, 1991). $U_{1-\alpha/2}$ = 1,96 represents the value of the normal random variable for a risk α equal to 0.05 (confidence level). The margin of error *(d)* provided for any parameter to be estimated from the survey was 4.47%. Thus, the sample size *n* of traditional poultry farmers has been determined as 480. Based on this sample size, 20 poultry farmers were surveyed in each selected village and respondents were randomly selected accordingly.

An in-person contingent valuation survey was administrated to the 480 poultry farmers. Individual surveys were conducted from March to April 2017, which is the best period of the year for interviews since few people work in the field during the dry season. The questionnaire was written in french (Appendix) but the interviews were entirely conducted in the respondents' local languages. Face-to-face interviews were conducted in the presence of a translator when needed. This face-to-face interview was more appropriate as it helps to clearly explain the contingent scenario and background information to illiterate and poorly educated respondents thus avoiding hypothetical bias (Shi *et al.*, 2014). The face-to-face interviews are also more flexible and reliable (Hoyos and Mariel, 2010) and they are better than inquiries made by e-mails, telephone or postal survey (Arrow *et al.*, 1993) in helping to substantially reduce the protest rate and non-responses. Nevertheless, the "social desirability bias" also called "cheap talk" was controlled during the administration of the questionnaires with frequent exchanges with agricultural extensions officers who knew the respondents better than us.

Most of the questions were closed-ended, although some open-ended questions were included to investigate respondents' perception on fly larvae meal use. Outside the principal research questions (the willingness to pay), data were also recorded on socioeconomic characteristics[1] of respondents. At the end of the investigations in each village, the feedback was made in the presence of poultry farmers and agricultural extensions officers.

2.2 WTP elicitation methods

This study used a field experimental bid to reveal small poultry farmers' preferences for fly larvae meal use to feed traditional chicken. The double-bounded contingent valuation procedure was used. The traditional poultry farmers were submitted to a sequence of open-ended questions which gradually helped narrow the WTP. In contrast to single-bounded contingent valuation format, a double-bounded format provides more econometric precision than closed-ended questions lose compared with open-ended questions (Hanemann *et al.*, 1991; Hoyos and Mariel, 2010). The hypothesis of the double-bounded contingent valuation method is that the responses to the two bids are underlying to the same value of WTP and therefore the second bid increases the information on the true WTP of the respondent (Alberini, 1995). To overcome some problems arising in the double-bounded approach, the second bid is only presented to the respondents if it is consistent with the respondent's previous answer. The double-bounded contingent valuation approach is generally preferred over open questions, which are more practical in email survey (Shi *et al.*, 2014). As the survey was conducted face-to-face, protest responses with zero or extremely high values could be given by the poultry farmers (Watson and Ryan, 2007).

Fly larvae may be used fresh, especially at the small-scale farm (Rakotonirina, 1990), or can be made into meal (Hwangbo *et al.*, 2009; Makkar *et al.*, 2014). For industrial or

[1] Such as age, gender, occupation, educational level, main occupation, number of family workers, income, motivation for fly larvae meal use, etc.

semi-industrial production, the meal form is recommended because of the long-term conservation constraints of live fly larvae, which quickly pupate. The nutrients contained in the meal form are as acceptable as those of the fresh form (Makkar *et al.*, 2014). In this study, fly larvae meal option was considered rather than fresh fly larvae to allow a proper comparison with fish meal that is sometimes used in poultry feed. After being informed about the use of fly larvae in animal feeding, traditional poultry farmers were questioned regarding the payment vehicle for the fly larvae meal usage. The respondents who did not protest the payment vehicle were submitted to the contingent scenario with the payment bids, where respondents face a list of bids randomly drawn (Hoyos and Mariel, 2010).

In the experiment, the structure of the contingent scenario was as follows: "Fish meal is used as protein source for chicken feed. The international prices of fish meal are between FCFA 1,000 (€ 1.52) and FCFA 1,200 (€ 1.83) per kg. Fish meal is imported and sold at the local market at FCFA 550 (€ 0.84) per kg by one major importer firm which dominates the market of animal provender in Benin. The low prices can be attributed to the low-quality of the fish meal with lower protein content. Fly larvae meal are an appropriate source of animal protein for traditional chickens. They improve the performances of local chickens (e.g. Average Daily Gain, Food Conversion Ratio, etc.) and they reduce the cost of feed protein. They can replace low-quality fish meal that is used to feed poultry. Would you be willing to pay a sum of FCFA M_i^I per kg to feed your local chickens with fly larvae meal? ". M_i^I is a random value taken into a vector of 7 bids (600; 700; 800; 900; 1,000; 1,100; 1,200). The bids containing seven levels of the monetary payment can be considered reasonably efficient (Carson and Hanemann, 2005). The minimum bid of FCFA 600 (€ 0.91) corresponds to the minimum cost of producing 1 kg of fly larvae meal. Knowing that 1 kg of fly larvae meal required 4 kg of fresh fly larvae, the minimum bid is equivalent to 4 kg of fresh fly larvae, which are produced at a minimum cost of FCFA/kg 150 (€/kg 0.23) (600 = 150 *4). The maximum bid of FCFA 1,200 (€ 1.83) corresponds to the present production cost of 1 kg of fly larvae meal. It is also equivalent to 4 kg of fresh fly larvae, which are produced at a cost of FCFA/kg 300 (€/kg 0.48) (1,200 = 300*4) (M. Kenis and S.C.B. Pomalégni, adapted from Roffeis *et al.*, 2018). These costs are likely to decrease when production systems improve. The first bid M_i^I was followed by the second bid, M_i^U increased when the first bid was accepted, or M_i^L decreased when the first bid was refused by FCFA 100 (€ 0.15), which corresponds to the additional cost to increase or decrease, to a certain level, the quality of the fly larvae meal (content, presentation, etc.). Each poultry farmers surveyed had a first bid M_i^I and the following bid M_i^L or M_i^U according to their response to the first bid, where $M_i^L \prec M_i^I \prec M_i^U$ (Table 1). Four possible responses were used: (a) both responses were "Yes"; (b) both responses were "No"; (c) "Yes" response followed by "No" response; d) "No" response followed by "Yes" response.

An ex-ante approach was used to correct the hypothetical bias on WTP (Loomis, 2011). During the investigation, it was clearly explained to the poultry farmers surveyed that the amount (bids) proposed would be paid for the coming years so that they have fly larvae meal in the markets. This information was given to make a choice that was as realistic as possible. Furthermore, the poultry farmer should feel that his/her response will have policy implications so that he/she feels comfortable supporting or opposing the proposed policy.

Table 1. Random bid schemes used in the double-bounded contingent valuation procedure.

Bid schemes	Decreased follow-up bid in FCFA (if 'No' for M_i^I	Initial bid in FCFA (M_i^I)	Increased follow-bid in FCFA (if 'Yes' for M_i^I)
Scheme 1	500	600	700
Scheme 2	600	700	800
Scheme 3	700	800	900
Scheme 4	800	900	1,000
Scheme 5	900	1,000	1,100
Scheme 6	1,000	1,100	1,200
Scheme 7	1,100	1,200	1,300

2.3 Data and empirical model

2.3.1 Data

The main socioeconomic characteristics of the sample were as followed. In total, 23.75% of poultry farmers surveyed were females whereas 76.25% were males. The average number of local chickens owned by the investigated poultry farmers was around 25. The poultry flock species by descending order of importance were chickens (97.92%), guinea fowl (28.96%), ducks (24.79%), pigeons (11.25%), and turkeys (3.33%) and others (20.83%). The ecotypes of local chickens encountered among the respondents' flock were: the southern ecotype or "Yaya" (83.13%), the "Fulani" ecotype (19.42%), a hybrid ecotype called "Yovokloklo" which is a cross between local and exotic roosters and hens (11.25%), the "Holli" ecotype (7.71%), "Sahwé" ecotype (4.38%) and other local races (0.42%). The poultry farming methods were dominated by the scavenging method (55.05%) followed by the semi-scavenging (42.54%) and confinement methods (2.37%). The average age of respondents was 44 years, with an average age of 45 years for female farmers against 43 years for male farmers. The average years of experience in poultry farming was 16. Although the respondents were all poultry farmers, 61.25% and 10.63% of them had agriculture or livestock and trade as main occupation, respectively. There were 52.29% literate or educated against 47.70% illiterate and only about 4.37% of them were members of a professional organization of poultry farmers. The overall annual income per poultry farmer varied and averaged FCFA 610,663.50 (€930.95). The average annual agricultural income was FCFA 421,563.50 (€ 642.67), representing 69.03% of the average annual overall income of poultry farmers. Poultry production contributes on average to 25.15% of the annual agricultural income (FCFA 106,023) of the poultry farmers surveyed.

Poultry farmers surveyed were aware of the possibility of using fly larvae as poultry feed (92.50%) against only 7.50% who did not know this usage before our survey. Despite this, only 8.54% of poultry farmers surveyed had used fly larvae to feed their chickens against 91.45% who had never used them. In total, 394 poultry farmers (82.08%) were motivated to use fly larvae meal for feed chicken. The motivations varied among respondents. Most, (80%) respondents were motivated by the improvement of the nutritional quality and performance (growth and laying) of their local chickens and (65.42%) respondents mentioned the reduction of feed costs as motivation. At the time of the study, only 41 poultry farmers surveyed (8.54%) had used fish meal as chicken feed, and 39 of them (8.13%) would have liked to replace the fish meal with other protein sources, the rest does not currently use protein to feed their poultry. The motivations behind replacing fish meal with other proteins were: high price of fish meal (37.78%), bad quality of fish meal (26.67%), non-availability of fish meal on the local market (13.33%) and others factors (22.22%). The low use of protein to feed poultry generates low zootechnical performances in many farms.

2.3.2 Econometric model and specification

An interval regression model was developed to determine the factors influencing the WTP and to estimate sample WTP as function of the characteristics of the respondents (Breffle *et al.*, 1998; Fu *et al.*, 2011; Kpadé *et al.*, 2017). Because bids proposed to respondents are defined in certain intervals, interval regression was used to model outcomes that have interval censoring. To elicit WTP, each respondent *i* was considered to accept the payment vehicle for a WTP of fly larvae meal which is equal to Y_i^* and related to the characteristics X_i by the equation:

$$Y_i^* = X_i\beta + \varepsilon_i \tag{2}$$

where β is the coefficient associated to each characteristic, and ε_i is assumed to have zero as average and follows a normal distribution. The data were organized as left-censored for the "No -No" responses, right-censored for "Yes-Yes" responses, and interval-censored for "Yes-No" or "No-Yes" responses for each poultry farmers surveyed. Following Hanemann *et al.* (1991), Y_i^* is not observed, but each respondent WTP *i* was in the interval $\left[M_i^L, M_i^U\right]$. The probability of "Yes-No" response is:

$$\Pr\ (M_i^I \prec Max\ \ \text{WTP} \le M_i^U) \tag{3}$$

The probability of "No-Yes" response is:

$$\Pr\ (M_i^I \succ Max\ \ \text{WTP} \ge M_i^U) \tag{4}$$

The probability of the right-censored data, "Yes-Yes" response is given by:

$$\Pr(M_i^I \le Max\ \ \text{WTP and } M_i^U \le Max\ \ \text{WTP}) \tag{5}$$

And the probability for the left-censored data, "No-No" response is as follows:

$$\Pr(M_i^I \succ Max\ \ \text{WTP and } M_i^L \succ Max\ \ \text{WTP}) \tag{6}$$

The econometric software Stata MP V.13 software (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP) was used to estimate the maximum likelihood function through interval regression model. The interval regression model estimates the probability that a latent variable is included in a given interval (Cawley, 2008; Fu *et al.*, 2011; Kpadé *et al.*, 2017). At last, the estimations of the interval regression model were used to calculate the individual WTP (post-estimation prediction), the average and median WTP of the sample. Table 2 lists the bids and explanatory variables used in the econometric analysis. Four types of variables could potentially affect the respondents' WTP: personal characteristics of poultry farmers, characteristics of poultry farms, type of flock, factors of motivations. The personal characteristics of poultry farmers, the characteristics of poultry farms, and the factors of motivation were considered to positively affect the WTP whereas the type of flock was considered to positively or negatively affect the respondents' WTP.

Table 2. Statistics of bids and explanatory variables for WTP.

Variables	Description	N	Minimum	Maximum	Mean *(Standard Deviations)*	Expected Signs
Bids						
Upper bound of WTP	Upper bound level (FCFA)	196	500	1300	788.77 *(193.42)*	
Lower bound of WTP	Lower bound level (FCFA)	274	500	1300	850.00 *(209.70)*	
Initial bid of WTP	Bid level proposed (FCFA)	480	600	1200	826.00 *(189.00)*	
Independent variables						
Sex	Sex of poultry farmer (1 = male, 0 = female)	480	0	1	0.76 *(0.40)*	+
Age	Age of poultry farmer (years)	480	17	80	43.57 *(12.84)*	+
Gross income	Annual total income received by the poultry farmer, including non-farm income (FCFA)	480	45,000	7,000,000	610,633.54 (*862,225.36*)	+
Farm income	Annual farm income of poultry farmer (FCFA)	480	0	7,000,000	421,563.50 *(744,196.80)*	+
Percent poultry income	Part of poultry income in annual farm income (%)	480	0	100	25.15 *(31.17)*	+
Scavenging farming	Scavenging poultry farming (1=Yes, and 0 if not)	480	0	1	0.55 *(0.49)*	+
Semi- scavenging farming	Semi-scavenging poultry farming (1=Yes, and 0 if not)	480	0	1	0.42 *(0.49)*	+
Confinement farming	Confinement poultry farming (1=Yes, and 0 if not)	480	0	1	0.02 *(0.15)*	+
Credit access	Credit access for poultry farmer (0= Not access; 1= Yes)	480	0	1	0.17 *(0.37)*	+
Experience in poultry farming	Experience in poultry farming (years)	480	0	60	16.00 *(11.53)*	+
Education	Formal or functional education (years)	480	0	16	3.00 *(4.05)*	+

Variables	Description	N	Minimum	Maximum	Mean *(Standard Deviations)*	Expected Signs
Fly larvae use awareness	Farmer awareness on fly larvae as feed (0= Not known; 1= Yes)	480	0	1	0.92 *(0.26)*	+
Fly larvae use	Adoption of fly larvae in poultry feeding before (0= Not used; 1= Yes)	480	0	1	0.09 *(0.28)*	+
Family workers (number)	Number of family workers on the poultry farming	480	0	16	4.00 *(3.00)*	+
Local chicken (number)	Number of local chickens of the poultry farmer	480	0	500	24.58. *(35.83)*	+
Farming as main occupation	Main occupation of poultry farmer (1=agriculture or livestock; 0=else)	480	0	1	0.61 *(0.48)*	+
Fish meal use	Fish meal using in farm for local chicken feed (1= Yes, and 0 if not)	480	0	1	0.08 *(0.28)*	+
Motivation to improve chicken nutritional quality	Motivation for fly larvae use to improve nutritional quality of local chicken (Yes = 1, if not 0).	480	0	1	0.80 *(0.16)*	+
Motivation to improve poultry performances	Motivation for fly larvae use to improve performances of local chicken (Yes =1, if not 0).	480	0	1	0.80 *(0.16)*	+
Motivation to reduce feeding cost	Motivation for fly larvae use to reduce feeding cost (Yes =1, if not 0).	480	0	1	0.65 *(0.40)*	+

Note: If the lower bound of WTP was less than FCFA 500 (€ 0.76), or if upper bound of WTP was over FCFA 1,300 (€ 1.98), then they were set to missing values.

3. Results

3.1 Payment vehicle

In the double-bounded contingent valuation procedure, respondents were first subjected to the acceptance or not of the payment vehicle. Out of the 480 respondents, 86 poultry farmers (17.90%) protested the payment vehicle because of: the lack of trust placed on fly larvae (36.03%), the lack of means of payment (25.73%), for the fact that fly larvae are an available natural resource for which there is no need to pay (13.97%), and others reasons (24.26%). Comparing the socioeconomic characteristics of the accepters and the protesters of the payment vehicle, Table 3 showed that accepters were younger, more educated, had a higher number of local chicken in their farms, had higher gross annual and farm incomes and depended more on poultry farming financially.

Table 3. Comparison of characteristics of accepters and protesters of payment vehicle.

Characteristics	Mean (*Standard Deviation*)		Pr (|T| > |t|)
	Accepters	Protesters	
Age (years)	43.10 (*12.27*)	45.73 (*15.11*)	0.085*
Experience in poultry farming (years)	16.22 (*11.56*)	14.22 (*11.33*)	0.145
Education (years)	3.56 (*4.08*)	2.54 (*3.83*)	0.035**
Local chickens (number)	27.18 (*38.67*)	12.64 (*11.96*)	0.000***
Family workers (number)	4.30 (*2.64*)	3.32 (*1.81*)	0.001***
Gross income (FCFA)	696,166.20 (*925,410.70*)	218,941.90 (*201,994.50*)	0.000***
Farm income (FCFA)	483,270.30 (*805,606.60*)	138,860.50 (*147,641.30*)	0.000***
Percentage of poultry income (%)	26.62 (*31.37*)	18.40 (*29.46*)	0.026**

*Significant at 10%; **Significant at 5%; ***Significant at 1%.

Table 4. Traditional poultry farmers' responses to double bids.

Answer to first bid	Answers to second bid		Total Frequency *(%)*
	Yes Frequency *(%)*	No Frequency *(%)*	
Yes	198 *(50.24)*	25*(6.35)*	223*(56.59)*
No	50*(12.70)*	121*(30.71)*	171*(43.41)*
Total	248*(62.94)*	146*(37.06)*	394*(100.00)*

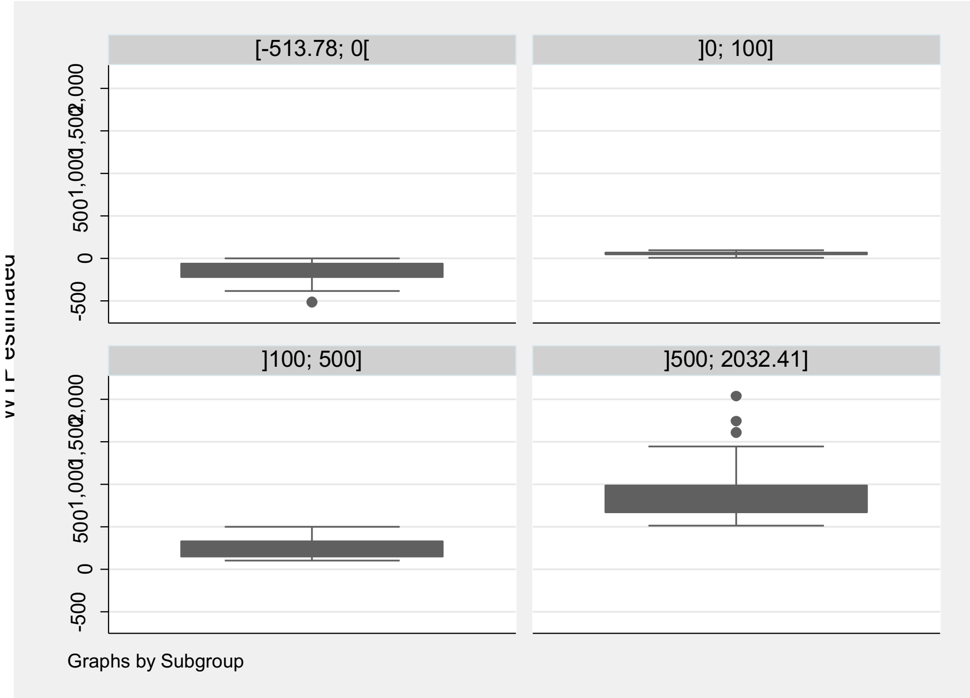
3.2 Bids acceptance

Out of the 394 traditional poultry farmers having accepted the payment vehicle (82.10%), 56.59% had accepted the first bid against 43.41% who refused. In total, 50.24% accepted both bids when the first was increased by FCFA 100 (€ 0.15) against 30.71% who refused both bids even when a decrease of FCFA 100 (€ 0.15) to the first bid was proposed (Table 4). Also, 6.35% of the poultry farmers accepted the first bid but refused the second bid, while 12.70% refused the first but accepted the second bid proposed. In the econometric modeling, the 86 poultry farmers that protested the payment vehicle were not considered as they refused to participate in the fly larvae meal market development. The development of the scenario contingent was also stopped at this step for these 86 poultry farmers. Only the 394 poultry farmers who accepted the payment vehicle were considered in the WTP estimation.

3.3 Factors affecting traditional poultry farmers WTP

Table 5 shows the results of the interval regression model to identify the factors influencing the WTP. In total, 19 out of the 20 explanatory variables were retained in the final

Figure 1. Distribution of WTP per kg of fly larvae according poultry farmers in Benin.



model, as two variables, motivation to improve poultry performances and motivation to improve chicken nutritional quality, were correlated. Eight factors significantly affected the respondents' WTP (sex, education, farming as main occupation, scavenging poultry farming, gross income, fly larvae use awareness, fly larvae use, motivation to reduce feeding cost) (Table 5). Five of these factors positively affected the respondents' WTP (sex, farming as main occupation, gross income, fly larvae use, motivation to reduce feeding cost) whereas three factors affected negatively the WTP, namely education, scavenging poultry farming and fly larvae use awareness. The signs of the coefficients of those three factors were opposite to what was expected (Table 2).

Based on the post-estimation of the interval regression model predictions, 394 individual WTP were estimated. In total, 134 respondents had negative WTP between -513.78 and 0 with a standard deviation (SD) of FCFA/kg 99.78; 31 respondents had WTP between 0 and 100 (SD= FCFA/kg 24.19); 180 respondents had WTP between 100 and 500(SD = FCFA/kg 112.71) and 49 respondents had WTP between 500 and 2,032.41(SD = FCFA/kg 328.46) (Figure 1). In total, 134 respondents had negative WTP. Respondents with the negative WTP were considered as a zero value in the sample because those respondents were not able to pay for the fly larvae meal according their profile, even though they accepted the payment vehicle. The 260 individual positive WTP were considered with no right-truncation because those respondents could financially pay fly larvae, independently to the amount they can afford. Finally, the average WTP for the sample in

Table 5. Factors affecting respondents' WTP.

Explanatory variables	Coefficients (*Standard Error*)
Sex (1= male, 0=female)	181.30*** (*67.04*)
Age (years)	-2.78 (*2.98*)
Experience (years)	0.39 (*3.51*)
Education (years)	-14.58** (*7.28*)
Family workers (number)	3.78 (*12.05*)
Farming as main occupation (1 =Yes, 0=No)	166.25**(*66.14*)
Local chicken (number)	1.10 (*1.05*)
Scavenging farming_(1=Yes, and 0 if not)	-293.05* (*162.46*)
Semi-scavenging farming (1=Yes, and 0 if not)	88.88 (*162.64*)
Confinement farming (1=Yes, and 0 if not)	88.67 (*220.88*)
Farm income (FCFA)	-4.61e-5 (*1.03e-4*)
Gross income (FCFA)	1.97e-4** (*8.60e-5*)
Percent poultry income (%)	0.07 (*0.89*)
Credit access (1 =Yes , 0= No)	-7.04 (*74.30*)
Fly larvae use awareness (1 =Yes, 0=No)	-262.01* (*142.66*)
Fly larvae use (1 =Yes, 0=No)	189.60** (*93.48*)
Fish meal use (1= Yes, and 0 if not)	-85.13 (*96.80*)
Motivation to improve chicken nutritional quality (1 =Yes, 0=No)	2300.99 (*68858.25*)
Motivation to reduce feeding cost (1 =Yes, 0=No)	303.06*** (*94.82*)
Constant	-1445.13 (*68858.73*)
/lnsigma	5.97*** (*0.09*)
sigma	393.16 (*34.61*)

Observations summary:
394 observations
121 left-censored observations
198 right-censored observations
75 interval observations
Log likelihood = -388.06; LR chi2(19) = 144.10; Probability > chi^2 = 0.000

* Significant at 10%; ** Significant at 5%; *** Significant at 1%

post estimation was FCFA/kg 225.10 (€/kg 0.34) of fly larvae meal against a median WTP estimated at FCFA/kg 127.81 (€/kg 0.19). The standard deviation was FCFA/kg 300.70 (€/kg 0.46).

4. Discussion

This study evaluated WTP of traditional poultry farmers in Benin to use fly larvae meal as a source of animal protein in local chicken feed, and analyzed the factors influencing their WTP. The protest rate found in this study is low compared that of other similar studies, e.g. 58% founded by Grappey (1999) or 44.06% reported by Drichoutis *et al.(* 2016). In this study, protesters were excluded in the WTP estimation to distinguish protest bids from true zero. Protesters are typically considered to be outside the market and should thus be omitted from the analysis used to derive WTP estimates (Villanueva *et al.*, 2017). Protest bids are often registered by respondents who may place a higher- or lower-than-average value on the commodity in question but refuse to pay based on ethics or other reasons (Halstead *et al.*, 1992; Ready *et al.*, 1995). Moreover, the payment vehicle plays a major role in the decision making of the respondents (Loomis, 2011; Diederich and Goeschl, 2014). The payment vehicle provides the context for payment (Morrison *et al.*, 2000) and needs to be credible, coercive and incentive compatible (Hoyos and Mariel, 2010). Special attention has been given to the choice of the payment vehicle (Travisi and Nijkamp, 2008), which alters the resulting WTP (Rowe *et al.*, 1980). In willingness to pay scenarios, the payment vehicle must be presented fully and clearly, and should be convincingly described with the relevant budget constraint emphasized (Arrow *et al.*, 1993).

4.1 Variation in respondents' WTP

The traditional poultry farmers' WTP varied according to their very heterogeneous socio-economic conditions, fly larvae perception, costs and benefits associated with the use of fly larvae as a protein source to feed local chickens. This result conformed with numerous studies on natural resources valuation (Perman *et al.*, 2011; Wu *et al.*, 2016). Based on the interval regression model, out of the eight factors significantly affect poultry farmers' WTP.

Five were positively correlated with WTP. Primarily, sex has a positive significant effect on the WTP. Men have a higher WTP compared to women, indicating a gender effect on the level of traditional poultry farmers WTP, as observed by Vidogbéna *et al.* (2015) and Wu *et al.* (2016). Farming as main occupation also had a positive effect on WTP. Respondents whose main occupation is agriculture or farming had higher WTP compared to those who have another primary occupation. Moreover, the gross income had a positive effect on the respondents' WTP, confirming previous studies which found a positive effect of income from the field of environment and natural on WTP (Mogas *et al.*, 2006; Halkos and Jones, 2012). The econometric analysis highlighted that respondents that had already used fly larvae were willing to pay more, probably because they were convinced of the advantages of the use of fly larvae in poultry feeding. They saw fly larvae as an alternative feed, even though it was not marketed yet. The current users of fly larvae produced themselves limited quantities to feed their poultry. Feed cost is a major constraint limiting the competitiveness of small poultry farms in Africa. Even though the local price of fish meal is lower compared to the international due to its notoriously of bad quality (Proteinsect, 2017), the analysis of the respondents attitudes showed that, the more poultry farmers were motivated to reduce their poultry feed cost by replacing fish meal, the higher was their WTP. Poultry farmers saw fly larvae meal as an innovation that could be adopted to help them to reduce the cost of poultry production.

Three factors negatively affected WTP of the respondents. The education level had a significant negative effect on WTP. This result was similar to that of Jaleta *et al.* (2013). It suggests that poultry farmers who were illiterate or less educated had more time to look after their livestock and their feed. More educated poultry farmers probably had other professional occupation and, thus, were less available to care for their livestock. Moreover, respondents with higher levels of education may initially be more critical and suspicious of innovative approaches and the cost involved. They may finally end up adopting the innovative approaches after some analysis. On the other hand, it is often observed that low education levels of respondents often block the adoption of new production techniques (Sall *et al.*, 2010). Scavenging farming was negatively related to WTP. In scavenging mode, chickens can easily pick up food residues and invertebrates and, therefore, the poultry farmer feels he/she does not need to pay a high price for the purchase of the protein ingredients. This kind of farmers did not usually pay for protein ingredients to feed poultry. To valorize fly larvae on farms, a poultry farmer understands that the proposed fly larvae and other insects are already being searched by these chickens in garbage piles and other wastes. However, they may not realise that adding fly larvae to the diet of scavenging flock could strongly enhance their growth and survival. Therefore, a policy to promote fly larvae meal in scavenging poultry farming could be subsidies to support fly production or purchase among smallholder farmers to demonstrate the benefits of fly larvae meal before its selling on the market. Fly larvae use awareness was also negatively related to WTP because those respondents had already information on fly larvae as feed and were less incited to pay for its use in poultry feeding. Our finding showed that fly larvae could be a cheap and sustainable source of protein that can be promoted and sold to small poultry farmers at an affordable price.

4.2 Development of fly larvae meal market

The post estimation of the average WTP indicated a wide heterogeneity among respondents. This heterogeneity increased the standard deviation because the distribution was not normal. Other studies also highlighted that some individuals had negative WTP for the change (Fu *et al.*, 2011; Pavel *et al.*, 2015). The average WTP was calculated by considering the negative WTP as zero (Fu *et al.*, 2011). The average WTP estimated for fly larvae meal in this study was 59% lower compared to the local market price of fish meal with low quality. This is also probably lower than the expected production costs in a small fly larvae production system. Roffeis *et al.* (2018) calculated the cost of producing house fly larvae on chicken manure in a small system in Mali to vary between 1.09 and 2.08 €/kg. If the demand of fly larvae meal increases, the challenge faced by fly larvae producers will be to produce and to sell fly larvae meal at an acceptable price for small poultry farmers. This will oblige enterprises to be innovative in their production process to ensure financial benefits.

5. Conclusion

Poultry farmers are facing a major constraint of feed, representing about 70% of the total production costs in developing countries. Finding a sustainable and cheaper ingredient for poultry farming is needed to increase their competitiveness. This study applied a field bid experiment to assess the economic feasibility of fly larvae meal as an alternative feed in replacement for fish meal. Then, we analyzed WTP for using fly larvae as a protein source to feed traditional poultry in Benin. Respondents were mostly willing to pay for it and are ready to use it, although the amount they are willing to pay is different according to poultry farmers. The average WTP estimated at FCFA/kg 225.10 (€/kg 0.34) for fly larvae was lower than the local price of fish meal. Meeting the demand of fly larvae meal for poultry farmers in Benin requires that it is produced on a large scale. This production requires the creation of small-scale innovative enterprises and the development of equipment that can reduce production costs thus making the enterprises financially viable. Information sharing and sensitization on fly larvae meal use as a low cost protein source and as a sustainable alternative of fish meal in traditional poultry farms is required for better food and nutritional security.

6. References

Agbédé, G. N. and Mpoame, M. (1994). Essai d'Utilisation de la Farine de Vers de Terre *Eudrilus eugeniae* dans l'Alimentation des Poulets de Chair en Finition. *Tropicultura* 12: 3-5.

Alberini, A. (1995). Optimal Designs for Discrete Choice Contingent Valuation Surveys: Single-bound, double-bound, and bivariate models. *Journal of Environmental Economics and Management* 28: 287-296.

Amaefule, K.U. and Osuagwu, F.M. (2005). Performance of Pullet Chicks Fed Graded Levels of Raw Bambarra Groundnut (*Vigna subterranean (L.) Verdc*) Offal Diets as Replacement for Soybean Meal and Maize. *Livestock Research for Rural Development* 17: 5-10.

Arrow, K., Solow, R., Portney, P.R., Leamer, E. E., Radner, R. and Schuman, H. (1993). Report of the NOAA Panel on Contingent Valuation. Rockville, MD: Blue Ribbon' Panel report to the National Oceanic and Atmospheric Administration.

Barcelo, P.M. and Barcello, J.R. (1991). The Potential of Snail (*Pila leopoldvillensis*) Meal as Supplement in Broiler Diets. *Tropicultura* 9: 11-13.

Basak, B., Pramanik, M.D.A.H., Rahman, M.S., Tarafdar, S.U. and Roy, B.C. (2002). Azolla (*Azolla pinnata*) as a Feed Ingredient in Broiler Ration. *International Journal of Poultry Sciences* 1: 29-34.

Bell, J. G. (1992). The Village Chicken and Disease Control. *Tanzanian Veterinary Journal* 29: 44-46.

Breffle, W.S., Morey, E. R. and Lodder, T. S. (1998). Using Contingent Valuation to Estimate a Neighbourhood's Willingness to Pay to Preserve Undeveloped Urban Land. *Urban Studies* 35(4): 715-727.

Buldgen, A., Determinan, F., Sall, B. and Compere, R. (1992). Etude des Paramètres Démographiques et Zootechniques de la Poule Locale du Bassin Arachidier Sénégalais. *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux* 45(3-4) : 341-347.

Buza, J.J. and Mwamuhehe, H.A. (2001). Country Report: Tanzania. Proceedings of ACIAR n°103, Canberra: AICIA, 38-42.

Carson, R. T. and Hanemann, W. M. (2005). Contingent Valuation. In Karl-Göran, M. and Jeffrey, R.V. (eds), Handbook of Environmental Economics: Valuing Environmental changes. Amsterdam: Elsevier, Vol. 2, 821-936.

Cawley, J. (2008). Contingent Valuation Analysis of Willingness To Pay to Reduce Childhood Obesity. *Economics & Human Biology* 6: 281-292.

Charlton, A. J., Dickinson, M., Wakefield, M. E., Fictches, E., Kenis, M., Han, R., Zhu, F., Kone, N., Grant, M., Devic, E., Bruggeman, G., Prior, R. and Smith, R. (2015). Exploring the Chemical Safety of Fly Larvae as a Source of Protein for Animal Feed. *Journal of Insects as Food and Feed* 1: 7-16.

Chrysostome, C. (1997). Utilisation des Termites pour le Démarrage des Pintadeaux: Essai d'Alimentation en Milieu Rural. Proceedings of the International Network for Family Poultry Development Workshop (INFPDW), M'Bour, Sénégal: INFPDW, 117-124.

Dagnelie, P. (1998). Statistiques Théoriques et Appliquées. Brussels: De Boeck.

Delgado, C. L., Narrod, C. A. and Tiongco, M. M. (2008). Determinants and Implications of the Growing Scale of Livestock Farms in Four Fast-Growing Developing Countries. Research Report, Washington, DC: International Food Policy Research Institute.

Diederich, J. and Goeschl, T. (2014). Willingness To Pay for Voluntary Climate Action and its Determinants: Field-experimental Evidence. *Environmental and Resource Economics* 57(3): 405-429.

Drichoutis, A. C., Lusk, J. L. and Pappa, V. (2016). Elicitation Formats and the WTA/WTP Gap: A Study of Climate Neutral Foods. *Food Policy* 61: 141-155.

FAO (2014). Edible Insects: Future Prospects for Food and Feed Security. Rome: FAO.

Farina, L., Demey, F. and Hardouin, J. (1991). Production de Termites pour l'Aviculture Villageoise au Togo. *Tropicultura* 9:181-187.

Fu, T.T., Lin, Y.M. and Huang, C.L. (2011). Willingness To Pay for Obesity Prevention. *Economics & Human Biology* 9: 316-324.

Goromela, E.H., Kwakkel, R.P., Verstegen, M.W.A. and Katule, A.M. (2006). Strategies to Optimize the Use of Scavenge Able Feed Resource Base by Smallholders in Traditional Poultry Production Systems in Africa: A Review. *African Journal of Agricultural Research* 1(3): 91-100.

Grappey, C. (1999). Fiabilité des Résultats de l'Évaluation Contingente et Modes d'Interrogation, une Application à la Ressource en Eau Souterraine. *Economie Rurale* 254: 45-53.

Guèye, E. F. (1998). Village Egg and Fowl Meat Production in Africa. *World's Poultry Science Journal* 54: 73-86.

Guèye, E.F. (2002). Family Poultry Research and Development in Low-Income Food Deficit Countries: Approaches and Prospects. *Outlook on Agriculture* 31(1):13-21.

Gunaratne, S.P., Chandrasiri, A.D.N., Hemalatha, W.A.P.M. and Roberts, J.A. (1993). Feed Resource Base for Scavenging Village Chickens in Sri Lanka. *Tropical Animal Health and Production* 26:249-257.

Halkos, G. and Jones, N. (2012). Modeling the Effect of Social Factors on Improving Biodiversity Protection. *Ecological Economics* 78:90-99.

Halstead, J M.; Luloff, A.E. and Thomas, H. S. (1992). Protest Bidders in Contingent Valuation. *Journal of Agricultural and Resource Economics* 21(2): 160-169.

Hanemann, M., Loomis, J. and Kanninen, B. (1991). Statistical Efficiency of Double-Bounded Dichotomous Choice Contingent Valuation. *American Journal of Agricultural Economics* 73(4): 1255-1263.

Hoyos, D. and Mariel, P. (2010). Contingent valuation: Past, Present and Future. *Prague Economic Papers* 4: 329-343.

Hwangbo, S., Choi, S. H., Kim, S. W., Son, D. S., Park, H. S., Lee, S. H. and Jo, I. H. (2009). Effects of Crude Protein Levels in Total Mixed Rations on Growth Performance and Meat Quality in Growing Korean Black Goats. *Asian Australasian Journal of Animal Sciences* 22(8): 1133-1139.

Ideris, A., Ibrahim, A. L. and Spradbrow, P. B. (1990). Vaccination of Chickens against Newcastle Disease with a Food Pellet Vaccine. *Avian Pathology* 19(2): 371-384.

Jaleta, M., Kassie, M. and Shiferaw, B. (2013). Trade-offs in Crop Residue Utilization in Mixed Crop-Livestock Systems and Implications for Conservation Agriculture. *Agricultural Systems* 121: 96-105.

Kenis, M., Koné, N., Chrysostome, C.A.A.M., Devic, E., Koko, G.K.D., Clottey, V.A., Nacambo, S. and Mensah, G.A. (2014). Insects Used for Animal Feed in West Africa. *Entomologia* 2(2): 107–114.

Kitalyi, A.J. and Mayer, A. (1998). Village Chicken Production Systems in Rural Africa: Household Food Security and Gender Issues. Animal Production and Health Paper 142, Rome: FAO.

Kpadé, C.P., Mensah, E. R., Fok, M. and Ndjeunga, J. (2017). Cotton Farmers' Willingness To Pay for Pest Management Services in Northern Benin. *Agricultural Economics* 48 (1): 105-114.

Loomis, J. (2011). What's to Know about Hypothetical Bias in stated Preference Valuation Studies? *Journal of Economic Surveys* 25(2): 363–370.

Lwanga, S. K. and Lemeshow, S. (1991). Sample Size Determination in Health Studies: A Practical Manual. Geneva: World Health Organization.

Makkar, H.P.S., Tran, G., Heuzé, V. and Ankers, P. (2014). State-of-the-Art on Use of Insects as Animal Feed. *Animal Feed Science and Technology* 197: 1–33.

Mogas, J., Riera, P. and Bennett, J. (2006). A Comparison of Contingent Valuation and Choice Modeling with Second-Order Interactions. *Journal of Forest Economics* 12: 5–30.

Morrison, M. D., Blamey, R. K. and Bennett, J. W. (2000). Minimising Payment Vehicle Bias in Contingent Valuation Studies. *Environmental & Resource Economics* 16: 407–422.

Mutungi, C., Irungu, F. G., Nduko, J., Mutua, F., Affognon, H., Nakimbugwe, D., Ekesi, S. and Fiaboe, K. K. M. (2017). Postharvest Processes of Edible Insects in Africa: A Review of Processing Methods, and the Implications for Nutrition, Safety and new Products Development. *Critical Reviews in Food Science and Nutrition*: 1-23. https://doi.org/10.1080/10408398.2017.1365330

Narrod, C. A., Pray, C. E. and Tiongco, M. (2008). Technology Transfer, Policies, and the Role of the Private Sector in the Global Poultry Revolution. Discussion Paper No. 00841, Washington D.C.: International Food Policy Research Institute.

Njue, S.W., Kasiiti, J.L., Macharia, J.M., Garcheru, S.G. and Mbugua, H.C.W. (2002). Health Management Improvements of Family Poultry Production in Africa: Survey Results from Kenya. In FAO (ed), Characteristics and Parameters of Family Poultry Production in Africa. Rome: FAO/IAEA, 39-45.

Nkegbe, E.K., Adu-Aboagye, G., Affedzie, O.S., Nacambo, S., Boafo, A. B., Kenis, M., and Wallace, P. (2018). Potential Health and Safety Issues in the Small-Scale Production of Fly Larvae For Animal Feed – A Review. *Ghanaian Journal of Animal Science* 9: 1-10.

Pavel, M.S., Chakrabarty, S. and Gow, J. (2015). Assessing Willingness To Pay for Health Care Quality Improvements. *BMC Health Services Research* 15(43):1-10.

Perman, R., Ma, Y., Common, M., Maddison, D. and McGilvray, J. (2011). Natural Resource and Environmental Economics. 4th edition, Edinburgh, England: Pearson Education Limited.

Pomalégni, S.C.B., Gbemavo, D.S.J.C., Kpadé, C.P., Kenis, M. and Mensah, G.A. (2017). Traditional Use of Fly Larvae by Small Poultry Farmers in Benin. *Journal of Insects as Food and Feed* 3(3): 187-192.

Pomalégni, S. C. B., Gbemavo, D. S. J. C., Kpadé, C. P., Babatoundé, S., Chrysostome, C. A. A. M., Koudandé, O. D., Kenis, M., Glèlè Kakaï, R. L. and Mensah, G. A. (2016). Perceptions et Facteurs Déterminant l'Utilisation des Asticots dans l'Alimentation des Poulets Locaux (*Gallus gallus*) au Bénin. *Journal of Applied Biosciences* 98: 9330 -9343.

Proteinsect (2017). Enabling the Exploitation of Insects as a Sustainable Source of Protein for Animal Feed and Human Nutrition*:* Final Report Summary, European Union, United Kingdom, UK: Proteinsect. http://cordis.europa.eu/result/rcn/170042_en.html. Accessed 26 May 2017.

Rakotonirina, R.S. (1990). Utilisation de l'Asticot de Musca domestica dans l'Alimentation des Poules Pondeuses dans les Petits et Moyens Elevages. Ecole Supérieure des Sciences Agronomiques (ESSA), Université d'Antananarivo. Antananarivo, ESSA:

Ready, R.C., Whitehead, J.C. and Blomquist G.C. (1995). Contingent Valuation When Respondents are ambivalent. *Journal of Environmental Economics and Management* 29: 181-196.

Roe B., Haab, T. C. and Sohngen, B. (2004). The Value of Agricultural Economics Extension Programming: An Application of Contingent Valuation. *Applied Economic Perspectives and Policy* 26 (3): 373-390.

Roffeis, M., Wakefield, M.E., Almeida, J., Alves Valada, T.A.R., Devic, E., Koné, N'G., Kenis, M., Nacambo, N., Fitches, E.C., Koko, G.K.D., Mathijs, E., Achten, W.M.J. and Muys, B. (2018). Life Cycle Cost Assessment of Insect Based Feed Production in West Africa. *Journal of Cleaner Production* 199: 792-806.

Rowe, R., D'Arge, R. and Brookshire, D. (1980). An Experiment on the Economic Value of Visibility. *Journal of Environmental Economics and Management* 7: 1-19.

Sall, M., Gafsi, M. and Bonnassieux, A. (2010). Les Systèmes de Production dans la Région de Kolda (Sénégal): Dynamique des Innovations à Travers Aviculture Villageoise. In Coudel, E., Devautour, H., Soulard, Ch.-T. and Hubert, B. (eds), ISDA 2010, Montpellier, France: Cirad-Inra-SupAgro, 1-10.

Shi, L., Gao, Z. and Chen, X. (2014). The Cross-Price Effect on Willingness-To-Pay Estimates in Open-Ended Contingent Valuation. *Food Policy* 46: 13-21.

Spradbrow, P. B. (1997). Special Requirement for Village Chickens. In Mowatand, N. and Rweyemamu, M. (eds), Vaccine Manual: The Production and Quality Control of Veterinary Vaccines for Use in Developing Countries. Rome: FAO, 123-126.

Travisi, C. M., and Nijkamp, P. (2008). Valuing Environmental and Health Risk in Agriculture: A Choice Experiment Approach to Pesticides in Italy. *Ecological Economics* 67(4): 598-607.

Vidogbéna, F., Adégbidi, A., Tossou, R., Assogba-Komlan, F., Martin, T., Ngouajio, M., Simon, S., Parrot, L. and Zander, K. K. (2015). Consumers' Willingness To Pay for

Cabbage with Minimized Pesticide Residues in Southern Benin. *Environments* 2 : 449-470.
Villanueva, A. J., Glenk, K. and Rodríguez-Entrena, M. (2017). Protest Responses and Willingness to Accept: Ecosystem Services Providers' Preferences towards Incentive-Based Schemes. *Journal of Agricultural Economics* 68 (1):1-21.
Vorsters, A., Aminou, T. and Demey, F. (1994). Récolte de Termites pour l'Aviculture à Songhaï (Bénin). *Cahiers Agricultures* 3: 265-266.
Watson, V., and Ryan, M. (2007). Exploring Preference Anomalies in Double Bounded Contingent Valuation. *Journal of Health Economics* 26: 463-482.
Wei, X.; Guan, Z. and Zhu, H. (2016). Farmer's Willingness to Participate in Wetland Restoration: A Hurdle Model Approach. *Agricultural Economics* 47: 1–9.
Wu, L., Wang, H., Zhu, D., Hu, W. and Wang, S. (2016). Chinese Consumers' Willingness To Pay for Pork Traceability Information: The Case of Wuxi. *Agricultural Economics* 47: 71–79.

Appendix

QUESTIONNAIRE FOR ESTIMATING TRADITIONAL POULTRY FARMERS' WTP IN BENIN

Survey sheet N°|_____________| Date of survey: |____|____|____| Name of investigator:……………………

The purpose of this survey is to determine if Beninese's poultry farmer is willing to use fly larvae as protein source to feed his livestock of local chicken. If yes, how much is he willing to pay for?

A. SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENT

CHARACTERISTICS	Code	Responses
1. Province (DEPART)	1= Alibori, 2 = Borgou, 3= Atacora, 4= Donga, 5 = Collines, 6=Zou, 7=Plateau, 8 = Ouémé, 9= Atlantique, 10=Littoral, 11=Mono, 12= Couffo	
2. Dstrict (COMMUNE)	Enter the name of the District	
3. Village (VIL)	Enter the name of the village	
4. Name and surname of the respondent (NPENQ)	Enter correctly the name and the surname of the poultry farmer	
5. Socio-cultural groups (ETHNIE)	1. Fon and related 2. Bariba and related 3. Dendi and related 4. Adja and related 5. Yom & Lokpa related 6. Betamaribe and related 7. Peulh and related 8. Yoruba and related 9. Other socio-cultural groups of Benin 10. Foreign	
6. The different animals constituting the livestock of the poultry farmer (ANIMAL)	1= chicken ; 2= guinea fowl ; 3= duck ; 4= pigeons ; 5= turkey ; 6= other	
7. Number of the dominant species in the livestock (ED)	Enter the species and the number	
8. What are the local chicken ecotypes of your farm (RAPL)?	1=holli ; 2=fulani ; 3=sahwè ; 4= yaya ; 5=yovokoklo ; 6= other	
9. Number of local chicken (EFFEC)	Enter the number	
10. Type of Livestock farming (ME)	1=Scavenging ; 2= Semi-scavenging ; 3=Confinement	
11. Marital status (SIMA)	1=married ; 2=divorced ; 3=single, 4 = widower, 5=other	
12. Number of agricultural assets (AE)	Enter the number	
13. Household size of the poultry farmer (EMEL)	Enter the number	
14. Age (AGE)	Enter the poultry farmer's personal response (number of years) or make an approximation in case of no response	
15. Education level (NINST)	0=Not literate; 1= literate ; 2= primary ; 3= secondary, 4= professional training ; 5= higher ; and enter the number of years of study	
16. Main occupation (PROFPRI)	1=Farmer or livestock farmer; 2= trader ; 3= agri-food processor; 4= official in activity ; 5=Mechanic ; 6=Carpenter ; 7=other (specify and continue the list)	

17. Number of years in poultry farming (EXPE)	Enter the response (number of years)	
18. To which network or livestock farmer association do you belong to (RESEAU)?	Enter the response	
19. Do you have access to a micro finance institution (AIMF)? Which one?	1=Yes, 0=No	
20. What is your annual global income? (REVGLO) ?	Enter the quantified income (data)	
21. What is your annual farm income (RAN)?	Enter the quantified income (data)	
22. What is the share of poultry income in annual farm income **(**PARAN)**?**	Enter the response (on 10)	
23. Do you know that fly larvae can be used for chicken feeding (COLAMOU)?	1= Yes; 0=No	
24. Did you use fly larvae to feed local chicken (AFAS)?	1= Yes ; 0=No	
25. Do you currently use fish meal to feed local chicken (UFAP)?	1= Yes; 0= No	
26. Would you like to replace fish meal with another protein source (SUS)?	1= Yes ; 0= No	
27. If yes to question 26. Why do you want to substitute fish meal (RSFAP)?	1=bad quality, 2=unavailability of the fish meal on the local market, 3=high price, 4= other	
28. What other ingredients are used as protein source to feed local chicken (ASP)?	1= soy flour, 2 = oil cake, 3 = any, 4= other to be specified	

B. DOUBLE BID PROCEDURE TO PROPOSE

29. The fish meal is often used as protein source to feed chickens. The price per kg of fish meal on the international market is between FCFA/kg 1,000 and FCFA/kg 1,200. This fish meal is sold on the local market at FCFA/kg 550. This low price can be attributed to the low quality of the fish meal sold with low protein content. Fly larvae meal proved to be nutritional as source of animal protein for local chickens. It can replace the fish meal with low quality used to feed local chickens. In addition, the use of fly larvae meal improves zootechnical performance of your local chickens (average daily gain, consumption index, etc.) and reduce the costs of protein feeding. Would you be willing to pay for fly larvae meal as a protein source to feed your local chickens?

Yes ☐ No ☐

30. If Yes, would you accept to pay FCFA/kg X to feed your local chickens?

The vector X[2] to be proposed is composed of 7 bids: FCFA 600; FCFA 700; FCFA 800; FCFA 900; FCFA 1,000; FCFA 1,100 and FCFA 1,200.

[Yes] Select and go to the question **31.** [No] Select and go to the question **32. with k=100**

31. Could you pay FCFA/kg X+k ? Select [Yes] or [No] and go to **34.**

32. Could you pay FCFA/kg X- k ? Select [Yes] or [No] and go to **34.**

33. If the answer for question 29 is No; so why?

No means to pay: [ ]

Refusal of payment vehicle : [ ]

No value given to fly larvae: [ ]

Other (specify and continue the list): [ ]

34. If the answer to question **29** is Yes, what is your level of motivation for using fly larvae (DEGMOT)?
1= very motivated; 2= motivated; 3 =indifferent: 4=not motivated; 5=little motivated.[3] |_____________|

35. Are you motivated to use fly larvae to increase the nutritional quality of your local chickens (MQUAL)? 1=Yes; 0=No |_____________|

36. If Yes, what is the level of the MQUAL (DEGMQUAL)? 1= very motivated; 2= motivated; 3 =indifferent: 4= not motivated; 5= little motivated: …………….

37. Are you motivated to use fly larvae to increase zootechnical performance of your local chickens (MPERZ)? 1=Yes ; 0=No :………………

38. If Yes, what is the level of MPERZ? 1= very motivated; 2= motivated; 3 =indifferent: 4= not motivated; 5= little motivated:…………………….

39. Are you motivated to use fly larvae to reduce the costs of feeding (MCOT)? 1=Yes; 0=No:……………….

40. If Yes, what is the level of MCOT? 1= very motivated; 2= motivated; 3 =indifferent: 4= not motivated; 5= little motivated: …………….

41. What can we do to promote the use of fly larvae to all poultry farmers (RECOM)?
a. train poultry farmers to produce fly larvae …………………………….
b. promote the consumption of poultry fed with fly larvae ……………..
c. Other (specify)……………………………………………………………………………………………………
……

[2] FCFA 600 correspond to the minimum production cost of 1 kg of fly larvae meal, *i.e.*, equivalent to FCFA 150 as minimum production cost of 1 kg of fresh fly larvae. FCFA 1,200 correspond to the maximum production cost of 1 kg of fly larvae meal, *i.e.*, equivalent to FCFA 300 as maximum production cost of 1 kg of fresh fly larvae. We increment and decrement the initial bid by 100 FCFA, which corresponds to the marginal cost to improve the quality of the fly larvae meal.

[3] We use 1-5 LikertScale to evaluate the level of motivation.

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Full Research Article

The impacts to food consumers of a Transatlantic Trade and Investment Partnership[#]

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Abstract. Primary agriculture is a textbook example of competitive supply with many producers outputting homogenous products, in contrast to firms in the processed food sector produce heterogeneous products while differing in productivity. Our model of trade reform explicitly accounts for the differences between the markets for primary agriculture and food processing. To demonstrate this point, we use a computable general equilibrium (CGE) model to quantify potential impacts of a trade agreement between the EU and US. Crucially, our heterogeneity-firm setup allows for the allocation of NTMs as 'fixed costs', which provides an alternative angle to previous literature that only considered NTM costs in a more conventional framework (e.g., tariff equivalent). Further, the use of this framework allows us to provide detailed welfare impacts, providing more information on the impacts to consumers who purchase mainly processed food and little primary agricultural output, a point often unrepresented in previous analysis of NTM reform.

Keywords. Trade Policy, Imperfect competition, Heterogeneous firms, Simulations.

JEL Codes. F12, F14, F47.

1. Introduction

Primary agriculture is a textbook example of competitive supply with many producers outputting homogenous products while firms in the processed food sector produce heterogeneous products. Thus, there are important differences in productivity, size, and exporting behavior among these firms that should be reflected in quantitative analysis. While manufacturing has typically received the firm heterogeneity treatment, the potential Transatlantic Trade and Investment Partnership (TTIP)[1] provided an instance of using

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[1] We note that the chances for implementation in the near future is slim; however, negotiations have not officially ended (unlike the Trans-Pacific Partnership). The United States Trade Representative still maintains a webpage devoted to the potential agreement. https://ustr.gov/ttip

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an agri-food sector (i.e., food processing) that exhibits firm heterogeneity characteristics. Luckstead and Devadoss (2016) analyze the potential impact of TTIP assuming heterogeneity of firm involved in food processing. However, that study uses a single sector model that neglects feedback with other sectors, including agriculture as a major upstream link of the processed food sector.

The potential TTIP agreement generated a large amount of research, which may not be surprising given that the agreement would have linked the world's two largest economies. Although the above mentioned paper incorporated a firm heterogeneity setup in their analysis of TTIP, most research still considers firms as homogenous (e.g., Arita *et al.* 2014, 2017; Beckman et. 2015; Beckman and Arita, 2017; Berden *et al.* 2009; Disdier *et al.* 2015; Egger *et al.* 2015; Fontagne *et al.* 2013; Welfens and Irawan 2014; Beghin *et al.*, 2016). Despite their traditional model approaches, these papers make two points relevant to trade policy analysis. First, tariffs are usually low in developed countries (relative to developing countries), especially for manufacturing and services. However, in developed countries, agriculture is usually more protected relative to other sectors, with higher tariffs, tariff-rate quotas, and non-tariff measures (NTMs).[2] Second, for developed countries, NTMs are becoming more of a trade barrier tariffs, with almost all of the papers that compare the two concluding that NTM removal (even partial removal) could generate larger trade gains than those from tariff removal. The NTM topic is also relevant for firm heterogeneity, since under the standard Armington assumption, NTMs are typically treated simply as ad-valorem equivalents (AVEs). This differs from the heterogeneous firm layout e.g. used in Akgul *et al.* (2016) or Luckstead and Devadoss (2016), that treats them (partly) as fixed costs of trade.

Our work here builds on the previous TTIP analysis, by starting with the view that reforming agri-food trade might generate the largest relative trade gains. We focus on the processed food sector as it accounts for the largest share of bilateral trade in agri-food between US-EU, and because it can be characterized as exhibiting all the signs of a sector with heterogeneous firms.[3] Berden *et al.* (2009) note that one percent of processed food firms account for 52 percent of total sales. these large firms regularly modify and improve the characteristics of their products to meet the requirements and changing preferences of different consumer groups and to differentiate themselves from competitors.[4] Following most TTIP analysis, we employ a CGE model that encompasses all sectors and their interactions, but integrate a firm heterogeneity approach for processed food and all other types of manufacturing. This firm heterogeneity specification allows us to provide more information on impacts to consumers with evidence on the impacts to consumer welfare from a change in the number of new varieties entering the processed food sector, information that is not available in a standard perfect competition setup. Our model also details welfare impacts in general, providing information on an aspect of TTIP so far largely ignored.

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[2] One could examine the average Most Favoured Nation (MFN) tariffs reported to the World Trade Organization to confirm this point. The EU trade-weighted MFN rate for agriculture is 8.7% compared to 2.8% for non-agriculture. The U.S. rates are 2.3% and 4.0%. The largest gap is likely for Japan: 1.4% and 12.9%.

[3] Particularly relevant to TTIP, the EU and US account jointly for one third of global trade in processed food (UN Comtrade, 2015); and they trade (bilaterally) more processed food products than any other partners globally (FAS/USDA, 2014; Olper *et al.*, 2014).

[4] In addition, high product differentiation and considerable differences in firms' size and productivity has led some (e.g., Neff *et al.*, 1996; Francois *et al.*, 2013) to label the processed food sectors as monopolistic competition, which is often used to characterize firms with heterogeneity.

2. Modeling framework

Global CGE models are generally considered well suited for ex-ante appraisal of trade agreements as they consider bilateral trade and trade barriers in a consistent microeconomic behavioral framework and account for interlinkages between sectors. Here we use the flexible and modular CGE model by Britz and Van der Mensbrugghe (2017) extended by the heterogeneous firm module of Jafari and Britz (2018a) (see the online appendix for its detailed documentation[5]). Next, we discuss briefly the general structure of the model.

2.1 Perfect competitive sectors

Sectors with perfect competition are depicted as in the standard GTAP model (Hertel, 1997), with cost-minimizing behavior under constant returns to scale (CRS) production technologies along with utility maximizing consumers in competitive markets. Relevant to this work, the perfect competition sectors use an Armington trade setup where a constant elasticity of substitution (CES) function, specific for each agent, i.e. final consumers, government, savings and the different production sector, drives competition between domestically produced products and imports. A second CES nest, which is not agent specific, depicts the import demand composition from bilateral trade flows. Hence, the Armington setup considers commodities produced in the same region as homogenous, but different from commodities stemming from other regions. For example, all dairy products from the EU are assumed to be of the same quality and fetching the same price. On the supply side, production is defined as the Leontief aggregate of value added and intermediate inputs bundles; the value added composition is based on a CES aggregate of primary factors while the composition of intermediate demand is based on fixed physical input coefficients.

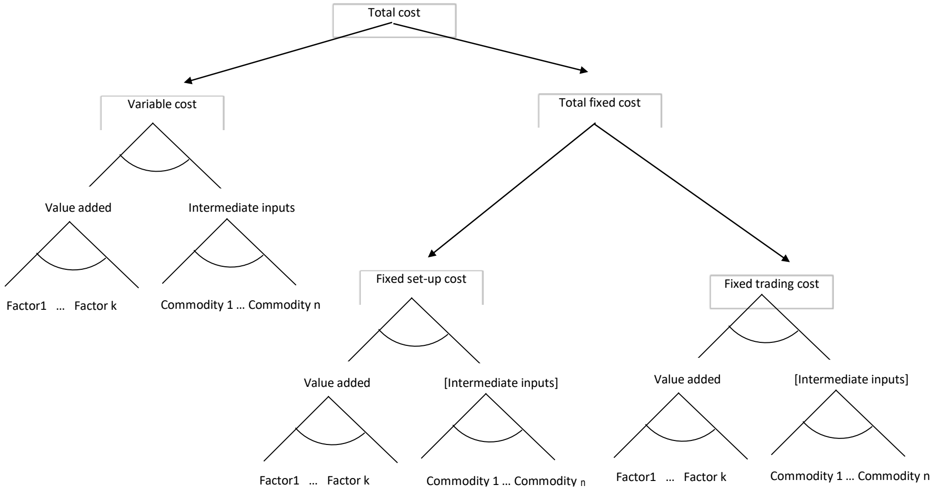
2.2 Heterogeneous sectors

In each sector there is a continuum of firms that are heterogeneous with regard to productivity, and each firm produces its own distinct variety. While firms are free to enter or exit the market, entrance requires covering fixed costs. Firms learn about their productivity level once they enter the market, and then choose to stay or exit. Firms with too low of a productivity level will not be able to cover their fixed cost, and therefore exit the industry. For those that survive, only the most productive ones are involved in exports since they can cover the fixed costs of exporting, while less productive firms only serve the domestic market.

In this framework, the number of firms operating on the domestic market and on the bilateral trade links depends on the characteristics of the domestic market and bilateral trade costs. Since each firm produces a single distinct variety, the total number of varieties available in any given country depends on the number of firms operating in the domestic market and the number of firms exporting to that country. Accordingly, the total number of varieties available to consumers in a given country is determined endogenously. In this

[5] Jafari and Britz (2018) published that online appendix as part of their paper, provided here again for ease.

Figure 1. Production structure in Melitz sectors.



Source: Authors' illustration.

context, any policy shock that leads to changes in variable or fixed costs can change the fraction of firms operating on domestic and on trade links, and therefore the number of varieties available to consumers.

On the demand side, the composite demand of each agent for each commodity is defined as the Dixit-Stiglitz composite of demand for average firm level varieties around the world[6]. That index can be interpreted as a standard CES aggregator where the import quantity impact is additionally multiplied by the change in the number of operating firms providing a love of variety effect.

Each heterogeneous firm produces one single unique variety and therefore, the number of varieties produced in a regional industry is equal to the number of operating firms. The production structure is shown in Figure 1, where total cost is the sum of variable and fixed costs per firm, the latter consists of fixed costs to enter the enter the industry and fixed cost on each trade link. The variable cost nest uses both primary factors and intermediates based on a constant return to scale technology, while fixed cost only relate to primary factors. However, if the overall total cost share of value-added in a sector is small, the fixed cost nest also comprises a share of intermediate composite. This alternative is identified by the intermediate composite in brackets. The value added and intermediate bundles are CES composites of primary factors of production and intermediate inputs, respectively. The total value added (not shown here) is the sum of value added used in both variable and fixed cost nesting. Similarly, the total uses of intermediate commodities and primary factors (not shown here) are the sum of their use in fixed and variable cost nesting.

[6] The heterogeneous firm model defines the so-called "average firm" depicting the average productivity of all firms operating on a specific trade link.

Consistent with the monopolistic competition assumption, each firm applies a markup pricing rule, i.e. it collects rent stemming from producing a specific variety, which covers its fixed costs. Marginal production costs are corrected for the average productivity effect of firms operating on each bilateral trade link. The average productivity of firms on each trade link is determined from a Pareto distribution function which encompasses a so-called cut-off productivity level. Only firms with productivity equal to or higher than that specific threshold level for each bilateral trade link will operate on that link, while the remaining firms are forced to exit. The number of operating firms on a link is derived from a zero profit condition where the revenue of the average firm must be equal to its bilateral fixed cost. However, ensuring zero profit for operating firms on each trade link does not ensure zero profits for the industry as a whole, due to the sunk costs associated with the entry of new firms in the industry. Therefore, zero profit at the industry level is assured by a free entry condition in the industry, indicating that the expected profit for firms over their lifetime must be equal to the overall industry fixed set up costs.

Trade liberalization filters through this type of model differently than in the standard Armington setup, beginning with the reallocation of resources between firms. For example, a policy that decreases bilateral export cost will encourage some firms that initially did not export (those with low productivity) to start trading. This leads both to an increase in the number of exporters and a decrease in the average productivity of exporters (since those firms that just entered the export market were less productive to begin with). Due to fixed cost per firm, an increase in the number of exporters implies that the industry as a whole uses more resources. This increases input prices in the domestic market, leading to some lower productive firms to exit the domestic market. As a result, the average productivity in the domestic market increases. Since some of the least productive firms exit the industry, the productivity for the industry increases and generates a welfare gain (as those firms that now enter the export market are relatively more productive than those leaving the domestic market). On the importing side, similar adjustments in industry structure take place while consumer benefits from more varieties being present on the import side.

2.3 Model parameterization and calibration

A major advantage of this firm heterogeneity model is that it does not require as much information on industries and consumers as the original Melitz (2003) model. Indeed, only two parameters are needed for each sector: one that describes the productivity distribution of the industry (based on a Pareto distribution) and another that is the elasticity of substitution among domestic and imported varieties. We use the estimate of 3.8 from Bernard *et al.* (2003) for the elasticity of substitution, and an estimate of 4.6 for the Pareto shape parameter from Balistreri *et al.* (2011).

2.4 Sectoral and regional aggregation

Table A1 in the Appendix provides details on how we treat the sectors in our application. We generally keep the full sectoral detail of GTAP sectors to prevent bias (Britz *et al.*,

2016) but aggregated the processed food sectors in the GTAP data base for two reasons. First, while there is in consensus in the literature that the processed food sector in general should be treated with heterogenous firms, there is no information on if some sectors (e.g., meat or dairy production) should be excluded and treated as homogenous instead. Second, as discussed below in more detail, data on the potential NTM reduction between the EU and the US suitable for our analysis is available only at the aggregated level.

To capture the impact of a proposed TTIP agreement on third countries, we aggregate the GTAP data base to 10 regions (European Union, United States, Canada, MERCOSUR, China, ASEAN 10, Mediterranean countries, Other Northern Europe[7], low-income countries, Other OECD and Rest of World). Our mapping of regions to the low-income countries aggregate follows the current World Bank classification.

3. Quantifying the policy experiment

The model is calibrated based on version 9 of the Global Trade Analysis Project (GTAP) database (Aguiar *et al.*, 2016), which provides a snapshot of world economy in 2011. Figure 2 reports bilateral ad-valorem trade weighted tariffs from the database. It reveals that processed food, beverage and tobacco products, and textile and clothing are the sectors subjected to the highest tariffs. In most cases, the applied rate of the EU is lower than that for the US.

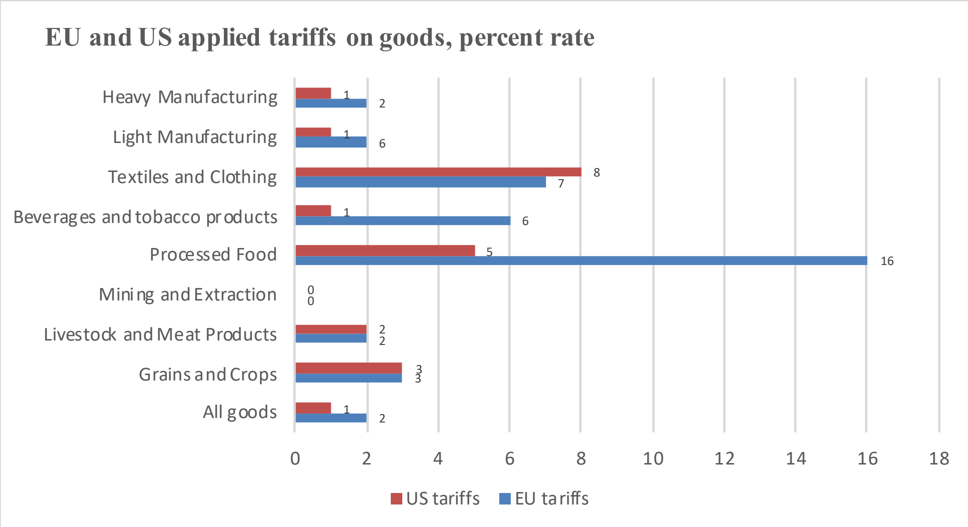
NTMs are not explicit in the data base and need to be incorporated before they can be subjected to policy experiments. The AVEs of NTMs that are potentially removable if a deep trade agreement is reached are taken from Egger *et al.* (2015), the estimated AVE for processed food is 33.83%.[8] It is not based on the latest negotiations status of TTIP, but rather more generally reflects the expected change if the two trade partners move to a deep FTA agreement given the empirical evidence from past FTAs.

We analyze two scenarios (see Table 1): the first scenario considers completely removing import tariffs for all commodities between the EU and the US, while the second one adds NTM reform. Removing existing tariffs is straightforward as they are part of the data base, whereas the second scenario requires allocating the NTM costs estimated by Egger *et al.* (2015). CGE models treat the trade cost effects of NTMs as either rent-generating or cost creating. Modeling the rent-generating effect is straightforward using either an "export tax equivalent" – changing export taxes or a "tariff equivalent" approach—changing import taxes, depending on where the rent are assumed to occur. Changes in the cost generating basis of NTMs are modeled by changing the variable portion of trade costs (since there are no fixed costs in an Armington model). However, NTM costs often reflect a 'fixed cost' component. For example, the US is able to export beef to the EU, but that beef is produced differently than how most beef sold domestically in the US is produced. To be able to export beef to the EU, US producers must have separate facilities or incur other fixed cost type of costs. As our firm heterogeneity structure is able to account for

[7] Other Northern Europe include Switzerland, Norway and Rest of European Free trade Association (EFTA)

[8] It should be noted that one would expect the NTMs between the US and the EU to be region specific (i.e., asymmetric). However, Egger *et al.* (2015) estimated the trade cost equivalents of a deep trade agreement between two regions. Therefore, these estimates should not be interpreted as the current level of NTMs but rather as the trade costs that two regions could reduce due to NTM removal when moving to a deep FTA.

Figure 2. Applied MFN tariff on transatlantic trade.



Source: Data extracted from version 9 of the Global Trade Analysis Project (GTAP) database (Aguiar *et al.*, 2016).

fixed cost, we explicitly change variable and fixed costs for EU-US trade links drawing on Jafari and Britz (2018a). One should note that NTMs could also have demand side effects when regulations affect consumer behavior, typically captured by changing either the consumer willingness to pay (as in Walmsley and Minor, 2016) or Armington elasticities. Although TTIP might provoke such demand side shifting effects, we leave them out due to missing empirical evidence.

Breden *et al.* (2009) suggested 60% of NTMs in EU-US are cost generating and 40% are rent generating. The later is then allocated by 2/3 to import duties and 1/3 to export taxes following Francoise *et al.* (2013) and Egger *et al.* (2015), (see Table 1). The cost portion of the NTM is allocated to variable and bilateral fixed costs in equal shares following Jafari and Britz (2018a).

4. Scenario analysis

While we presume that costs related to NTMs are already observed in the global SAM, rents related to NTMs probably hide in capital income flows and are clearly so far not allocated bi-laterally. We therefore first run a simulation to include the rent generating effects associated with NTMs currently in place between the US and the EU by introducing respectively increasing bi-lateral import and/or export taxes. That augmented database serves as the benchmark. In the following, we discuss the simulated impacts of both scenarios on trade, production, and welfare. Then, we turn to the specific outcomes for the food processing sector with a focus on the information given by the firm heterogeneity model.

Table 1. Scenario layout.

	Tariffs shocks	AVEs shocks			
		Total AVEs reduction divided into the last three columns	Import tax	Export tax	Bilateral fixed and variable trade cost
	(1)	(2)	(2)*0.4*2/3	(2)*0.4*1/3	(2)*0.6
Scenario 1	-100% reduction for all economic sectors	-	-	-	-
Scenario 2	-100% reduction for all economic sectors	-33.83%	-9.0%	-4.50%	-20.3%
Modeled as	Reduction in bilateral import tariff		Reduction in import tariffs representing rents in importer country	Reduction in export taxes representing rents in exporter country	Converted to an equivalent reduction in bilateral fixed and variable trade cost

Source: authors.

4.1 Effects on trade flows

Table 2 shows simulated changes in the volume of aggregate exports. Removing import tariffs (scenario 1) increases EU exports to the US increase by 4.78%, while US exports to the EU increase by 6.8%.[9] Adding NTM reform on top of tariff removal boosts bilateral trade further, by 9.7% from the EU to the US, and by 8.5% from the US to the EU. However, with increases of 0.2% (tariff removal only) and 0.5% (NTM reform included), respectively, the changes in global EU exports are minor; while total US exports expand more significantly (by 1.4% and 2.6%). These findings are comparable with Francois *et al.* (2013). Some regions including China, ASEAN 10, "low-income countries", and "Other Northern Europe" have marginally increases in their exports to either the EU or US, depending on the scenario. In the first scenario, Canada has a decrease in their bilateral exports to both regions, but in the second scenario, Canada has an increase in their exports to the EU. In summary of these changes in regional trade flows, overall world trade increases marginally by 0.3% and 0.4%, respectively.

Table 3 focuses on export flows for the processed food sector. The higher tariff protection in that sector leads to larger changes compared to the results reported above: EU exports to the US of processed food increase by 39% while US exports to the EU increase by 121% (for tariff removal). These findings are consistent with the partial-equilibrium model results of Luckstead and Devadoss (2016), but the magnitude of the impacts found here is different due to the use of different elasticities and feedback effects in our CGE modelling. As the AVE estimates of the expected changes in existing NTMs between the

[9] Bilateral changes are not presented here, but are available upon request from the authors.

Table 2. Change in aggregate exports by region [% change].

Regions	Scenario 1			Scenario 2		
	EU	US	Total	EU	US	Total
World	0.2	1.1	0.3	0.4	1.8	0.4
EU	-0.2[1]	4.8	0.2	-0.3	9.7	0.5
Other Northern Europe	0.1	0.2	0.2	0.0	-0.4	-0.1
US	6.8		1.4	8.5		2.6
Canada	-0.1	-0.3	-0.2	1.3	-0.1	0.2
Mercosur	-0.2	0.1	0.0	-0.1	-0.5	-0.1
China	0.0	0.3	0.2	0.5	-0.5	0.1
ASEAN 10	-0.4	0.5	0.7	0.2	-0.7	0.2
Other OECD	-0.2	0.0	0.0	0.5	-0.6	0.0
EU Mediterranean Partners	-0.3	0.3	-0.1	0.1	-0.5	0.0
Low Income	-0.3	0.3	-0.1	0.1	-0.1	0.0
Rest of World	-0.2	0.1	0.0	0.1	-0.5	0.0

Notes: exporters in rows, importers in columns.
Source: model results.
[1] The reader should note that the numbers presented in the column "EU" showing EU to EU exports is due to an aggregation effect. Sales to the domestic market of a nation are not reported as exports in the SAM. However, if we aggregate individual EU countries, the former bi-lateral trade links between two EU nations occur now inside one aggregate and become the diagonal trade flow in this column. The domestic sales of the EU aggregate are defined from adding up the domestic sales of individual EU countries.

EU and US are quite high and exceed existing tariff levels, bilateral trade volumes increase considerably for processed food in the second scenario. EU exports to the US almost quadruple, while US exports to the EU multiply by more than seven. This leads to changes in total exports of processed food for the EU by almost 9% and by 63% for the US. The trade diversion effects of that second scenario in the processed food sector is accordingly sizeable: most EU trading partners lose about 4% of their exports while exports to the US from the non-EU countries decreases by around 10%.

Trade impacts for primary agriculture are minor (see Table A2 and A3) which reflects low tariffs (see Figure 2) and low exports values. EU exports of primary agricultural products to the US amount to about 83 million, vice versa it is 6 million. Our analysis also shows that the impact on average manufacturing trade between two regions is small (see Table 4.4) due to low tariffs between the regions.

4.2 Effects on domestic output quantities

Table 4 presents information on production changes across all sectors. For processed food, the EU faces a decrease in both scenarios, while the US increases its production. However, the increase in US production is small, as the 63% increase in exports is mostly offset by an increase in imports (46 %) (See Table 3). Opposite and stronger effects are simulated for beverages and tobacco, with a 5% increase in EU production and a 16%

Table 3. Export volumes by region for "processed food" [% change].

Regions	Scenario 1			Scenario 2		
	EU	US	Total	EU	US	Total
World	1.5	5.3	1.1	7.2	46.2	7.4
EU	0.2	39.4	1.2	-1.7	394.2	9.3
Other Northern Europe	-0.7	-0.1	-0.4	-5.4	-10.8	-4.4
US	120.9		9.4	748.5		63.4
Canada	-1.0	-0.4	-0.4	-5.7	-11.3	-8.6
Mercosur	-0.7	0.0	-0.2	-3.9	-9.1	-1.6
China	-0.7	0.0	-0.1	-3.9	-9.3	-2.4
ASEAN 10	-1.0	-0.3	-0.3	-3.7	-8.9	-1.7
Other OECD	-0.7	-0.1	-0.1	-3.8	-9.3	-2.7
EU Mediterranean Partners	-0.6	0.0	-0.3	-4.5	-9.7	-2.5
Low Income	-0.6	0.0	-0.3	-4.5	-9.5	-2.5
Rest of World	-0.7	0.0	-0.2	-4.1	-9.4	-2.1

Source: model results.

decrease in the US. This happens for two reasons: 1) the EU has larger base exports of beverages and tobacco relative to the US; 2) the US has relatively higher tariffs on beverages and tobacco compared to processed food. Other sectors of the economy show only marginal changes. An exception is the output of "Textiles and Clothing", which has a 2.5% increase in the EU in the first scenario. This gain disappears in the second scenario as resources flow to beverages and tobacco in order to meet the large increase in production. Overall, the domestic output of processed food sectors in the EU is simulated to increase by 1.4% in the second scenario, while US output drops by 2.9%. This result is different from that found in other TTIP studies. Those studies generally conclude that the US has large production gains at the expense of the EU.

4.3 Effects on welfare

Welfare impacts are measured based on the equivalent variation (EV) criterion, i.e., the amount of money to be added to the regional household's benchmark income at benchmark prices to reach the same utility as under simulated income and prices. There are global welfare gains of 5.6 billion USD when tariffs are removed (see Table 5), of which 2.8 billion USD accrue to the EU and 5 billion USD to the US (the results are comparable with Francois *et al.*, 2013); the remaining countries, with the exception of China, have losses below 1 billion USD. Both changes in the intensive and extensive margin of trade are important in determining the welfare changes in other countries: Following a reduction in trade barriers between the US and EU, the intensive margin of trade between the two regions increases, diverting trade with other countries and causing welfare to decrease. However, a reduction in trade barriers between the EU and US helps increase the average productivity of firms operating on the domestic market and/or operating on

Table 4. Industrial output by sector [% change].

Sectors	EU		US	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Total	0.00	-0.01	0.02	0.00
Processed food	-0.11	-0.05	0.30	0.46
Beverages and Tobacco	0.13	5.67	-0.23	-16.00
Grains and Crops	-0.13	0.29	0.23	-0.24
Livestock	-0.08	0.03	0.22	0.23
Mining and Extraction	-0.01	-0.05	-0.05	0.07
Textiles and Clothing	2.52	-0.01	0.28	1.11
Light Manufacturing	-0.09	-0.24	0.51	0.15
Heavy Manufacturing	-0.13	-0.40	-0.25	0.30
Utilities and Construction	0.00	0.00	0.05	-0.01
Transport and Communication	0.02	0.07	0.01	0.02
Other Services	-0.01	0.01	-0.01	0.02

Source: model results.

trade links other than EU-US trade link. This results in an increase in the intensive margin of trade (i.e., increase in varieties) in other countries, which is welfare increasing. The total welfare impact on third countries is therefore determined based on the total volume of trade, i.e., the sum of changes in intensive and extensive margins of trade.

All regions are better off compared to the first scenario if NTMs are also reduced, several regions besides the EU and US now experience welfare increases, which results in a global welfare gain of 22.4 billion USD. The removal of NTMs increases average domestic productivity, simulating the extensive trade margin, and improving welfare compared to the first scenario. Still, welfare losses occur in Canada, Mercosur, ASEAN 10, and other OECD countries. The EU has the largest additional welfare gains, increasing from 2.8 billion USD to 13.8 billion USD under the second scenario. The US has an additional 5 billion USD added in the second scenario to reach a total of 7.8 billion USD. The welfare improvements in the second scenario match findings by Balistreri *et al.* (2011) who reports that NTM reduction in the Melitz (2003) framework increases welfare considerably.

Further, our welfare decomposition analysis reveals that the largest portion of welfare gains are associated with the scale effect (associated with the increase in returns to scale), the productivity effect (expansion in market shares of efficient firms), and variety effects (i.e., increases in the number of varieties face by consumers). While term of trade and allocative efficiency contribution is small, the fixed cost effect (due to the increase in firms fixed cost payments) reduces welfare (Table 6).

4.4 Firm-level impact of policy shocks in processing food sectors

Table 7 shows the change to the average firm (as shown in rows) associated with the production and sale of processed food in the EU for different bilateral trade markets. The

Table 5. Changes in welfare [Billion USD].

Regions	Scenario 1	Scenario 2
World	5.6	22.4
EU	2.8	13.8
Other Northern Europe	-0.2	0.1
US	5.0	7.8
Canada	-0.1	-0.1
Mercosur	-0.1	-0.1
China	0.0	0.6
ASEAN 10	-0.2	-0.1
Other OECD	-0.7	-0.2
EU Mediterranean Partners	-0.2	0.2
Low Income	-0.1	0.1
Rest of World	-0.7	0.3

Source: model results.

Table 6. Welfare decomposition analysis.

	Scenario 1	Scenario 2
EU	2.8	13.8
Allocative efficiency	0.0	0.5
Term of trade effect	0.1	1.1
Variety effect	1.3	5.2
Scale effect	1.9	9.7
Productivity effects	0.9	4.2
Fixed cost effects	-1.3	-6.9
Other effects	-0.1	0.0
US	5.6	22.4
Allocative efficiency	0.3	0.9
Term of trade effect	-0.1	1.7
Variety effect	1.8	4.7
Scale effect	3.6	11.7
Productivity effects	2.6	8.5
Fixed cost effects	-2.3	-5
Other effects	-0.2	-0.1

Source: Authors' calculations based on model results.

first column refers to the domestic market, the second column denotes intra-EU trade, the third and fourth columns show EU trade with the US and other regions not included in the transatlantic trade block (hereafter referred as nonTTIP). The last column relates to overall industry performance.

Table 7. Average firm results for EU domestic sales and exports of processed food [% change].

	Scenario 1					Scenario 2				
	Domestic sales	EU	US	nonTTIP	Total sale	Domestic sales	EU	US	nonTTIP	Total sale
Firm price	-0.2	-0.1	9.5	0.0	0.8	-0.9	-0.9	17.6	0.0	1.3
Number of operating firms	-0.6	0.1	52.7	0.0	4.3	-2.9	-2.7	666.5	0.9	55.8
Avg. output per firm	0.2	0.1	-8.7	0.1	0.1	1.0	1.0	-35.5	0.1	0.8
Avg. productivity per firm	0.1	0.0	-8.8	0.0	-0.9	0.7	0.7	-35.7	0.0	-2.9
Industry Fix costs	0.0	0.0	0.0	0.0	0.0	0.1	0.1	-24.2	0.0	-0.1
Fix costs per unit	0.3	-0.2	-28.3	0.0	-2.1	2.0	1.9	-84.7	0.0	-7.3
Industry Variable costs	-0.6	0.1	52.7	0.0	-0.2	-3.0	-2.6	481.2	1.2	-0.4
Variable costs per unit	-0.3	-0.1	9.5	0.0	0.8	-1.1	-0.9	17.6	0.0	1.2
Total output sold	-0.4	0.2	39.4	0.1	0.0	-1.9	-1.7	394.2	1.3	0.7

Source: Based on model results.

The changes in the EU-US trade link for the tariff removal scenario shows a typical reaction of the firm heterogeneity model: tariff removal reduces the average import price in the US, allowing less productive EU firms to operate on that trade link. This increases the number of firms and varieties exported to the US (52%), providing benefits to US consumers. Per unit fix costs drops by 28%; however, lower average productivity increases the variable costs per unit by about 9.5%. There is an increase in total output sold to the US of 39%, but increasing the number of operating firms decreases the average productivity of the firms operating on that trade link (-8.8%).[10] Thus, the average size of these firms also drops – average output per firm decreases by about the same percentage. The average firm exporting to the US after these changes is less productive and smaller. Together, these changes constitute a new equilibrium with zero profits for the firms operating on that trade link, while monopolistic prices charged are equal to the willingness to pay for the specific quality delivered on that trade link given the number of varieties available.

The impacts of the second scenario on EU-US bilateral trade are more pronounced: besides tariff removal, we also shock variable and fix costs related to NTMs for EU-US bilateral trade. This amplifies the effect compared to the first scenario, as now all firms face a higher willingness to pay in bilateral trade, and experience cost savings before supply and demand adjust. This allows far less efficient firms to operate in bilateral trade: the number of the EU firms exporting to the US increases by 666%[11] while average productivity (35%) and firm size (-35%) on the trade link drop. Average per unit variable costs increase by 18%, which translates into changes in the average firm price, while total output for EU-US bilateral trade almost quadruples. The fix cost of the industry operating on

[10] Note that in Table 7 and subsequent tables, even though the number of operating firms increases, the total output change is small because each firms now produces less output. This is equivalent to saying that large increases in the extensive margin are compensated by a reduction in the intensive margin of trade.

[11] Only a small share of firms operate on the link before trade liberalization which are the firms with the highest productivity. Given the shape of the productivity distribution, a significant decrease in bilateral trade cost leads to a nover-proportional increase in that share and increase at the same also the number of traded varieties on the link.

Table 8. Average firm results for US domestic sales and exports of processed food [% change].

	Scenario 1				Scenario 2			
	Domestic sales	EU	nonTTIP	Total sale	Domestic sales	EU	nonTTIP	Total sale
Firm price	-0.1	24.6	0.0	2.3	-2.0	35.6	0.0	3.1
Number of operating firms	-0.6	174.9	-0.9	15.1	-5.0	1421.0	4.0	132.0
Avg. output per firm	0.3	-19.6	0.3	0.2	1.9	-44.2	0.0	1.6
Avg. productivity per firm	0.2	-19.7	0.0	-1.9	1.4	-44.5	0.0	-4.1
Industry Fix costs	0.1	0.1	0.0	0.1	-0.1	-24.4	0.0	-0.2
Fix costs per unit	0.4	-54.7	0.0	-4.6	3.1	-91.1	0.0	-8.0
Industry Variable costs	-0.4	175.2	-0.4	0.4	-5.5	1050.5	3.6	-0.4
Variable costs per unit	-0.1	24.6	0.0	2.2	-2.5	35.6	0.0	2.9
Total output sold	-0.3	120.9	-0.3	0.4	-3.1	748.5	3.7	1.3

Source: Based on model results

that link decreases by 24%, reflecting our assumption of reduced trade costs (see Table 1). However, the original reduction is partly offset by the loss in average productivity, and at the same time distributed to a much higher output quantity. The combined impact on per unit fix costs on that link drops by around -85%. The finding is in line with the literature emphasizing the importance of the extensive margin of trade (e.g., Hummel and Klenow, 2005; Chaney, 2008; among others). No significant changes occur on the EU-nonTTIP link, such that overall changes in trade reflect only the discussed EU-US bilateral changes.

The expansion in exports combined with an on average less productive firm that trades, increases the overall input demand in the economy. This in turn bids up factor and other intermediate prices. As a first order impact, production costs increase and profits on other trade links decline, which induces some of the less productive firms to exit the EU domestic market. The number of operating firms in the domestic market decreases by 0.6% and 2.9% in the first and second scenario. As firms with lower productivity exit, factors are reallocated towards higher-productive and larger firms, thus the average productivity of firms operating in the domestic market rises by 0.1% and 0.7%. This leads to a decline in variable per unit costs of 0.3% and 1.1%, and an increase in average output per firm of 0.2% and 1%. However, the increase in average firm output does not compensate for the decrease in the number of firms operating in the domestic market. Consequently, domestic sales decline by 0.4% and 1.9%. This, along with lower firm prices of -0.2% and -0.9%, reflects the increased competition with US imports.

The impact on export flows of processed food from the US to the EU is presented in Table 8. Note first the impact on US-EU trade: following the reduction in border protection and trade cost, less productive firms find it profitable to enter the trade market. Thus, the number of operating firm on the US-EU link increases by a factor of 1.7 in the first scenario and by 14[12] in the second scenario. This lowers average productivity on that link, such that there are increases in the average firm price and output. Still, US exports to the

[12] Please see footnote 12.

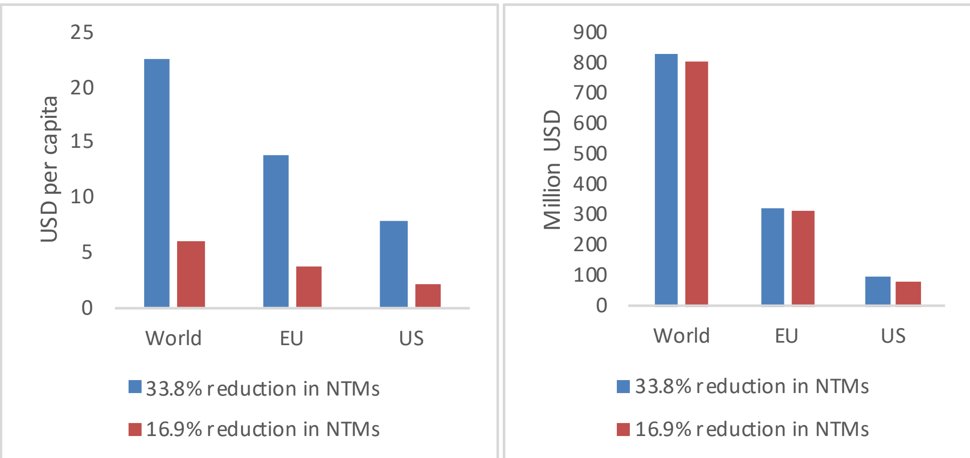
EU increase considerably (by a factor of 1.2 and 7.5), which reflects tariff removal plus an increased willingness to pay due to a higher number of varieties. Export expansion ultimately negatively affects the output sold in the domestic market by 0.3% in the first scenario and 3% in the second. Accordingly, total US processed food sales increases by only 0.4% (in the first scenario) and 1.3% (in the second).

5. Sensitivity analysis

The policy shock, model structure and parameterization jointly determine the model results. We check their robustness with regard to welfare and the volume of exports in the processed food sector. Given the uncertainties on the future of TTIP negotiations, we first perform a sensitivity analysis with regard to tariff and NTM reduction. To do so, we impose a 50% tariff shock (similar to Francois *et al.*, 2013) instead of the 100% removal in the benchmark. This essentially takes into account agricultural products that could be exempted from tariff removal. Our results (not shown here) indicate negligible impacts on trade in processed food and welfare and a small impact on overall primary agriculture trade. We also perform a sensitivity analysis for the NTM reduction scenario, but allowing for only half of the reduction in NTM costs. Figure 3 shows that the simulated changes in trade in processed food are 75-95% and welfare gains are 27-30% lower compared to the earlier results.

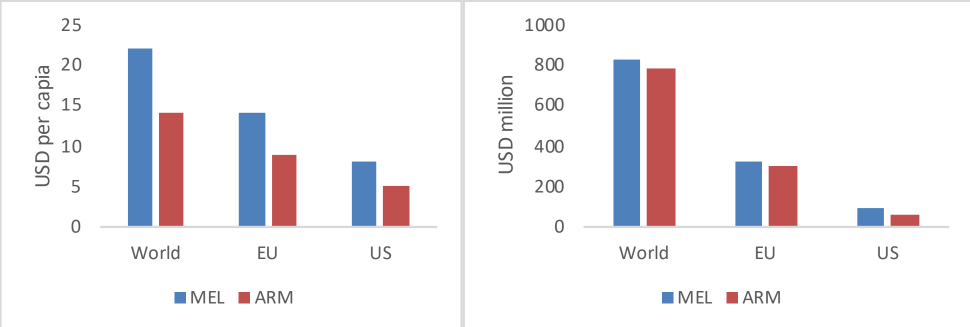
Next, we compare changes in welfare and trade in processed food in the tariff/NTM removal between model setups, i.e. proceed food and all manufacturing sectors have the firm heterogeneity setup (*MEL*), and the more conventional structure where all the sectors follow the standard Armington specification (*ARM*). Welfare in *ARM* scenario is about 40-50% and trade effects are 10-30% lower compared to the firm heterogeneity configura-

Figure 3. Change in welfare [Equivalent variant per capita in constant USD] and export volumes [Million constant USD] under lower reduction of NTMs.



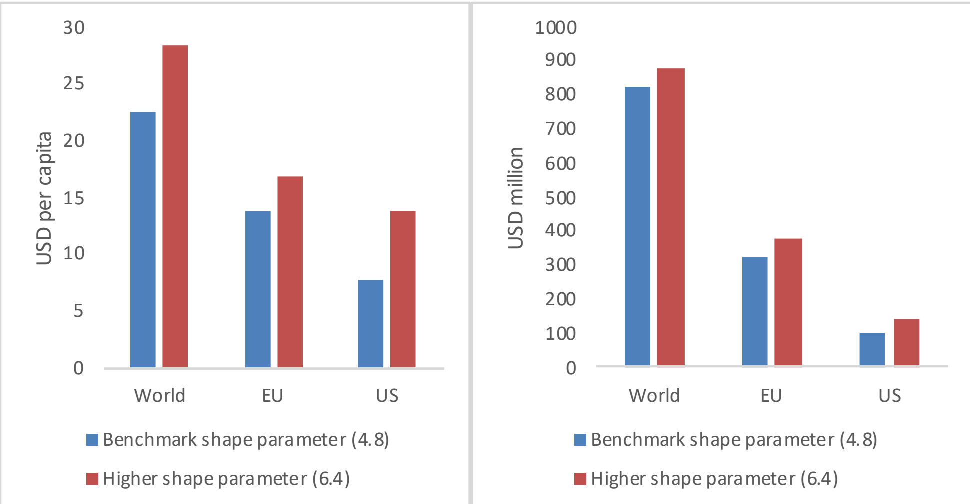
Source: Simulation results.

Figure 4. Change in welfare [Equivalent variant per capita in constant USD] and export volumes [Million constant USD] under the under Melitz and Armington specification.



Source: Simulation results.

Figure 5. Change in welfare [Equivalent variant per capita in constant USD] and export volumes [Million constant USD] under different shape parameters of the Pareto distribution of firm productivity.



Source: Simulation results.

tion (Figure 4). Comparable relative differences in welfare and trade flows are reported by Hosoe (2017), and Jafari and Britz (2018b) for a simulation of Brexit in a CGE model.

Lastly, an additional sensitivity analysis shows that trade expansion and welfare gains are higher under a higher shape parameter, i.e. if the distribution of firms' productivity becomes steeper. In Figure 5, we compare the results when the shape parameter is one-third higher than the benchmark value. The gain in welfare is 30-80% and trade in processed food is 20-40 % higher than under the default parameters across different regions. The results are comparable with Zhai (2008), who simulated a 50% reduction in manufacturing tariffs across the world. We also test the implication of increasing the benchmark Armington elasticities by one-third but keeping the original shape parameter. Our results (not shown here) reveals that that under this assumption, exports are about 10-12% lower across regions, with only a modest impact 4-5% increase in welfare.

6. Conclusion

This study employs a CGE model with a firm heterogeneity setup for processed food and manufacturing to simulate impacts of a potential TTIP agreement on the EU, the US and other countries. This setup allows us to trace the impacts on the intensive and extensive margin of trade as well as on firm productivity. In addition, in accounting for firm heterogeneity by allowing fixed costs to vary, we can more flexibly allocate NTM compared to the more conventional Armington set-up. We simulate the impacts of (i) removing all bilateral tariffs currently in place between the EU and the US; and (ii), an additional removal of NTMs in food processing sectors. Dismantling bilateral import tariffs leads to bilateral trade impacts that are below +10%, and limited welfare and trade diversion effects. As empirical estimates in the previous literature of the welfare impacts of NTMs suggest that these form considerable barriers, and the results of our second scenario are consistent with those of the earlier studies. In particular, EU welfare increases from 2 billion USD under the first scenario to 13.8 billion USD under the second. The larger increase in exports for food processing stems almost entirely from more firms exporting, which underlines the importance of the Melitz model in the analysis. However, increased exports are offset by lower domestic sales in both regions, such that overall industry output changes little. A sensitivity analysis on the core parameters used in the model shows the robustness of the overall results.

Our results differ from previous analysis of TTIP, which suggested that the US would see larger increases than the EU in agri-food production and exports. While this is still somewhat the case for primary agriculture, our results indicate that the EU could see larger production gains for processed food with the U.S. experiencing a decrease in output. Our results also indicate that tariff removal alone could benefit both regions once productivity gains are considered—something that cannot be shown with the typical Armington model setup. In the end, consumers could benefit most from a TTIP agreement as prices are likely to fall and the diversity of products available increase.

Our study could only draw on rather aggregate estimates of the costs caused by NTMs in the food processing sector. Thus, as the sector is highly heterogeneous, future work could try to provide more disaggregated estimates of costs related to NTMs and their composition (rents in importer and exporter country, variable or fixed cost of trade, demand shifting etc.). That would clearly not only improve the analysis of a potential TTIP agreement, but more generally economic impact assessment of FTAs and multilateral trade liberalization.

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8. References

Aguiar, A., Narayanan, B. and McDougall, R. (2016). An Overview of the GTAP 9 Data Base. *Journal of Global Economic Analysis* 1 (1): 181-208.

Akgul, Z., Villoria, N.B. and Hertel, T.W. (2016). GTAP-HET: Introducing Firm Heterogeneity into the GTAP Model. *Journal of Global Economic Analysis* 1 (1): 111-180.

Arita, S., Beckman, J., Kuberka, L. and Melton, A. (2014). Sanitary and Phytosanitary Measures and Tariff Rate Quotas for U.S. Meat Exports to the European Union. http://www.ers.usda.gov/publications/pub-details/?pubid=37588. Accessed 15 November 2017.

Arita, S., Beckman, J. and Mitchell, L. (2017). Reducing Transatlantic Barriers on U.S.-EU Agri-Food Trade: What Are The Possible Gains?. *Food Policy* 68: 237-247.

Balistreri, E.J., Hillberry, R.H. and Rutherford, T.F. (2011). Structural Estimation and Solution of International Trade Models with Heterogeneous firms. *Journal of International Economics* 83(2): 95–108.

Beckman, J. and Arita, S. (2017). Modeling the Interplay Between Sanitary and Phytosanitary Measures and Tariff-Rate Quotas under Partial Trade Liberalization. *American Journal of Agricultural Economics* 99(4): 1078-1095.

Beckman, J., Arita, S. and Mitchell, L. (2015).The Transatlantic Trade and Investment Partnership and Agriculture: A Quantitative Analysis. Agricultural & Applied Economics Association Conference Paper.

Beghin, J.C., Bureau, J.C. and Gohin, A. (2016). The Impact of an EU-US Transatlantic Trade and Investment Partnership Agreement on Biofuel and Feedstock Markets. *Journal of Agricultural Economics* 68: 321-344.

Berden, K.G., Francois, J., Thelle, M., Wymenga, P. and Tamminen, S. (2009). Non-Tariff Measures In EU-US Trade And Investment – An Economic Analysis. http://trade.ec.europa.eu/doclib/docs/2009/december/tradoc_145613.pdf. Accessed 15 November 2018.

Britz, W. and Van der Mensbrugghe, D. (2018). The Standard GTAP Model in GAMS, Version 7. *Journal of Global Economic Analysis* 3(1): 1-83.

Britz, W. (2017). CGEBox—A Fexible and Modular Toolkit for CGE Modelling with a GUI. University of Bonn, Bonn. http://www.ilr.uni-bonn.de/em/rsrch/cgebox/cgebox_GUI.pdf. Accessed 25 September 2017.

Britz W. and Van der Mensbrugghe, D. (2016) Reducing Unwanted Consequences of Aggregation in Large-Scale Economic Models - A Systematic Empirical Evaluation with the GTAP Model. *Economic Modelling* 59: 462-473.

Britz W. and Van der Mensbrugghe, D. (2017). A Flexible, Modular and Extendable Framework for CGE Analysis in GAMS. 20th GTAP Conference. 59: 462–473.

Chaney, T. (2008). Distorted Gravity: The Intensive and Extensive Margins of International Trade. *American Economic Review* 98 (4): 1707-1721.

Disdier, A.C., Emlinger, C. and Fouré, J. (2016). Interdependencies between Atlantic and Pacific Agreements: Evidence from Agri-Food Sectors. *Economic Modelling* 55: 241-253.

Egger, P., Francois, J. Manchin M. and Nelson, D. (2015). Non-Tariff Barriers, Integration and the Transatlantic Economy. *Economic Policy* 30 (83): 539-584.

FAS/USDA. (2014). Agricultural Exports to the European Union: Opportunities and Challenges.

http://www.fas.usda.gov/data/agricultural-exports-european-union-opportunities-and-challenges. Accessed 15 March 2018.

Fontagné, L., Gourdon, J. and Jean, S. (2013).Transatlantic Trade: Whither Partnership, Which Economic Consequences?. http://www.cepii.fr/PDF_PUB/pb/2013/pb2013-01.pdf. Accessed 15 March 2018.

Francois, J., Manchin, M., Norberg, H., Pindyuk O. and Tomberger, P. (2013). Reducing Transatlantic Barriers to Trade and Investment – An Economic Analysis. http://trade.ec.europa.eu/doclib/docs/2013/march/tradoc_150737.pdf. Accessed 15 March 2018.

Hertel, T.W. (1997). Global Trade Analysis: Modelling and Applications. Cambridge University Press.

Hertel, T.W., Walmsley, T.L. and Itakura, K. (2001). Dynamic Effects of the "New Age" Free Trade Agreement between Japan and Singapore. *Journal of Economic Integration* 16: 446-484.

Hosoe, N. (2017). Impact of Border Barriers, Returning Migrants, And Trade Diversion In Brexit: Firm Exit And Loss Of Variety. Economic Modelling 69: 193-204.

Hummels, D. and Klenow, P.J. (2005).The Variety and Quality of a Nation's Exports. *American Economic Review* 95(3): 704-723.

Jafari Y. and Britz, W. (2018a). Modelling Heterogeneous Firms and Non-Tariff Measures in Free Trade Agreements Using Computable General Equilibrium. *Economic Modelling* 73: 279-294.

Jafari Y. and Britz, W. (2018b). Brexit: An Economy-Wide Impact Assessment on Trade, Immigration, and Foreign Direct Investment. *Empirica* https://doi.org/10.1007/s10663-018-9418-6.

Luckstead, J. and Devadoss, S. (2016). Impacts of the Transatlantic Trade and Investment Partnership on Processed Food Trade under Monopolistic Competition and Firm Heterogeneity. *American Journal of Agricultural Economics* 98(5): 1389-1402.

Melitz, M.J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica* 71(6): 1695-1725.

Neff, S., Harris, M., Malanoski, M. and Ruppei, F. (1996). U.S. Trade In Processed Foods. In globalization of the processed foods market, ed. D.R. Henderson, C.R. Handy, and S.A. Neff, 25–65 (1996). USDA, Economic Research Service, Washington, D.C.

Olper, A., Curzi, D. and Pacca, L. (2014). Trade, Import Competition and Productivity Growth in the Food Industry. *Food Policy* 49(1): 71-83.

Van der Mensbrugghe, D. (2018). The Standard GTAP Model in GAMS, Version 7. *Journal of Global Economic Analysis* 3(1): 1-83.

Welfens, P. and Irawan, T. (2014). Transatlantic Trade and Investment Partnership: Sectoral and Macroeconomic Perspectives for Germany, the EU and the US. *International Economics and Economic Policy* 11: 293-328.

Walmsley, T.L. and Minor, P. (2016). Willingness to Pay in CGE Models, ImpactECON Working Paper No. 04, ImpactECON: Boulder, CO, USA.

Zhai, F. (2008). Armington Meets Melitz: Introducing Firm Heterogeneity in a Global CGE Model of Trade. *Journal of Economic Integration* 23(3)3: 575-604.

Appendix. Supplemental tables

Table A1. Sectoral correspondence of GTAP 9 sector to new sectors.

Number	Code	Description	Pre model Aggregation	Post model aggregation	Market Structure
1	PDR	Paddy rice	Paddy rice	Grains and Crops	PC
2	WHT	Wheat	Wheat	Grains and Crops	PC
3	GRO	Cereal grains nec	Cereal grains nec	Grains and Crops	PC
4	V_F	Vegetables, fruit, nuts	Vegetables, fruit, nuts	Grains and Crops	PC
5	OSD	Oil seeds	Oil seeds	Grains and Crops	PC
6	C_B	Sugar cane, sugar beet	Sugar cane, sugar beet	Grains and Crops	PC
7	PFB	Plant-based fibers	Plant-based fibers	Grains and Crops	PC
8	OCR	Crops nec	Crops nec	Grains and Crops	PC
9	CTL	Bovine cattle, sheep and goats, horses	Bovine cattle, sheep and goats, horses	Livestock	PC
10	OAP	Animal products nec	Animal products nec	Livestock	PC
11	RMK	Raw milk	Raw milk	Livestock	PC
12	WOL	Wool, silk-worm cocoons	Wool, silk-worm cocoons	Livestock	PC
13	FRS	Forestry	Forestry	Mining and Extraction	PC
14	FSH	Fishing	Fishing	Mining and Extraction	PC
15	COA	Coal	Coal	Mining and Extraction	PC
16	OIL	Oil	Oil	Mining and Extraction	PC
17	GAS	Gas	Gas	Mining and Extraction	PC
18	OMN	Minerals nec	Minerals nec	Mining and Extraction	PC
19	CMT	Bovine meat products	Processed food	Processed food	FH
20	OMT	Meat products nec			
21	VOL	Vegetable oils and fats			
22	MIL	Dairy products			
23	PCR	Processed rice			
24	SGR	Sugar			
25	OFD	Food products nec			
26	B_T	Beverages and tobacco products	Beverages and tobacco products	Beverages and tobacco products	FH
27	TEX	Textiles	Textiles	Textile and clothing	FH
28	WAP	Wearing apparel	Wearing apparel	Textile and clothing	FH
29	LEA	Leather products	Leather products	Light Manufacturing	FH
30	LUM	Wood products	Wood products	Light Manufacturing	FH
31	PPP	Paper products, publishing	Paper products, publishing	Light Manufacturing	FH
32	P_C	Petroleum, coal products	Petroleum, coal products	Heavy Manufacturing	FH

Number	Code	Description	Pre model Aggregation	Post model aggregation	Market Structure
33	CRP	Chemical, rubber, plastic products	Chemical, rubber, plastic products	Heavy Manufacturing	FH
34	NMM	Mineral products nec	Mineral products nec	Heavy Manufacturing	FH
35	I_S	Ferrous metals	Ferrous metals	Heavy Manufacturing	FH
36	NFM	Metals nec	Metals nec	Heavy Manufacturing	FH
37	FMP	Metal products	Metal products	Light Manufacturing	FH
38	MVH	Motor vehicles and parts	Motor vehicles and parts	Light Manufacturing	FH
39	OTN	Transport equipment nec	Transport equipment nec	Light Manufacturing	FH
40	ELE	Electronic equipment	Electronic equipment	Heavy Manufacturing	FH
41	OME	Machinery and equipment nec	Machinery and equipment nec	Heavy Manufacturing	FH
42	OMF	Manufactures nec	Manufactures nec	Light Manufacturing	FH
43	ELY	Electricity	Electricity	Utilities and Construction	PC
44	GDT	Gas manufacture, distribution	Gas manufacture, distribution	Utilities and Construction	PC
45	WTR	Water	Water	Utilities and Construction	PC
46	CNS	Construction	Construction	Utilities and Construction	PC
47	TRD	Trade	Trade	Transport and Communication	PC
48	OTP	Transport nec	Transport nec	Transport and Communication	PC
49	WTP	Water transport	Water transport	Transport and Communication	PC
50	ATP	Air transport	Air transport	Transport and Communication	PC
51	CMN	Communication	Communication	Transport and Communication	PC
52	OFI	Financial services nec	Financial services nec	Other Services	PC
53	ISR	Insurance	Insurance	Other Services	PC
54	OBS	Business services nec	Business services nec	Other Services	PC
55	ROS	Recreational and other services	Recreational and other services	Other Services	PC
56	OSG	Public Administration, Defense, Education, Health	Public Administration, Defense, Education, Health	Other Services	PC
57	DWE	Dwellings	Dwellings	Other Services	PC

Notes: FH: Firm heterogeneity, PC: Perfect Competition (Armington).

Table A2. Export volume by region for "crop products" [% change].

Exporters	Partners										
	EU	Other Northern Europe	US	Canada	Mercosur	China	ASEAN 10	Other OECD	EU Mediterranean Partners	Low Income	Rest of World
	First scenario										
World	0.3	0.0	1.4	-0.2	-0.2	-0.3	-0.2	-0.2	-0.3	-0.2	-0.3
EU	-0.3	0.0	16.4	0.5	-0.2	0.0	0.0	0.4	-0.1	-0.1	0.0
US	15.1	-1.1		-0.7	-1.3	-1.2	-1.1	-0.7	-1.2	-1.2	-1.2
	Second Scenario										
World	0.5	-1.8	2.8	-1.7	-0.6	-0.5	-1.2	-0.8	-0.4	-0.3	-0.5
EU	-0.1	-1.7	17.4	-0.1	-0.7	0	-0.8	0.2	-0.1	-0.2	-0.1
US	14.1	-4	0	-2.8	-2.9	-2.5	-3.2	-2.1	-2.4	-2.5	-2.5

Table A3. Export volume by region for "livestock products" [% Change].

Exporters	Partners										
	EU	Other Northern Europe	US	Canada	Mercosur	China	ASEAN 10	Other OECD	EU Mediterranean Partners	Low Income	Rest of World
	First scenario										
World	0.2	-0.2	1.3	0.0	-0.1	-0.2	-0.1	0.0	-0.2	-0.1	-0.1
EU	0.0	-0.2	9.9	0.2	-0.2	-0.1	-0.1	0.2	-0.2	-0.1	-0.1
US	11.5	-0.5		-0.1	-0.6	-0.4	-0.4	-0.2	-0.5	-0.4	-0.4
	Second Scenario										
World	-0.5	-0.9	-2.2	4.9	-0.1	0	-0.2	1.2	0.2	-0.1	0
EU	-0.6	-0.8	9.4	3.4	0	0.3	0	0.9	0.2	0.3	0.2
US	13.5	1.5	0	5.8	2.1	2.6	2.2	3	2.5	2.5	2.4

Table A4. Export volume by region for overall manufacturing sectors [% Change].

Exporters	Partners										
	EU	Other Northern Europe	US	Canada	Mercosur	China	ASEAN 10	Other OECD	EU Mediterranean Partners	Low Income	Rest of World
	First scenario										
World	0.3	-0.1	1.3	0.0	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0
EU	-0.2	0.0	3.9	0.3	-0.1	0.0	0.1	0.1	0.1	0.1	0.1
US	5.2	-0.4		-0.2	-0.5	-0.5	-0.4	-0.4	-0.4	-0.3	-0.4
	Second Scenario										
World	0.4	-0.1	1.4	-0.4	-0.4	-0.1	0.0	-0.1	-0.1	-0.1	-0.1
EU	-0.3	-0.1	3.6	-0.3	-0.5	-0.3	-0.2	-0.3	-0.2	-0.2	-0.2
US	5.3	-0.4	0.0	-0.6	-0.9	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5

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Full Research Article

The income effect of CAP subsidies: implications of distributional leakages for transfer efficiency in Italy

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Abstract. Enhancing farm income level is one of the main purpose of the Common Agricultural Policy (CAP). The ability to reach such a goal can be measured in terms of transfer efficiency, that is affected by the presence of distributive leakages through the agro-food system. The present work aims to shed light on the income distributional effects of the main forms of CAP subsidies in Italy over the period 2008–2014: single payment scheme, coupled payment and second pillar aids. To this aim, an Arellano–Bond linear dynamic panel-data estimation (based on a database provided by the Italian FADN) is performed. Results show that all the main types of CAP support have a significant income effect, even though some relevant differences occur between decoupled and coupled components of direct payments received by Italian farmers as a consequence of distributional leakages.

Keywords. CAP subsidies, transfer efficiency, income effect, Arellano-Bond, Italy.

JEL Code. Q18

1. Introduction

In the last decades, the Common Agricultural Policy (CAP) has moved from price support policies to direct payments, causing a dramatic increase of the transparency of transfer. As a consequence, public aids for farmers has been scrutinized by the general public and taxpayers who are interested to know who receives such payments (Agrosynergie, 2011). Moreover, the distribution of subsidies and incomes among subjects and economic sectors became a relevant topic, because some of those may not be the primary intended beneficiaries of the policy.

The incidence of agricultural policy has been investigated by measuring the transfer efficiency, that provides a means for comparing the benefits to producers with the combined costs to consumers and taxpayers and to society as a whole. This term is usually defined as the ratio of income gain of the targeted beneficiaries and the sum of the associ-

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ated governments expenditure and consumer costs (Dewbre *et al.*, 2001). All in all, this concept allow assessing the distribution of the costs and benefits of the policy among different interest groups, defined in terms of their roles as consumers, taxpayers, producers or supplies of factors of production (Alston and James, 2002). Despite a significant literature has paid attention mainly to some specific mechanism that affect transfer efficiency (such as the capitalization effect of the Single Payment Scheme), Scholars have also focused on the transfer efficiency of agricultural support as a whole, in order to evaluate and somehow measure the whole effectiveness of agricultural policies in delivering additional income to farm households. In this regard, empirical evidences tend to support the theoretical findings that not only agricultural producers, but also other market participants along the vertical chain, may benefit from agricultural subsidies. OECD (1996) reported that a broad quantification of transfer efficiency suggests that as little as one-fifth of the benefits of market price support resulted in additional income for farm households. In more detail, it has been demonstrated that those support measures causing the greatest distortion to production and trade are also the least efficient in providing income benefits to farmers (Dewbre *et al.*, 2001). It clearly follows that the type of support matters when measuring its impact on farm income.

The present work aims to shed lights on the distributional effects of the main forms of CAP subsidies in Italy over the period 2008-2014, where both coupled and decoupled payments have been coexisting along with second pillar aids (that is, Rural Development Programs – RDPs). To this purpose a dynamic panel data estimation is implemented to quantify the impact of these different policy tools on farm income and to indirectly evaluate the transfer efficiency of these aids. The paper is organized as follows: section two reports the literature on transfer efficiency of CAP aids with particular emphasis on the comparison among the different types of public aids. Section three describes the evolution of the CAP instruments in Italy. Section four illustrates data and the empirical methods used in the study. Section five shows empirical findings and discusses the results in the lights of the existing literature. Lastly, conclusion and final remarks are reported.

2. Theoretical framework

2.1 The transfer efficiency

Where income support is an objective, it is important that the policy pursues it in an efficient way, since the ability of the considered policy to enhance the income level of agricultural households can be measured in terms of transfer efficiency. In this regard, three main source of inefficiency have been reported by Agrosynergie (2011): targeting efficiency, economic costs and distributive leakages. As for the first aspect, Corden (1957), Bhagwati (1971) and more recently Guyomard *et al.* (2004) show that the standard policy recommendation is to follow the principle of targeting policies to their specific objectives. With concerns to the second element, subsidies are costly to introduce, administer an enforce; these costs and the effects of producer responses to the incentive to cheat also change the deadweight losses from each of the policies, their distributional consequences and their efficiency as means of transferring income to producers (Alston and James, 2002). The latter issue refers to the case in which a part of the economic support "leak" to non-farm owners of resources, as it is benefitted from subjects who may not be intended beneficiaries of the policy by means of both increased farm production costs and decreased farm income. According to the OECD (1996) "*no support policy linked to agricultural activity succeeds in delivering more than half the monetary transfer from consumers and taxpayers as additional income to farm households*". Despite the leakages could also be viewed as a sort of positive spillover effect that impact on incomes of other stakeholders of the agri-food system (input suppliers, consultancy services, buyers and so on), the intriguing question is: where does the rest of the money for farmers provided by the public authorities go?

The overall subsidy effect on farm income depends on the magnitudes of multiple factors. First, subsidies may increase input prices (for example, fertilizers, land and capital), thus channelling policy benefit to input suppliers. Since subsidy-induced changes in input use are likely to result in changes in some input prices, therefore named recipient of the subsidy payment is unlikely to capture all of the benefits. Second, subsidies may lead to lower output prices, thus generating policy gains for consumers, Third, subsidies may interact with other markets (as in credit constraint) or may alter farm behaviour (substitute private farm activities), which may enhance or reduce farm profits depending on the type of induced effect (Ciaian *et al.*, 2015; Ciaian and Swinnen, 2009).

To sum up, whether agricultural support benefits farmers closely depends on whether farmers own the resources they use in production (Latruffe and Le Mouël, 2009). When farmers do not own such inputs, payments may not belong to the group of the intended main beneficiaries of the policy. Indeed, empirical evidence exists on the fact that part of the support provided by agricultural policies (including direct payments) contributes to increasing the costs of resources, the income of input suppliers and the income of non farming landowners. However, the level of transfer efficiency and the destination of the money transfer differ according to the policy instrument (Agrosynergie, 2011).

2.2 Types of support and transfer efficiency

The literature review reveals that scholars have investigated how income distributional effects differ based on subsidy types. Empirical evidences indicated that compared to area payments, market price support is indeed a relatively inefficient and trade distorting way of supporting farm incomes. Direct payments based on output or on variable input use, however, are also highly inefficient and trade distorting when compared to area payments. This latter, requiring planting of specific crops, are however less efficient and more trade distorting than payments made irrespective of the use to which the land is put (Dewbre *et al.*, 2001). Moreover, farmers report that the largest share of direct payment receipts tend to be used to cover agricultural production crops (Goodwin and Mishra, 2005). As a consequence, an increased demand for inputs drives the increase in factor expenditure, with significant effects on the costs of input (land, fertilizers, pesticides and so on) (Kirwan, 2009).

2.2.1 Leakages related to coupled payments

Many scholars have analysed how income distributional effects differ between coupled and decoupled payments. It is well known that some income support policies are explicitly linked with production decisions in the sense that these latter can alter the magnitude of income support: this linkage is generally called coupling and breaking the linkage is called decoupling. The term "coupled" itself links payments to a specific stimulating production activity and these payments are available to farms in all Member States and include crop area direct payments and animal direct payments. In general, studies focus on the effects of coupled subsidies in narrowly defined agricultural sectors and results showed that a significant part of coupled payments could be leaked away to other agents through changes in market prices and this effect diminishes farms' benefits from subsidies. The leakage is positively correlated with coupling because it implies a stronger link of subsidies to farm activities and thus stronger impact on the aggregate price level (Rizov *et al.*, 2013). More in general, since coupled payments clearly have production impacts and due to the fact that the greater the production impact of direct payments the less they push up rental values, it follows that such an increased production results in lower commodity prices and higher input prices as well as it also dilutes the impact that direct payments have on land rent (Kirwan, 2009).

2.2.2 Decoupled payments and the capitalization effect

As a consequence, because the production impacts of explicitly coupled supports sometimes have been quite substantial and costly to the government, many policies have been modified to reduce or break the coupling (Hennessy, 1998). Therefore, the last reforms of the CAP have led to the decoupling of direct payments from production.

Decoupled payments were introduced in order to curb over-production and to reduce the trade-distorting and inefficiency effects of the CAP (Howley *et al.*, 2012). Literature suggests that, depending on both farm size and the duration of the tenant-landlord agreement, the decoupled direct payments linked to land positively influence land rents, because only those who own or have rented (eligible) land can claim the payments (Kilian and Salhofer, 2008; Kirwan and Roberts, 2015). This result is due to the fact that the SPS is still "coupled" to agricultural land and has a high potential for capitalization into land values. With some exceptions (Guastella *et al.*, 2013), scholars showed that decoupled payments exert a larger impact on rents than coupled payments. Such a capitalization effects vary from to 0.20 to 0.90 euro (or dollar) for each euro transferred to the farmers (Ciaian and Kancs, 2012; Kirwan, 2009; Patton *et al.*, 2008; O'Neill and Hanrahan, 2016; Breustedt and Habermann, 2011; Kilian *et al.*, 2012). Under certain circumstances the decoupled payments are even fully reflected in rental values (Hendricks *et al.*, 2012). More in general, whether agricultural support benefits farmers closely depends on whether farmers own the resources they use in production (Latruffe and Le Mouël, 2009). It follows that, the greater the share that goes to land and landowners, the less effective direct payments ultimately become as a means of supporting farmers' incomes (Patton *et al.*, 2008). As a consequence, what appears clearly is that part of the payments is capitalized in land prices, implying that the governments could have partially missed their target of providing income support to farmers (Latruffe and Le Mouël, 2009).

2.2.3 Second Pillar aids and distributional impacts

Lastly, potential leakages effects could also affect RDP aids, that include different policy measures, ranging from area payments to investment supports. As for the first category, both less favoured area (LFA) payments and agri-environmental payments are compensatory type of aids, granted for a range of farm activities that should cover additional costs and farm income foregone resulting from adoption of environmental management practises (Ciaian *et al.*, 2015). The transfer efficiency of such a type of area payments may again be hindered by the above-mentioned capitalization of the aids into the land value. The second category covers only a share of the total cost of a programme of investment activity either for farm practises (capital items) or for a farmer (training courses and other qualifications). Since these public aids are known by suppliers, they can be partially absorbed into the prices for input and services, so that the transfer efficiency of the payment decreases.

3. Policy framework: the application of the CAP in Italy

CAP reforms have seen a progressive move away from direct market interventions and production specific subsidies. To this purpose, since 1992 the CAP of the EU has been reformed several times. First Pillar (direct payments and Common Market Organization - CMO) is the most important in financial terms and it currently consumes more than 60% of the overall CAP resources (Henke and Coronas, 2011; Ciliberti and Frascarelli, 2015).

3.1 Decoupled payments

The 2003 Fischler CAP reform significantly reduced and partially replaced the previous coupled payments system with the decoupled payments (SPS). Under this scheme, each farm was allocated an amount of entitlements; they can receive decoupled payments if they have both entitlements and an equal amount of eligible land. However, the SPS is not linked to a specific land area, since the entitlements can be activated by any eligible farmland in the region. Moreover, farms can expand or decrease their stock of entitlements by buying or selling entitlements on the market from other farms. As concerns Italy, it must be noted that the historical model of the SPS was implemented from 2005 to 2014. Under this model the payment per hectares varied strongly across farms, depending on the coupled payments farmers received in historical reference period (2001-2003) (Erjavec *et al.*, 2011).

3.2 Coupled payments

CDPs include crop area direct payments and animal direct payments. In general, they are land-based subsidies linked to the cultivation of certain crops, implying that the level of the crop CDP does not depend on production level, but on the area cultivated with eligible crops. The coupled animal direct payments are either output (animal) type of payments (such as beef premiums, slaughter premiums) or subsidies linked to non-land input.

Aftere the introduction of decoupling in 2005 MSs were allowed to grant optional coupled payments in specific cases. Additional payments granted under Article 69 of Reg.

(EU) 1782/2003 were considered as coupled[1], with the provision that they were not granted to all producers of a sector, but were based on certain eligibility criteria.

This optionality was maintained after the CAP Health Check in 2009 with the introduction of Article 68[2] of Council Regulation (EC) 73/2009. However, it broadened the range of such Specific Support, with the possibility of granting coupled payments depending on the objectives assigned of the last supply control measures (milk quotas, sugar quotas and vineyard planting rights).

3.3 The second pillar

The rural development policy represents the other core element of the CAP that is implemented in a more targeted and programmed approach compared to other measures (Uthes *et al.*, 2017). The paper focuses only on specific measures that absorb a high share of the budget for regional RDP: Less favoured area (LFA) payments, agri-environmental payments and investments support. The LFA scheme is a longstanding measure that provides a broad-scale mechanism for maintaining the countryside in marginal areas. Agri-environment measures provide payments to farmers who subscribe, on a voluntary basis, to environmental commitments related to the preservation of the environment and maintaining the countryside. Lastly, investments aids cover only a share of the total cost of a one-off or short-term programme of investment and/or training activity aiming at improving the competitiveness and sustainability of the farming sector.

4. Methodology

4.1 The econometric model

Based on theoretical studies, the methodology used assumes a profit-maximizing farm and analyses the effect of subsidies on farm profits. According to the literature assuming a profit-maximizing farm (Floyd,1965; Alston and James, 2002; de Gorter and Meilke, 1989;Gardner, 1983; Guyomard et al, 2004; Salhofer, 1996; Ciaian and Swinnen, 2006, 2009: Ciaian *et al.*, 2015), the optimal farm profit (π) depends on input and output prices, subsidies and farm characteristics.

In details, consider an agricultural economy with n farms. The output of each farm is a function of the amount of land (A) and non-land inputs (K), which captures also other capital inputs used by the farm. The production function is represented by f(A, K) with $f_i > 0$, $f_{ii} < 0$, $f_{ij} > 0$, for i, j = A and K. Furthermore, define s as the subsidy (area payment) per unit of land, and assume that all land in the analysis qualifies for the subsidies, the representative farm objective function is (Ciaian and Swinnen, 2009):

$$\pi = pf(A,K)+sA-rA- wK(1+i) \tag{1}$$

[1] In Italy, this type of payment was activated for several sectors: cereals, oilseeds and protein crops, tobacco, sheep and goat and so on.

[2] Under Article 68 sectors supported under the quality measure for the period 2010-2014 are beef meat, sheep and goat meat, olive oil, milk, tobacco, sugar and floriculture.

where p is the price of the final product, s are subsidies for unit of land, r is the price of land, w is the unit price of other capital inputs, and i is the interest rate.

More precisely, profit is affected by both the indirect (that is, through subsidy impact on input and output price) and the direct effects of subsidies on profits, as follows (Ciaian *et al.*, 2015):

$$\pi = \pi[p(CDP,RDP,SPS),r(CDP,RDP,SPS),w(CDP,RDP,SPS),CDP,RDP,SPS,X] + \varepsilon \quad (2)$$

where, as concern subsidies, CDP are crop coupled subsidies, RDP are rural development payments, SPS are decoupled payments. Moreover, X is a vector of observable covariates and ε is the residual.

It follows that the profit equation (2) accounts for both the direct and indirect effect of subsidies on farm profits. Totally differentiating equation (2) yields the following relationship between profits and subsidies:

$$d\pi = \left[\frac{d\pi}{dp}\frac{dp}{dCDP} + \frac{d\pi}{dr}\frac{dr}{dCDP} + \frac{d\pi}{dw}\frac{dw}{dCDP} + \frac{d\pi}{dCDP}\right]dCDP +$$

$$\left[\frac{d\pi}{dp}\frac{dp}{dRDP} + \frac{d\pi}{dr}\frac{dr}{dRDP} + \frac{d\pi}{dw}\frac{dw}{dRDP} + \frac{d\pi}{dRDP}\right]dRDP + \quad (3)$$

$$\left[\frac{d\pi}{dp}\frac{dp}{dSPS} + \frac{d\pi}{dr}\frac{dr}{dSPS} + \frac{d\pi}{dw}\frac{dw}{dSPS} + \frac{d\pi}{dSPS}\right]dSPS + \frac{d\pi}{dX}dX + \varepsilon$$

where $\frac{d\pi}{dp}$, $\frac{dp}{ds}$, $\frac{d\pi}{dr}$, $\frac{dr}{ds}$ and $\frac{d\pi}{dw}$, $\frac{dw}{ds}$ are parameters representing the indirect impact of subsidies on profits (that is, through subsidy impact on input and output prices) and $\frac{d\pi}{ds}$ is the direct effect of subsidies on profits for s= CDP, RDP, SPS.

Equation (3) can be rewritten as:

$$d\pi = \delta 0 + \delta CDP dCDP + \delta RDP dRDP + \delta SPS dSPS + \delta X dX + \varepsilon \quad (4)$$

where

$$\delta_x = \frac{d\pi}{dX}, \delta_{CDP} = \frac{d\pi}{dp}\frac{dp}{dCDP} + \frac{d\pi}{dr}\frac{dr}{dCDP} + \frac{d\pi}{dw}\frac{dw}{dCDP} + \frac{d\pi}{dCDP}, \delta_{RDP} =$$

$$\frac{d\pi}{dp}\frac{dp}{dRDP} + \frac{d\pi}{dr}\frac{dr}{dRDP} + \frac{d\pi}{dw}\frac{dw}{dRDP} + \frac{d\pi}{dRDP}, \delta_{SPS} =$$

$$\frac{d\pi}{dp}\frac{dp}{dSPS} + \frac{d\pi}{dr}\frac{dr}{dSPS} + \frac{d\pi}{dw}\frac{dw}{dSPS} + \frac{d\pi}{dSPS}$$

Parameters δ_s (for s= CDP, RDP, SPS) measure the net impact of subsidies on farm profits by accounting for the above-mentioned both direct and indirect subsidy effects. In other words, they indicate the income effects of subsidies in terms of policy rents, which farmers receive for each additional euro of CAP subsidies.

Even though the model contains the main variables determining the incidence of agricultural subsidies, there are also unobservable time-invariant farm characteristics which both affect dependent variable and are correlated with explanatory variables. In addition, there are also time-varying region fixed effects that cannot be ignored. Therefore, in order to reduce possible sources of bias, farm fixed effects are included (Ciaian and Kancs, 2012). Moreover, according to Kirwan (2009), in order to absorb farm-specific time-invariant unobserved factors, the first difference of the series are applied, since the resulting farm income model in the first difference eliminates the unobserved heterogeneity component that remains fixed over time. As a result, the final econometric model is specified as follows:

$$\Delta\pi_{jt}=\delta_0 + \delta_{CDP}\Delta CDP_{jt} + \delta_{RDP}\Delta RDP_{jt} + \delta_{SPS}\Delta SPS_{jt} + \delta_X\Delta X_{jt} + \delta_r R_r + \delta_{ffj} + \varepsilon_{jt} \quad (4)$$

where π is the profit of the farm *j* at the time *t*.

However, an estimation issue is due to the fact that subsidies are not assigned to farmers randomly, but rather they are affected by regional productivities and farms' crop choices (Moro and Sckokai, 2013). This fact implies that in the econometric model these variables (CDP, SPS, RDP, OS) are endogenous since they reflect the characteristics of countries'/regions' land and farmer's behaviour.

First, in order to reduce the individual heterogeneity bias, farm fixed effects and regional control variables are included in the estimable equations, respectively $\delta_f f_j$ and $\delta_r R_{r.}$. In more details, the first differences of series are adopted in order to absorb farm-specific time-invariant unobserved factors, since they eliminate the unobserved heterogeneity component that remains fixed over time. Lastly, in order to address the issue of endogeneity, the Arellano and Bond robust two-step generalized method of moment (GMM) estimator is applied and a set of valid and reliable instruments is adopted (see table 1). The GMM estimator is applied since it is particularly suitable for datasets with a large number of cross sections. Lastly, the Windmeijer (2005) bias-corrected robust variances is used in order to correct for the intrinsic downward bias of the robust two step GMM standard errors.

4.2 Data and variables

The source of data used in the empirical analysis is the Italian FADN (Farm Accountancy Data Network) provided by the Council for Agricultural Research and Economics (CREA). The FADN is the only source of micro-economic data that is harmonized and is representative of the commercial agricultural holdings in the whole EU (Moro and Sckokai, 2013). The survey does not, however, cover all the agricultural holdings in the EU, but only those which are of a size allowing them to rank as commercial holdings.

Based on previous study (Ciaian and Kancs, 2012; Michalek *et al.*, 2014; Ciaian *et al.* 2015) in the present study a balanced panel dataset with 24'668 observations of n=3'524 Italian farms over the period 2008-2014 (t=7) is adopted, meaning that farms in the sample are traced over the same period of time. Moreover, the sample is stratified on three key variables, i.e. location (21 NUTS regions and 3 altimetric areas), economic size (6 size classes) and farm type (19 typologies).

Variables used in the econometric model are organized in order to effectively identify the relationship between net farm income[3] and subsidies (table 1). Descriptive statistics are provided in table A of the Appendix.

More in details, the dependent variable is calculated as the change in net farm income. Based on the document "Farm accounting data network: an A to Z methodology" (European Commission, 2010) the net farm income is obtained by subtracting taxes, variable expenses (intermediate, land, labour) and fixed costs (depreciation and interest payments) from the total farm revenues (output and subsidies). As concerns subsidies, they are SPS, CDPs (crop area payments, animal payments), the RDP (investment support, environmental payments, LFA and other rural development payments) and OS (that accounts for other types of subsidies, such as those from the CMO). The above-mentioned variables are expressed per hectare. The advantage of using per hectare values instead of totals per farm is the reduction of the potential problem of heteroskedasticity. The farm size varies strongly in regions and sectors covered by this study, implying that the value of farm income, as with the other variables (output, subsidies and so on), also varies significantly in the cross-sectional dimension.

In order to account for the dynamic adjustment of farm income, lagged dependent (1 lag) is created in order to incorporate feedback over time. Moreover, since variables related to subsidies (CDP, SPS, RDP and OS) are endogenous, lags are used as instruments along the exogenous and lagged dependent variables. More in details, the choice of lags as instruments was selected by checking the validity of different sets of instruments. Table 1 summarizes both lags and type of variables (exogenous, endogenous and instrumental).

The covariates matrix (X) includes variables which contribute to explain the variation in profits among farms, respectively referred to two main categories: inputs and productivity and management practises.

Independent variables linked to the first set of covariates include rented land ratio (expressed as the ratio of rented land to UAA, Rented_land), sharecropped land (expressed as the ratio of sharecropped land to UAA, Share_land), own labour ratio (that is the ratio of unpaid input to total labour, Own_labour), and liabilities-to-assets ratio (that is the ratio of total liabilities to total farm assets, Liabilities_assets).

Given that productivity is an important determinant of farm profitability, if not controlling for its variation among farms, it may be confounded with the estimated subsidy effect on profits. Therefore, productivity differences among farms are controlled including in the econometric model variables. They are: output per hectare (Output), farm size (expressed in ESU), irrigated land ratio (ratio of irrigated land to UAA), the building machinery value per hectare (Machinery) and the ratio of total livestock output to total farm output (Output_livestock), the total livestock units (LU) and the stock of agriculture products (product_stock).

Likewise, management practises affect the organization of farm activities and thus also have a direct impact on farm profitability. Covariates capturing those practises are the

[3] Even though there could be income effects from the subsidies beyond the farm operating income, the household non-farm income is not accounted since it is well-known that one of the main CAP goals is to enhance farm incomes.

Table 1. List of variables.

Category	Variable name	Lags	Type	Description	Unit of measure
Dependent variable(π)	NFI	1	:	Net farm income	€/ha (Δ%)
Subsidies (s)	CDP	0 and 1	endogenous	Coupled payments	€/ha
	SPS			Decoupled payments	€/ha
	RDP			Rural development payments	€/ha
	OS			Other subsidies	€/ha
Covariates (X) - inputs -	Rented_land	0	exogenous	Ratio of rented area to Utilized agricultural area (UAA)	%
	Share_land			Ratio of sharecropped land to UAA	%
	Own_labour			Ratio of unpaid input to total labour	%
	Liabilities_assets			Ratio of total liabilities to total farm assets	%
Covariates (X) - productivity -	Output	0	endogenous	Hectare value of total output of crops and crop products, livestock and livestock products and of other products	€/ha
	Size	0	instrumental	Economic size of holding expressed in European size units (ESU)	€
	Irrigated_land			Ratio of irrigated land to UAA	%
	Machinery			Value of buildings and machinery	€/ha
	Output_livestock			Ratio of total livestock output to total farm output	%
	LU			Total livestock units	N. of head
	Product_stock			Stock of agricultural products	€/ha
Covariates (X) - management practises -	Own_ consumption		exogenous	Ratio of farmhouse consumption and farm use to total output	%
	Wood_land			Ratio of woodland area to UAA	%

own consumption ratio, that indicate the ratio of farmhouse consumption and farm use to total output, as well as the ratio of woodland area to UAA.

5. Results and discussion

Henceforth outcomes of the Arellano-Bond test for the Italian FADN sample (based on period 2008-2014) are shown. First of all, it must be noted that the specification test allows not rejecting the null hypothesis of no serial autocorrelation in the first-differenced errors at order 1. It entails that the model has not misspecification problem. Concerning the Sargan test of over identifying restrictions, it shows that the instrumental variables are uncorrelated to some set of residuals and therefore they are acceptable instruments. Moreveover, the Windmeijer bias-corrected robust standard errors allow to both account for heteroscedasticity and correct for autocorrelation as well.

In order to facilitate the presentation and the relative discussion or results, table 2 reports different categories of variables used in the model (i.e., lagged dependent, subsidies and covariates). What emerges from the estimations is that the farm income at the time *t-1* somehow negatively affects (-0.005) the farm income at the time *t*. Even though this result may seem counterintuitive, it indeed recalls the well-known "cobweb theorem" (Kaldor, 1934; Ezekiel, 1938). This latter explains how price instability in a supply-demand framework – caused by low price elasticity of supply and demand – along with the assumption of a lagged response by production to price changes, can give rise to irregular fluctuations in prices and quantities in agricultural markets. Such a peculiar characteristic of the agricultural sector obviously causes unexpected and reverse relationships between prices, quantities and, as a consequence, incomes at various stages in time.

The contribution of the model however concerns the effect of CAP subsidies on farm income over the period under investigation. All the main variables related to public aids (that is, CDP, SPS, RDP, OS) are significant. SPS represents the main source of public support for farmers and results highlight that it is highly able to sustain incomes. In this regard, it should be noted that the total income effect (e.g. including both contemporaneous and lagged effect) of the SPS is 0.978, implying that a great part of such aid is transferred to farmers and only a small share go to the other actors of the supply chain (landowner, input suppliers and output buyers). In this regard, since the implementation of the SPS scheme started in 2005, a flourishing literature has pointed out the potential distorsive effect due to the fact that non-farming landowners can extract a rent from such form of payment that is indeed "coupled" to the land (Ciaian and Kancs, 2012; Ciaian and Swinnen, 2006; Kilian and Salhofer, 2008; Kirwan and Roberts, 2015; Klaiber *et al.*, 2017; Patton *et al.*, 2008; Viaggi *et al.*, 2013). According to the literature in this field, the capitalization effect of SPS into land rents varies from 0.2 to 0.8 (Breustedt and Habermann, 2011; Kilian *et al.*, 2012; O'Neill and Hanrahan, 2016; Patton *et al.*, 2008). These results imply that depending on specific characteristics of each MSs on average about half of the direct aids are capitalized into land rents. In more details, as for New EU Member States (EU-12), the rental price of farmland increseas between 0.18 and 0.20 EUR for each unit of SAPS payment[4] (Ciaian and Kancs, 2012). Moreover, other studies confirms that also in the US a significant share of the direct aids are reflected in rental rates (varying from 20% to 100%, depending on the form of support). All in all, the model reveals a high transfer efficiency for SPS in the observed period, meaning that the capitalization of the SPS into the land rents in Italy was scarce, according to Guastella *et al.* (2013). Furthermore, it must be noted that, since their introduction decoupled payments have not completely led farmers to be more market oriented (Burfisher and Hopkins, 2003; O'Neill and Hanrahan, 2016), and such an effect may have reduced the transfer efficiency, as confirmed by

[4] It is a transitional, simplified income support scheme which was offered to the Member States who joined the EU in 2004 and 2007 (EU-12) as an option at the date of accession in order to facilitate the implementation of direct payments. This scheme replaces (with some exceptions) all direct payments with a single area payment. The level of the payment is obtained by dividing the country's annual financial envelope with its respective utilized agricultural area. It is simpler than the SPS because there is no need to establish and administer payment entitlements. However it does not offer to farmers the flexibility of entitlements based on individual needs, such as sales or lease.

Table 2. Arellano-Bond (first difference) dynamic GMM estimator: results (estimates based on period 2008-2014).

Variable	Coefficient (Std. Err.)	P>z	
NFI (-1)	-0.005 (0.000)	0.000	***
CDP	-1.242 (0.376)	0.001	**
CDP (-1)	0.540 (0.195)	0.006	**
SPS	0.117 (0.069)	0.089	*
SPS (-1)	0.861 (0.320)	0.007	**
RDP	0.067 (0.010)	0.000	***
RDP (-1)	0.215 (0.010)	0.000	***
OS	-0.197 (0.037)	0.000	***
OS (-1)	-0.061 (0.022)	0.007	**
Rented_land	3.325 (3.633)	0.360	
Share_land	6.104 (3.379)	0.071	*
Own_labour	3.106 (2.709)	0.252	
Liabilities_assets	-0.103 (0.091)	0.258	
Output	0.055 (0.001)	0.000	***
Own_consumption	-11.675 (5.424)	0.031	**
Wood_land	-1.870 (2.997)	0.533	
Observations	17620		
Number of farms observed	3524		
N. of instruments	77		
Wald chi2	5257.30	0.000	***
Arellano-Bond for zero autocorrelation in first-differenced errors (H0: no autocorrelation)			
AR(1) (Prob>z)	-1.345	0.178	
AR(2) (Prob>z)	-0.991	0.321	
Sargan test of over identifying restrictions H_0: overidentifying restrictions are valid			
SR (Prob>chi^2)	57.295	0.610	

*p<0.10; **p<0.05; ***p<0.001

empirical evidences of decoupled payments used so as to subsidise loss-marketing activities (Breen *et al.*, 2005; Howley *et al.*, 2012; Kazukauskas *et al.*, 2014).

With regard to RDP measures, estimates point out a significantly positive influence of these aids on farm income. What emerges is that the total effect (lagged plus simultaneous effect) on farm income is 0.282 for each euro of RDP aids, even though these aids do not evidently aim to sustain farm income. Indeed, it is well-known that their main objectives are, on the one hand, to foster various types of investments (in both physic and human capital) and, on the other hand, to cover opportunity costs related to the adoption of low income (but environmental-friendly) activities and techniques (e.g., organic farming and so on) mostly in disadvantaged areas. Moreover, since both agri-environmental and less favoured area payments are linked to the amount of land owned/rented, a possible explanations of such a result could be that a significant amount of these aids could be capitalized into rental values as well as in the input prices (seeds, fertilizers, machines and so on) as well as in the cost of services (transaction costs, assistance costs and so on).

Very interestingly, the other type of direct payment of the First Pillar – the CDP – shows an immediate negative effect on farm income (-1.242), followed by a lagged but positive impact on profitability (+0.540). Therefore, what emerges is that the total effect of CDP on farm income is still inegative (-0.702). Here, many causes may potentially determine such an impact that could explain why this form of payment has been criticized since its introduction in the early '90s. Scholars have indeed always recognized that such an aid is able to affect (and somehow to distort) product decisions, by incentivizing the cultivation of specific crops without taking into account the real needs of the demand, with negative consequence both on farm efficiency and total factor productivity (Hennessy, 1998; Mary 2013; Zhu *et al.*, 2012). Such an impact on production decision may explain the negative impact on farm income in the short run, due to the fact that the CDP induces farmers to produce/feed not profitable crops/livestock. In addition to this opportunistic behaviour that such a payment generates on the supply side, inducing beneficiaries to "farm" the subsidies in spite of the crops, in the meanwhile the presence of an aid linked to specific productions induces input suppliers and buyers of agricultural commodities (i.e., wholesalers, middlemen, processors, manufacturers) to somehow intercept an amount of such a subsidy, by lowering the price of the commodities (Alston and James, 2002; Hendricks *et al.*, 2012; OECD, 1996; Rizov *et al.*, 2013). It follows that the payment is (at least in part) taken away from farmers to the benefit of other actors along the agro-food supply chain (Breen *et al.*, 2005; Ciliberti and Frascarelli, 2015; McDonald *et al.*, 2014; O'Neill and Hanrahan, 2016; Russo *et al.*, 2009). Moreover, Patton *et al.* (2008) showed that different types of coupled payments are capitalized in land rents in Northern Ireland and such an effect absorbs half of the value of the aid. Apart from the above-mentioned explanations, other causes of this outcome could be that CDP has for a long time subsidized low quality production and, more in general, has not represented an incentive for competitiveness at all (Latruffe *et al.*, 2009; Zhu and Oude Lansink, 2010). It, on the contrary, has triggered speculative and opportunistic behaviours that actually hampered a market-oriented approach. Lastly, also the OS shows a total negative effect on farm income (-0.258). Such a result could be attributed to the fact that, likewise CDP, this type of aids are also mainly aimed to subsidize specific products, therefore causing a similar impact on farm incomes.

As concerns covariates, for each set of explanatory variables some estimated coefficients have the expected sign and are significant as well. With regard to the inputs, results confirms that sharecropped land positively contribute to increase the farm income (+6.104), since they represents a cheap alternative to land rent or land tenure. As concerns productivity, the model reveals the expected positive impact of the total output on farm income (+0.055). Accordingly, with regard to management practises, the model confirms that self-consumption (-11.675) – especially in small or very small Italian farms managed by so-called hobby-farmers – obviously causes a relevant and significant decrease of the farm income, due to the fact that the farm output is not sold but is used to satisfy family needs only.

6. Conclusions

Even though farmers are the only beneficiaries of various forms of public support established by the CAP, a vast literature has shown that some leakages however occur. Such a phenomenon may be relevant when both input supplier and output buyers (that is, wholesalers, processors, manufacturers), thanks to their market and bargaining power, are able to extract some rents from the public aids. In this regard, the present paper aimed to shed lights on the transfer efficiency of CAP subsidies in Italy. To this purpose, data from the national FADN allowed analysing the distribution of public support among the several players of the Italian agro-food system over the period 2008-2014, so as that a first contribution for this – to the best of the authors' knowledge – still unexplored research field in Italy is provided.

The dynamic panel data estimation reveals that all the main typologies of aids established by the CAP significantly affected the variation of the farm income in Italy. More in details, the national implementation of the SPS, CDP and RDP aids over the investigated period contributed to an increase of the profitability of Italian farms, despite of a significant transfer of public resources from the primary sector to other stages of the agro-food supply chains or even external to the primary sector. Such a phenomenon somehow confirms the presence of opportunistic behaviours of both input suppliers (e.g., landowners and input dealers that increase prices of land/products they rent/sell to farmers in order to indirectly take advantage of the SPS and/or RDP scheme) as well as of buyers that – exploiting their purchasing power – contract lower prices for agricultural commodities. Very interestingly, results show that the impact of CDP negatively affects income variation of Italian farms, even though only in the short run. This type of subsidy, introduced in the early '90s as transitory means of support to replace price support, has been criticized for a long time due to the fact that it clearly influences production decisions and therefore alters market equilibrium. Furthermore, both the existence and the amounts of such a payment, by definition "coupled" to specific crops/livestock, is also well known by several suppliers and buyers that therefore try opportunistically to take advantage from it. As a result, the CDP may simply become a sort of surreptitious transfer of public resources to none other than agro-food industry companies (i.e., suppliers, landowners, processors, manufacturers). Moreover, it may also distort (and reduce) the incentive for quality with immediate negative consequences on output prices and, in the long term, on farms ability to be competitive in both national and international markets.

To sum up, these empirical evidences have important policy implications for the implementation of the CAP in Italy. First of all, results allow confirming that even though farm income substantially benefitted of the implementation of the CAP, the transfer efficiency of public financial resources officially intended for farmers was hindered by leakages that are occurred in Italy over the period 2008-2014. More in details, what emerges is that decoupled income transfers without mandatory production (SPS), as well as incentives for investments and compensatory payments (RDP) are preferable to coupled measures (CDP) for ensuring an annual and continuous support to farmers income.

In conclusion, it is straightforward that a different allocation of CAP resources in Italy may bring more advantages for farmers, decreasing leakages and increasing transfer efficiency. In this regard, an indication for the future is that both the reform paths towards a more targeted and tailored support for farmers and, on the other hand, national implementation of the CAP rules should aim to properly address the causes of such leakages in order to improve the transfer efficiency of public aids, due to the fact that enhancing farm incomes still remains one of the main priority of the CAP.

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8. References

Agrosynergie (2011). Evaluation of Article 68 measures – final support. Brussels.

Alston, J.M. and James, J.S. (2002). The Incidence of Agricultural Policy. In Gardner, B.L. and Rausser, G.C. (eds.), Handbook of Agricultural Economics 2(B). Amsterdam: Elsevier, 1689-2249

Arellano, M. and Bond, S. (1991). Some Tests of Specification For Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *Review of Economic Studies* 58: 277–297.

Bhagwati, J.N. (1971). The Generalized Theory of Distortions and Trade. In Bhagwati, J.N., Mundell R.A., Jones, R.W. and Vanek, J., (eds.), Trade, Balance of Payments and Growth: Papers in International Economics in Honor of C.P. Kindleberger. Amsterdam: North-Holland Publishing Company.

Breen, J.P., Hennessy, T.C. and Thorne, F.S. (2005). The Effect of Decoupling on the Decision to Produce: An Irish Case Study. *Food Policy* 30: 129-144.

Breustedt, G. and Habermann, H. (2011). The Incidence of EU Per-Hectare Payments on Farmland Rental Rates: A Spatial Econometric Analysis of German Farm-Level Data. *Journal of Agricultural Economics* 62(1): 225-243.

Burfisher, M.E. and Hopkins, J. (2003). Farm Payments: Decoupled Payments Increase Households' Well-Being, not Production. *Amber Waves* 38-45.

Ciaian, P. and Swinnen, J.F.M. (2006). Land Market Imperfections and Agricultural Policy Impacts in the New EU Member States: A Partial Equilibrium Analysis. *American Journal of Agricultural Economics* 88(4): 799–815.

Ciaian, P. and Swinnen, J.F.M (2009). Credit Markets Imperfections and the *distribution of policy rents*. *American Journal of Agricultural Economics* 91(4): 1124-1139.

Ciaian, P., Kancs, d'A. (2012). The Capitalization of Area Payments into Farmland Rents: Micro Evidence from the New EU Member States. *Canadian Journal of Agricultural Economics* 60: 643-673.

Ciaian, P., Kancs, d'A. and Gomez Y Paloma, S. (2015). Income Distributional Effects of CAP Subsidies. Microevidence from the EU. Outlook on Agriculture 44(1): 19-28.

Ciliberti, S. and Frascarelli, A. (2015). A Critical Assessment of the Implementation of CAP 2014-2020 Direct Payments in Italy. *Bio-based and applied economics* 4(3): 261-277. DOI: 10.13128/BAE-16377

Corden, W.M. (1957). Tariffs, Subsidies and the Terms of Trade. *Economica* 24: 235-242.

de Gorter, H. and Meilke, K.D. (1989). Efficiency of Alternative Policies for the EC's Common Agricultural Policy. *American Journal of Agricultural Economics* 71: 592-603.

Dewbre, J., Antòn J. and Thompson, W. (2001). The Transfer Efficiency and Trade Effects of Direct Payments. *American Journal of Agricultural Economics* 83(5): 1204-1214.

Erjavec, E., Chantreuil, F., Hanrahan, K., Donnellan, T., Salputra, G., Kožar, M. and van Leeuwen, M. (2011). Policy Assessment of an EU Wide Flat Area CAP PAYMENTS SYSTEM. *Economic Modelling* 28: 1550-1558.

European Commission (2010)."Farm Accounting Data Network: An A to Z methodology. Available at: http://ec.europa.eu/agriculture/rica/pdf/site_en.pdf Accessed 18 July 2018.

Ezekiel M., (1938). The Cobweb Theorem. *The Quarterly Journal of Economics* 52(2): 255-280.

Floyd, J.E. (1965). The Effects of Farm Price Supports on Returns to Land and Labour in Agriculture. *Journal of Political Economy* 18: 297-313.

Gardner, B. (1983). Efficient Redistribution through Commodity Markets. *American Journal of Agricultural Economics* 65(2): 225-234.

Goodwin, B.K. and Mishra, A.K. (2005). Another Look at Decoupling: Additional Evidence on the Production Effects of Direct Payments. *American Journal of Agricultural Economics* 87: 1200-1210.

Guastella, G., Moro, D., Sckokai, P. and Veneziani, M. (2013). The Capitalization of Area Payment into Land Rental Prices: Micro-Evidence from Italy. Selected poster prepared for presentation at the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual meeting. Washington DC, August 4-6, 2013.

Guyomard, H., Le Mouël, C. and Gohin A. (2004). Impacts of Alternative Agricultural Income Support Scheme on Multiple Policy Goals. *European Review of Agricultural Economics* 31(2): 125-148.

Hendricks, N.P., Janzen, J. P. and Dhuyvetter, K.C. (2012). Subsidy Incidence and Inertia in Farmland Rental Markets: Estimates from a Dynamic Panel. *Journal of Agricultural and Resource Economics* 37(3): 361-378.

Henke, R. and Coronas, M.G. (2011). The Financial and Distributive Aspects of Direct Payments in the New CAP. *International Agricultural Policy* 1: 63-84.

Hennessy, D.A. (1998). The Production Effects of Agricultural Income Support Policies under Uncertainty. *American Journal of Agricultural Economics* 80: 46-57.

Howley, P., Breen, J., Donoghue, C.O. and Hennessy, T. (2012). Does the Single Farm Payment Affect Farmers' Behaviour? A Macro and Micro Analysis. *International Journal of Agricultural Management* 2(1): 57-64.

Kaldor, N. (1934). A Classificatory Note on the Determinateness of Equilibrium. *The Review of Economic Studies* 1(2): 122-136.

Kazukauskas, A., Newman, C. and Sauer, J. (2014). The Impact of Decoupled Subsidies on Productivity in Agriculture: A Cross-Country Analysis Using Microdata. *Agricultural Economics* 45: 327-336.

Kazukauskas, A., Newman, C. and Thorne, F. (2010). Analysing the Effect of Decoupling on Agricultural Production: Evidence from Irish Dairy Farms Using the Olley and Parks Approach. *German Journal of Agricultural Economics* 59: 144-157.

Kilian, S. and Salhofer, K. (2008). Single Payments of the CAP: Where Do the Rents Go?. *Agricultural Economics Review* 9(2): 96-106.

Kilian, S., Antòn, J., Salhofer, K. and Röder, N. (2012). Impacts of 2003 CAP Reform on Land Rental Prices and Capitalization. *Land Use Policy* 29: 789-797.

Kirwan, B. and Roberts, M. (2015). Who Really Benefits from Agricultural Subsidies? Evidence from Field-Level Data. Working paper of University of Hawai'i 15(7): 1-29.

Kirwan, B.E. (2009). The Incidence of U.S. Agricultural Subsidies on Farmland Rental Rates. *Journal of Political Economy* 117(1): 138-164.

Klaiber, H.A., Salhofer, K. and Thompson, S.R. (2017). Capitalization of the SPS into Agricultural Land Rental Prices under Harmonization of Payments. *Journal of Agricultural Economics* 68: 710-726.

Latruffe, L. and Le Mouël, C. (2009). Capitalization of Government Support in Agricultural Land Prices: What Do we Know?. *Journal of Economic Surveys* 23(4): 659-691.

Latruffe, L., Guyomard, H. and Lemouel, C. (2009). The Role of Public Subsidies on Farms' Managerial Efficiency: An Application of a Five-Stage Approach to France. Working paper SMART-LERECO no. 09-05, Rennes, France.

Mary, S. (2013). Assessing the Impacts of Pillar 1 and Subsidies on TFP in French Crop Farms. *Journal of Agriculture Economics* 64: 133-144.

Mc Donald, R., Macken-Walsh, A., Pierce, K. and Horan, B. (2014). Farmers in a Deregulated Dairy Regime: Insights from Ireland's New Entrants Scheme. *Land Use Policy* 41: 21-30.

Michalek, J., Ciaian, P. and Kancs d'A (2014). Capitalization Of Single Payment Scheme into Land Value: Generalized Propensity Score Evidence from the European Union. *Land economics* 90(2): 260-289.

Moro, D. and Sckokai, P. (2013). The Impact of Decoupled Payments on Farm Choices: Conceptual and Methodological Challenges. *Food Policy* 41: 28-38.

OECD (1996). Factors Conditioning the Transfer Efficiency of Agricultural Support. Organization for Economic Co-Operation and Development: Paris.

Patton, M., Kostov, P., McErlean, S. and Moss, J. (2008). Assessing the Influence of Direct Payments on the Rental Value of Agricultural Land. *Food Policy* 33: 397-405.

Rizov, M., Pokrivcak, J. and Caian, P. (2013). CAP Subsidies and Productivity of the EU farms. *Journal of Agricultural Economics* 64: 537-557.

Russo, C., Goodhue, R.E. and Sexton, R.J. (2009). Agricultural Support Policies in Imperfectly Competitive Markets: Why Market Power Matters in Policy Design. *American Journal of Agricultural Economics* 93(5): 1328-1340.

Salhofer, K. (1996). Efficient Income Redistribution for a Small Country Using Optimal Combined Instruments. *Agricultural Economics* 13:191–199.

Tranter, R.B., Swinbank, A., Wooldridge, M.J., Costa, L., Knapp, T., Little, G.P.J. and Sotomayor, M.L. (2007). Implications for Food Production, Land Use and Rural Development of the European Union's Single Farm Payment: Indications from a Survey of Farmers' Intentions in Germany, Portugal and the UK. *Food Policy* 32: 656-671.

Uthes, S., Sattler, C., Reinhardt, F., Piorr, A., Zander, P., Happe, K., Damgaard, M. and Osuch, A. (2008). Ecological Effects of Payment Decoupling in a Case Study Region in Germany. *Journal of Farm Management* 13: 219-230.

Viaggi, D., Bartolini, F., Puddu, M. and Raggi M. (2013). The Impact of the 2013 CAP Reform On Land Markets in Italy. In Swinnen, J. and Knops, L. (eds), Land, Labour

and Capital Markets in European Agriculture: Diversity under A Common Policy. Brussels: Centre for European Policy Studies.
Windmeijer, F. (2005). A finite Sample Correction for the Variance of Linear Efficient Two-Step GMM Estimators. *Journal of Econometrics* 126: 25–51.
Zhu, X., Demeter, R.M. and Oude Lansink, A. (2012). Technical Efficiency and Productivity Differentials of Dairy Farms in Three EU Countries: The Role of CAP Subsidies. *Agricultural Economics Review* 13: 66-92.
Zhu, X. and Oude Lansink, A. (2010). Impact of CAP Subsidies on Technical Efficiency of Crop Farms in Germany, the Netherlands and Sweden. *Journal of Agricultural Economics* 61: 545-564.

Appendix

Table A. Descriptive statistics of variables.

Variable	Obs	Mean	Sd	Min	Max	Unit of measures
NFI	24,668	182.5	20,229.4	-515,950.0	2,637,476.0	(Δ%) €/ha
CDP	24,668	59.2	341.8	0.0	17,934.4	€/ha
SPS	24,668	297.6	956.8	0.0	105,050.0	€/ha
RDP	24,668	115.3	967.0	0.0	87,273.3	€/ha
OS	24,668	49.5	638.4	0.0	47,050.5	€/ha
Rented_land	24,668	34.2	39.5	0.0	100.0	%
Share_land	24,668	7.8	21.8	0.0	100.0	%
Own_labour	24,668	87.4	22.7	0.0	100.0	%
Liabilities_assets	24,668	4.2	72.2	0.0	6,252.2	%
Output	24,668	13,006.4	48,295.0	-20,524.0	1,724,127.0	€/ha
Size	24,668	117.3	986.5	0.0	98,807.9	€
Irrigated_land	24,668	39.9	43.6	0.0	100.0	%
Machinery	24,668	6,181.9	19,526.8	0.0	512,428.6	€/ha
Output_livestock	24,668	21.8	35.4	0.0	100.0	%
LU	24,668	282.2	4,850.7	0.0	261,093.0	N. of head
Product_stock	24,668	16,443.9	341,083.5	0.0	39,800,000.0	€/ha
Own_consumption	24,668	1.1	3.4	0.0	100.0	%
Wood_land	24,668	3.8	12.9	0.0	100.0	%

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Short Communication

Bioeconomy and the Common Agricultural Policy: will a strategy in search of policies meet a policy in search of strategies?

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Abstract. Both the revised EU Bioeconomy strategy and the proposals for the Common Agricultural Policy (CAP) 2021-2027 were released in 2018. This paper explores the connection between these two policy areas, the needs for economic and policy research and the way economic literature in the field of the Bioeconomy is meeting these needs. The paper concludes that the two policies are highly complementary in principle, but the current exploitation of potential synergies is largely delegated to the implementation stage of the CAP, hence to country and local programming authorities. To make both policies effective, and to bring about constructive synergies, the availability of bridging concepts allowing for territorial-level integration of chain and ecosystem services views is key. However, on the practical side, monitoring indicators for policy and economic/management support to developing sectors is even more important. Support to innovation design, uptake and exploitation will remain key to the sector and will need a proactive and participatory collaboration among multiple actors. The increased relevance of the role of ecosystem services and environmental attention in both policies will make the results more dependent on the ability to understand the value of public goods and to incorporate them into policy design and marketing strategies.

Keywords. Bioeconomy, Common Agricultural Policy, Rural development, EU.

JEL. Q00, Q01, Q02, Q57.

1. Introduction and objectives

Interest in the Bioeconomy has been growing steadily in recent years, both in policy and literature. A growing number of countries have Bioeconomy strategies and are implementing policies that promote the development of the Bioeconomy (El-Chichakli *et al.*, 2016; German Bioeconomy Council, 2018). Markets for bio-based solutions are growing and are attracting the attention of consumers and investors alike. Applications are at times

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visible but in some cases appear to be simple (drop-in) substitutes to existing products.Yet technological change is fully under way, with continuous new solutions being proposed (Wesseler and Von Braun, 2017; Ronzon *et al.*, 2017). Cross-cutting connections among different value chains are now countless and growing exponentially.

The concept of the Bioeconomy as the aggregate of the sectors using biological resources is now undergoing consolidation, at least in Europe. Agriculture, forestry and food are at the core of the Bioeconomy while the most important progress in terms of markets concerns new sectors, such as bio-based materials and bioenergy. Sectors of the Bioeconomy such as forestry, aquaculture and marine production are seen as major areas for future development. The idea that the Bioeconomy needs to be sustainable and circular is getting stronger as well as the awareness that these features are not implicit in the Bioeconomy, but rather need to be purposefully promoted.

The context driving these trends is different than it was at the beginning of the history of the Bioeconomy. Climate change concerns, long-term sustainability objectives and circular economy objectives (European Commission, 2015) have reinforced the focus on bio-based solutions. While energy concerns are less often in the news, they are taking on greater importance due to their linkages with climate change causes and adaptation strategies. The guiding focus on the UN Sustainable Development Goals has made evident how comprehensive concepts such as the Bioeconomy are key to managing the interplay between social concerns and sustainable economic growth in an interwoven economy.

In spite of the above-mentioned trends, several (or perhaps the majority of) Bioeconomy activities linked to bio-based solutions, bioenergy and co-product management are far from being cost-competitive with fossil resources. In addition, technologies are often insufficiently stable and reliable with respect to market expectations. For these reasons, uptake is slower than sought by promoters and increased efficiency is needed. One of the keys to this increased efficiency is the connection between bio-based and bioenergy chains through biorefinery optimisation, but the issues at stake are much wider and involve the efficiency of the whole system of biomass production and use, as well as the consistent accounting of public good components linking society and market values. Moreover, general knowledge of the Bioeconomy as a concept and a vision remains poor.

On the EU policy side, a new boost to the Bioeconomy has been given by the EU Commission through the revision of the 2012 Bioeconomy strategy and several studies aimed at quantifying the economic role of the Bioeconomy. This was followed by the launch of the revised Bioeconomy strategy in October 2018 (European Commission, 2018). Meanwhile, the whole programming period 2021-2027 is under discussion, notably with new proposals for the CAP related to this period.

Economic research has been developing in parallel (Lewandowski, 2018; Viaggi, 2018; Wesseler, Banse and Zilberman, 2015; Viaggi, 2016). In 2018, Scopus reported 123 papers related to the Bioeconomy in the fields of economics, business and social sciences, with a growth of about +66% compared to the previous year and a constant increase over time.

This paper aims to provide a review of the policy challenges brought about by the revised Bioeconomy strategy and the CAP legislative proposals, with a focus on the connection between these two policy areas. Based on this, the paper discusses needs for support and research in the field of economics and policy, matches these with the related trends in literature, and provides insights into future research developments targeting the most relevant current challenges.

The next section (section 2) provides an overview of the revised Bioeconomy strategy, the proposed CAP reform and the connections between the two policy initiatives. Section 3 discusses economic and policy research needs emerging in response to these policy developments. Section 4 provides a discussion and concluding remarks.

2. The EU Bioeconomy strategy and the CAP

2.1 The revised Bioeconomy strategy

The announced revision of the EU Bioeconomy strategy followed a 2-year process building on the previous 2012 strategy. The evaluation of the strategy painted a rather positive picture in terms of strategy and action plan implementation (European Commission, 2017). Funding has increased for Bioeconomy research and action has been taken in several directions. Bioeconomy concepts have affected different policy areas in the EU and a number of countries now have their own Bioeconomy strategy. Italy is among them, with a broadly supported strategy published in 2017.

In addition, a manifesto for the Bioeconomy in Europe was published in 2017. Several relevant topics for attention and further action were included; in particular, it is noteworthy that there is an emphasis on the role of regions in the development of the Bioeconomy and the need for focused training and education.

The revised Bioeconomy strategy (European Commission, 2018), basically maintains the same objectives of the 2012 strategy, namely:

- ensuring food and nutrition security;
- managing natural resources sustainably;
- reducing dependence on non-renewable, unsustainable resources whether sourced domestically or from abroad;
- mitigating and adapting to climate change; and
- strengthening European competitiveness and creating jobs.

Instead, from a definition point of view, the revised strategy includes some relevant novelties. The Bioeconomy is now defined as follows (European Commission, 2018):

"The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services. To be successful, the European bioeconomy needs to have sustainability and circularity at its heart. This will drive the renewal of our industries, the modernisation of our primary production systems, the protection of the environment and will enhance biodiversity."

The most interesting feature is the placement of sustainability and circularity at the heart of the notion of Bioeconomy. The definition also explicitly highlights the role of ecosystems and their services. On the contrary, innovation and new technologies, in particular genetic engineering, have much less emphasis. Biomedicines and health biotechnology remain excluded.

To achieve the objectives above, the communication envisages three action areas:

1. Strengthen and scale-up the bio-based sectors, unlock investments and markets; this includes: mobilisation of public and private stakeholders, in research, demonstration and deployment of bio-based solutions (Action 1.1); a Circular Bioeconomy Thematic Investment Platform (Action 1.2); identification of bottlenecks, enablers, and gaps affecting bio-based innovations, and providing voluntary guidance on their deployment (Action 1.3); environmental performance information (Action 1.4); facilitation of the development of new sustainable biorefineries (Action 1.5); contribution to the global challenge of plastic-free oceans (Action 1.6).
2. Deploy local bioeconomies rapidly across Europe; this includes: develop a StrategicDeployment Agenda (Action 2.1); Pilot actions enhancing synergies between existing EU instruments to support local activities (Action 2.2); set up of EU Bioeconomy policy support facility for Member States (Action 2.3); piloting on education and skills (Action 2.4).
3. Understand the ecological boundaries of the Bioeconomy; this includes: enhancing the knowledge base and understanding of specific Bioeconomy areas (Action 3.1); implementation of an EU-wide, internationally coherent monitoring system (Action 3.2); voluntary guidance for operating the Bioeconomy within safe ecological limits (Action 3.3); integration of the benefits from biodiversity-rich ecosystems (Action 3.4).

2.2 The proposed CAP reform

After the release of preliminary documents in 2017, the Commission published the legislative proposals for the post 2020 CAP in June 2018.

The objectives of the future CAP are:

- to ensure a fair income to farmers;
- to increase competiveness;
- to rebalance the power in the food chain;
- climate change action;
- environmental care;
- to preserve landscapes and biodiversity;
- to support generational renewal;
- vibrant rural areas; and
- to protect food and health quality.

The basic structure of the CAP is not expected to change dramatically, in particular the organisation into two main pillars. However, in terms of measures, the CAP will bring some important novelties. These include the refocusing of the direct payments towards a basic payment for sustainability; the replacement of the current cross-compliance and greening measures with a new enhanced conditionality scheme; and the provision of voluntary ecological payments (eco-schemes) in the first pillar.

A critical aspect of the CAP reform is the new delivery model, leaving to strategic plans to devise precise actions for implementation. Strategic plans are expected to cover all CAP measures and to be designed at Member State (MS) level. This implies a larger level of flexibility for MS concerning the design of measures and implementation, while the European Commission will monitor the results on the basis of a list of indicators. This should, in principle, allow for higher efficiency through greater flexibility and better targeting, but will also rely more on decentralised coordination and management capacity.

The CAP reform is accompanied by an important effort toward innovation and research, with a proposed allocation of 10 billion euro to agriculture and food in Horizon Europe. This continues the coordination between the CAP and research policy already established during the 2014-2020 period.

2.3 The Bioeconomy strategy and the CAP: opportunities, drawbacks and emerging policy issues

In spite of the obvious interplays, the convergence between the Bioeconomy strategy and the CAP is still weak; however, the rural development objectives in the Bioeconomy strategy and the explicit mention of the Bioeconomy (as well as of the need for biomass production) in the CAP are important steps forward in the field of policy harmonisation. Notably, this does not only concern the areas in which the Bioeconomy is mentioned, but also other components of the CAP including the international dimension.

The CAP does not contain/impose any specific measure related to non-food Bioeconomy sectors; however several measures can be used in this direction by local strategy design. A number of CAP measures can indeed contribute to the Bioeconomy. These include: a) those strengthening the role of farmers in the supply chain; b) sectorial programmes if connected to bio-based products; c) enhanced conditionality, including crop rotation provisions; d) voluntary eco-schemes,which are mandatory for MS; e) coupled income support, directly or indirectly affecting specific value chains; f) rural development measures (including agri-environmental schemes, innovation and investment support, knowledge transfer measures). However, the decision to use these measures to support the Bioeconomy development will be in the hands of Member States or local authorities.

One stated CAP objective (also in the documentation about strategic plans and their evaluation) is directly connected to the Bioeconomy, namely: "Promote employment, growth, social inclusion and local development in rural areas, including bio-economy and sustainable forestry". In terms of CAP result indicators for the monitoring of evaluation plans, two main indicators are specific to the Bioeconomy: R.15 Green energy from agriculture and forestry: Investments in renewable energy production capacity, including bio-based and R.32 Developing the rural bioeconomy: Number of Bioeconomy businesses developed with support.

On the other hand, the Bioeconomy strategy envisages a number of supporting instruments that could be used by the CAP implementation strategy. These primarily concern initiatives for sustainability diagnostics and intra-regional coordination.

In addition, there seem to be a number of procedural meeting points in the two strands of policy in as much as both envisage some implementation plan at the country or regional level. This could provide an opportunity for greater coordination to the extent that it does not result in duplication. Indeed, the CAP strategic plans offer an improved opportunity for coordination with the Bioeconomy strategies through needs analysis and the setting of objectives. One potential issue, however, remains the scale of coordination and inter-scale dialogues.

Potential conflicts are difficult to envisage. The most evident issue is that of biorefinery development and investment programmes, which have the potential to affect the farming sector and could lead to undesired effects if the two areas of intervention are not locally coordinated.

3. Challenges for economic & policy support

3.1 Bioeconomy definitions and boundaries

From the definition point of view, the Bioeconomy is shaping up and consolidating at least in terms of the sectors involved. The new strategy makes it more explicit that the Bioeconomy is the aggregate of all sectors using living organisms and this partially goes beyond a number of discrepancies found in the literature between different approaches to the Bioeconomy. These do tend to remain, however, when the Bioeconomy is viewed from different regional or stakeholder perspectives (de Besi and McCormick, 2015).

The current trends in the EU policy clarify once more that the Bioeconomy concept will not substitute our current notion of sectors, such as agriculture, food etc., at least in the short-term, but will rather provide a complementary view at system level. This separation will also remain as such in the policy realm. This is a reasonable strategy, which is legitimate with path-dependency motivations, as sector identity and related policy are already quite consolidated and have been developed over time. On the one hand, the difficulty in understanding and communicating what the Bioeconomy is will continue. Indeed, there is a consolidation of the view of the Bioeconomy as a bridging concept rather than a sector. On the other hand, the definition of the Bioeconomy has clearly expanded in the direction of accounting for ecosystems, clarifying the increasing trends towards the need for a consistent inter/trans-sectoral approach to the management of biological resources.

Biorefineries are clearly seen as a key connection point among the Bioeconomy sectors. Their development across Europe is somehow the most practical action envisaged in the strategy. This is very relevant as biorefineries are peculiar solutions connecting different value chains and at the same time are the strategic topic to connect the industrial and territorial visions of the Bioeconomy. However, chain coordination and consistency with the ecosystem services perspective needs to be carefully investigated.

3.2 Bioeconomy sectors and markets

The pragmatic identification of the Bioeconomy as an overarching concept encompassing or including different sectors, as well as the envisaging of only a (mainly) strategic approach from the point of view of Bioeconomy policy, somehow refocuses attention, including for the Bioeconomy, on the functioning of markets and their dynamics. The developing of new markets (except for bioenergy) seems to remain not supported by strong direct incentives from policy, but rather promoted by soft measures related to primary production, chain structure, certification and information.

Here, a focal point remains cost-competitiveness with similar fossil-based products and the distinction between drop-in and new products (Petrovič, 2015). On the one hand, this requires an improved understanding of consumer and citizen behaviour, on the other hand it needs to address supply side (cost) issues. These topics are emphasised for markets for new products, such as innovative (in terms of value proposition) bio-based products.

The increased relevance of the role of ecosystem services and environmental attention in both policies will shine light on the ability to understand the value of public goods and to incorporate them into policy design and marketing strategies.

3.3 System view

The territorial planning envisaged in the Bioeconomy strategy and the strategic planning envisaged in the revised strategy call for both a description and an understanding of Bioeconomy systems. In this direction, the Bioeconomy literature already seeks to deliver interpretations of complex Bioeconomy systems through the evolution of the concept of value chains into a vision of value webs (Scheiterle *et al.*, 2016; Virchow *et al.*, 2016); at the same time, examples, especially of biomass provisions for biorefineryand logistics, need to explicitly address the connection between process design and territorial scale. This, in turn, extends to international biomass and value flows. The direct consideration of the engagement of consumers and citizens is also a key factor in these processes.

The inclusion of ecosystems into this view, and the Socio-Ecological System approach as a potential interpretation of society's action are also under way. An attempt to merge these approaches into a unified view goes under the proposed term Socio-Ecological Technological Value-Enhancing Web System (SETVEWS)(Viaggi, 2018), which is still, however, undefined in operational terms.

The system view not only provides a vision of the Bioeconomy, but also highlights the need to understand the role of logistic organisation (Lamers *et al.*, 2015), chain structure (Espinoza Pérez *et al.*, 2017) and flexibility (Swartz, Wang and Mastragostino, 2015) as the key to efficiency. In addition, the understanding of system organisation needs to take into account technological potential. In particular, the increasing ability to break down and recompose biomass has lead the emergence of the concept of platform products as key "connectors" in the biomass flows, with potential implications on system organisation and market power (Bomtempo, Chaves Alves and De Almeida Oroski, 2017).

3.4 Policy coordination and territorial governance

Both Bioeconomy and agricultural policy require territorial level programming. This is connected to the system view and the need to consistently manage resources and opportunities in a landscape (ecosystemic) framework. In addition, the topic of policy coordination is of paramount importance. The Bioeconomy is already most often promoted by a mix of policy instruments with different strategies and composition depending on the individual country and location (German Bioeconomy Council, 2015). The focus on strategy emphasises these needs.

In a more analytical way, the picture above requires the ability to understand the working of policy mixes. Research and innovation policy clearly plays a major role in this context. The CAP already includes a variety of different measures which consistency is sometimes not straightforward (or clearly lacking). Addressing the Bioeconomy consistently requires, greater effort with regard to connecting agriculture, food, fisheries, industrial and environmental sectors, energy policies, as well as activities related to research, innovation and education.

In addition, this strategic approach highlights the need for working approaches to participation and governance. This has been an area of particular focus in the literature on participatory decision-making, and, among other issues, highlights the positive role of the Bioeconomy as an 'umbrella concept' to provide a dialogue platform for different views of the future. On the other hand, for the same reasons, it runs the risk of remaining just a buzzword with unclear references to the use of biomass. Indeed, in a communication context, 'Bioeconomy' can be qualified as a 'boundary object' or a 'bridging concept', i.e. serving specific interests of different stakeholders under a generally accepted conceptual umbrella (Hodge, Brukas and Giurca, 2017).

The relevance of the topic has been highlighted in contexts in which the different players have rather different backgrounds and power, so it is of special importance for rural areas. This implies the consideration of two connected aspects. One is the role of local institutions in the governance of the Bioeconomy. The other is the involvement of the ecosystem service view as compared with the value chain view.

3.5 Innovation

The definition of the Bioeconomy used in the revision of the EC Communication seems to downplay innovation and research. In particular, genetic engineering, which was at the core of some of the founding documents by other bodies (e.g. OECD) is has no particular relevance here. In fact, looking at the actions proposed, research and innovation is still high in the agenda and even more important in economic terms. Most likely, in the current setting, innovation stands behind the scenes and is less to be interpreted as a specific set of technologies and rather as whatever is needed to promote the objectives of developing Bioeconomy sectors in industrial terms while guaranteeing circularity and sustainability. This approach certainly brings Bioeconomy innovation closer to current practices in agriculture and rural innovation such as the Innovation systems perspective adopted by the Agricultural Knowledge and Innovation Systems (AKISs) or the collaborative perspective used by the EIP AGRI measures.

However, it is also connected to information, education and human capital, and is linked to industrial innovation. On the other hand, innovation is connected to appropriate incentives related to the features of final products, and hence cannot be thought of as being disconnected from markets and value chain development.

The link among research disciplines is even more important, as also implied by transdisciplinary research linked to multi-actor driven processes. The balance between multi-actor emphasis and consistent new research has, however, proven to be difficult to manage and this will be a key issue to tackle in order to provide genuine and result-focused innovation systems.

One important perspective here relates to the trend towards technology design as an explicit process aimed at specific achievements and within circular innovation processes, which implies an even greater degree of coordination.

3.6 Defining and measuring

The problem with measuring the Bioeconomy remains at the core, due also to the dearth of suitable data (Wesseler and Von Braun, 2017; Ronzon *et al.*, 2017; Lokko *et al.*, 2017). Besides agriculture and food, bio-based sectors such as energy, biomaterials, and biorefineries are largely included in other sectors' statistics and require difficult disaggregation procedures and, at times, questionable assumptions.

On the other hand, the new definition and policy approach require a move towards a more functional use of measurements, most notably in three directions:

- First, in the direction of measuring the actual progress of Bioeconomy sectors and in particular, understanding the dynamics of emerging sectors such as those of bio-based products.
- Second, in the direction of understanding the sustainability of current Bioeconomy systems, with a focus on the new field of measurement represented by circularity and consolidating areas such as the connection with ecosystem services and public goods; while the Bioeconomy strategy focuses to a significant extent on the concept of ecological boundaries, the CAP more and more explicitly focuses attention on the positive potential of the primary sector to produce valuable public goods.
- Third, in the direction of having measures suitable for policy evaluation or even for performance/impact measurement linked to the provision of CAP payments.

3.7 Communication, awareness and education

Communication, awareness and education are clearly important for an emerging sector of the economy. The first straightforward aspect is linked to awareness and acceptability by the general public, which is well known to be critical for new products such as those obtained through genetic modification. Furthermore, information is linked to market expressions of willingness to pay. This is clearly key in a policy approach only weakly based on direct incentives and more focused on the promotion of innovation.

The role of education and human capital in the Bioeconomy is of primary interest to the academia. Noteworthy initiatives are being developed that range from primary to post-university and Lifelong Learning, but the role of Bioeconomy studies in curricula remains, to a large extent, questionable and under developed.

4. Discussion and conclusions

Research and interpretation of the Bioeconomy is taking shape (Viaggi, 2018). The sought after interaction between the CAP and Bioeconomy is now at a crossroad, with the revised Bioeconomy strategy and the upcoming CAP reform, ushering in significant opportunities for coherent and synergetic support, while at the same time leaving the details of these synergies rather open to local action. Both strategic approaches also bring with them a number of implications for economic research related to policy.

While the Bioeconomy is consolidating as one of the biggest phenomena of our age, it continues to be in search of an identity. There are different dimensions to this identity-building process. One is policy, as can be expected from an emerging area of the economy. However, the EU's Bioeconomy action and most country strategies rely more on strategies than Bioeconomy policies, leaving to specific sector policies the role to implement actions. This is also the case of the EU. This approach is in itself understandable, due to the fact that some parts of the Bioeconomy have long-term policy structures, the implementation of which is rather consolidated with reforms depending on path-dependency.

As for the CAP reform there is a reliance on decentralised strategic planning, which is fuelling debate about implementation procedures (new delivery model) and priority setting.

Accordingly, this is an ideal time to discuss the coordination between the Bioeconomy and agricultural priorities and policies. The explicit call for convergence (or the beginning of dialogue) between Bioeconomy and the CAP is a relevant step forward. Certainly, strong support for economic information is imperative. Economics is moving forward in building this identity through an increasing number of works and new concepts. The next step is to improve the application of these concepts to the next generation of policy problems. The main contributions likely rest in providing a coherent system view, helping to identify priorities and designing improved mixes of policy instruments. Each of these areas of action is facing a number of new challenges, as discussed above. The enlargement of the Bioeconomy concept to ecosystem services and the more neutral view of innovation also represent important topics to be dealt with in economic research.

Finally, both from an academic and sector perspective, greater attention is needed to bring the Bioeconomy into the education system. Perhaps there will never be a Bioeconomist profession, but the comprehensive vision of the Bioeconomy and an economic focus on its evolving components will undoubtedly be of great importance for any professional working with biological resources in the future.

5. References

de Besi, M. and McCormick, K. (2015). Towards a Bioeconomy in Europe: National, Regional and Industrial Strategies. *Sustainability* 7(8): 10461-10478. doi: 10.3390/su70810461.

Bomtempo, J.-V., Chaves Alves, F. and De Almeida Oroski, F. (2017). Developing new platform chemicals: What is required for a new bio-based molecule to become a platform chemical in the bioeconomy?. *Faraday Discussions* 202. doi: 10.1039/c7fd00052a.

Bonaccorso, M. (2016). The Bioeconomy Revolution. Kindle ver. Edizioni Ambiente, Milano.

El-Chichakli, B., von Braun, J., Lang, C., Barben, D. and Philp, J. (2016). Five Cornerstones of a Global Bioeconomy. *Nature* 535: 221-223.

Espinoza Pérez, A. T., Camargo, M., Narváez Rincón, P. C. and Alfaro Marchant, M. (2017). Key Challenges and Requirements for Sustainable and Industrialized Biore-

finery Supply Chain Design and Management: A Bibliographic Analysis. *Renewable and Sustainable Energy Reviews* 69: 350-359. doi: 10.1016/j.rser.2016.11.084.
European Commission (2015). Closing the loop - An EU Action Plan For the Circular Economy. COM(2015) 614 final. Bruxelles.
European Commission (2017). Review of the 2012 European Bioeconomy Strategy. Bruxelles.
European Commission (2018). A Sustainable Bioeconomy for Europe: Strengthening the Connection Between Economy, Society and the Environment. Updated Bioeconomy Strategy. *Bruxelles*. Available at: https://ec.europa.eu/research/bioeconomy/pdf/ec_bioeconomy_strategy_2018.pdf#view=fit&pagemode=none.
German Bioeconomy Council (2015). Bioeconomy Policy (Part II) Synopsis of National Strategies Around the World. Berlin. Available at: https://biooekonomierat.de/fileadmin/Publikationen/berichte/Bioeconomy-Policy_Part-II.pdf
German Bioeconomy Council (2018). Bioeconomy Policy (Part III): Update Report of National Strategies Around the World. Berlin. Available at: http://gbs2018.com/fileadmin/gbs2018/Downloads/GBS_2018_Bioeconomy-Strategies-around-the_World_Part-III.pdf.
Hodge, D., Brukas, V. and Giurca, A. (2017). Forests in a Bioeconomy: Bridge, Boundary or Divide?. *Scandinavian Journal of Forest Research* 32(7): 582-587. doi: 10.1080/02827581.2017.1315833.
Lamers, P., Tan, E. C. D., Searcy, E. M., Scarlata, C. J., Cafferty, K. G. and Jacobson, J. J. (2015). Strategic Supply System Design - A Holistic Evaluation of Operational and Production Cost for a Biorefinery Supply Chain. *Biofuels, Bioproducts and Biorefining* 9(6): 648-660. doi: 10.1002/bbb.1575.
Lewandowski, I. (ed.) (2018). Bioeconomy. Shaping the Transition to a Sustainable, Biobased Economy. Springer.
Lokko, Y., Heijde, M., Schebesta, K., Scholtès, P., Van Montagu, M. and Giacca, M. (2017). Biotechnology and the Bioeconomy - Towards Inclusive and Sustainable Industrial Development. *New Biotechnology* 40(A): 5-10. doi: 10.1016/j.nbt.2017.06.005.
Petrovič, U. (2015). Next-Generation Biofuels: A New Challenge for Yeast. *Yeast* 32: 583-593. doi: 10.1002/yea.3082.
Ronzon, T., Piotrowski, S., M'Barek, R. and Carus, M. (2017). A Systematic Approach to Understanding and Quantifying the EU's Bioeconomy. *Bio-based and Applied Economics* 6(1): 1-17. doi: 10.13128/BAE-20567.
Scheiterle, L., Ulmer, A., Birner, R. and Pyka, A. (2016). From Commodity-Based Value Chains to Biomass-Based Value Webs: The Case of Sugarcane in Brazil's Bioeconomy. *Journal of Cleaner Production* 172: 3851-3863. doi: 10.1016/j.jclepro.2017.05.150.
Swartz, C. L. E., Wang, H. and Mastragostino, R. (2015). Operability Analysis of Process Supply Chains-Toward the Development of a Sustainable Bioeconomy. *Computer Aided Chemical Engineering* 36:355-384. doi: 10.1016/B978-0-444-63472-6.00014-8.
Viaggi, D. (2016). Towards an Economics of the Bioeconomy: Four Years Later. *Bio-based and Applied Economics* 5(2): 101-112. doi: 10.13128/BAE-20086.
Viaggi, D. (2018). The Bioeconomy. Delivering Sustainable Green Growth. CABI Publishing.

Virchow, D., Beuchelt, T. D., Kuhn, A. and Denich, M. (2016) Biomass-Based Value Webs: A Novel Perspective for Emerging Bioeconomies in Sub-Saharan Africa. In Gatzweiler, F.W. and von Braun, J. (eds), Technological and Institutional Innovations for Marginalized Smallholders in Agricultural Development. Springer Open: 225-238. doi: 10.1007/978-3-319-25718-1_14.

Wesseler, J., Banse, M. and Zilberman, D. (2015). Introduction Special Issue "The Political Economy of the Bioeconomy". *German Journal of Agricultural Economics* 64: 209-211. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-84949545519&partnerID=tZOtx3y1.

Wesseler, J. and von Braun, J. (2017). Measuring the Bioeconomy: Economics and Policies. *Annual Review of Resource Economics* 9: 275-298. doi: 10.1146/annurev-resource-100516-053701.

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