LUND UNIVERSITY
School of Economics and Management

Master's Programme in Economic Growth, Population and Development

Determinants of organically farmed acreage expansion within the European Union

An empirical analysis based on aggregate Eurostat data

by

Harmat Frigyes

fr0175ha-s@student.lu.se

Abstract: Many consider organic farming to be a solution to agriculture's potential agricultural crises. Accordingly, the European Union's Organic Action Plan aims to increase the share of organically farmed acreage drastically over the next decade. Research concerning the drivers of organic farming expansion could prove vital, and a wide range of empirical literature explores the topic. However, previous studies employ smaller samples, and their results are very often at odds. Unique in its scope, this thesis synthesizes previous research in Europe-wide aggregate fixed-effects models in search of findings generalizable for the whole continent, focusing on farm structural and farmer demographic characteristics. The analyses span 27 countries and 243 regions between 2005 and 2016, addressing both levels of aggregation separately. Our results suggest that the acreage-weighted ratio of female farm managers and the acreage-weighted average level of farm managers' agricultural training in a given spatial unit are positively associated with organically farmed land area. Average farm size displays a reverse-U shaped relationship with organic acreage, but the unit-increase effect turns negative only in the highest ends of the distribution. Meanwhile, acreage-weighted average farmer age seems to have a U-shaped relationship with the extent of land under organic practice. The results, however, vary in their statistical reliability. The thesis provides a good starting point for future research on the topic; while the results provide interesting implications for the European Union's ambitious Organic Action Plan.

EKHS22
Master's Thesis (15 credits ECTS)
May 2021
Supervisor: -
Examiner: Jonas Ljungberg
Word Count (base text excluding tables, footnotes, captions etc.): 19038

I would like to thank Alexandra López Cermeño for her valuable advice and support.

Table of Contents

List of Figures

List of Tables

1 Introduction and Background

1.1 Key concepts, aim and structure of the study

At its core, organic farming is a holistic farm-management approach, where off-farm inputs are substituted by on-farm management practices (Dabbert, Häring & Zanoli, 2004). Besides eliminating artificial pesticide and fertilizer use, the original concept entails a wide range of ecological best practices, such as cover cropping, natural manuring, crop rotation and biological pest control. These are aimed at, among others, to maintain and improve soil health and biodiversity, promote resource cycling and enhance resilience of agricultural and surrounding natural systems (SARE, 2020). Organic farming and other, closely related environmentally-friendly production methods pose an alternative to “conventional” farming, an industrialized mode of agricultural operation that developed in Europe during the post-war period.[1]

Organic farming has been a quickly expanding hot topic in the European agricultural research agenda for the past two decades (Aleixandre, Aleixandre-Tudó, Bolaños-Pizarro & Aleixandre-Benavent, 2015). That is understandable, as agriculture worldwide is facing several looming ecological crises due to climate change and soil loss, among others. Europe is no exception, and the Common Agricultural Policy (CAP) has been placing steadily increasing emphasis on the ’greening’ of European agriculture. Currently about 8.5% of the EU’s total utilized agricultural area (UAA) is farmed organically. The EU’s Organic Action Plan, part of the European Green Deal, aims to push this figure to 25% by 2030 (European Commission, 2021/1). According to the European Commission, the current 8.5% would reach 15-18% at the current rate of expansion by 2030.

The Organic Action Plan mostly focuses on the demand side (European Commission, 2021/2) to accelerate expansion by promoting organic sales channels and educating consumers. However, research regarding the determinants of organic acreage expansion may also be a key facilitator in tailoring optimal CAP policies to meet the ambitious objective of 25% by

[1] Sections 1.2 and 1.3 expand on these notions in detail.

2030. Rahmann et al. (2017) predict scientific research to become more important than ever in the development of organic farming – they call not only for biological, but also for socioeconomic research. This thesis will undertake such an endeavour, mainly focusing on the effects of farm structural and farmer demographic characteristics on organic acreage expansion.

A broad literature of econometric-oriented research examines the drivers of conversion to organic farming. However, while their empirical approaches tend to be similar, their results are often at odds. These studies have mostly relied on limited, nationally or regionally confined samples, scattered in space and time.[2] On the other hand, they employ high-quality farm-level data. Recently, Serebrennikov, Thorne, Kallas & McCarthy (2020) have been the first to present a meta-study in an attempt to summarize and organize the empirical literature on the topic.

This thesis is written in a similar spirit. Indeed, to forward the research objective on organic farming, it is crucial to thoroughly take account of previous research. However, to facilitate relevant policymaking, it would also be important to assess which of the earlier results possess external validity on the European level. [3]

Due to the different nature of data and methods permitted thereby when compared to these earlier studies, this thesis will not be able to directly assess the external validity of earlier results *per se*. [4] However, the thesis will use these studies as its starting point in constructing its empirical analysis. Unprecedented in its scope, the thesis is based on aggregate Eurostat figures structured as panel data, covering the vast majority of UAA within the EU between 2005 and 2016. Thereby the thesis will still enable us to infer which of the notions found in earlier empirical literature on organic farming can be backed through such continent-wide analyses.

---

[2] See Appendix E.

[3] External validity refers to whether the conclusions obtained from studying a certain sample can be generalized on the larger population the sample was drawn from. In this case, "external" refers to the European Union. The samples from the referred earlier studies are regarded as being drawn from a larger population of all EU farms, hence the need to infer which of their results are valid to generalize on a European level. The EU FSS, serving as the basis of this analysis, employs this pan-European farm population as its survey population.

[4] This will be expanded upon in detail in sections 4 and 5.

Summing up, the thesis' primary research question is: Based on its recent evolution, which farm and farmer characteristics determine the expansion of organic acreage within Europe? [5] An alternative research question is: which previous empirical findings regarding the determinants of organic farming expansion, and to what extent, can we generalize in the context of the European Union?

The rest of Section 1 provides the background of the thesis. The concept of organic farming will be expanded on in detail, as well as clarified within the context of European legislation, by which we will define organic farming in our analysis. As due, the section will also present organic farming's main critiques. The section will then continue by presenting the history of organic farming within Europe. It will do so through setting it within the greater patterns of the structural transformation of European agriculture, arguing that it is more than a simple shift in production methods. Based on this, the thesis establishes further motivation to gain understanding of organic acreage expansion as a continent-wide phenomenon.

Sections 2 and 3 are the main literature review of this paper. Section 2 concerns theory. The section begins with a historical overview of the general conceptualization of farmers' decision-making within economic sciences. This will be followed by a presentation of theoretical approaches, and the lack thereof, found within the econometric studies that comprise the basis of this thesis. The choice not to opt for a concrete theoretical framework is explained based on a juxtaposition of this review and available data.

Section 3 presents a thorough analysis of empirical research concerning the drivers of conversion to organic agriculture within Europe. First, the role of subsidies and policy will be considered separately, as these factors could not be efficiently captured in the dataset. The section continues with a categorical review of nearly every other numerically quantified factor that is present within empirical literature, divided into farm structural and farmer demographic characteristics. Moreover, the section also presents a range of additional important factors – organic market infrastructures and societal attitudes regarding the environment – that have not yet been quantitatively operationalized by the literature. While aggregate data has its drawbacks, it also permits the inclusion of such variables, which will serve as controls for the thesis' analysis.

[5] Meaning of those that can be operationalized through nationally and regionally aggregated Europe-wide data.

Section 4 explains the choice and construction of data and methods in detail. Unlike its predecessors, the thesis will employ aggregate data, where the dependent variable is the percentage of utilized agricultural area that is farmed organically within the given spatial unit. The bulk of the data is obtained from the Eurostat agricultural database, with additional variables obtained from the FiBL and manually aggregated data from the European Social Survey series. The thesis will include national and regional-level analyses. The final dataset spans 27 European countries and 243 NUTS2 regions, examined through five time points between 2005 and 2016.[6] The thesis will employ fixed-effects regressions, iterated through numerous different specifications on both country and regional levels. Section 5 begins with a brief spatial analysis to help visualize and contextualize the process of organic expansion within Europe. This will be followed by a presentation of the results obtained from our econometric models, as well as their detailed explanations. Section 6 concludes.

In studying the expansion of organic acreage expansion as a large-scale historical process, the thesis aims to uncover new knowledge concerning the big picture of the evolution of organic farming on the continent. In doing so, the thesis can hopefully present findings that may be beneficial for the European Union's ambitious Organic Action Plan agenda. Even if the obtained results have no outright policy implications, the thesis should serve as a good starting point for future research on the expansion of organic farming in Europe.

[6] NUTS (Nomenclature of Territorial Units for Statistics / Nomenclature des Unités Territoriales Statistiques) is the EU's primary classification of geographical entities for statistical purposes. Depending on size, individual countries (NUTS0) are divided into NUTS1, NUTS2, NUTS3 and Local Administrative Units. Proportions of division vary by country. For example, Portugal is divided on the NUTS1 level into its continental and two overseas landmasses. In Germany, However, NUTS1 corresponds to states, while NUTS2 to government regions.

1.2 Full picture, relevance and critiques of Organic Farming

As mentioned earlier, organic farming is a collection of environmentally conscious agricultural practices resulting in a mode of operation that challenges conventional industrialized agriculture. The full picture – or more so, the idea – of organic farming has strong societal components tied tightly to the overriding ecological morality and social responsibility in farm management. It has been regarded by many not only as an operational, but also as an institutional alternative to conventional agriculture, focusing on farmer autonomy and fairer, more human relations between producer and customer (Darnhofer, D'Amico & Fouilleux, 2019).

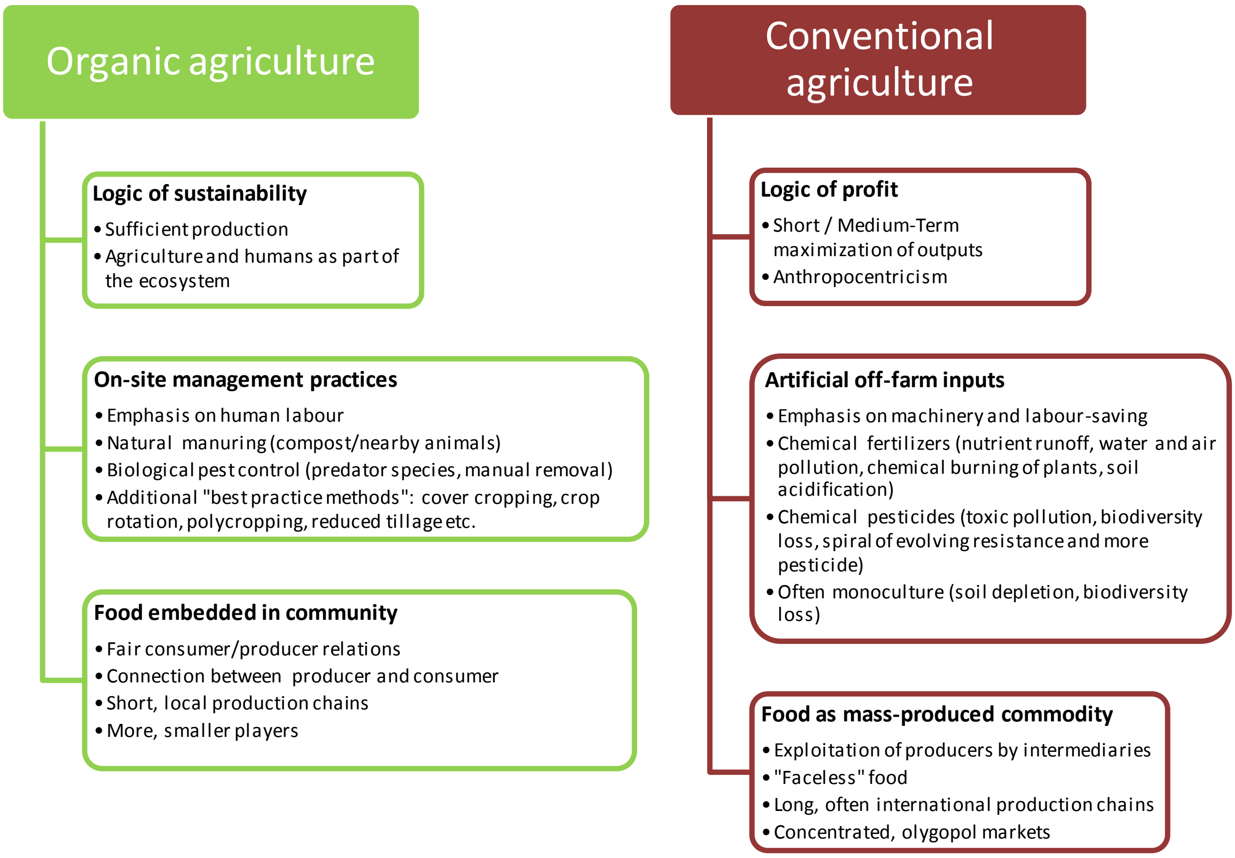

Figure 1: Organic vs. conventional / productivist agriculture. Source: author's own work based on the wider surveyed literature

Detailed explanations of the full concept and its development are presented in Lockeretz (2007), Bellon & Penvern (2014), as well as on the IFOAM website. [7] Figure 1 above juxtaposes the idea of organic farming to conventional agriculture. Note that the image refers to the idealized organic principles, and not necessarily the reality that is manifested in actual European agricultural production.

Regardless of the full implications of the original concept, today the term „Organic" has a wide range of interpretations (Seufert, Ramankutty & Mayerhofer, 2017; Eden, 2011). [8] In EU legislation, „Organic" is a regulated food label, only available to producers certified in accordance with EC Regulation 834/2007 (Brzezina, Biely, Helfgott, Kopainsky, Vervoort & Mathijs, 2017; Serebrennikov et al., 2020). This thesis' analysis, as well as most of the presented literature, examines the evolution of organic farming as defined by Regulation 834.[9] Individual organic farmers can vary greatly in their respective managerial practices and adherence to the full concept.[10]

Nonetheless, a wide body of literature reports of organic farming's environmental benefits, such as improving soil health and quality (Dabbert, Häring & Zanoli., 2004; Mäder & Berner, 2012; Parras-Alcántara & Lozano-Garcia, 2014; Achuelo, 2016; Morvan, Verbeke, Laratte & Schneider, 2018), biodiversity (Dabbert, Häring & Zanoli., 2004; Belfrage, Björklund & Salomonsson, 2005; Rader, Birkhofer, Schmucki, Smith, Stjernman & Lindborg, 2014; Tuck, Winquist, Mota, Ahnström,Turnbull & Bengtsson, 2014) and climate resilience (Aguilera, Lassaletta, Gattinger & Gimeno, 2013; Jacobi, Schneider, Mariscal, Huber, Weidmann, Botazzi & Rist, 2015; Li, Peterson, Tautges, Scow & Gaudin, 2019; Rollan, Hernández-Matías & Real, 2019).

Facing the predicted effects of climate change on global agricultural yields (see FAO, 2016), environmentally conscious agricultural practice can be critical. The EU CAP has – at least formally – long stressed that agriculture is not only a producer of food, but a provider of various environmental and societal services (Darnhofer, Lindenthal, Bartel-Kratochvil & Zollitsch, 2010; Rønningen, Renwick & Burton, 2012). For the 2021-2017 programming

[7] International Federation of Organic Agriculture Movements (IFOAM) - Organics International.
[8] Insofar as a single 'original' concept can be traced – this, too, is up for debate, as the forerunners of OF appeared at similar times in different locations, often only vaguely influencing each other (Dabbert, Häring & Zanoli, 2004; Lockeretz, 2007).
[9] And its precedessor, EC Regulation 2092/91.
[10] This notion of the many-fold dimensions of the term has to be kept in mind when assessing any statistic or study regarding the impacts, drivers and characteristics of organic farming.

period, the CAP lists improving sustainability and resilience among its foremost goals (European Commission, 2018).

However, several scholars (Emsley, 2001; Trewavas, 2001; Pickett, 2013) criticize organic farming´s extensive approach to production, citing detrimental effects on wildlife conservation and food security through reducing land productivity.[11] A second strain of criticism is the 'conventionalization' hypothesis.[12] The concept refers to organic agriculture losing touch with its original principles, resulting in an uncanny resemblance to conventional production in aim and practice.[13]

In the European context, conventionalization is partially permitted by the rise of multinational corporations, expansion of global trade in organic products and their appearance in large supermarket chains (Allen & Kovach, 2000; Best, 2008; Darnhofer et al., 2010; Dinis, Ortolani, Bocci & Brites, 2015; Desquilbet, Maigné & Monier-Dilhan, 2018). On the other hand, numerous scholars criticize European legislation – both EC 2092/91 and EC 834/2007 – for setting the bar for accreditation low, focusing on the most easily measurable production methods and inputs (Gibbon, 2008; Padel, Röcklinsberg & Schmid, 2009; Klein & Winickoff, 2011; Fouilleux & Loconto, 2017; Seufert, Ramankutty & Mayerhofer; 2017). [14] It is up to farmers' individual commitment to adhere to less tangible organic principles. Large variation exists, and many[15] organic farmers choose to outperform the regulated minimums out of environmental and social concerns (Best, 2008; Darnhofer et al., 2010; Dinis et al., 2015).

For a proper contextualization of the remainder of this paper, these criticisms have to be kept in mind. While the Organic Action Plan is a commendable step, this paper will not argue that

[11] As the argument goes, it would take much more land to produce the same amount of food with only organic farming. To understand the context, one needs to remember that vastly different practices can fall under the term „organic". Moreover, organic technology and knowledge is constantly evolving. In 2001, Emsley mentioned a 75% land yield reduction, while a 2018 meta-study by Röös et al. only writes of a 20% general reduction.
[12] The concept was first introduced by Buck, Getz & Guthman (1997) referring to the Californian organic sector.
[13] This entails profit motives overriding environmental concerns; intensifying the use of mechanical machinery-based heavy tilling to substitute herbicides; not going further than substituting prohibited inputs with their closest non-prohibited counterparts and in general exploiting every loophole presented by the regulations to penetrate the organic niche market while minimizing the actual costs, risks and overall effort of going organic.
[14] It must be mentioned that the text of the official document refers extensively to the core values and aims of organic farming. However, only a a highly watered-down selection carries over to the actual, legally binding part (Padel, Lampkin & Foster, 2007). See EC (2020), here: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32007R0834
[15] To the knowledge of the author, there is no overall estimate for Europe. But for example, in the sample of 352 Portugalian and Italian organic farmers in Dinis et al. (2015), 60% exhibited 'deep organic' practices and attitudes.

organic farming as it currently exists is „the" solution, nor its opposite.[16] However, in the following section, it will argue that it can be understood as part of deeper structural changes in European agriculture, and as such, deserves scholarly attention.

1.3 History of Organic Farming and the post-war structural transformation of European agriculture

The concept of organic farming originates from the early 1900's, mostly from Europe's German and English-speaking countries. From the very beginning, the organic movement was in explicit opposition of what was considered 'modern' agriculture at the time (Dabbert, Häring & Zanoli, 2004; Lockeretz, 2007). From the 1950's, national policies and the overarching CAP implemented what was coined the era of 'productivist' agricultural regimes by scholars (Wilson, 2001; Knudsen, 2007; Wilson, 2007; Rønningen, Renwick & Burton, 2012).[17] Embedded within Europe's larger structural transformation patterns, this regime resulted in unprecedented asset concentration, specialization and labour force reduction, as well as technological shifts relying on heavy use of machinery and bio-chemical inputs. During the 'productivist' decades, organic farming existed as a dispersed ideology-driven fringe movement, representing the polar opposite of the ruling agricultural regime – refer to Figure 1. (Lockeretz, 2007; Brzezina et al., 2017).

This „Fordist" model of agriculture (after Wilson, 2001; Wilson, 2007) had political and social dimensions as well. Production was ensured through subsidies coupled to produced quantities, encouraging overproduction and a disregard of environmental consequences (Rønningen, Renwick & Burton, 2012). The productivist understanding put an equation mark between the countryside and agricultural production, and food was decoupled from most of its localized cultural and social components (Wilson, 2007).

From the 1980's, however, the environmental degradation of productivist agriculture, as well as the overproduction problem, could no longer be ignored (Wilson, 2007; Rønningen, Renwick & Burton, 2012). Organic farming gained increasing public popularity and official

[16] It is true that there are several other ecologically oriented farming approaches, as well as stand-alone methods not included by organic regulations – such as integrated farm management and reduced tillage, respectively (Trewavas, 2001; Carr, Mäder, Creamer & Beeby, 2012; Mäder & Berner, 2012; Parras-Alcántara & Garcia, 2014). Although Mäder & Berner (2012) suggest that reduced tillage methods have the best synergic effects when combined with organic farming practices.
[17] CAP: Europe's Common Agricultural Policy, conceived around 1958 and launched in 1962.

attention. Several scholars hypothesize a deep-cutting shift in agricultural policy attitudes to have taken place during the mid-eighties, moving away from the unconditional maximization of outputs and turning towards environmental and social concerns (Wilson, 2007). The first national organic labels were introduced in the late eighties, and in 1991, the concept officially became part of EU agricultural policy.[18] EC Regulation 2092/91 laid out the rules of accredited organic production and labelling, while 2078/91 and 2078/92 introduced subsidy support for organic produce (Baillieux & Scharpe, 1994; Moran, 2002; Gibbon, 2008; Padel, Röcklinsberg & Schmid, 2009; Stolze & Lampkin, 2009; Kallas, Serra & Gil, 2010; Klein & Winickoff, 2011; Brzezina et al., 2017) [19].

Simultaneously, the CAP reforms of 1992 and 2003 gradually moved away from production subsidies towards single farm payments calculated by acreage and other factors (Baillieux & Scharpe, 1994; Offermann, Nieberg & Zander, 2009). The CAP changes of 2003 and 2013 introduced and reinforced additional subsidies for farmers who take part in 'greening' activities (Offermann, Nieberg & Zander, 2009; Serebrennikov et al., 2020). In today's CAP agenda, the environmental aspect is emphasized more than ever (Darnhofer et al., 2010; European Comission, 2020), and the principles of organic farming correspond to these ambitions, as presented in the Organic Action Plan. [20]

During these years, numerous scholars argued the emergence of a 'post-productivist' or 'multi-functional' agricultural regime, juxtaposing it with the productivist regime. This dichotomy is highly debated, with some authors proposing a concept of neo-productivism instead, while others simply deny its empirical foundation (Knudsen, 2007; Wilson, 2007; Rønningen, Renwick & Burton, 2012). Nonetheless, this discourse seems to be the most dominant conceptualization of Europe's ongoing agricultural transformation. Wilson (2007) asserts that the most prominent strain of the discourse concerns agriculture's environmental implications. Considering the relationship of the organic concept to both the productivist regime and the later broader policy shifts of the EU, it follows that organic farming is more than a simple shift in production technologies. It can be understood as a significant component of agricultural structural change. At the very least, the rise of organic farming can be thought of as a predecessor to potential deep-cutting structural shifts. The suggestion of

[18] Until 1993, the EU was known as the European Community.
[19] EC Regulation 2092/91 was the legal precedessor of Regulation 834/2007.
[20] The new CAP also emphasizes agriculture's other supposed functions, such as binding together rural societies, attracting rural tourism and generating employment.

organic farming representing deeper structural shifts in European agriculture has been present in academic literature since the late 1990's (Gardebroek & Jongeneel, 2004).

The Organic Action Plan backs these notions. Besides environmental benefits, the targeted increase in organic farming is expected to bring about structural changes in EU agriculture. On one hand, the European Commission hopes for a general shortening of supply chains and increasingly localized processing and trade circuits (European Commission, 2021/1). On the other hand, the Commission (2020) notes that organic farming generally creates 10-20% more jobs per hectare than conventional agriculture, indicating an expected rise in agriculture's labour share. All in all, it seems that the ambitious plans regarding organic farming aim to partially roll-back several of the productivist era's structural developments.

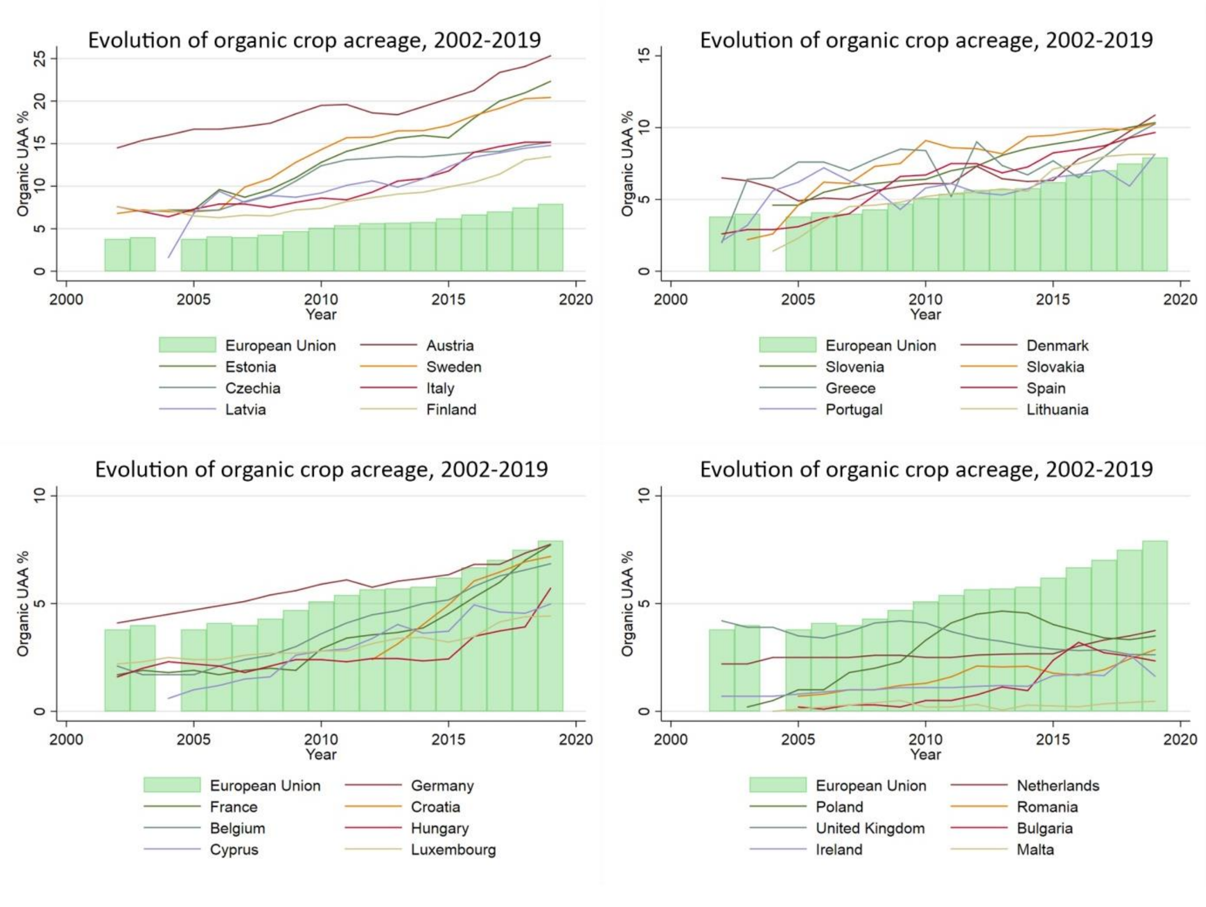

Figure 2: Evolution of organic crop acreage in the EU, 2002-2019. Source: author's visualization based on the Eurostat agricultural database.

In accordance with the aforementioned developments, European organic acreage has expanded considerably, but dispersion is not equal between countries. Today, about 8.5% of the European Union's total utilized agricultural area (UAA) is farmed organically.[21] Europe's organic leader is Austria, with Estonia and Sweden coming close behind. The lowest percentages are found in the UK, Ireland, Romania, Bulgaria and Malta, as per the Eurostat agricultural database.[22] Figure 2 above presents the evolution of organic crop acreage within the EU.[23]

The causes for between-country variation are not well understood by the literature. Using fixed-effects methods, this thesis won't contribute to this understanding, either. However, it is known that while EU legislation sets certain standards, the details of implementation are up to national decision-making (Michelsen, 2009; Offermann, Nieberg & Zander, 2009). The interplay of governments, interest groups and national organic organizations has resulted in varying policy environments across member states. The economic viability of organic farming also greatly depends on consumer demand, which results from an interplay of purchasing power, environmental moralities and the social perception of the organic concept itself (Baillieux & Scharpe, 1994; Dabbert, Häring & Zanoli, 2004; Andersen, 2011). Even with strong consumer demand, organic production requires well-developed processing and marketing channels, and international trade further confounds the picture (Dabbert, Häring & Zanoli, 2004). Figure 3 presents the evolution of per capita organic consumption in the EU.[24]

These notions create a set of conditions that are difficult to accurately quantify and operationalize for econometric research. Several scholars argue that due to this, the European expansion of organic farming requires analysing through qualitative, narrative-based research (Darnhofer, D'Amico & Fouilleux, 2019). While this thesis opts to join the ranks of studies employing an econometric approach, the validity of such claims cannot be denied.

[21] Estimated figures from 2019.
[22] Romania and Bulgaria comprise the Union's poorest countries, while Malta is a tiny island nation – the low percentage of organic farming is somewhat understandable there. However, the United Kingdom and Ireland are interesting cases, as both have relatively good attributes for a high prevalence of organic cultivation (Läpple & Kelley, 2013).
[23] Source: Eurostat. Figures represent percentage of organically farmed area of total crop area. The figures slightly differ from the ones used in the analysis, as those refer to total UAA instead of crop area . Grouping is according to order of percentages in 2019. Only these figures were annually available. Note the differences in the Y-axis and the proportion to the EU-average.
[24] Source: FiBL database. Note the differences in the Y-axis figures. FiBL data is approximative.

In either case, understanding the rise of organic farming is an important aspect of studying European agriculture's on-going transformation. Moreover, environmental protection and climate resilience are becoming more vital than ever, as reflected in the EU Organic Action Plan. Considering these points, understanding the expansion of organic acreage on a historical European level can be regarded as a crucial component of the European agricultural research agenda.

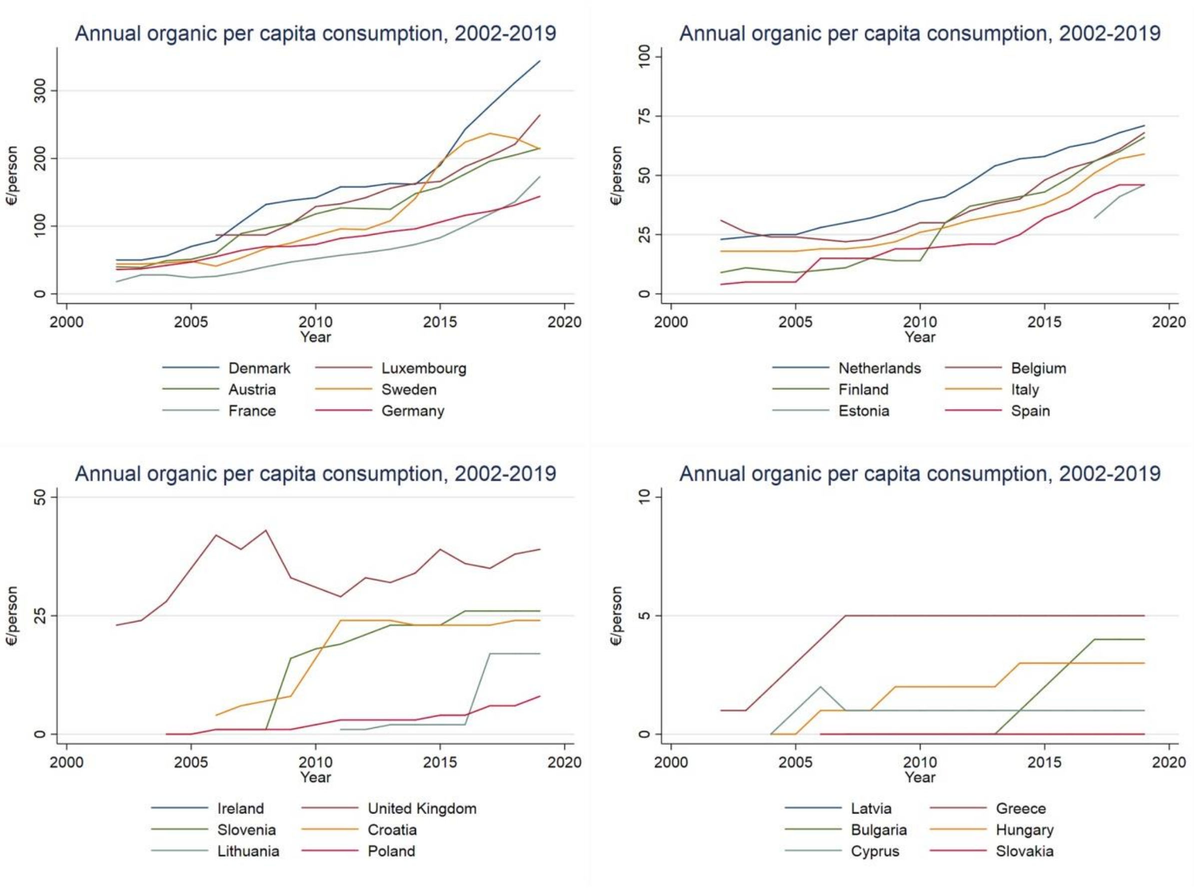

Figure 3: Evolution of per capita organic consumption in the EU, 2002-2019. Source: author's visualization based on the FiBL database.

2 Review of Theory

2.1 Farmers' Decision-Making

The conversion of farmland to organic production is a function of farmers' decision-making. While the full concept entails more, organic farming is usually understood as a choice of technology while looked at through a theoretical lens (Serebrennikov et al., 2020). What drives, then, a farmer's decision to switch to a certain technology? Interestingly enough, the history of agricultural economic theory regarding the issue shows quite parallel patterns with the evolution of European policy.

Before the mid-century, agriculture was mostly thought of as a backwards sector, gripped by culturally induced inertia and irrationality – for a seminal example, see Lewis (1954). The academic discourse searching for the drivers of agricultural technology adoption was kick-started by Griliches' 1957 hybrid corn study (Genius, Pantzios & Tzouvelekas, 2006; Chatzimichael, Genius & Tzouvelekas, 2014). During these years, it was T. W. Schultz (1964 in particular) who, using microeconometric methods, 'brought' farmers into the neoclassical mainstream, asserting that they were as rational and profit-motivated as any other agent. However, in doing so, Schultz essentially rendered agricultural economics the same as any other economics (Andersson & Rohne Till, 2018).

According to the Schultzian understanding, farmers would switch to a new technology as long as – and only if – it seemed economically more viable than its alternatives, provided it was known and available to them. This theoretical development coincides in time with the 'rationalization' and corporatization of European agriculture.[25] By the 1980's-1990's, behavioural economics had penetrated the agricultural field with the notion that besides profit, a wide range of political, social and other beliefs and motivations interact within the decision-making process (Burton, Rigby & Young, 2003). These motivations can be intrinsic or extrinsic: the former represent the decision-maker's internal morality, while the latter refer to

---

[25] Although as a Chicago hardliner, Schultz was very much against the various marked distortions European policy used to ensure food supplies (Andersson & Rohne Till, 2018).

real or perceived social pressures (Mzoughi, 2011). These theoretical developments coincide with the hypothesized appearances of 'post-productivist' and 'multifunctional' agricultural regimes in Europe (as per Wilson 2007). One of the earliest such papers specifically concerning agricultural technology adoption was Lynne (1995). Based on a Florida case study in which local authorities encouraged strawberry growers to change their irrigation methods, Lynne uncovered dual utility functions. One was the 'conventional' „I" utility, which interacted with a morally guided „We" utility in the governance of decisions. The concept of such a „We" utility is especially relevant when discussing environmental moralities and their effects.

Despite the existence of such papers, Burton, Rigby & Young (2003) note that most of the previous papers on the adoption of organic farming specifically had considered purely economic risk-reward approaches. However, Burton, Rigby & Young (2003) also review a wide array of theoretical as well as empirical works that suggest that organic farming adoption may depend on not only economic, but demographic (such as age, sex, education) and moral characteristics. By 2011, Mzoughi refers to these notions as „established" within the literature, citing a range of papers successfully challenging the hegemony of conventional neoclassical theory within the agricultural realm. Mzoughi (2011) asserts that it was from the late 2000's that an increasing number of papers began exploring non-financial intrinsic and extrinsic motivators of organic farming. The literature also acknowledges the potential conflict between intrinsic and extrinsic motivations. Salhi, Grolleau, Mzoughi & Sutan (2012) suggest that expected decreases in social status can hinder the diffusion of *a priori* win-win type technologies.

Farmer heterogeneity is an interesting aspect that bears important implications for this thesis. Läpple & Kelley (2013) assert that farmers with differing environmental attitudes have different utility functions, e.g. decision-making, as well. Best (2008) provides similar results. Relating to the conventionalisation hypothesis, the study suggests that early and late adopters of organic farming have different utility functions, with late adopters caring much more about financial factors than early ones. Moreover, Burton, Rigby & Young (1999) note that farmers that chose to certify as organic and those that don't but practically operate organically also have different weights in their decision-making processes.

Multi-sample econometric studies relying on farm-survey data, such as Chatzimichael, Genius & Tzouvelekas (2014), are pivotal in pinpointing country differences in decision-making and utility functions.[26] When pitching empirical studies where the same characteristics seem to have opposite effects, this notion of heterogeneity is useful to keep in mind. The decisions of farmers in different places and times might be governed by different factors.[27] This notion is important in the motivation of the thesis' aim to derive which previous results can be backed by a Europe-wide analysis.

Summing up, a certain cycle of theoretical thinking can be traced. In the beginning, agricultural economics – insofar as it existed – was unique in its rather negative assumptions of the sector. Schultz and the Chicago School managed to shoo away these assumptions at the cost of the distinct character of the sector's economic study. With the advance of behavioural economics, the growing influence of other areas of social studies, the assertion of heterogeneous actors and the boom in environmental considerations, agricultural economics gained back its distinct character. But this time, it did so without losing the quality of economic rationality it was imbued with in the 1960's. Even from an economics-based approach, the study of agriculture and organic farming opens up the possibility – and need – for interdisciplinary study. The full picture needs to cover not only profitability, but all the attitudes, relationships and socio-political structures concerning those involved.

2.2 Theoretical approaches in empirical studies concerning organic farming adoption

This paper will opt for an econometric approach. Serebrennikov et al. (2020) present a meta-study of econometrics-oriented papers that examine the drivers of organic farming within Europe. Instead of a broad overview such as the one presented above, Serebrennikov et al. (2020) list a few more concrete theoretical models for farmers' technology adoption. These are the Theory of Planned Behaviour (TPB, see Ajzen, 1991); the closely related Transactional Model of Human Action (see Willock, 1999); the Theory of Acceptance Criteria (see Sattler & Nagel, 2010); and the theories around innovation diffusion (see Baregheh, Rowley & Sambrook, 2009 and Rogers, Singhal & Quinlan, 2019).

[26] The referred study examines organic farming conversion in Greece and Germany. The study finds that different attitudes regarding the environment, subsidies and fellow farmers etc. affect decisions differently in the two samples. Farmer demographic and farm structural characteristics also have different effects.
[27] Although another possible explanation could be the variance between policy environments, as described in Section I.3.

In addition to the studies featured in Serebrennikov et al. (2020), a number of other empirical works were retrieved. As suggested by Serebrennikov et al. (2020), the TPB is the most prominent – yet it is still only employed by two studies (Kaufmann, Stagl & Franks, 2009; Läpple & Kelley, 2013). The various, yet closely-knit theories of innovation diffusion are mentioned in Läpple & Van Rensburg (2011). Burton, Rigby & Young (1999, 2003), Kallas, Serra & Gil (2010) and Mzoughi (2011) present a broad overview of general theory, similar to the one presented in 3.1. Genius, Pantzios & Tzouvelekas (2006), Läpple & Van Rensburg (2011) and Chatzimichael, Genius & Tzouvelekas (2014) focus on various theories surrounding the role of social learning and information acquisition. However, Pietola & Lansink (2001), Gardebroek (2006), Läpple (2010), Tiffin & Balcombe (2011), Läpple & Kelley (2015), Dinis et al. (2015), Brzezina et al. (2017) and Chmielinski, Pawlowska, Bocian & Ousch (2019) only refer to a minimal amount of theory, or no theory at all.

About half of the retrieved papers touch on theory only marginally, and as Sections 3 and 4 will present, the literature provides contradictory expectations regarding the coefficients' direction for many of our tested variables.[28] Accordingly, this thesis will not pick a specific theoretical background. This choice is backed by the nature of the data available for this thesis. All of the retrieved empirical studies relied on farm-level survey data; this study employs aggregate Eurostat figures for farm characteristics. This limits the operationalization of any specific group of factors that would justify the use of a focused theoretical approach. Rather, Section 3 will overview the determinants of organic farming dissemination identified by earlier empirical research. Additionally, several factors not yet quantitatively examined within the literature will be added and explained, partially representing the extrinsic motivators described in 2.1. Of these factors, the dataset explained in Section 4 attempts to approximate and operationalize all that are possible to do so on a European level. Nonetheless, the implications of the theoretical evolution presented above are reflected in these variables and their interpretations.

[28] As an author's note, it also seems that regardless of the chosen theoretical viewpoint; the empirical models, the selection of variables, the results and their interpretation can look rather similar in the retrieved studies.

3 Drivers of organic farming adoption and expansion

3.1 The adoption process

The rapid rise of organic farming covered in Section 1 has had numerous driving factors that prompt farmers to adopt organic farming and opt for certification. Before going on, it may be useful to briefly overview the characteristics of the adoption process itself. When a farmer decides to adopt organic practice, they must abide by the guidelines set out in EC Reg. 834/2007 and turn to the nation-specific authorities to begin the certification process. The certification costs are usually technically borne by the farmer, but depending on member state, CAP subsidies may cover these (Padel, Lampkin & Foster, 1999). The conversion period itself is a highly risky time, with a long pay-off interval. Yields may potentially drop, new technologies may require time to learn and implement efficiently, but the premium prices associated with organic produce are not available at least until the first harvests after a successful certification (Baillieux & Scharpe, 1994; Bouttes, Bancarel, Doumayzel, Viguié, Cristobal & Martin, 2020).[29] In many cases, adoption can be foregone due to fears of being overwhelmed by weeds and pests in the first months without compensation (Schneeberger, Darnhofer & Eder, 2002).

On the other hand, Bouttes et al. (2020) find that even during the financially risky conversion period, organic farming increases farmers' satisfaction. In an earlier study, Bouttes, Bize, Maréchal, Michel, Cristobal & Martin (2019) also find that in the long run, organic practice can significantly increase productivity and decrease dependence on CAP subsidies – all in all, organic farming can potentially reduce risks once the initial period is successfully navigated.[30] Nonetheless, the initial risks and difficulties are present, and organic conversion is a serious decision with long-term consequences.

[29] As explained earlier, organically grown produce can only be sold as organic once the official label has been „earned" through official certification.
[30] Both studies use a sample of dairy farmers, these results may or may not carry over to farmers dealing mostly with plants or meat animals.

Serebrennikov et al. (2020) review 11 empirical studies to identify five distinct groups of drivers. These are: farmer and household characteristics; farm financial and structural characteristics; farmer attitudes and beliefs; sources of information and communication channels; institutional and legal attributes. Upon a wider examination of existing literature, it can be confirmed that these categories aptly cover most of the empirically examined organic driving factors.[31] However, two additional categories of factors may be added. One concerns market infrastructures and sales channels for organic products. The other, closely related group represents the aforementioned extrinsic motivators of behavioural economics. These are the salient attitudes regarding environmental concerns and organic farming within farmers' respective societies.

The main empirical part of this thesis will consider numerically operationalizable factors, which results in having to omit most policy implications. However, the role of policy can and should not be underplayed. The next sub-section will first briefly overview the critical role that European and national policy developments, mostly subsidy programs, play in organic farming adoption. While most policy-related driving factors cannot be implemented in the empirical section, they have to be kept in mind for the full picture.

3.2 Policy drivers – an overview

By institutional environment, Serebrennikov et al. (2020) only consider subsidies. Financial support in EU and national subsidy schemes includes a one-off conversion payment and continued maintenance payments, both calculated by farm organic acreage. Moreover, farmers also receive investment grants and other payments for partaking in animal welfare and agri-environmental services (Stolze & Lampkin, 2009; Offermann, Nieberg & Zander, 2009).[32] Since 2003, maintenance subsidies are decoupled from crop production (Offermann, Nieberg & Zander, 2009). It must also be remembered that while European policy provides guidelines, the exact amount and distribution of subsidies between sectors, as well as eligibility requirements and certification processes vary by member state (Michelsen, 2009; Offermann, Nieberg & Zander, 2009).

[31] A total of 18 econometric studies were processed. Serebrennikov et al. (2020) use a limited keyword-based filtering approach. The review of studies' bibliographies, as well as a more extensive online search, resulted in the retrieval of 7 additional studies.
[32] Non-organic farmers may also get payments for greening activities. Also note that since 2003, these subsidies are paid out as annual single farm payments, while beforehand they got to farmers as separate payments.

Empirical research by Pietola & Lansink (2001), Genius, Pantzios & Tzouvelekas (2006), Kaufmann, Stagl & Franks (2009), Läpple & Kelley (2013), Chatzimichael, Genius & Tzouvelekas (2014) and Chmielinski et al. (2019) reveal a positive and significant effect of subsidies on potential conversion.[33] Furthermore, Zander, Nieberg & Offermann (2008) and Offermann, Nieberg & Zander (2009) assert that these direct payments are an important factor in the financial viability in EU organic farming. According to Zander, Nieberg & Offermann (2008), subsidies contribute 4-6% of gross organic farm output in Western Europe, and 4-19% in Eastern Europe. For family farms, this can be up to 10-30% and 75% respectively. In contrast, Offermann, Nieberg & Zander (2009) find that organic farming was the most dependent on subsidies in the United Kingdom, Germany and Denmark.

However, subsidies are not everything. The most extensive study evaluating CAP effects on organic farming adoption is Sanders (2011). Both quantitative and qualitative analyses reveal subsidy policy to be a major driver. Nonetheless, they also find that these policies can do little without well-developed markets, consumer demand and a general trust towards policies. Chatzimichael, Genius & Tzouvelekas (2014), Brzezina et al. (2017) and Chmielinski et al. (2019) also warn that subsidies in themselves are not the strongest factors, and they alone will not be enough to foster widespread adoption. Similarly to Sanders (2011), they instead urge informational campaigns both across farmers and society, and a promotion of organic market infrastructure and sales channels. Moreover, Brzezina et al. (2017) warn that increasing subsidies might also reinforce inefficient loops and further increase farm dependence and vulnerability.

In formulating policy packages, cooperation between stakeholders and authorities is critical (Sanders et al., 2011). A case study by Moschitz, Stoeva, Slavova, Pickard, Georgieva & Stolze (2018) explains how the Bulgarian organic strategy failed to encourage conversion figures policymakers hoped for. As the main cause of this failure, they identify strictly top-down policymaking. Besides that no organic farming association existed previously in the country, policymakers completely ignored consumers and farmers. However, while a well-crafted and coherent organic strategy is beneficial, the literature suggests that the presence or lack thereof does not explain between-country differences (Michelsen, 2009; Sanders, 2011).

[33] The results were identified as statistically significant based on the 10% significance level and above.

3.3 Empirically examined non-policy drivers in the literature

The following section provides an overview of quantifiable non-policy type drivers that have been examined within the empirical organic farming literature. Note that not every factor or group of factors presented within this literature review is included in this thesis' analysis. The relevant variables that could be operationalized are explained in Section 4.1. All of the retrieved empirical studies consider limited samples usually confined to a single county or region, most often examined over shorter time periods. Samples may differ not only regarding space and time, but also type of farming operation – see Appendix E. Accordingly, the studies are often at odds regarding the direction and magnitude of certain coefficients. From our theory overview, the notion of farmer heterogeneity in decision-making, as well as the multi-faceted nature thereof, is critical. It is possible that while all of the mentioned studies managed to retrieve internally valid results regarding their sample, potential spatial and temporal variation in decision-making functions may inexorably lead to opposing results.

Simplifying the classification approach of Serebrennikov et al. (2020), drivers examined by the literature will be grouped into two main groups: farm structural characteristics and farmer demographic characteristics. Farm structural characteristics include farm size; land tenure; type of agricultural operation; labour; family labour and household characteristics; off-farm activities and non-commercial production; and location. Farmer demographic characteristics include age; sex; education / training / know-how; social circles and information acquisition; environmental attitudes; economic attitudes and risk aversion. It must be noted that there can be significant overlap between drivers and categories: for example attitudes, location and social circles are highly intertwined through spatial spill-over effects.

3.3.1 Farm structural characteristics

Farm size

Farm size is one of the most frequently featured variables. Generally, the coefficient can point either way. Two salient explanations exist to account for the potential effects. One argues that farm size is a proxy for farm financial strength, and thus potential buffering for risks. The other one argues that larger farms are reluctant to adopt a risky new technology due to potential yield losses, presumably on the notion that they have more to lose (Serebrennikov et al., 2020). Heavy usage of machinery and external inputs can also provide economies of scale that benefit larger farms more.

Genius, Pantzios & Tzouvelekas (2006), Läpple & Van Rensburg (2011) and Chmielinski et al. (2019) report farm size to pose a significantly negative effect on organic farming adoption.[34] Meanwhile, Schneeberger, Darnhofer & Eder (2002) find that organic farms are bigger on average; Pietola & Lansink (2001) report a positive significant effect and Chatzimichael, Genius & Tzouvelekas (2014) find a positive significant effect in their Greek sample. On the other hand, Burton, Rigby & Young (1999), Burton, Rigby & Young (2003), Läpple & Kelley (2015) find no significant effect. Chatzimichael, Genius & Tzouvelekas (2014) also find no significant effect in their German sample.

The stark differences between individual studies may point us to two potential directions. On one hand, farm size may have different connotations and consequences across the samples, due to the differences in space, time, and type of agricultural operation. On the other, it may be possible that introducing a quadratic component may reveal a nonlinear relationship.

Land Tenure

The effects of land tenure on farmer's decision making are a well-studied aspect of agricultural economics. Many studies find that farmers who own their land securely are generally more likely to make investments that require longer time-periods to pay off (Fenske, 2011). Moreover, they might be more attached to the land itself, thus more likely to engage in ecologically friendly practice for its own sake. Despite this, only one empirical study (Chmielinski et al., 2019) examines the effect of land tenure on organic farming adoption. The findings of Chmielinski et al. (2019) confirm the generally established points. Land tenure has a positive significant coefficient – after controlling for total land size, the percentage of owned land has the most sizeable marginal effect.

Type of Agricultural Production: Land Type, Livestock Density

The type of agricultural operation is tied closely to the kind of land present on the farm. While grazing usually takes place on permanent grassland, crops are grown on arable land (Eurostat classification). Both of these factors are touched upon by the literature, albeit not extensively.

Pietola & Lansink (2001), Läpple (2010), Läpple & Van Rensburg (2011) and Läpple & Kelley (2015) all find that livestock density – head of livestock per area – has a significant

[34] In this section, significant refers to the coefficient reaching at least the „one-star" confidence level, generally 95 or in some cases 90 percent, as identified by the respective authors.

negative effect on organic farming adoption. Läpple (2010), Läpple & Van Rensburg (2011) and Läpple & Kelley (2015) consider drystock farms, telling us little about the differences between types of agricultural operations. Pietola & Lansink (2001), however, suggest that farms that are specialized on animal husbandry have a lower chance of conversion.

On the contrary, Chmielinski et al. (2019) find that dairy and other animal-grazing focused farms have the highest chances for conversion. Moreover, in Austria, most organic operations are permanent grassland-based cattle farms in the mountainous regions (Schneeberger, Darnhofer & Eder, 2002). Läpple & Kelley (2013) assert that extensive methods of agriculture, such as cattle grazing, favour organic conversion since they already share several of its characteristics.[35] The negative coefficient of livestock density in Läpple (2010), Läpple & Van Rensburg (2011) and Läpple & Kelley (2015), only looking at dairy farms, supports this notion.[36] Bouttes et al. (2019) also affirm that dairy farms relying on extensive grazing opposed to external feed concentrates change the least during conversion. These notions suggest that operationalizing dairy cattle density and general livestock density separately may be an appropriate strategy for the most accurate results.

Labour

The main technological aspect of organic farming is the replacement of off-farm inputs with on-farm management practices. This renders organic farming a labour-intensive method compared to conventional modes of operation. Accordingly, the literature cites labour as a critical factor.

Kallas, Serra & Gil (2010) asserts that the more labourers a farm has per acre, the higher the chances of organic conversion. Schneeberger, Darnhofer & Eder (2002) and Brzezina et al. (2017) find that one of the main barriers to organic adoption is the risks and fears associated with additional labour requirements. Pietola & Lansink (2001) suggest that the more labour-intensive a farm's conventional operations are, the less likely it is for the farm to convert.

These notions suggest that employed labour and the labour base available for agriculture in the surrounding area are both important factors in organic dissemination. Brzezina et al. (2017) also add that labour gets more costly as less of it is available. As for future research, perhaps the relative price of agricultural labour could also be worth examining. Moreover,

[35] Ireland, however, has one of the lowest conversion rates despite its agricultural sector mostly consisting of extensive, cattle-based operations on permanent grassland. This „mystery" is in the focus of their study. (Läpple & Kelley, 2013).

[36] The more extensive a cattle-based operation is, the more grazing space it will have per animal.

mechanisation could also be a potential factor, as farms that have invested more into machinery may be reluctant to switch to technologies requiring more manual labour.[37]

Family Labour, Farm household size and status

On one hand, the study of family size and household characteristics regarding organic conversion seems to be closely tied to the issue of labour. Kallas, Serra & Gil (2010) find that family labour employment has a positive significant effect on organic conversion, whereas Burton, Rigby & Young (1999, 2003) and Tiffin & Balcombe (2011) present similar results regarding household size. This may be due to increased trust, loyalty and co-operation within family units compared to regular labour. Läpple & Kelley (2015), however, challenge these results by finding that household size has no significant effect on adoption chances. On the other hand, Schneeberger, Darnhofer & Eder (2002) examine household characteristics from the perspective of succession. They find that lack of a successor is a serious barrier to organic adoption. Thus, the literature generally suggests that *ceteris paribus,* the more family-based a spatial unit's agriculture is, the higher we can expect adoption rates to be.

Off-farm activities and non-commercial production

Non-agricultural entrepreneurial activity is another explored factor within the literature. Kallas, Serra & Gil (2010) find a positive association between such operations and likelihood of organic adoption. Läpple & Van Rensburg (2011) and Läpple & Kelley (2015), however, find no significant effect thereof. Moreover, Läpple (2010) finds that such activities actually increase the chances of abandonment of organic practice, presumably due to the higher opportunity costs of labour. Non-commercial production is examined by Burton, Rigby & Young (1999, 2003). They find that the more a farmer wants to maximize own (including the household's) consumption, the more likely they are to adopt organic farming. This could be due to either the associated health benefits with organic farming, or the decreased magnitude of commercial risks caused by conversion.

Location, Region, European East/West divide

The Bulgarian case-study of Moschitz et al. (2018) reveal that local contexts have to be taken into account, both when designing policy and when examining regional differences in adoption. In Western Europe, organic farming had been developing for almost a hundred years, and by the time EC 2078/92 was implemented, a wide range of networks existed, covering producers, consumers, policymakers and researchers alike. In Eastern Europe, on the

[37] Farm labour intensity, however, will be the only factor included, as allowed by available data.

other hand, organic farming was largely unheard of before the end of the twentieth century. Moreover, Western Europe is also ahead in terms of social capital, manifesting in better multilateral trust measures between stakeholders when compared to the former Eastern Bloc. The importance of trust and social capital is emphasized by Sanders et al. (2011) and Moschitz et al. (2018).

Offermann, Nieberg & Zander (2009) also note that organic subsidy payments are ’phased in’ over a 10-year period from the time of ascension to the EU. In the first year of EU membership, new entrants gain access to only 25% of CAP funding, which grows to 100% over a 10-year period. This is to further exacerbate the differences between the EU15 and later entrants. Moreover, Michelsen (2009) reports that conflicts of interest between conventional and organic actors can have severe effects on public organic expenditure. In his sample, most Eastern-European countries that ascended in 2004 had high levels of such conflict, resulting in lower relative levels of expenditure than in their Western counterparts.

Within-country variation should also be considered. The only econometric study to explicitly assess the issue by including a regional categorical variable was Chmielinski et al. (2019). Their positive and significant results indicate that intra-country location has an effect that other variables can’t explain. Läpple & Kelley (2015) examine spatial clustering of organic farms in Ireland. They find that due to spillover effects in attitudes, as well as informational and relationship networks that tend to be localized, spatial clustering of organic farming is a prominent phenomenon. Parra López & Calatrava Requena (2005) assert that regardless of individual characteristics, the location of the farm within the country is a very strong indicator of the time of organic conversion. Moreover, Serebrennikov et al. (2020) suggest that environmental variables, such as aridity and soil erosion can also be an indicator of conversion chances. These notions support the thesis’ choice to employ fixed-effects panel models on both country and regional levels.

3.3.2 Farmer demographic characteristics

Sex

Several studies examine the effect of the farm manager's / household head's sex on organic farming adoption. The only study not to find a significant effect is Mzoughi (2011), although even in his sample, females have a much higher share of organic farming. Chatzimichael, Genius & Tzouvelekas (2014) present that females are less likely to convert in both their Greek and German samples, although they admit that this might be due to bias arising from the low overall number of female farmers in the Greek sample. On the other hand, Burton, Rigby & Young (1999, 2003) and Tiffin & Balcombe (2011) find sex a very strong determinant of adoption. In Tiffin & Balcombe (2011), the farm manager being female has one of the most sizeable and significant coefficients. Similarly, Burton, Rigby & Young (1999, 2003) report that females have a conditional probability of conversion almost two and a half times greater than males. Additionally, Dinis et al. (2015) asserts that female-led organic farms tend to be less 'conventionalized' than their male-led counterparts.

Age

Farmer age is found to have a negative significant effect in Burton, Rigby & Young (1999), Kallas, Serra & Gil (2010), Läpple & Van Rensburg (2011) and Läpple & Kelley (2015). Genius, Pantzios & Tzouvelekas (2006) report this negative effect to operate through reduced willingness or ability to seek out new information. Läpple (2010) and Mzoughi (2011) find no significant effect. However, Mzoughi (2011) also asserts that organic farmers are younger in general.

However, Chatzimichael, Genius & Tzouvelekas (2014) provide additional insight on the issue by introducing a quadratic component. In their Greek sample, age appears to have a nonlinear, reverse-U-shaped effect, meaning that middle-aged farmers are the most likely to convert, while the chances decrease as we move towards the age-extremes. The youngest of farmers may simply lack the know-how or financial buffering ability to make the conversion. On the other hand, farmers approaching retirement might have lowered chances through Genius, Pantzios & Tzouvelekas's (2006) information-acquisition effect, increased risk aversion, different environmental attitudes or simply due to galvanized habits.

Uniquely in the German sample of Chatzimichael, Genius & Tzouvelekas (2014), age is linearly positive and significant; the quadratic term has no significant effect. This may be due to the fact that farmers tend to have more savings as they age, which could act as buffer capital against risks. On the other hand, age could also be a proxy for agricultural experience, which could decrease the technical difficulties of conversion.

However, none of the studies explicitly differentiate between age and year of birth. Regarding environmental attitudes, the time of one's early socialisation, as well as salient attitudes among one's peer groups may be an important aspect. In most of the empirical studies, this is accounted for by explicitly including some form of environmental attitude variable. This thesis' estimation strategy will also correct for possible bias arising from this issue.[38]

Education, know-how, training

Organic farming is a very knowledge-intensive sector, where exchange of knowledge is crucial both for dissemination and continued successful operation (Burton, Rigby & Young, 1999; Bliss, Padel, Cullen, Ducottet, Mullender, Rasmussen & Moeskops, 2019; Läpple & Van Rensburg, 2011). Morgan & Murdoch (2000) conceptualize the rise of organic farming within the framework of the 'learning organization' and the 'knowledge economy'. Moreover, they suggest that conventional and organic farming have completely different knowledge-chains. In conventional agriculture, knowledge forms a backwards, top-down chain of one-size-fits all information, becoming one of the many external inputs. In organic farming, however, knowledge is highly localized: farmers must be familiar with the characteristics of their own land and seasons to operate efficiently; once more becoming „knowing agents". Whereas Achuelo (2016) asserts that lack of information and agricultural know-how is one of the primary deterrents of organic farming adoption.

Based on these assertions, education, farming experience and agricultural training could be expected to have an effect on adoption. They can be expected to operate in different ways, however. Agricultural experience and training, as well as agriculture-oriented higher education provide hands-on, immediate know-how on how to operate a farm, and potentially also on the ecological foundations of organic farming. Whereas education might have a positive relationship with willingness and ability to seek out and process new information.[39]

However, the presence of higher education in farmers does not seem to have a significant effect in the literature (Burton, Rigby & Young, 1999; Burton, Rigby & Young, 2003; Läpple & Kelley, 2015). Mzoughi (2011) finds that the high school dummy has a positive significant effect on organic farming adoption – however, he does not specify the educational attributes

[38] Year of birth is time-constant, therefore filtered out by fixed effects.
[39] This relationship may not necessarily be causal, in which case, education could serve as a proxy.

connected to the dummy's 0 value. Chatzimichael, Genius & Tzouvelekas (2014) may clarify this with the finding that years of education have a positive linear, and a negative quadratic coefficient. A possible explanation could be that up to a certain point, the positive effects on learning capabilities increase chances, but people who invested in attaining several years of higher education would rather base their choices more on profitability to recover the costs.

Interestingly, hands-on farming experience is only investigated by Läpple (2010), who finds a positive significant coefficient towards adoption. This could be explained by that farmers who are more confident with farming practice itself see less of a risk in the technicalities of organic farming. Specifically agriculture-oriented training and education is not examined by either of the retrieved studies.

Social circles and information acquisition

As established, organic farming is highly information-intensive. Besides education, training and hands-on experience, farmers may also exchange knowledge within social circles, as well as seek out new information from various other sources. The effects of attitudes, possibilities and methods thereof have been examined by Burton, Rigby & Young (1999, 2003), Genius, Pantzios & Tzouvelekas (2006), Kaufmann, Stagl & Franks (2009), Kallas, Serra & Gil (2010), Läpple (2010), Läpple & Van Rensburg (2011), Tiffin & Balcombe (2011), Läpple & Kelley (2013, 2015) Chatzimichael, Genius & Tzouvelekas (2014), Dinis et al. (2015), Bliss et al. (2019) and Serebrennikov et al. (2020), making it one of the most prominent features in the literature.

Burton, Rigby & Young (1999, 2003), Läpple & Van Rensburg (2011), Tiffin & Balcombe (2011) and Läpple & Kelley (2015) empirically assert that peer-to-peer learning is more conducive to organic dissemination than 'conventional' sources. Farmers who mostly get their information from other farmers have a higher chance of adoption than those who prefer advisory services, retailers, consumers, or media such as TV/internet/newspapers.[40] Moreover, Genius, Pantzios & Tzouvelekas (2006) and Läpple & Van Rensburg (2011) find that adopters of organic farming tend to use significantly more external information in their decision-making than non-adopters. However, according to Läpple & Van Rensburg (2011), this effect is mostly due to the attitudes of late adopters, suggesting that early adopters convert on a more ideologically-driven basis.

[40] While these points are useful to emphasize the importance of peer-to-peer learning, the negative significant coefficients of media sources in Läpple & Van Rensburg (2011) and Läpple & Kelley (2015) are naturally dependent on the contents of such media, thereby on cultural differences across space and time.

Läpple & Van Rensburg (2011) as well as Läpple & Kelley (2015) find that knowing another organic farmer has a significant positive coefficient on adoption chances. Kallas, Serra & Gil (2010) find that proximity to other organic farms also has a positive significant coefficient on conversion. Läpple & Kelley (2015) implicitly suggest the importance of peer-to-peer communication in asserting that attitudes have strong spatial spillovers, resulting in the aforementioned spatial clustering of organic farms. Chatzimichael, Genius & Tzouvelekas (2014) provides further insight into this phenomenon. In their Greek sample, knowing a homophilic adopter has a four times greater chance than knowing an economically successful one or a 1000-Euro increase in conversion subsidies.[41] However, in the German sample, the homophilic effect is much less pronounced, and subsidy increases tend to be relatively more efficient, highlighting the potential cultural heterogeneity in decision-making.

Perhaps unsurprisingly, social influence and peer-to-peer interaction can cut both ways. As noted before, Salhi et al. (2012) assert that win-win type technologies can be hindered by negative peer pressure. Correspondingly, Läpple & Kelley (2013) note that despite favourable conditions, Ireland has very low conversion rates – they partially find the answer in that most Irish farmers perceive a negative social perception of organic practice.

Environmental attitude

Conversion to organic farming may be a risky endeavour in many cases, whereas its profitability is not necessarily above that of conventional farming. It comes, however, with a plethora of supposed environmental benefits. Therefore, moral attitudes concerning the environment are one of the most saliently examined drivers in the literature.

Burton, Rigby & Young (1999, 2003), Kallas, Serra & Gil (2010), Läpple (2010), Läpple & Van Rensburg (2011), Mzoughi (2011) and Läpple & Kelley (2013, 2015) all operationalize environmental attitudes to find that it usually has one of the most sizeable positive significant coefficients on adoption chances. Mzoughi (2011) picks apart environmental attitudes into intrinsic and extrinsic motivators, examining the desire not to feel guilty and the need to show environmental commitment towards others separately – both are positive and significant. Läpple (2010) also finds that organic farmers with higher environmental concerns are less likely to quit and revert to conventional practice. Besides moral concerns, Burton, Rigby & Young (1999, 2003) also review non-moralized cognitive perceptions: they ask farmers

[41] Homophilic meaning one with similar characteristics to the farmer whose adoption likelihood is under examination.

whether they think conventional agriculture is indefinitely sustainable or not, and also whether they think if only organic farming can satisfy food needs on the long term. Presumably, these perceptions are highly correlated with each other, as well as environmental morality. In the 1999 regressions, both have a positive significant coefficient, while in the 2003 revision they lose significance.

Economic attitude, risk aversion

Besides attitudes concerning environmental questions, farmers' economic orientation is also a well-explored factor. It has been established earlier that organic conversion represents an array of risks. Accordingly, risk aversion is negative and significant with regards to conversion likelihood in every study that examines it (Gardebroek, 2006; Kallas, Serra & Gil, 2010; Mzoughi, 2011; Läpple & Kelley, 2015).

Profit orientation, perhaps closely linked to risk attitude, is also an important factor. Läpple & Kelley (2015) and Mzoughi (2011) assert that more profit-oriented farmers are significantly less likely to adopt organic practice. Moreover, there is differentiation between early and late adopters: in Läpple & Van Rensburg (2011), this effect is only significant for early and medium adopters, but not for late ones. This once again suggests that as time progresses, new conversions are more and more a matter of economic interest; those who convert out of environmental concerns may tend to do it as soon as it becomes viable to them. Pietola & Lansink (2001) also provide an interesting point: farms with lower returns are more likely to adopt organic farming than those with high profitability. This may very likely have to do with attitudes to risk and profit, as farms that already reap good profits have a reason to be reluctant to adopt risky new technologies.

3.4 Gaps in the empirical literature, additional factors

The past sub-sections provided a comprehensive overview of existing empirical literature concerning the adoption of organic farming. Two important issues can be identified. First, as noted before, organic dissemination is mostly understood as a technology adoption model. Technology adoption, on the other hand, is a matter of both supply and demand. This notion may be especially relevant for organic farming. Adoption opens up the production of a slightly differentiated range of products, as opposed to simply changing the conditions of producing products already available to the producer. As follows naturally, organic products will then have their own distinct demand patterns and market opportunities. While the empirical literature takes a thorough and exhaustive account of potential supply-side variables, none of the retrieved studies synthetize these with – or focus on – demand-side factors.

The wider literature, on the other hand, attributes great importance to consumer demand and organic market infrastructures. To a much lesser extent, it also mentions societal attitudes regarding environmental issues. It is perhaps due to the survey-based nature of most empirical studies that these factors were not yet considered by empirical analysis. While using aggregate data to compare regional entities may reduce the strength of our models, it also allows for the inclusion of these factors as control variables. While this thesis' analysis still focuses on supply-side characteristics, it is the first empirical study on the topic to synthetize these with demand-side variables – therefore, it is an important step towards filling this gap in the literature. Sections 3.4.1 and 3.4.2 expand further upon these groups of factors.

Another potential 'gap' of the literature is the often contradictory results associated with each variable. Regarding this issue, the thesis contributes in two ways. First, it employs a Europe-wide dataset, eliminating problems stemming from potential heterogeneities between the limited samples scattered both temporally and geographically. Second, it is also the first to employ quadratic coefficients regarding farm size.[42] Therefore, this thesis will help 'smooth out' certain contradictions in empirical literature on the continental level.

3.4.1 Markets and consumer demand

While economic attitude is important, the basic feasibility of any enterprise *per se* boils down to the availability of markets for its produce. As consumer demand and organic infrastructures are an important aspect of the economic viability of organic farming, they stand in connection with farmers' economic attitudes.[43] Komorowska (2014) notes that organic acreage is largest in countries where domestic demand also seems to be large. On the other hand, Dabbert, Häring & Zanoli (2004) claim that the order of countries regarding acreage and market size do not necessarily follow each other, presumably due to differences in land use intensity. In any

[42] See Section 4 for the specifications of the data.
[43] As the Data section will reveal, economic viability is not possible to properly proxy through aggregate Eurostat data. Thus, this category will partially help cover those gaps.

case, for continued expansion of organic farmland, it is intuitively obvious that markets must keep pace with previous expansions.

Andersen (2011) lists price premiums as one of the most significant barriers to the expansion of organic consumption. Dabbert, Häring & Zanoli (2004) presents the huge differences in organic price premium levels across Europe. They go on to assert that such premiums stem not only from the actual costs of production, but also depend on the efficiency and extent of processing, distribution and sales infrastructures for organic produce, which differ greatly across countries. To pay a price premium, consumers must perceive the higher value of organic produce, which depend on consumer values and priorities, also varying by country (Dabbert, Häring & Zanoli, 2004).

Dabbert, Häring & Zanoli (2004), Andersen (2011) and Eden (2011) suggest that in general, quality – health, freshness, taste etc. – is at least as, but usually more, important as the environmental and moral aspects of organic produce for consumers. Despite this, the organic label refers exclusively to the methods of production, not the product itself. Accordingly, the literature has noted that there tends to be confusion among consumers about the meaning of „organic" (Baillieux & Scharpe, 1994; Eden, 2011). Moreover, Lobley, Butler & Winter (2013) find that ethically guided consumption shows a stronger preference for local produce than for organic. Consequentially, it may be useful to know to what extent local and organic overlap in different regions.

In either case, demand for organic produce is projected to outpace organic supply in Europe (Komorowska, 2014; Brzezina et al., 2017). But when translating this to acreage growth projections, international trade must be taken into account. For example, Komorowska (2014) explains the growth of Polish organic orchards with a rise in German demand. It is also a serious question that to what extent imports from established foreign organic sectors can strangle the growth of domestic acreage in laggard countries. As long, intercontinental organic supply chains stretching all the way to the tropics are becoming more widespread (Fouilleux & Loconto, 2017), trade competition may pose a threat to European acreage growth altogether.

3.4.2 Salient attitudes across farmers' respective societies

While the attitudes of farmers, as well as their perception of other farmers' attitudes have been widely studied, little is known about the effects of the environmental attitudes of farmers' non-agricultural societal surroundings. These attitudes may very well act as part of consumer demand patterns; therefore, these two groups of factors are potentially interrelated. Moreover, by operationalizing such variables, one could potentially proxy extrinsic motivators outlined by general theory, as presented in 2.1. However, Andersen (2011) suggests that even with 'politically green' people, the superiority of organic regarding environmental morality is often questioned. Insofar as farmers themselves believe that organic practice is environmentally beneficial, however, societal attitudes, contacted through personal networks or media, can also represent extrinsic motivation (e.g. peer pressure) for farmers to convert. Naturally, when operationalizing such variables, several assumptions must be made about what they actually represent, and how their coefficients can be interpreted. This will be discussed in the Data section.

4 Data and Methods

4.1 Data

Most of this thesis' agricultural data is retrieved from Eurostat's open agricultural database. Eurostat aggregate farm data is based on the European Farm Structure Survey (FSS). The original FSS datasets are based on surveys targeting individual holdings, collected by all member states individually. The surveys take place according to European legislation, so that the resulting datasets are as harmonized and comparable as possible (Eurostat, 2019). Data from the FSS is available from 2005, 2007, 2010, 2013 and 2016. Due to confidentiality issues, Eurostat aggregates all data by country and / or region. This thesis will employ data at country (NUTS0) and NUTS2 levels.[44] The FSS' survey population covers all agricultural holdings which meet a set of minimum requirements set by national authorities based on European legislation (Eurostat, 2019).

Apart from agricultural data, Eurostat also provides certain country-level control variables to measure the most basic structural differences. Country-level agricultural labour data was retrieved from the World Bank Open Dataset. Country-level data on the development of consumer markets is mainly provided by the Research Institute of Organic Agriculture (FiBL).[45] When constructing market data, FiBL relies on national statistical offices, governments, certifiers and the private sector (FiBL, 2020). The study also utilizes data from the European Social Survey (ESS). The ESS is a cross-national, bi-annual, academically driven survey that measures the attitudes, beliefs and behaviours of populations from the EU and its proximity. ESS data will be utilized from 2004, 2006, 2010, 2012 and 2016. While ESS data is based on surveying individuals, this thesis will use country-level aggregates. ESS employs statistically representative sampling methods, minimizing possible bias from aggregation. Prior to data extraction, the necessary weighting procedure described in Kaminska (2020) was applied.

[44] Depending on availability. NUTS levels will be specified for each variable further in the section.
[45] The abbreviation stems from the German name, *Forschunginstitut für Biologischen Landbau*. Based in Switzerland, FiBL is one of the world's leading organic farming research centres.

The thesis' panel dataset includes 27 countries and 243 NUTS2 regions. The coverage of the data is the current EU 27, plus the United Kingdom and minus Greece.[46] The UK was included due to having been part of the EU during the examined period. Greece was dropped due to suspicious data discrepancies, pointing to potential errors in either the gathering or aggregation processes.[47] The various specifications will examine the five FSS time points from 2005 to 2016. Croatia, Romania and Bulgaria joined the EU after the initial FSS wave of 2005, but they were included all the way nonetheless.[48] Within the empirical research of the topic, this thesis is unique in its coverage, reflecting the notion that the spread of organic farming can be examined as a large-scale historical process.

As noted before, not every factor presented in the literature review could be operationalized on an aggregate European level. On the farm level, no suitable variables could be constructed regarding household size and status, and the extent of non-commercial production. On the individual farmer level, environmental and economic attitudes, as well as the role of social circles and information-acquisition behaviours, had to be omitted altogether. Of factors relating to education, know-how and training, only direct agricultural training could be included.

The following paragraphs will explain in detail the construction of variables included in the analysis. At the end of the sub-section, Table 1 in 4.1.1 will summarize the included variables and present their coefficient expectations along with supporting empirical research, as per Section 3. Meanwhile, Table 11 is available in Appendix A, presenting the metadata of each variable described below, including data source and temporal coverage information on both NUTS0 and NUTS2 levels. Summary statistics are presented in 4.1.2. General problems and issues connected with our resulting dataset are outlined in 4.1.3.

Outcome variable

The outcome variable is the percentage of the respective entity's utilized agricultural area (UAA) converted or under conversion to organic agriculture, as certified by official authorities according to Reg. 834/2007. As the outcome variable is defined as acreage, not number of farms, manager characteristics will also be operationalized as weighted by acreage.

[46] However, not every region of its respective country is included in all time-points. The most unfortunate case is that more than half of Germany's NUTS2 regions are missing from 2005 to 2010. This somewhat weakens the generalizability of our results, but not nearly to an extent that invalidates the endeavour of the thesis.
[47] The most apparent sign was a very unlikely fluctuation in average farmer ages within regions. Moreover, a high percentage of data was missing altogether.
[48] The countries provided data to the FSS before ascension.

Country Control Variables

PPP GDP per capita (measured as thousand Euros) is included, as the decisions of both farmers and consumers generally depend on the amount of resources available. To measure potential structural differences in agriculture – basically, how far „ahead" a country is in the conventionally understood structural transformation process – agricultural labour percentage and agriculture's percentage in GDP were also added. Respective country-level values are attached to NUTS2 entities, and the variables will be present in regional regressions.

Farm structural characteristics

Average farm size was calculated by dividing the total UAA by the number of farms.[49] As noted in the literature review, a squared size variable is included. Land ownership was calculated by dividing respective UAA by the acreage that is managed by its owner.

Characteristics of agricultural production are measured by including the percentage of UAA that is permanent grassland and permanent crops, separately. Livestock density is provided by Eurostat, while dairy cattle density was calculated by dividing the number of dairy cows by UAA.[50] Regions with high prevalence of extensively managed dairy farming can be expected to have high percentages of permanent grassland, with low densities of dairy cattle and other livestock.[51]

The Annual Work Unit values of total directly and regularly employed labour force and the directly employed labour force comprising of the holder's family are used to measure labour and family labour intensity, expressed as AWU / acre.[52] Off-farm economic activities were measured on an acreage basis. The percentages of UAA that are held by a holder who has a primary or secondary non-agricultural economic activity, respectively, are included. Eurostat also provides the percentage of farms who consume at least 50% of their own produce. This variable was considered as a proxy for the general magnitude of own consumption. However, farms that consume half their produce are probably unlikely to opt for certification and spatial coverage was very poor.[53] As the literature does not establish this factor as a major one

[49] UAA is measured in acres throughout the analysis.
[50] This variable was missing for Germany. Since Germany represents a huge chunk of European agriculture, with the most (38) NUTS2 regions, German regional level data was substituted by country-level data.
[51] This relies on the assumption that permanent grassland is actively being utilized as pasture. A quick examination of Austrian data confirms this hypothesis.
[52] AWU is a special measure developed to account for the high seasonal variability and part-time work prevalence in agriculture. One AWU roughly corresponds to one person's one year of full-time employment.
[53] If they consume so much, they would lose out on the benefits of increased market prices. Moreover, such small farms presumably do not have the necessary buffer capital to shoulder the risky conversion period. Also, the FSS filters out the smallest of farms, where such consumption patterns could be prevalent – see 4.1.3.

anyways, the variable was not included. Percentage of UAA under moderate or severe soil erosion by water is also included. Regarding this variable, data was filled by simple linear calculation to correspond to the five main FSS rounds.[54] However, this variable is prone to reverse causality due to the alleged beneficial effects of organic farming on soil.

Farmer demographic characteristics

Eurostat provides a breakdown of UAA by managerial age-group. Age-groups are defined by 10-year intervals. Average farmer age was calculated by assuming the average of each age-group to be the median of its interval, and then producing the average of these median-ages weighted by the acreages managed by each age-group in the respective entity. A square age term is also included. The ratio of females is also calculated on an acreage basis, being the percentage of UAA managed by females.

Farmer training is provided as acreage managed by farmers with no, basic or full formal agricultural training, respectively. These were moulded into a continuous variable by assigning a value from 1 to 3 to each category, and then calculating the average by acreage weights.

Farmer education is not provided by Eurostat. The ESS includes occupational and educational categories, but the relatively small sample sizes do not allow for the inclusion of a variable constructed from them, as in several cases, there is only one observation per country with an agricultural occupation. The case is the same with farmer environmental attitudes. Moreover, no data was found to measure either economic attitudes or social and information-acquisition characteristics at such coverage.

Organic Markets and Infrastructure

Eurostat provides annual data on food consumption as a percentage of total household expenditure. As organic produce is generally more expensive than conventional products, households' tendencies to prioritize between consumption items can be useful to control for. Annual data on per capita organic consumption and organic retail sales is provided by the FiBL. Variable values are in Euros, thereby for countries not using the Euro, fluctuating exchange rates may result in bias when comparing data over time (FiBL, 2020). Organic retail sales are measured as million Euros. To account for potential reverse causality in case supply

[54] Data is provided for 2000, 2010 and 2016. The calculation for year T is the following: $erosion_{T-1} + (erosion_{T+1} - erosion_{T-1}) / ((t+1) - (t-1) / t - (t-1))$

drives demand, these variables are included as 3-year moving averages, with a 1-year lag.[55] Unlike Eurostat data, information provided to FiBL is unregulated and completely voluntary. This results in relatively poor coverage, as several countries have partially or completely missing series. FiBL does not provide regional-level data. Country-level data will be substituted in the NUTS2 regressions.

As for infrastructure, both Eurostat and the FiBL provide data regarding the number of various kinds of organic operators.[56] No volume or value information is available; thereby these are not very useful.[57] However, the efficiency of organic infrastructure mostly governs the supply of organic produce that gets to the shelves, not directly to consumers. Therefore, sales and consumption data already 'include' the relevant effects.

Societal attitudes

The ESS provides several opportunities to measure society-wide environmental attitudes. However, the ESS is recorded in different time points than the FSS. Therefore, the following variables were lagged to correspond to the five FSS time points. The latest available data points were used, resulting in 1-year lags in 2005, 2007 and 2013, while no lag in 2010 and 2016.

In a direct manner, the questionnaires include the statement „Protecting the environment is important"; where respondents can answer how much they feel it describes them on a 4-grade Likert-scale, 1 being the most important.[58] For an easier interpretation of results, the scale was reversed in the dataset. Up until 2010, ESS does not have NUTS2 level data. Moreover, the number of green voters in the sample is usually too low to permit reliable analysis at a regional-level breakdown. Additionally, NUTS1, and perhaps even NUTS2, is too coarse a resolution to measure direct, spatially relevant social influence. While websites, TV channels and large newspapers usually cover the entirety of countries, making the dissemination of attitudes much less spatially constrained. Therefore, NUTS0 level data was extracted and attached to respective regional entities as well.

[55] I.e. the figure for 2005 is the average of 2004, 2003 and 2002. If less than 3 consecutive years are available, the sum is divided by the number of available years.
[56] Such as processers, importers etc.
[57] As pure numbers say nothing about the capacity of a processor or importer. Between entities, one may have fewer but larger operators and the same capacity as another, confounding the regression. Within entities, mergers may take place that reduce numbers, but increase capacity.
[58] Wording and the context of the question differs across rounds, but the idea remains the same. Naturally, a variable with so many culturally embedded aspects is not very reliable between countries – however, we are using fixed effects regressions.

As for indirect methods, the ESS surveys political attitudes as well as voting patterns. The ratio of respondents who voted their country's respective green party in the last election is the most straightforward of these.[59] Such variables are arguably much more reliable than a simple question about the importance of green matters, as it involves backing attitudes with actions. However, it must be considered that green parties differ, and environmentally-aligned voters can have several other political agendas they choose to prioritize. Moreover, the variable may have an effect through the political weight gained by environmental issues, not by direct societal pressure *per se*.

Besides vote counts, respondents are also asked which political party they feel the closest to. A variable was created measuring the percentage of respondents who felt closest to their respective countries' green party out of those who had such a party preference. This one is free from potential problems associated with strategic voting – however, it also depends on the parties themselves regardless of voters' environmental attitudes. Moreover, it picks up more frequent variations in attitudes, as the last vote does not change for 4 years.[60]

The importance of trust towards authorities is also established as an important aspect of whether a farmer will engage or not in the certification process. The ESS asks respondents about the extent to which they trust their countries' legal systems on a scale of 1 to 10. This variable will also be included. Regarding these variables, it is possible that farmers' attitudes and political preferences share the same distribution with the general populace. While this is very highly unlikely, this assumption would render these variables a valid proxy for measuring farmer attitudes.

[59] While the samples are considered representative, the questionnaires yield very slightly different figures from the actual voting outcome registers. However, using the ESS provides a much less time-consuming strategy to obtain these. Another small problem is the different timing of national elections.
[60] This latter notion can cause some minor problems, as countries have their elections at different times.

4.1.1 Summary of variables and expected coefficients

Table 1: Variables, expected coefficients and supporting empirical research

Variable (UoM)	Expected coeff.	Supporting empirical research
		Farm structural characteristics
farm size (acres)	+	Schneeberger, Darnhofer & Eder (2002); Pietola & Lansink (2001); Chatzimichael, Genius & Tzouvelekas (2014)
	-	Genius, Pantzios & Tzouvelekas (2006); Läpple & Van Rensburg (2011); Chmielinski et al (2019)
farm size2 (acres)	?	No empirical research to date; this thesis is the first study to employ a quadratic term
land ownership (%/100)	+	Chmielinski et al (2019)
permanent grassland (%/100)	+	Chmielinski et al (2019) (indirectly)
permanent crops (%/100)	?	
livestock density (head/acre)	+	Chmielinski et al (2019) (indirectly)
	-	Pietola & Lansink (2001); Läpple (2010); Läpple & Van Rensburg (2011); Läpple & Kelley (2015)
dairy cattle density (head/acre)	+	Chmielinski et al (2019) (indirectly)
	-	Läpple (2010); Läpple & Van Rensburg (2011); Läpple & Kelley (2015).
labour intensity (AWU/acre)	+	Pietola & Lansink (2001); Schneerberger, Darnhofer & Eder (2002); Kallas, Serra & Gil (2010); Brzezina et al (2017)
family labour intensity (AWU/acre)	+	Kallas, Serra & Gil (2010)
off-farm main (%/100)	+	Kallas, Serra & Gil (2010)
	-	Läpple (2010)
off-farm secondary (%/100)	+	Kallas, Serra & Gil (2010)
	-	Läpple (2010)
soil erosion (%/100)	?	
		Farmer demographic characteristics
farmer age (years)	+	Chatzimichael, Genius & Tzouvelekas (2014)
	-	Burton, Rigby & Young (1999); Kallas, Serra & Gil (2010); Läpple & Van Rensburg (2011); Läpple & Kelley (2015); Genius, Pantzios & Tzouvelekas (2006)
farmer age2 (years)	-	Chatzimichael, Genius & Tzouvelekas (2014)
female ratio (%/100)	+	Burton, Rigby & Young (1999, 2003); Tiffin & Balcombe (2011)
	-	Chatzimichael, Genius & Tzouvelekas (2014)

farmer training (1-3)	+	No direct research but the empirical literature places very strong emphasis on know-how
	Organic markets and infrastructure	
HS food percent (%)	+	Based on wider non-empirical literature
organic PCC (€)	+	Based on wider non-empirical literature
organic retail volume (million €)	+	Based on wider non-empirical literature
	Societal attitudes	
green vote ratio (%/100)	+	No empirical research; reasonable expectation
green closeness (%/100)	+	No empirical research; reasonable expectation
environment's importance (1-4)	+	No empirical research; reasonable expectation
	Country controls	
PPP GDP per capita (thousand €)	+	No empirical research; reasonable expectation
agricultural labour percent (%)	+/-	No empirical research
agricultural GDP percent (%)	+/-	No empirical research

Source: author's own work based on surveyed literature.

4.1.2 Summary statistics

Country / NUTS0 level

Table 2: Summary statistics on the NUTS0 level..

Variable (UoM)		Mean	Std. Dev.	Min	Max	Observations
			Outcome variable			
organic percentage	overall	5,18	4,30	0,10	18,7	N = 124
(%)	between		3,90	0,46	13,8	n = 26
	within		1,90	-0,70	11,2	T-bar = 4,77
			Country controls			
GDP / capita	overall	26,22	11,8	8,16	78,8	N = 124
(1000€)	between		11,5	11,35	68,3	n = 26
	within		2,84	15,9	39	T-bar = 4,77
agri. lab. percent	overall	6,00	5,80	1,03	32,3	N = 124
(%)	between		5,66	1,23	29	n = 26
	within		1,16	0,07	10,1	T-bar = 4,76
agri. GDP percent	overall	1,76	1,27	0,19	8,08	N = 124
(%)	between		1,19	0,27	5,27	n = 26
	within		0,45	0,03	4,58	T-bar = 4,77
			Farm structural characteristics			
avg. farm size	overall	34,01	29,02	3,05	152	N = 124
(acres)	between		27,7	3,27	117	n = 26
	within		8,79	0,40	68,5	T-bar = 4,77
avg. farm size2	overall	1992	3428	9,28	23221	N = 124
(acres)	between		3097	10,72	14586	n = 26
	within		1463	-5503	10627	T-bar = 4,77
land ownership	overall	0,53	0,19	0,09	0,82	N = 124
(%/100)	between		0,19	0,16	0,79	n = 26
	within		0,04	0,39	0,64	T-bar = 4,77
permanent grassland	overall	0,32	0,19	0,00	0,91	N = 124
(%/100)	between		0,19	0,01	0,80	n = 26
	within		0,03	0,18	0,43	T-bar = 4,77
permanent crops	overall	0,05	0,07	0,00	0,27	N = 124
(%/100)	between		0,07	0,00	0,25	n = 26
	within		0,00	0,03	0,06	T-bar = 4,77
livestock density	overall	0,93	0,75	0,22	3,80	N = 124
(head/acre)	between		0,77	0,26	3,51	n = 26
	within		0,06	0,68	1,21	T-bar = 4,77
dairy cattle density	overall	0,18	0,16	0,04	0,97	N = 124
(head/acre)	between		0,15	0,04	0,82	n = 26
	within		0,02	0,09	0,33	T-bar = 4,77
labour intensity	overall	0,07	0,05	0,02	0,23	N = 124
(AWU/acre)	between		0,05	0,02	0,17	n = 26
	within		0,02	0,00	0,17	T-bar = 4,77
fam. labour intensity	overall	0,02	0,02	0,00	0,09	N = 124
(AWU/acre)	between		0,02	0,00	0,08	n = 26
	within		0,01	0,00	0,06	T-bar = 4,77

off-farm main	overall	0,13	0,08	0,01	0,46	N = 124
(%/100)	between		0,08	0,03	0,34	n = 26
	within		0,03	-0,03	0,26	T-bar = 4,77
off-farm sec.	overall	0,12	0,12	0,01	0,52	N = 124
(%/100)	between		0,09	0,02	0,35	n = 26
	within		0,07	-0,12	0,31	T-bar = 4,77
soil erosion	overall	15,5	16,9	0,07	63,6	N = 124
(%)	between		17	0,09	63,2	n = 26
	within		0,56	13,8	17,6	T-bar = 4,77
			Farmer demographic characteristics			
avg. age	overall	51,3	2,54	43,3	56,8	N = 106
(years)	between		2,42	47,2	55,4	n = 24
	within		1,00	46,7	53,9	T-bar = 4,42
avg. age2	overall	2639	259	1876	3224	N = 106
(years)	between		247	2232	3075	n = 24
	within		100	2211	2881	T-bar = 4,42
female ratio	overall	0,13	0,07	0,03	0,32	N = 124
(%/100)	between		0,07	0,03	0,30	n = 26
	within		0,01	0,10	0,17	T-bar = 4,77
farmer training	overall	1,95	0,37	1,12	2,70	N = 99
(1-3)	between		0,36	1,25	2,67	n = 26
	within		0,11	1,38	2,27	T-bar = 3,81
			Organic markets & infrastructure			
HS food percent	overall	14,8	4,78	7,80	29,8	N = 124
(%)	between		4,77	8,40	27,6	n = 27
	within		0,70	12,7	17,0	T-bar = 4,77
organic PCC	overall	32,7	40,0	0,04	172	N = 102
(€)	between		35,9	0,63	119	N = 24
	within		18,2	-29,4	101	T-bar = 4,25
organic retail volume	overall	0,77	1,41	0,00	7,93	N = 102
(million €)	between		1,25	0,00	5,46	N = 24
	within		0,51	-1,48	3,25	T-bar = 4,25
			Societal attitudes			
green vote ratio	overall	0,03	0,03	0,00	0,11	N = 99
(%/100)	between		0,03	0,00	0,08	n = 25
	within		0,01	-0,02	0,06	T-bar = 3,96
green closeness	overall	0,03	0,03	0,00	0,10	N = 99
(%/100)	between		0,03	0,00	0,08	n = 25
	within		0,01	-0,01	0,07	T-bar = 3,96
env. importance	overall	2,86	0,21	2,40	3,37	N = 99
(1-4)	between		0,18	2,59	3,19	n = 25
	within		0,11	2,47	3,12	T-bar = 3,96
legal trust level	overall	4,96	1,17	2,22	7,60	N = 99
(1-10)	between		1,16	2,41	7,33	n = 25
	within		0,33	4,02	5,93	T-bar = 3,96

Source: author's own calculations based on Eurostat, World Bank Open Data, FiBL database, European Social Survey (rounds 2-5 and 7).

Region / NUTS2 level

Table 3: Summary statistics at the NUTS2 level

Variable/*(U.o.M.)*		Mean	Std. Dev.	Min	Max	Observations
			Outcome variable			
organic percentage	overall	4,82	5,75	0,00	51,8	N = 1093
(%)	between		5,25	0,08	33,1	n = 243
	within		2,37	-8,75	23,5	T-bar = 4,49
			Country controls			
GDP / capita	overall	26,7	7,56	8,16	78,8	N = 1093
(1000€)	between		7,29	10,8	68,3	n = 243
	within		2,02	16,4	37,2	T-bar = 4,49
agri. lab. percent	overall	5,11	5,76	1,03	32,3	N = 1093
(%)	between		5,59	1,19	30,9	n = 243
	within		1,03	-0,83	9,21	T-bar = 4,49
agri. GDP percent	overall	1,61	1,20	0,19	8,08	N = 1093
(%)	between		1,13	0,27	5,97	n = 243
	within		0,38	-0,12	4,43	T-bar = 4,49
			Farm structural characteristics			
avg. farm size	overall	45,5	45,9	0,91	286	N = 1093
(acres)	between		44,3	0,98	271	n = 243
	within		10,2	-8,76	103	T-bar = 4,49
avg. farm size2	overall	4175	9776	0,84	81566	N = 1093
(acres)	between		9366	0,98	73717	n = 243
	within		2267	-14822	21631	T-bar = 4,49
land ownership	overall	0,49	0,20	0,07	0,96	N = 474
(%/100)	between		0,19	0,09	0,96	n = 239
	within		0,05	0,20	0,79	T-bar = 1,98
permanent grassland	overall	0,34	0,23	0,00	0,99	N = 474
(%/100)	between		0,23	0,00	0,99	n = 239
	within		0,01	0,30	0,39	T-bar = 1,98
permanent crops	overall	0,05	0,09	0,00	0,65	N = 473
(%/100)	between		0,09	0,00	0,65	n = 239
	within		0,00	0,03	0,07	T-bar = 1,98
livestock density	overall	0,96	1,06	0,03	8,23	N = 1093
(head/acre)	between		1,04	0,05	7,42	n = 243
	within		0,10	0,13	1,79	T-bar = 4,49
dairy cattle density	overall	0,18	0,22	0,00	1,47	N = 992
(head/acre)	between		0,21	0,00	1,28	n = 205
	within		0,03	0,04	0,40	T-bar = 4,84
labour intensity	overall	0,07	0,07	0,00	0,62	N = 1024
(AWU/acre)	between		0,07	0,00	0,41	n = 214
	within		0,02	-0,10	0,42	T-bar = 4,79
fam. labour intensity	overall	0,02	0,03	0,00	0,25	N = 1024
(AWU/acre)	between		0,03	0,00	0,18	n = 214
	within		0,01	-0,05	0,16	T-bar = 4,79
off-farm main	overall	0,11	0,08	0,00	0,37	N = 472
(%/100)	between		0,07	0,02	0,37	n = 238

	within		0,03	-0,03	0,25	T-bar = 1,98
off-farm sec.	overall	0,16	0,14	0,00	0,58	N = 472
(%/100)	between		0,14	0,01	0,54	n = 238
	within		0,03	-0,03	0,36	T-bar = 1,98
soil erosion	overall	17,3	21,4	0,00	88,4	N = 1091
(%)	between		20,9	0,00	86,7	n = 243
	within		0,85	9,15	26,1	T-bar = 4,49
			Farmer demographic characteristics			
avg. age	overall	51	3,47	24,1	62,0	N = 820
(years)	between		2,88	41,1	61,8	n = 228
	within		1,90	34,0	68,0	T-bar = 3,6
avg. age2	overall	2611	337	583	3848	N = 820
(years)	between		287	1951	3821	n = 228
	within		171	1212	4010	T-bar = 3,6
female ratio	overall	0,12	0,07	0,02	0,41	N = 1091
(%/100)	between		0,07	0,02	0,39	n = 243
	within		0,02	0,04	0,22	T-bar = 4,83
farmer training	overall	1,97	0,35	1,16	2,74	N = 463
(1-3)	between		0,35	1,20	2,73	n = 235
	within		0,05	1,77	2,17	T-bar = 1,97
			Organic markets & infrastructure			
HS food percent	overall	13,4	4,40	7,80	29,8	N = 1091
(%)	between		4,29	7,95	27,9	n = 243
	within		0,62	11,4	15,6	T-bar = 4,83
organic PCC	overall	36,4	34,3	0,04	172	N = 1032
(€)	between		32,3	0,47	119	n = 236
	within		16,3	-25,6	105	T-bar = 4,37
organic retail volume	overall	1,61	1,98	0,00	7,93	N = 1032
(million €)	between		2,34	0,00	7,24	n = 236
	within		0,61	-0,65	4,08	T-bar = 4,37
			Societal attitudes			
green vote ratio	overall	0,03	0,03	0,00	0,12	N = 961
(%/100)	between		0,03	0,00	0,09	n = 242
	within		0,01	-0,03	0,06	T-bar = 3,97
green closeness	overall	0,03	0,03	0,00	0,10	N = 961
(%/100)	between		0,03	0,00	0,08	n = 242
	within		0,01	-0,02	0,08	T-bar = 3,97
env. importance	overall	2,86	0,19	2,40	3,33	N = 961
(1-4)	between		0,16	2,59	3,19	n = 242
	within		0,10	2,46	3,05	T-bar = 3,97
legal trust level	overall	5,04	0,98	2,22	7,60	N = 961
(1-10)	between		0,98	2,41	7,33	n = 242
	within		0,30	4,10	6,01	T-bar = 3,97

Source: author's own calculations based on Eurostat, World Bank Open Data, FiBL database, European Social Survey (rounds 2-5 and 7).

4.1.3 General data problems and limitations

Data Aggregation

The overwhelming majority of studies researching the drivers of organic farming adoption rely on raw, unaggregated survey data. Such datasets are either gathered as primary data by the researchers (see Läpple, 2010; Läpple & Van Rensburg, 2011; Läpple & Kelley, 2013; Läpple & Kelley, 2015; Bouttes et al., 2019; Bouttes et al., 2020), or result from being granted access to the source files of national databases (for example, Chmielinski et al., 2019). As it gives researchers the freedom to plan the surveys, the former case allows for the most sophisticated research designs. The latter, however, trades in a bit of design freedom for reduced costs and potentially increased coverage.[61] This thesis' strategy of using continent-wide aggregate data pushes this trade-off to the extreme. While the resulting dataset restricts the possibilities of statistical analysis, it allows for the widest coverage in any such study to date. Naturally, then, it should be noted that the thesis' analysis cannot be expected to provide pinpoint predictions – the goal is to infer general points regarding the way certain factors affect the expansion of organic agriculture.

The statistical issues of aggregating survey data have been long established in academia (Clark & Avery, 1976; Pakes, 1979). In almost every situation, aggregating data results in losses of information (Clark & Avery, 1976). The aggregation effect seems to be represented by higher R^2 and slope coefficients compared to micro-level regressions, and this effect diminishes by decreasing the size of the spatial aggregation unit (Clark & Avery, 1976; Pakes, 1979). Regardless, the use of substitute aggregate data, due to resource limitations or confidentiality measures, remains an accepted procedure.

The aggregation problem has been explored in the agricultural field (Van Bussel, Ewert & Leffelaar, 2011; Finger, 2012; Fezzi & Bateman, 2015; Ram Maharjan et al., 2019) although to the knowledge of the author, not specifically regarding technology adoption.[62] Nonetheless, these studies largely confirm the general findings of biased coefficients increasing with the coarseness of spatial aggregation (Van Bussel, Ewert & Leffelaar, 2011; Ram Maharjan et al. 2019). Fezzi & Bateman (2015) and Ram Maharjan (2019) note that the aggregation effect tends to differ by region. Fezzi & Bateman (2015) attribute this effect to the differences in the variation of underlying characteristics across regions – the smaller the variation, the smaller

[61] Meaning money, time and labour.
[62] Ram Maharjan et al. features more than a dozen authors, hence the deviation from LUSEM referencing standards.

the bias. While no specific empirical strategy is employed to control for aggregation bias, these notions should be kept in mind when interpreting results.

Lagging and lack thereof

Optimally, variables in such a study should feature lagging of some sort: the decision-making process to adopt predates the first steps of certification, depending on the circumstances and experiences of earlier periods. No study was found that examines the time lag between the decision to adopt and the first actions being taken. However, it is very unlikely that this lag is in the magnitude of 2-3 years. Variables attained from the FSS do not allow for shorter lags, therefore they were used without lagging. It can be safely assumed that data from year X resembles last year's, or the last few months' situation better than data from year X-3. From the annually available country-level variables, only FiBL market data can be expected to have a significant problem stemming from reverse causation, and the rest are used unlagged. As for the FSS variables that cannot be lagged, only the ones used to proxy the prevailing types of production seem to pose problems. An established conventional farm's livestock density may affect its decision to adopt organic farming, but newly created holdings that decide to start out as organic may simply purchase the number of animals that best suits their planned practices. The potential issue with land area distribution follows a similar pattern, although most probably the transition between arable land, permanent grassland and permanent cropland is less fluid than changing the number of animals.

Coverage

The boundaries for minimum thresholds for survey population inclusion are set in European legislation, and national authorities are free to choose their own thresholds within these boundaries.[63] Regarding UAA, the maximum threshold is 5 hectares, although many countries still opt to include farms as small as 1 hectare or less.[64] Moreover, countries tend to modify their thresholds between survey rounds. Consequentially, a high amount of data is lost pertaining to the smallest agricultural holdings, and the magnitude of this loss may vary both between countries and survey rounds, leading to minor comparability issues and potential bias in analysis. However, as for overall coverage, legislation governing the rounds included required total UAA coverage for the survey population to reach at least 98% (Eurostat, 2020).

---

[63] As in, national authorities are required to include every agricultural operation that meets the respective threshold in the survey population, from which a representative sample is taken.

[64] 1 hectare equals 2.471 acres. Besides UAA a set of other thresholds exist, see https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farm_structure_survey_%E2%80%93_survey_coverage#Thresholds_described_in_legislation.C2.A0

While it is uncertain if this threshold had been met in every case, FSS data is still by far the most complete and comprehensive information available on European agriculture, and most probably the only viable choice for this thesis' analysis.

On the other hand, as described in the section and presented in the summary statistics, the constructed dataset is unfortunately far from being complete. Certain variables have several regions or entire countries missing, and the gaps are not the same across different variables. Running a regression with all variables included results in a 55% loss of observations on the country level. On the NUTS2 level, this loss is over 80%.

4.2 Methods

Empirical studies referred to in this paper use a wide variety of methods. However, as noted, their datasets are usually better suited to their specific needs, allowing for more advanced econometric techniques. These include duration analysis (Burton, Rigby & Young, 2003; Kallas, Serra & Gil, 2010; Läpple, 2010); simple (Chatzimichael, Genius & Tzouvelekas, 2014) and Bayesian probit models (Tiffin & Balcombe, 2011; Chatzimichael, Genius & Tzouvelekas, 2014; Läpple & Kelley, 2015); as well as logit models (Burton, Rigby & Young, 1999; Chmielinski et al., 2019).

Aggregate data is featured seemingly exclusively in diffusion studies (Burton, Rigby & Young, 2003; Kaufmann, Stagl & Franks, 2009; Kallas, Serra & Gil, 2010). These studies, however, often only use the extent of previous conversion as their independent variable (Kaufmann, Stagl & Franks, 2009), and their main purpose is to uncover and predict the general pace and extent of innovation diffusion within a certain entity. To the knowledge of this author, aggregate data has not been used in researching drivers of organic conversion and expansion, leaving us without previous, peer-reviewed science to base methods on. Therefore, instead of reaching beyond the limits of our data, this thesis will employ simple, but well-formulated panel regression techniques tailored to be as reliable as possible. All regressions will be run with robust standard errors to remedy potential heteroskedasticity.[65]

As noted in the previous sub-section, it is less than ideal to test all our variables within a single regression model. Kaufmann, Stagl & Franks (2009) state that it is often not

[65] STATA does not offer a built-in diagnostics package for panel regressions that could be used to measure heteroskedasticity. Robust errors in this sense are those obtained with STATA's „robust" option.

constructive to cram every variable into a single model when our sample is too small.[66] Instead, they suggest that the whole picture can be just as well examined through its segments, which strategy will be used now. Variables have to be grouped in ways to balance between potential OVB and problems stemming from missing observations and lacking degrees of freedom. Variables can be grouped by either theme, coverage, or both. In our summary statistics, N reveals the number of total observations with a record of the variable, n denotes the number of distinct panels having a record thereof, while the T / T-bar statistic denotes the average number of records per panel.[67] Both NUTS0 and NUTS2 level analyses will begin with a core specification that covers as much observations as possible, to which additional variable groups will be added in turns. For both levels, three main specifications will be presented in detail, featuring coverage-based grouping. After these, results from additional grouping methods will be reported. Full outputs for all regressions are presented in Appendix C.

When dealing with panel models, the question of fixed vs. random effects has to be addressed. While the Hausman test is an accepted empirical test to aid with the decision, it is important to understand the intuition behind. Fixed effects specifications help eliminate bias that can arise when certain characteristics, that are constant over time and vary by observational unit, are expected to correlate with independent variables in the model. In our case, geographical attributes are a prominent such group. Country-and-region-specific cultural characteristics are another one. The ESS variables aim to partially capture these on the country level, but it is obvious that the full extent of cultural heterogeneity is not covered.

On the other hand, random effects models mitigate bias arising from unobserved characteristics that are constant across observational units but vary with time – such as the effects of a crisis or other universal continent-wide shocks. As long as time-invariant attributes are uncorrelated with our independent variables, RE is considered consistent and more efficient than FE. However, this assumption is unlikely to be met in our case. Moreover, one of the main points of RE is to infer externally valid deductions when the sample is drawn from a larger population in which the underlying characteristics are normally distributed. From start to finish, this thesis focuses on the European Union – validity outside the continent

[66] Or, in this case, when coverage would limit an otherwise large sample.
[67] Panels in our case refer to spatial units. Moreover, As 5 timepoints are included, the T / T-bar statistic potentially ranges from 0 to 5.

is of little interest. Within the EU, almost every country and NUTS2 region is covered, therefore, RE is less attractive in this regard.

Backing intuition, a series of *xtoverid* tests was run in Stata. The null could be rejected in every valid instance with at least 99% confidence.[68] The regressions presented in the remainder of the study employ FE methods. One of the main drawbacks of FE is that we lose out on exploiting between-unit variation – our regression coefficients will refer to the effects of within-unit changes in independent variables. Keeping in mind the notion of potential spatial heterogeneity in decision-making functions, as well as the objectives of this thesis, this may not be that much of a problem. However, the thesis concerns a partially geographical topic. To let readers gain a visual image of Europe's organic dissemination, and to help better contextualize what stands behind the statistical analysis, a brief preliminary spatial analysis featuring a visualization of the development of our dependent variable on the NUTS2-level is presented in 5.1.

As for the main econometric analyses, the general fixed effects panel model is the following:

$$Y_{it} \text{ (organic percentage)} = \alpha + \beta\, CC_{it} + \beta\, FS_{it} + \beta\, FC_{it} + \beta\, OM_{it} + \beta\, SA_{it} + \acute{\eta}_i + \varepsilon_{it}$$

Where i refers to spatial unit, t refers to time, Y_{it} is the dependent variable (outcome) belonging to the given spatial unit in the given time point. The constant term is denoted by α, while β is the coefficient associated with the given dependent variable regarding the given spatial unit at the given time point. In the equation above, individual variables are grouped into summary terms for the sake of simplicity; CC refers to country controls, FS refers to farm structural characteristics, FC to farmer characteristics, OM to organic market variables, while SA means societal attitudes, grouped as described in Section 4.1. Time-invariant unobserved heterogeneity which we control for is denoted by $\acute{\eta}_i$, while ε_{it} is the general error term.

NUTS0 level

The analysis begins on the NUTS0 level. While fewer observations are at our disposal, data coverage ratios are much better than on the regional level. However, as the level of aggregation is coarser, these results are expected to be less reliable. In the first specification,

[68] STATA's standard Hausman test is not compatible with robust standard errors. Xtoverid is an user-written command designed for this issue. Valid instance refers to when the test could be run – on two occasions out of the total fifteen, the test reported degenerate RE estimates and would not run.

variables with the highest (129+) numbers of observations will be included. The high coverage ratio on the country level allows for the inclusion of 16 independent variables of the total 28 in the core model. This core model includes all the country controls and farm structural characteristics, and parts of farmer and organic market characteristics. A second specification will include FiBL and ESS variables, while the last specification includes all variables by adding the rest of the farmer demographic characteristics. The specifications will include 124, 84 and 60 observations, respectively. As a robustness check and a means to spot potential loss of information, three additional specifications are added that break the steps presented above down by thematic groups, with 83, 102 and 99 observations, respectively.[69] Table 12 in Appendix A presents both the main and robustness check specifications in detail.

NUTS2 level

When grouping variables on this level, it needs to be remembered that the coverage structure differs from the country level. There are variables that are only available from 2013 and 2016, filtering out about 60% of all observations. On the NUTS2 level, the core specification will contain variables with 1200+ observations minus FiBL variables, allowing for 10 out of the total 28.[70] The second specification includes variables with between 900 and 1100 variables, adding the rest of farmer characteristics, organic market variables and the ESS data. The last, full specification includes all variables. The main specifications feature 1091, 599 and 255 observations, respectively. On the NUTS2 level, the coverage structure allows – and calls – for a more diverse set of robustness checks. The steps were broken down according to both theme and coverage. Where applicable, remaining variables from each thematic group will be added in 2 steps: first those with between 900 and 1200 observations, second those with around 500. This results in six additional robustness check specifications with 1032, 961, 983, 820, 386 and 381 observations, respectively. Table 13 in Appendix A presents all specifications in detail.

[69] Thematic groups as in farm structural characteristics, farmer demographic characteristics etc.
[70] This arbitrary differentiation is necessary to avoid a large source of bias. FiBL data is denser from large, richer countries with many NUTS2 regions, hence the large difference of coverage ratios between levels. Including these variables within the core specification would exclude a high number of smaller, less developed countries, including Estonia, one of Europe's organic leaders.

5 Analysis

5.1 Preliminary spatial analysis

Figures 4 and 5 on the next pages present the organic acreage percentages of all NUTS2 regions with data coverage in 2005 and 2016, respectively. On one hand, an overall growth in organic percentages is clearly visible between the two time-points. On the other, the maps also highlight interesting spatial differences.

One strain of literature highlights the East/West divide (Offerman, Nieberg & Zander, 2009; Moschitz et al, 2018). The maps largely confirm this notion, albeit not so dramatically – from the former Eastern Bloc, it is mostly Romania and Bulgaria that lag behind. What becomes apparent is the presence and persistence of an "organic belt" spanning through the continent in a North-South direction, situated around Europe's central longitudes. Interestingly, the countries included are commonly understood to have strongly varied economic, cultural and geographical attributes, as well as different climates.

Within-country spatial variation is emphasized by Parra López & Calatrava Requena (2005), Läpple & Kelley (2015) and Chmielinski et al (2019). The maps clearly display such patterns, and in certain cases, f.e. Poland and Spain, internal variations seems to increase with time. A related notion is the strong persistence of patterns. The order of regions seems to change little over the period; both the darkest and the lightest regions of the map seem to be largely the same across the two time-points. Moreover, while most regions become 'one shade darker', a few geographical clusters – most notably Central Poland, Northern Spain, the UK, Ireland, North-Eastern France and Flemish Belgium – seem to stagnate over the period.

The explanations behind cross-regional patterns are beyond the scope of this thesis. However, future research could perhaps look further into the geographical patterns of organic expansion. Moreover, spatial clustering effects such as those examined by Läpple & Kelley (2015) and Kallas, Serra & Gil (2010), and related statistical issues such as spatial autocorrelation could also be considered by future research. See Appendix B for additional maps covering 2007, 2010 and 2013.

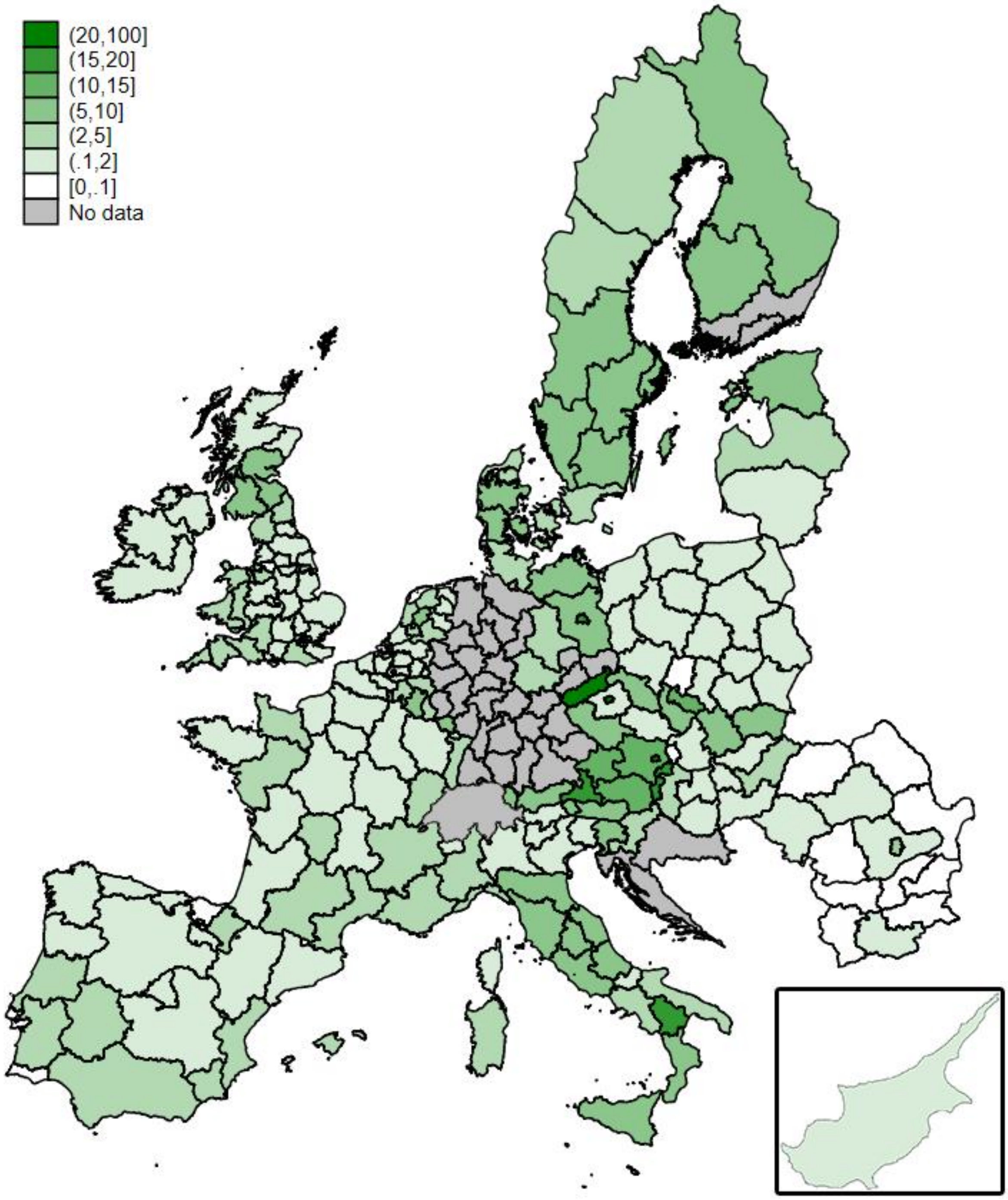

Figure 4: Organic acreage percentages by NUTS2 regions in Europe in 2005. Source: author's visualization based on the Eurostat agricultural database and Eurostat GISCO Geodata.

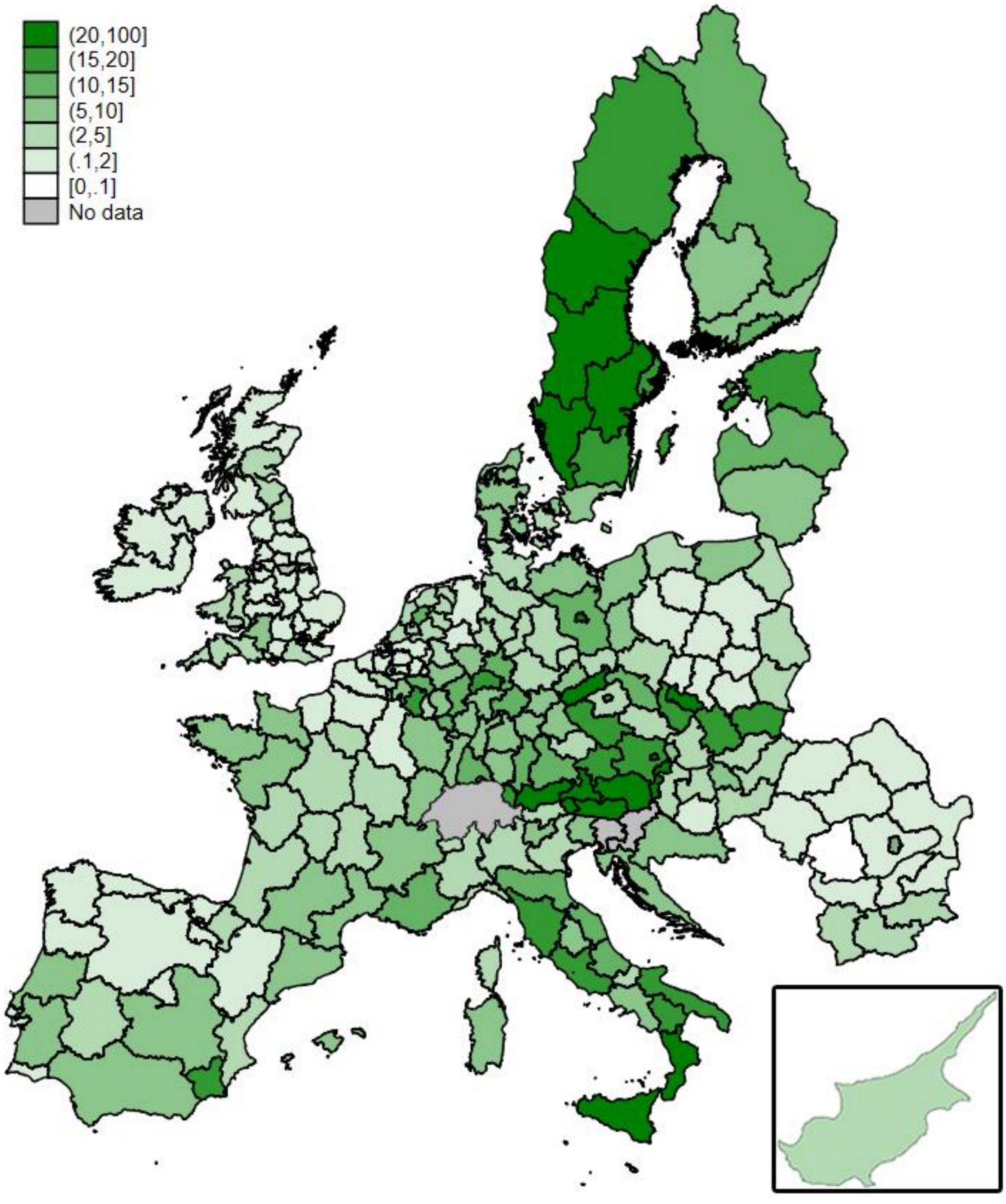

Figure 5: Organic acreage percentages by NUTS2 regions in Europe in 2016. Source: author's visualization based on the Eurostat agricultural database and Eurostat GISCO Geodata.

5.2 Analysis of results at NUTS0 level

Table 4: Results of main specifications at NUTS0 level

						** = p<0.1; **=p<0.05; ***=p<0.01*
organic percentage (%)	**S1**		**S2**		**S3**	
	Coeff.	**R. Std. Err.**	**Coeff.**	**R. Std. Err.**	**Coeff.**	**R. Std. Err.**
Farm structural characteristics						
avg. farm size (acres)	0,04	0,07	-0,02	0,06	0,38***	0,11
avg. farm size2 (acres)	0,0001	0,0004	0,0002	0,0003	-0,0016***	0,0005
land ownership (%/100)	-3,35	4,88	5,18	4,59	14,78**	5,33
permanent grassland (%/100)	-15,96*	8,41	-19,39	14,68	-17,31	13,49
permanent crops(%/100)	-92,28***	32,31	38,29	52,31	75,19	81,47
livestock density (head / ha)	3,15	3,11	-0,74	2,76	-2,11	2,87
dairy cattle density (head/ha)	-21,90*	12,13	-11,73*	6,14	-10,62	7,61
labour intensity (AWU/ha)	-22,97	53,05	-77,67	84,78	-78,59	77,91
fam. labour intensity (AWU/ha)	-16,06	122,27	141,30	153,13	259,99*	149,80
off-farm main (%/100)	1,10	3,89	-3,54	4,56	-6,44	6,85
off-farm sec. (%/100)	2,83	3,12	-0,53	2,99	3,19	2,56
soil erosion (%/100)	-0,22	0,33	-0,37	0,62	-0,47	0,54
Farmer demographic characteristics						
female ratio (%/100)	-14,95	16,81	41,04	29,11	36,44*	19,43
avg. age (years)					-11,18*	5,82
avg. age2 (years)					0,11*	0,06
farmer training					5,28***	1,75
Organic markets & infrastructure						
HS food percent (%/100)	0,57	0,46	0,49	0,50	-0,31	0,54
organic PCC (€)			0,06**	0,02	0,02	0,02
organic retail volume (million €)			-0,55	0,45	0,22	0,47
Societal attitudes						
green vote ratio (%/100)			8,37	14,75	-27,58	19,39
green closeness (%/100)			6,61	17,72	19,70	21,82
env. importance (1-4)			-1,86	1,71	-5,39***	1,88
legal trust level (1-10)			-0,62	0,57	-0,63	0,68
Country Controls						
GDP / capita (1000 €)	0,22**	0,09	0,24*	0,12	0,17	0,11
agri. lab. percent (%/100)	-0,34	0,18	-0,27	0,37	-0,11	0,80
agri. GDP percent	0,55	0,51	-1,71	1,71	-2,12	1,34
_cons	9,51	11,64	11,51	17,61	300,77	162,91
N_obs	124		84		60	
R_sq (within)	0,58		0,72		0,88	

Source: author's calculations.

When analysing results, one must note that while the dependent variable is defined as a 'real' percentage, the percentage-type predictors are operationalized as a ratio.[71] To obtain the effect of a percentage-point increase, the coefficients have to be divided by one hundred. The coefficients actually displayed in the regression outputs mean the effects of a unit-increase in the ratio, e.g. 100%, which is usually impossible in reality. The point of this is to make results more presentable by avoiding having to display too many decimals.

From the first glance, it seems that trading in variables for increased coverage is not the optimal strategy in our case, at least not on this coarseness of aggregation. The number of significant variables, as well as the significance levels is by far the highest in the specification with all variables included.[72] As could be expected, the R-squared increases steadily – the third model explains 88% of within-country variation in the outcome variable.

Regarding farm structural characteristics, variables regarding type of operation have a strong effect in the first regression. Permanent cropland has a very large significant negative coefficient in the first regression, but the coefficient direction is not consistent in subsequent specifications.[73] Permanent grassland, however, has a negative coefficient in all regressions, significant in the first. Dairy cattle density also has a persistent negative coefficient, significant two times out of three. This may suggest that in the context of our data, an increase in dairy cattle density has mostly meant an intensification of existing operations, while any new pastures have also mostly been added to host intensive operations. Nonetheless, the coefficients are difficult to interpret without further research. It also seems that dairy cattle density takes up the effect of overall livestock density. The results can be said to back Pietola & Lansink (2001), Läpple (2010); Läpple & Van Rensburg (2011) and Läpple & Kelley (2015).

In the third regression, land ownership appears with a positive significant effect, backing Chmielinski et al (2019). Family labour intensity – seemingly acting in tandem with and partially taking up the effect of labour intensity – also has a very large positive coefficient, backing Kallas, Serra & Gil (2010). Confirming the choice to include a quadratic term, farm size displays a significant reverse U-shaped relationship with organic expansion. The significant positive linear term backs Schneeberger, Darnhofer & Eder (2002); Pietola &

[71] E.g. *organic percentage* for a region with 20% organic acreage will be 20, but *female ratio* will be 0,15 for a region with 15% female farm managers.
[72] For the remainder of the analysis, significant means a confidence level of at least 90%.
[73] To clarify again: in S1, a one percentage-point increase in permanent cropland is associated with a 0,92 percentage-point decrease in organic acreage.

Lansink (2001) and Chatzimichael, Genius & Tzouvelekas (2014), while the negative quadratic effect indirectly supports Genius, Pantzios & Tzouvelekas (2006); Läpple & Van Rensburg (2011) and Chmielinski et al (2019). The results might either suggest that it is middle-sized farms that have the strongest propensity to operate organically, or simply translate to a positive effect of average size increase that slightly diminishes as we move higher up. Further analysis is presented in 5.4.

Farmer demographic characteristics also show interesting results in the third regression. The acreage-weighted ratio of female farm managers has a large, highly significant effect, supporting Burton, Rigby & Young (1999, 2003) and Tiffin & Balcombe (2011). Acreage-weighted average age shows a U-shaped coefficient, contradicting Chatzimichael, Genius & Tzouvelekas (2014). The linear negative coefficient, however, partially backs Burton, Rigby & Young (1999), Kallas, Serra & Gil (2010), Läpple & Van Rensburg (2011) and Läpple & Kelley (2015). First-glance intuition may suggest that it is younger and older farmers that have a higher propensity to operate organically as opposed to middle-aged farmers. However, before drawing conclusions, further analysis is needed – see 5.4. Acreage-weighted average farmer training level also appears with a positive, highly significant coefficient, backing the literature that underlines the know-how intensive nature of organic agriculture (Burton, Rigby & Young, 1999; Läpple & Van Rensburg, 2011; Bliss et al., 2019).

The groups of markets and infrastructure and societal attitudes, mostly included as controls, do not reveal much information. Organic consumption appears significant with the expected coefficient once. Environmental importance, however, displays a negative, highly significant effect in the third specification. This must be ’noise’, as there can be no plausible explanation for this direction of causation – this could potentially point to problems with the aggregate dataset. Of the macroeconomic country controls, the effect of per capita GDP seems to have a reasonable, expected effect.

Overall, while certain results look promising, one must not forget the immensive progressive loss of coverage. The third specification omits more than half of all available observations. It is possible that several results stem from the selection bias due to data availability issues. Before drawing conclusions, the robustness-check specifications shall be analysed. Table 5 below presents the results of our additional RC specifications.

Table 5: Results of RC specifications at NUTS0 level

						**** = p<0.1; **=p<0.05; ***=p<0.01***
organic percentage (%)	RC1		RC2		RC3	
	Coeff.	**R. Std. Err.**	**Coeff.**	**R. Std. Err.**	**Coeff.**	**R. Std. Err.**
Farm structural characteristics						
avg. farm size (acres)	**0,43*** **	0,07	-0,02	0,05	-0,01	0,05
avg. farm size2 (acres)	**-0,0016*** **	0,0003	0,0003	0,0003	0,0002	0,0003
land ownership (%/100)	1,83	5,42	3,50	4,39	-1,68	5,89
permanent grassland (%/100)	2,40	8,38	-15,40	9,03	**-26,29** **	9,87
permanent crops(%/100)	-13,97	30,92	-66,53	42,07	-61,40	66,03
livestock density (head / ha)	**3,68* **	2,13	1,05	2,74	-0,12	2,74
dairy cattle density (head/ha)	**-19,31*** **	5,56	-13,83	10,22	**-18,63** **	8,08
labour intensity (AWU/ha)	12,43	42,88	-53,23	51,49	-63,94	62,91
fam. Labour intensity (AWU/ha)	21,27	93,59	63,08	122,18	35,25	149,30
off-farm main (%/100)	8,37	5,68	-1,95	5,74	2,45	3,08
off-farm sec. (%/100)	**-5,90* **	3,40	0,01	2,61	2,50	3,11
soil erosion (%/100)	-0,18	0,31	-0,13	0,45	-0,10	0,45
F**armer demographic characteristics**						
female ratio (%/100)	-5,45	14,37	23,62	18,80	-7,24	22,77
avg. age (years)	-2,34	1,72				
avg. age2 (years)	0,03	0,02				
farmer training	**4,30*** **	0,90				
Organic markets & infrastructure						
HS food percent (%/100)	0,00	0,33	0,18	0,32	**0,97** **	0,38
organic PCC (€)			**0,05* **	0,03		
organic retail volume (million €)			-0,09	0,53		
Societal attitudes						
green vote ratio (%/100)					**30,31* **	16,54
green closeness (%/100)					-18,82	20,39
env. Importance (1-4)					-0,43	2,12
legal trust level (1-10)					-0,14	0,59
Country Controls						
GDP / capita (1000 €)	0,07	0,07	**0,13* **	0,07	**0,34*** **	0,10
agri. lab. percent (%/100)	**-0,43*** **	0,15	-0,21	0,21	-0,50	0,32
agri. GDP percent	-0,32	0,61	-0,02	0,98	-1,55	0,96
_cons	40,13	41,81	8,12	11,68	10,43	15,31
N_obs	83		102		99	
R_sq (within)	0,7687		0,6175		0,6698	

Source: author's calculations.

Of the previously mentioned results, the reverse U-shaped effect of average farm size is significantly present in one specification. In the other two, the coefficients show different patterns, although they are not statistically significant. The effect of permanent crops is significantly negative once, while dairy cattle density has a negative coefficient of similar magnitudes across all specifications, significant in both RC1 and RC3.

Regarding the type of agricultural operation, the RC specifications strongly back the notions deducted from our main regressions. While the U-shaped effect of acreage-weighted average farmer age is present in RC1, it is not statistically significant. The effect of acreage-weighted average farmer training, however, persists. Having a similar – and reasonable – magnitude and significance level across both specifications it is included in, the effect of farmer training can be regarded as confirmed on the country level.

As for effects of markets & infrastructures and societal attitudes variables, they display mostly reasonable and expected coefficients when significant, supporting the intuition that domestic demand patterns do play a role in the expansion of organic farming. Country control variables, chiefly GDP per capita, also fit into this pattern. Overall, the main takeaways on the European level with country-level aggregation regarding farm structural and farmer demographic characteristics are the following:

- The analysis strongly backs the know-how intensive nature of organic farming. An increase in the average agricultural training of farm managers weighted by acreage is strongly and positively associated with organic acreage expansion.
- An increase in the density of dairy cattle, as well as the expansion of dairy industry in general, seems to have a strong negative effect on organic acreage expansion. The results, however, are difficult to confidently interpret without further research.
- Average farm size seems to have a nonlinear, reverse U-shaped connection to organic acreage expansion. Further analysis is needed to draw conclusions and properly interpret the coefficients.

5.3 Analysis of results at NUTS2 level

Table 6: Results of main specifications at NUTS2 level

						*p<0.1; **=p<0.05; ***=p<0.01
organic percentage (%)	S1		S2		S3	
	Coeff.	**R. Std. Err.**	**Coeff.**	**R. Std. Err.**	**Coeff.**	**R. Std. Err.**
Farm structural characteristics						
avg. farm size (acres)	0,02	0,02	0,01	0,03	-0,06	0,19
avg. farm size2 (acres)	-0,00004	0,00007	0,00011	0,00014	0,00043	0,00116
livestock density (head / ha)	0,40	0,92	**-2,93***	1,52	-1,96	1,49
soil erosion (%/100)	-0,13	0,11	-0,18	0,18	0,54	0,83
dairy cattle density (head/ha)			0,43	4,84	10,97	7,91
labour intensity (AWU/ha)			**-29,59***	17,04	-22,55	17,87
fam. labour intensity (AWU/ha)			46,29	28,60	6,52	52,14
land ownership (%/100)					-1,78	7,16
permanent grassland (%/100)					15,01	12,39
permanent crops (%/100)					**133,22*****	36,68
off-farm main (%/100)					9,52	8,52
off-farm sec. (%/100)					7,30	10,07
Farmer demographic characteristics						
female ratio (%/100)	12,34	8,26	**24,95****	12,52	16,52	11,08
avg. age (years)			-0,13	0,76	1,01	0,65
avg. age2 (years)			0,001	0,01	-0,01	0,01
farmer training					1,72	2,81
Organic markets & infrastructure						
HS food percent (%/100)	**0,42****	0,17	-0,16	0,24	0,63	0,74
organic PCC (€)			**0,08*****	0,02	-0,01	0,04
organic retail volume (million €)			**-0,89*****	0,31	2,46	1,50
Societal attitudes						
green vote ratio (%/100)			0,57	11,25	-146,04	89,18
green closeness (%/100)			2,27	10,58	30,06	39,20
env. importance (1-4)			**-4,18*****	0,88	15,75	14,86
legal trust level (1-10)			**-0,92***	0,52	-5,21	3,96
Country Controls						
GDP / capita (1000 €)	**0,53*****	0,09	0,28	0,12	1,50	1,06
agri. lab. percent (%/100)	**-0,19****	0,10	0,00	0,19	2,73	3,22
agri. GDP percent	**0,45*****	0,16	0,04	0,53	-11,31	8,21
_cons	**-15,27*****	4,52	22,50	17,83	**-101,95***	53,49
N_obs	1091		599		255	
R_sq (within)	0,2793		0,4734		0,7726	

Source: author's calculations.

On the regional level, both the R-squared and the coverage-variables trade-off display similar trajectories. The first specification seems to include too few variables to provide useful insight regarding our main variables of interest. Meanwhile, the second and third specifications come with an extreme progressive loss of observations. Note that the third specification only includes data from 2013 and 2016.

Of farm structural characteristics, the nonlinear farm size effect from the NUTS0 level is present once in the first specification, but without significance. It also seems that refining the level of aggregation results in that the variables regarding dairy farming lose their strong effects. Additionally, permanent crop ratio displays a very strong positive effect in one specification.

Of farmer demographic characteristics, the U-effect of average farmer age persists regarding direction of coefficients, but is not significant in either specification. The ratio of female farm managers has a consistently positive coefficient across all main specifications, but turns significant in the second regression. The training level of farmers loses its strongly significant nature from the NUTS0 regressions. However, it must be mentioned that on the NUTS2 level, farmer training is only recorded in two time points, allowing for much weaker analyses.

The market infrastructures and societal attitudes variables display few and largely insensible significant effects. The macroeconomic country control variables are strongly significant with expectable coefficients in the first regression. Overall, it can be said that the core NUTS2 specifications did not manage to obtain, nor confirm, any strong results. The following paragraphs will overview the six additional RC specifications.

Table 7: Results of first three RC specifications at NUTS2 level

						*** = p<0.1; **=p<0.05; ***=p<0.01**
organic percentage (%)	RC1		RC2		RC3	
	Coeff.	R. Std. Err.	Coeff.	R. Std. Err.	Coeff.	R. Std. Err.
Farm structural characteristics						
avg. farm size (acres)	0,02	0,02	0,01	0,02	0,01	0,02
avg. farm size2 (acres)	-0,0001	0,0001	0,00001	0,0001	0,0001	0,0001
livestock density (head / ha)	-0,80	0,82	0,02	1,05	0,06	1,03
soilerosion	-0,16	0,13	0,08	0,16	-0,11	0,10
dairycattledensity					-1,24	4,38
labour intensity (AWU/ha)					-2,12	8,31
fam. labour intensity (AWU/ha)					-12,98	20,30
Farmer demographic characteristics						
female ratio (%/100)	**21,09****	9,37	9,42	9,81	**19,07*****	6,62
Organic markets & infrastructure						
HS food percent (%/100)	-0,18	0,16	**0,66*****	0,22	**0,51****	0,20
organic PCC (€)	**0,08*****	0,01				
organic retail volume (million €)	-0,22	0,30				
Societal attitudes						
green vote ratio (%/100)			**20,15****	9,16		
green closeness (%/100)			2,28	8,28		
env. importance (1-4)			-1,46	0,95		
legal trust level (1-10)			**-1,92*****	0,38		
Country Controls						
GDP / capita (1000 €)	**0,15***	0,06	**0,74*****	0,10	**0,44*****	0,08
agri. lab. percent (%/100)	**-0,18****	0,09	-0,19	0,15	**-0,24****	0,09
agri. GDP percent	**0,67****	0,32	**-1,53*****	0,50	**0,55*****	0,17
_cons	0,64	2,94	**-10,33***	5,91	**-14,01*****	4,53
N_obs	1032		961		983	
R_sq (within)	0,399		0,3504		0,2819	

Source: author's calculations.

Much like in the main specifications, the reverse-U shape effect of average farm size appears only once and without significance, while the directions of the coefficients display different patterns in the other two specifications. The other main variable of interest is the ratio of female farm managers. This coefficient is positive all along and significant in two of the three cases. This time, the markets, infrastructure and societal attitude groups show reasonable patterns, and the structural country controls persist with very strong overall effects. Overall, the first three RC specifications suggest that country-level effects can be as important as regional effects in governing regional organic expansion. This notion would suggest that domestic demand and social effects regarding organic production are not very highly localized. The next paragraphs will survey the second three RC specifications.

Table 8: Results of second three RC specifications at NUTS2 level

						**** = p<0.1; **=p<0.05; ***=p<0.01***
organic percentage (%)	RC4		RC5		RC6	
	Coeff.	**R. Std. Err.**	**Coeff.**	**R. Std. Err.**	**Coeff.**	**R. Std. Err.**
Farm structural characteristics						
avg. farm size (acres)	**0,09*****	0,02	0,05	0,05	-0,07	0,08
avg. farm size2 (acres)	**-0,0002****	0,0001	-0,0001	0,0002	0,0002	0,0003
livestock density (head / ha)	0,74	0,91	0,24	1,74	**-1,88****	0,95
soilerosion	-0,11	0,11	-0,35	0,49	-0,03	0,50
dairycattledensity			-9,88	5,51		
labour intensity (AWU/ha)			20,59	22,18		
fam. labour intensity (AWU/ha)			-58,43	43,19		
permanent grassland (%/100)			-4,22	10,54		
permanent crops (%/100)			**64,40****	28,04		
off-farm main (%/100)			**12,08*****	5,64		
off-farm sec. (%/100)			**9,17*****	3,27		
Farmer demographic characteristics						
female ratio (%/100)	**18,36****	10,10	**20,95****	9,55	**21,48***	11,51
avg. age (years)	**-1,31****	0,60			-1,01	0,62
avg. age2 (years)	**0,01****	0,01			0,01	0,01
farmer training					1,95	2,39
Organic markets & infrastructure						
HS food percent (%/100)	**0,33****	0,16	0,21	0,34	-0,15	0,30
Country Controls						
GDP / capita (1000 €)	**0,40****	0,09	**0,48*****	0,09	**0,63*****	0,13
agri. lab. percent (%/100)	**-0,18***	0,10	-0,09	0,18	0,08	0,31
agri. GDP percent	-0,02	0,43	0,26	0,71	0,84	0,99
_cons	18,68	14,69	-12,03	11,12	10,84	17,08
N_obs	820		386		381	
R_sq (within)	0,308		0,473		0,3775	

Source: author's calculations.

The effect of permanent crops is once again present with a strong positive coefficient. However, the NUTS2 level findings are highly inconsistent with the NUTS0 results, whereas the positive significant effects of off-farm activities, while backing Kallas, Serra & Gil (2010), are isolated across the analysis. Therefore, these notions can't be counted among the main findings of this thesis.

In the fourth RC specification, the reverse U-shape of average farm size is once again present with a high level of overall significance. RC5 displays a similar, but insignificant pattern regarding farm size, while RC6 once again shows a different pattern. The nonlinear U-effect of average farmer age is present in both specifications the variables are included in, and likewise significant in RC4. The ratio of females, however, has a consistently-sized and significant positive coefficient across all three RC specifications in question, which makes it the strongest result of the NUTS2 level regressions. The effect of farmer training, however, is still not significant on this level of aggregation, and the coefficient keeps its diminished size compared to the NUTS0 level effect.

Overall, the main takeaways following Europe-level analyses on NUTS2 level data aggregation are the following:

- The strongest result is that an increase in the ratio of land managed by female farm managers seems to have a positive effect on organic acreage expansion.
- The nonlinear relationships that average farm size and acreage-weighted farmer age displayed with organic acreage on the country level are present in the NUTS2 level analyses, although it is questionable as to what extent they can be considered confirmed.
- The positive effect of acreage-weighted farmer training could not be confirmed by the NUTS2 level analyses, while the effects regarding dairy cattle density and permanent grassland can be considered invalidated by the refined level of aggregation.

5.4 Validity, summary and interpretation of main results

Overall, the analyses did not provide results that were all-around consistent. Moreover, aggregate data is known to face a plethora of issues, as presented in 4.1.3. Therefore, it is important to first take account of the validity of our results for the sake of academic integrity.[74] Robust standard errors were introduced to account for potential heteroskedasticity and serial correlation. However, modified Wald tests still point to the presence of heteroskedastic residuals.[75]

A series of Shapiro-Wilk tests almost unequivocally rejects the assumption of normally distributed residuals. Complete formal normality, however, is not necessarily a requirement. Visual intuition based on a series of histograms and Q-Q plots still suggests a poor approximation of normality.[76] The distribution of variables on both levels shows a varied approximation of normality. Plots of years and average residuals may in some cases suggest

[74] Nonetheless, this step was usually omitted by the studies examined for this thesis.
[75] Via user-written command Xttest3 in STATA.
[76] Logging variables was attempted, but it did not remedy any of the issues at all. Logging also removes quadratic coefficients.

problems with serial correlation regarding our main specifications. On the other hand, residuals are within reasonable ranges – see Appendix D for validity check figures.

Overall, the issues somewhat overshadow the results and statistical reliability could definitely be stronger. However, they do not invalidate the analysis in light of our research objectives, as the goal of this thesis was not to provide pinpoint predictions, but to infer general points and to test which of the literature's already established points could be backed by a continent-wide aggregate analysis. In tandem, it should be stressed again that Eurostat data is officially supposed to be the basis of European policymaking, and the Eurostat FSS-based agricultural database is still the only choice permitting such an analysis. It must be nonetheless noted that the employed methods are equivalent to basic OLS techniques, and potential sources of endogeneity were not fully taken into account – causation can't be claimed with complete certainty. For future research, instrumental regression techniques could solve such problems and result in stronger analyses. Albeit these methods were considered, no suitable instruments were found that could be reliably operationalized on this scale. And while the methods used were simple, they fit the goal of this thesis.

With that in mind, it is also a question to what extent our main highlighted findings can be considered generalizable for the whole of the continent, as per the research questions of the thesis. Considering that finer levels of aggregation should take precedence over coarser-level data, the effect of the acreage-weighted ratio of female managers is the strongest finding of the thesis, and the only one which can be safely generalized based on our analyses. It is also based on this notion that the effects of dairy-related variables should not be included in the main takeaways of the thesis. However, the results regarding acreage-weighted farmer training may not have to be considered invalidated by the lack of significant effects on the NUTS2 level due to the low coverage – it can be still be considered a valid, but weaker finding pertaining to the country level.

Similarly, the nonlinear age effect is a weaker, but persistent finding: while the effect proved significant only twice, the same relationship was present in all regressions age was included in, except one. On the other hand, the nonlinear effect of average farm size, while significant more times than the age variables, was a lot less consistent across the analysis. However, every time the age effect proved significant, it was with this same nonlinear relationship. Therefore, while acknowledging its relative weakness, it can still be considered a relevant finding of this thesis.

Overall, the thesis identified one farm structural and three farmer demographic characteristics relevant to the research questions. While the results vary in their reliability, the thesis can be said to have fulfilled its research objectives successfully. The following paragraphs will now analyse and interpret these results in detail.

The strongest, and a very interesting, finding of this thesis is the positive effect of the ratio of land managed by female farm managers, suggesting that the corresponding results of Burton, Rigby & Young (1999; 2003) and Tiffin & Balcombe (2011) can be generalized for the continent. The significant coefficients range between 18 and 25 on the regional level. The numbers mean that a hypothetical 100 percentage-point increase in this ratio would result in the respective region's organic acreage ratio rising by 18 to 25 percentage-points.[77] However, one should be generally careful about deducting conclusions for cases that are out of the respective dataset's range, while aggregate data is known to have larger coefficients than raw data (Clark & Avery, 1976; Pakes, 1979). The summary statistics and the variable distribution graphs in Appendix D reveal quite low overall percentages of female farm managers in the sample, advising caution in the numerical interpretation of the coefficients.[78] As for explanations, one may lie in inherent female traits, as well as culturally evolved gender perspectives, or perhaps a combination of both. Another might be found in social structures: for example, it may be possible that managers who inherit their operations, and as such are 'born' into conventional agriculture, are generally males due to social custom, while females have a higher propensity to be recent entrants.[79] The results open the way for very interesting further research on the issue.

The country-level results suggest that increasing the acreage-weighted average training of farm managers by one 'level' expands organic acreage by about 5 percentage-points – the non-significant NUTS2 results, however, suggest a lower figure. The summary statistics reveal that the average training level is around 2, corresponding to basic agricultural training. Overall, the results suggest that raising agricultural training levels to full formal agricultural training for all farm managers would raise organic ratios somewhere between 1 and 5 percentage points. The explanation is rather obvious: organic farming is know-how intensive (Burton, Rigby & Young, 1999; Morgan & Murdoch, 2000; Läpple & Van Rensburg, 2011;

[77] Obviously, such an increase is impossible in regions where this ratio is larger than 0 – i.e. most cases.
[78] If one was to take these results at face value, one could infer that switching gender ratios in agricultural management would immedietaly result in outperforming the objectives of the Organic Action Plan by about an additional 100%. This is obviously highly questionable.
[79] This is purely unfounded speculation, but an interesting notion nonetheless.

Bliss et al., 2019). However, as for the second research question, no previous studies examined the effect of agricultural training as a numerically operationalized variable to date.

The statistically somewhat weaker results regarding the nonlinear effect of acreage-weighted average farm manager age needs further analysis to determine the true nature of the relationship. See Table 9 and Figure 6 below.

Table 9: Average farmer age nonlinearity analysis(significant coefficients)

Specification	Function minimum	Sample median	Sample mean	Sample maximum
N0S3	52,7	51,6	51,3	56,8
N2RC4	49,1	51,3	51	62

Source: author's calculations based on the Eurostat agricultural database.

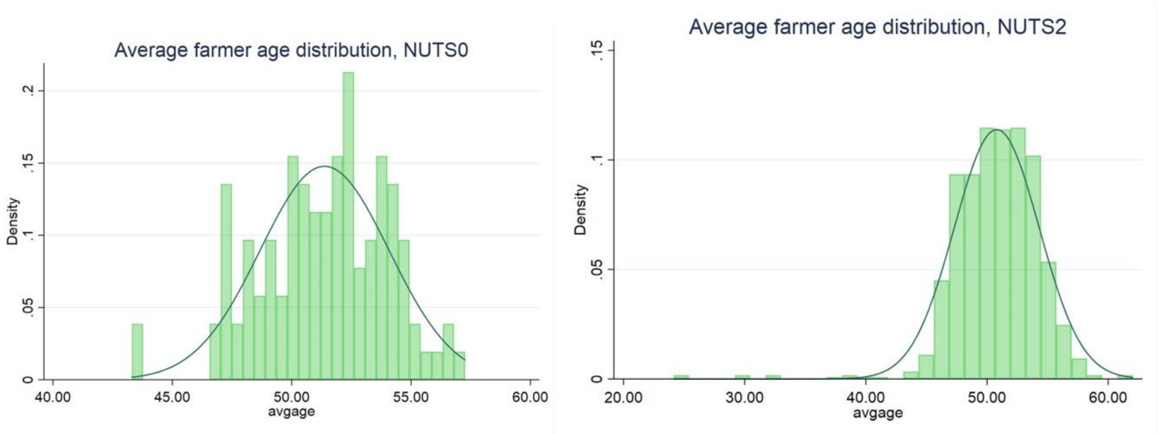

Figure 6: Distribution of average farmer age. Source: author's visualization based on the Eurostat agricultural database.

In both relevant specifications, the age functions reach their turning points[80] around their respective sample means and medians. From this we can infer a 'proper' U-shaped relationship between acreage-weighted average farm manager age and organic acreage. The U-shaped relationship may be explained by multiple factors. The involvement of younger people in organic practice may be due to generational shifts in socialisation norms and ideology – thus, part of this age effect may be picked up by directly measured attitudes in other studies. Meanwhile, the propensity of older farmers to be organic could be attributed to increased know-how and experience.

[80] The regression coefficients stand for the effects of a unit-increase in the variable; the minimum point is where the combined unit-increase effect of the base and the quadratic term turns into positive. Up until that point, an increase in average farmer age has a negative effect on organic percentage according to our models.

Economic reasoning could also be applied. Younger farmers may feel more „room" to experiment and take risks, but middle-aged operators could feel a pressure to safely pursue economic success for their own future and to provide for potential families. Older farmers, on the other hand, may have less to lose with a risky investment as their time horizons are shorter. Older people may also be entitled to additional financial aid, potentially allowing for the pursuit of more fulfilling (see Bouttes et al., 2020) modes of operation.[81] Note that when using terms such as „young", „middle-aged" and „older", the exact distribution of ages must be taken into account. In our sample, the age distribution does not correspond to the traditional understanding of these terms – the histograms show a more condensed age structure, presumably due to the aggregate nature of the data. In reality, the patterns outlined above may still apply. As for the second research question, there are no previous directly corresponding empirical findings that can be generalized on the continental level based on these results.

Table 10: Average farm size nonlinearity analysis

Specification	Function maximum	Sample median	Sample mean	Sample maximum
N0S3	121	26,6	34	152,4
N0RC1	134,5	26,6	34	152,4
N2RC4	224,6	33,7	45,5	285,6

Source: Author's calculations based on the Eurostat agricultural database.

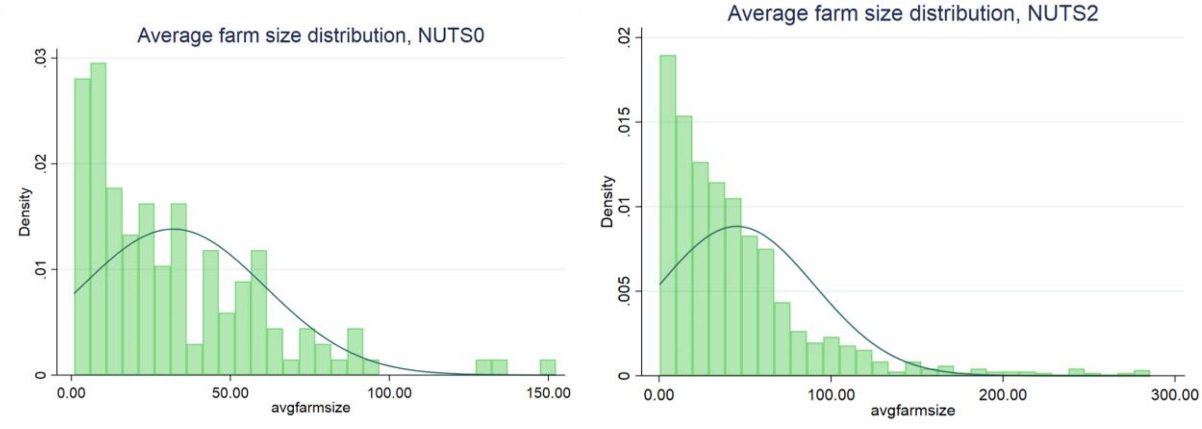

Figure 7: Distribtuion of average farm size. Source: author's visualization based on the Eurostat agricultural database.

[81] This notion is supported by some anecdotal evidence on the author's part. In late summer/fall of 2020, I was WWOOF-ing in Västra Götaland, Sweden. During this time I have got to know two legally retired organic farmers, who, despite working full-time, admitted to doing it mostly as a hobby that was permitted by their pensions. Moreover, they both operated 1-2 acre farms, underlining the finding that smaller operations may be difficult to run profitably as organic. Note that such farms are usually out of FSS populations.

Of the farm structural variables, farm size was the only one yielding results relevant to the research objectives – but statistically speaking; this is also the weakest contribution of the study. This paper is the first to include a quadratic term for farm size, and our models present a nonlinear relationship. As noted before, further analysis is needed to interpret nonlinearity. Table 10 above presents the maximum points of the farm size function in each relevant specification, while Figure 7 shows the distribution of average farm sizes across the NUTS0 and NUTS2 level datasets.

In all relevant specifications on both levels, the average farm size function's turning point is beyond the 95th percentile. For the most part, increases in average farm size can be said to have a progressively diminishing positive effect on organic acreage in our model. In this, our final results mostly back Pietola & Lansink (2001) and Chatzimichael, Genius & Tzouvelekas (2014) regarding their Greek sample. While not directly corresponding to this one, their results might be partially generalized on the European level.[82] Although just like with farmer age, one must remember that these refer to averaged figures, therefore, the interpretation depends on assumptions about within-unit distribution. As an explanation, farm size might be a proxy for farm financial strength, posing obstacles to smaller operations. To explain the negative quadratic term, perhaps as farms get larger they have more to lose by switching to risky technologies that may not have as good economies of scale (based on Serebrennikov et al., 2020).[83]

To wrap up, it may be constructive to once again clarify what the results mean in the context of our regressions. Our models studied the historical expansion of organic acreage in the EU through fixed effects regressions. The analysis looked at an evolution unfolding over roughly a decade – which ended five years ago – in an attempt to deduct conclusions generalizable to the present and future. Naturally, this might inherently present some caveats. Furthermore, the analysis did not compare different regions. Obtained coefficients refer to expected changes in organic acreage associated with a within-unit change in independent variables. E.g. we should not conclude that a region with a higher acreage-weighted ratio of female managers will have a higher percentage of organic UAA than a region with a lower such ratio. Instead, we can expect that a certain region will experience a rise in its organic acreage if its respective acreage-weighted female farm manager ratio increases.

[82] Naturally, while still keeping in mind the statistical weakness of this result.
[83] For example,investments in expensive machinery are presumably more profitable the bigger a farm gets.

6 Conclusion and discussion

6.1 Aims and summary of research

This thesis examined the determinants of organic acreage expansion – focusing on farm structural and farmer demographic characteristics – using fixed effects methods on a Europe-wide panel dataset based on aggregate Eurostat agricultural data. Based on the general need for more sustainable agriculture and the EU's Organic Action Plan, the thesis first established the objective of studying the past expansion of European organic acreage as a continent-wide process. The determinants of European farm-level organic conversion have been examined by a wide range of previous research, employing smaller samples scattered in space and time, often presenting opposing results. In light of this, the thesis framed two, very closely related research questions:

- Based on its recent evolution, which farm and farmer characteristics determine the expansion of organic acreage within Europe?
- Which previous empirical findings regarding the determinants of organic farming expansion, and to what extent, can we generalize in the context of the European Union?

Subsequently, the thesis set the rise of organic farming within the larger patterns of Europe's agricultural structural transformation, further motivating the objective of studying organic agriculture in a historical, continent-wide context. The following chronological review of relevant theory developments revealed the multi-faceted nature of farmers' decision-making, as well as its potential heterogeneity across different groups of farmers, which may explain the contradicting results of earlier literature on the topic. The thesis then reviewed every quantitatively studied determinant of farm-level organic conversion from retrieved studies, and operationalized nearly all of them in an immense spatially aggregated panel dataset along with a selection of additional variables. After running numerous fixed-effects specifications, the thesis' results suggest the following:

- An increase in the acreage-weighted ratio of female farm managers is positively associated with organic acreage expansion.
- An increase in the acreage-weighted average level of agricultural training of farm managers is positively associated with organic acreage expansion. This result pertains only to the country level.
- Acreage-weighted average farm manager age has a U-shaped relationship with organic acreage. An increase in the variable has a negative effect on organic acreage, while above a certain threshold the effect turns positive. This might suggest that it is younger and older farmers who tend to operate organically, as opposed to the middle of the age distribution. Based on significance levels, this result is less statistically secure.
- Changes in average farm size have a nonlinear effect on organic acreage, with a positive linear and a negative quadratic coefficient. For the most part, this translates to a progressively diminishing positive effect, as there are very few regions where average farm size is high enough for the combined effect to turn negative. This result, however, is the least statistically reliable of the four.

While the results are somewhat shadowed by data issues, the thesis managed to identify one farm structural and three farmer demographic characteristics that play a role in determining the expansion of organic acreage on a European level. The thesis also identified those earlier small-sample results that can be possibly generalized for the whole of the continent. Moreover, the thesis also contributed to the literature by providing potential answers to several seeming contradictions arising from the limitedness of previously examined samples. Overall, the thesis met its research aims successfully.

6.2 Implications for future research and policy

The thesis summarizes and synthetizes much of the literature and presents a comprehensive continental analysis, providing a good parting point for future research on the topic. It is unlikely that additional limited-sample, single-country studies examining farm-level organic conversion will uncover much more. In the question of quantitative drivers, the way forward would probably be overarching studies such as these, but with better data. More suitable datasets could also potentially permit the use of more advanced empirical techniques such as instrumental regressions to account for potential endogeneity. While obtaining recent, nonaggregated EU FSS and other surveys on a continental level would be ideal, confidentiality issues would probably make this very difficult, if not outright impossible. The construction of new, Europe-wide independent surveys would be very costly on the other hand. Focused qualitative research, however, could prove very useful in reinforcing and explaining the results obtained by this thesis. Besides training levels, no clear scientific explanation exists for either of the main conclusions. Qualitative analysis, involving as many stakeholder groups as possible, could also be the way forward in uncovering the still remaining issue of between-country variance, unlikely to be answered by econometric research.

As for policy implications, the Organic Action Plan already acknowledges the know-how intensive nature of organic farming. However, its main focus seems to lie on educating potential consumers and promoting scientific research (European Commission, 2021/1). The post-2020 CAP, on the other hand, is intended to include technical assistance and training courses on organic practice, as well as promoting farmer-to-farmer knowledge exchange schemes (European Commission, 2021/2). The thesis' results further justify this direction.

The policy implications of the age-related results underline the need to attract more young people into the agricultural sector.[84] The EU already recognizes the issue, and the CAP has a 'Young Farmer Payment' scheme to get farmers under 40 into the business (European Commission, 2021/3). However, the implications of age on organic farming are not mentioned. Perhaps a combination of further explanatory research and policy instruments could unlock synergies between the Organic Action Plan and the Young Farmer Payment scheme.

As for farm size, the author would definitely warn against policies promoting the concentration of farmland for the sake of organic agriculture. Instead, further research could look into the exact barriers smaller farms may face in adopting organic agriculture. Simultaneously, CAP schemes should constantly be assessed and refined to ensure a just system where operating sustainably is a rentable choice available to every farmer.

The strongest, and perhaps the most interesting, are the results regarding sex. On one hand, qualitative research uncovering sex-specific environmental attitudes amongst farmers could prove fruitful. On the other, the very low percentages of land managed by female farm

[84] For a number of obvious reasons, policies aiming to accelerate the ageing of the sector towards the upper ends of the distribution would be highly problematic.

managers are strikingly apparent.[85] Further research could also uncover the reasons behind this. Once potential barriers for women are identified, policy instruments empowering women to become farm managers should also be considered, at the very least for the sake of organic expansion.

Meanwhile, it is still important to keep the criticisms and caveats of organic farming in mind. While the Organic Action Plan is a commendable step towards a sustainable European agriculture, more goal-oriented research could also prove constructive. For example, how organic is organic within Europe? What is the extent of variation in true ecological friendliness between organic farmers of different characteristics? Even if the goals of the Organic Action Plan are met, are they truly enough to prevent European agriculture's potentially looming ecological crisis? What are its main alternatives to ensure the sustainability of our agriculture, and what can be said about their dispersion patterns?

While the literature concerning a more sustainable European agriculture, now complemented by this thesis, is extensive, research must not stop here. The future of the continent in all aspects is inexorably linked to the health of Europe's soil itself. Therefore, understanding both the biological and socio-economic conditions of ensuring sustainability in agriculture is crucial, and there is much left to answer.

[85] See summary statistics and Appendix D.

References

Achuelo, M. S. (2016). Crops for Better Soil - Profitable organic farming techniques based on traditional crops: contrasting soil degradation in the Mediterranean, European Commission, Available online: https://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=3921 [Accessed 1 December 2020]

Aguilera, E., Lassaletta, L., Gattinger, A. & Gimeno, B. S. (2013). Managing Soil Carbon for Climate Change Mitigation and Adaptation in Mediterranean Cropping Systems: A meta-analysis, *Agriculture, Ecosystems and Environment*, vol. 168, pp. 25-36

Ajzen, I. (1991). The Theory of Planned Behavior, *Organizational Behavior and Human Decision Processes*, vol. 50, no. 2, pp.179–211.

Aleixandre, J. L., Aleixandre-Tudó, J. L., Bolaños-Pizarro, M. & Aleixandre-Benavent, R. (2015). Mapping the Scientific Research in Organic Farming: A bibliometric review, *Scientometrics*, vol. 105, no. 1, pp. 295-309

Allen, P. & Kovach, M. (2000). The Capitalist Composition of Organic: The potential of markets in fulfilling the promise of organic agriculture, *Agriculture and Human Values*, pp.221-232

Andersen, A. H. (2011). Organic Food and the Plural Moralities of Food Provisioning, *Journal of Rural Studies*, vol. 27, no. 4, pp. 440-450

Andersson, M. & Rohne Till, E. (2018). Between the Engine and the Fifth Wheel: An analytical survey of the shifting roles of agriculture in development theory, in V. Penilla, H. Willebald (eds.) *Agricultural Development in the World Periphery*, London: Palgrave Macmillan

Baillieux, P. & Scharpe, B. (1994). Organic Farming, Luxembourg: Office for Official Publications of the European Communities

Baregheh, A., Rowley, J. & Sambrook, S. (2009). Towards a Multidisciplinary Definition of Innovation, *Management Decision*, vol. 47, no. 8, pp. 1323-1339

Belfrage, K., Björklund, J. & Salomonsson, L. (2005). The Effects of Farm Size and Organic Farming on Diversity of Birds, Pollinators, and Plants in a Swedish Landscape, *Ambio*, vol. 34, no. 8, pp. 582-588

Best, H. (2008). Organic Agriculture and the Conventionalization Hypothesis: A case study from west Germany, *Agriculture and Human Values*, vol. 25, no. 1, pp. 95-106

Bliss, K., Padel, S., Cullen, B., Ducottet, C., Mullender, S., Rasmussen, I. A. & Moeskops, B. (2019). Exchanging Knowledge to Improve Organic Arable Farming: An evaluation of knowledge exchange tools with farmer groups across Europe, *Organic Agriculture*, vol. 9, no. 4, pp. 383-398

Bouttes, M., Bancarel, A., Doumayzel, S., Viguié, S., Cristobal, M. S. & Martin, G. (2020). Conversion to Organic Farming Increases Dairy Farmers' Satisfaction Independently of the Strategies Implemented, *Agronomy for Sustainable Development*, vol. 40, no. 2, article no. 12

Bouttes, M., Bize, N., Maréchal, G., Michel, G., Cristobal, M. S. & Martin, G. (2019). Conversion to Organic Farming Decreases the Vulnerability of Dairy Farms, *Agronomy for Sustainable Development*, vol. 39, no. 2, article no. 19

Brzezina, N., Biely, K., Helfgott, A., Kopainsky, B., Vervoort, J. & Mathijs, E. (2017). Development of Organic Farming in Europe at the Crossroads: Looking for the way forward through system archetypes lenses, *Sustainability (Switzerland)*, vol. 9, no. 5, pp. 821-844

Buck, D., Getz, C. & Guthman, J. (1997). From Farm to Table: The organic vegetable commodity chain of Northern California, *Sociologia Ruralis*, vol. 37, no. 1, pp. 3–20

Burton, M., Rigby, D. & Young, T. (1999). Analysis of the Determinants of Adoption of Organic Horticultural Techniques in the UK, *Journal of Agricultural Economics*, vol. 50, no. 1, pp. 47-63

Burton, M., Rigby, D. & Young, T. (2003). Modelling the Adoption of Organic Horticultural Technology in the UK Using Duration Analysis, *Australian Journal of Agricultural and Resource Economics*, vol. 47, no. 1, pp. 29-54

Carr, P. M., Mäder, P., Creamer, N. G. & Beeby, J. S. (2012). Editorial: Overview and Comparison of Conservation Tillage Practices and Organic Farming in Europe and North America, *Renewable Agriculture and Food Systems*, vol. 27, no. 1, pp. 2-6

Chatzimichael, K., Genius, M. & Tzouvelekas, V. (2014). Informational Cascades and Technology Adoption: evidence from Greek and German organic growers, *Food Policy*, vol. 49, no. 1, pp. 186-195

Chmielinski, P., Pawlowska, A., Bocian, M. & Osuch, D. (2019). The Land Is What Matters: Factors driving family farms to organic production in Poland, *British Food Journal*, vol. 121, no. 6, pp. 1354-1367

Clark, W. A. V. & Avery, K. L. (1976). The Effects of Data Aggregation in Statistical Analysis, *Geographical Analysis*, vol. 8, no. 4, pp. 428-438

Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91, Brussels: European Council, Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02007R0834-20130701 [Accessed 29 November 2021]

Dabbert, S., Häring, A. M., Zanoli, R. (2004). Organic Farming: Policies and prospects, London: Zed

Darnhofer, I., D'Amico, S. & Fouilleux, E. (2019). A Relational Perspective on the Dynamics of the Organic Sector in Austria, Italy, and France, *Journal of Rural Studies*, vol. 68, pp. 200-212

Darnhofer, I., Lindenthal, T., Bartel-Kratochvil, R. & Zollitsch, W. (2010). Conventionalisation of Organic Farming Practices: From structural criteria towards an assessment based on organic principles. A review, *Agronomy for Sustainable Development*, vol. 30, pp. 67-81

Desquilbet, M., Maigné, E. & Monier-Dilhan, S. (2018). Organic Food Retailing and the Conventionalisation Debate, *Ecological Economics*, vol. 150, pp. 194-203

Dinis, I., Ortolani, L., Bocci, R. & Brites, C. (2015). Organic Agriculture Values and Practices in Portugal and Italy, *Agricultural Systems*, vol. 136, pp. 39-45

Eden, S. (2011). Food Labels as Boundary Objects: How consumers make sense of organic and functional foods, *Public Understanding of Science*, vol. 20, no. 2, pp. 179-194

Emsley, J. (2001). Going One Better than Nature?, *Nature*, vol. 410, pp. 633-634

European Commission (2018). Future of the Common Agricultural Policy, Available online: https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/future-cap_en [Accessed 3 December 2020]

European Commission (2020). EU Biodiversity Strategy for 2030, Available online: https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF [Accessed 15 April 2021]

European Commission (2021/1). Organic Action Plan, Available online: https://ec.europa.eu/info/food-farming-fisheries/farming/organic-farming/organic-action-plan_en [Accessed 15 April 2021]

European Commission (2021/2). Young Farmers, Available online: https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/income-support/young-farmers_en [Accessed 16 April 2021]

European Commission (2021/3). On An Action Plan For The Development Of Organic Production, Available online: https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/com2021_141-organic-action-plan_en.pdf [Accessed 15 April 2021]

Eurostat (2019). Glossary: Farm structure survey (FSS), Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Farm_structure_survey_(FSS) [Accessed 19 April 2021]

Eurostat (2020). Farm Structure Survey – Survey Coverage, Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farm_structure_survey_%E2%80%93_survey_coverage#cite_note-3 [Accessed 19 April 2021)

Fenske, J. (2011). Land Tenure And Investment Incentives: Evidence from West Africa, *Journal of Development Economics*, vol. 95, no. 2, pp. 137-156

Food and Agriculture Organization of the United Nations (2016). State of Food and Agriculture: Climate change, agriculture and food security, Rome: FAO

Fezzi, C. & Bateman, I. (2015). The Impact of Climate Change on Agriculture: Nonlinear effects and aggregation bias in Ricardian models of farmland values, *Journal of the Association of Environmental and Resource Economists*, vol. 2, no. 1, pp. 57-92

Finger, R. (2012). Effects of Crop Acreage and Aggregation Level on Price-Yield Correlations, *Agricultural Finance Review*, vol. 72, no. 3, pp. 436-455

Fouilleux, E. & Loconto, A. (2017). Voluntary Standards, Certification, and Accreditation in the Global Organic Agriculture Field: A tripartite model of techno-politics, *Agriculture and Human Values*, vol. 34, no. 1, pp. 1-14

Gardebroek, C. & Jongeneel, R. (2004). The Growth in Organic Agriculture: Temporary shift or structural change?, Short paper presented at 2004 AAEA Annual Meeting

Gardebroek, C. (2006). Comparing Risk Attitudes of Organic and Non-Organic Farmers with a Bayesian Random Coefficient Model, *European Review of Agricultural Economics*, vol. 33, no. 4, pp. 485-510

Genius, M., Pantzios, C. J. & Tzouvelekas, V. (2006). Information Acquisition and Adoption of Organic Farming Practices, *Journal of Agricultural and Resource Economics*, vol. 31, no. 1, 93-113

Gibbon, P. (2008). An Analysis of Standards-Based Regulation in the EU Organic Sector, 1991-2007, *Journal of Agrarian Change*, vol. 8, no. 4, pp. 553-582

IFOAM (2020). Available online: https://www.ifoam.bio/ [Accessed 23 Nov 2020]

Jacobi, J., Schneider, M., Pillco Mariscal, M., Huber, S., Weidmann, S., Bottazzi, P. & Rist, S. (2015). Farm Resilience in Organic and Nonorganic Cocoa Farming Systems in Alto Beni, Bolivia, *Agroecology and Sustainable Food Systems*, vol. 39, no. 7, pp. 798-823

Kallas, Z., Serra, T. & Gil, J. M. (2010). Farmers' Objectives as Determinants of Organic Farming Adoption: the case of Catalonian vineyard production, *Agricultural Economics*, vol. 41, no. 5, pp. 409-423

Kaminska, O. (2020), Guide to Using Weights and Sample Design Indicators with ESS Data, Available online: https://www.europeansocialsurvey.org/docs/methodology/ESS_weighting_data_1_1.pdf [Accessed 2 December 2020]

Kaufmann, P., Stagl, S. & Franks, D. W. (2009). Simulating the Diffusion of Organic Farming Practices in Two New EU Member States, *Ecological Economics*, vol. 68, no. 10, pp. 2580-2593

Klein, K. & Winickoff, D. E. (2011). Organic Regulation across the Atlantic: Emergence, divergence, convergence, *Environmental Politics*, vol. 20, no. 2, pp. 153-172

Komorowska, D. (2014). Development of Organic Production and Organic Food Market in Europe, *Acta Scientiarum Polonorum. Oeconomia*, vol. 13, no. 4, pp. 91-101

Läpple, D. (2010). Adoption and Abandonment of Organic Farming: An empirical investigation of the Irish drystock sector, *Journal of Agricultural Economics*, vol. 61, no. 3, pp. 697-714

Läpple, D. & Kelley, H. (2015). Spatial Dependence in the Adoption of Organic Drystock Farming in Ireland, *European Review of Agricultural Economics*, vol. 42, no. 2, pp. 315-337

Läpple, D. & Kelley, H. (2013). Understanding the Uptake of Organic Farming: Accounting for heterogeneities among Irish farmers, *Ecological Economics*, vol. 88, pp. 11-19

Läpple, D. & Rensburg, T. Van. (2011). Adoption of Organic Farming: Are there differences between early and late adoption?, *Ecological Economics*, vol. 70, no. 7, 1406-1414

Lewis, W. A. (1954). Economic Development with Unlimited Supplies of Labour, *The Manchester School*, vol. 22, no. 2, pp.139–191

Li, M., Peterson, C. A., Tautges, N. E., Scow, K. M. & Gaudin, A. C. M. (2019). Yields and Resilience Outcomes of Organic, Cover Crop, and Conventional Practices in a Mediterranean Climate, *Scientific Reports*, vol. 9, no. 1, article no. 12283

Lobley, M., Butler, A. & Winter, M. (2013). De l'alimentation Bio Locale Pour La Population Locale? Les Stratégies Commerciales En Faveur Des Produits Bio En Angleterre et Au Pays de Galles, *Regional Studies*, vol. 47, no. 2, pp.216–228.

Lockeretz, W. (ed.) (2007). Organic Farming: An international history, Wallingford, Available online: https://www-cabi-org.ludwig.lub.lu.se/cabebooks/ebook/20073257634 [Accessed 29 November 2020]

Lynne, G. D. (1995). Modifying the Neo-Classical Approach to Technology Adoption With Behavioral Science Models, *Journal of Agricultural and Applied Economics*, vol. 27, no. 1, pp. 67-80

Mäder, P. & Berner, A. (2012). Development of Reduced Tillage Systems in Organic Farming in Europe, *Renewable Agriculture and Food Systems*, vol. 27, no. 1, pp. 7-11

Maharjan, G. R., Hoffmann, H., Webber, H., Srivastava, A. K., Weihermüller, L., Villa, A., Coucheney, E., Lewan, E., Trombi, G., Moriondo, M., Bindi, M., Grosz, B., Dechow, R., Kuhnert, M., Doro, L., Kersebaum, K. C., Stella, T., Specka, X., Nendel, C., Constantin, J., Raynal, H., Ewert, F. & Gaiser, T. (2019). Effects of Input Data Aggregation on Simulated Crop Yields in Temperate and Mediterranean Climates, *European Journal of Agronomy*, vol. 103, pp. 32-46

Michelsen, J. (2009). The Europeanization of Organic Agriculture and Conflicts over Agricultural Policy, *Food Policy*, vol. 34, no. 3, pp. 252-257

Moran, D. (2002). Market Creation for Biodiversity: The role of organic farming in the EU and US, OECD Working Papers

Morgan, K. & Murdoch, J. (2000). Organic vs. Conventional Agriculture: Knowledge, power and innovation in the food chain, *Geoforum*, vol. 31, no. 2, pp.159–173.

Morvan, X., Verbeke, L., Laratte, S. & Schneider, A. R. (2018). Impact of Recent Conversion to Organic Farming on Physical Properties and Their Consequences on Runoff, Erosion and Crusting in a Silty Soil, *Catena*, vol. 165, pp. 398-407

Moschitz, H., Stoeva, S., Slavova, P., Pickard, D., Georgieva, Z. & Stolze, M. (2018). Rethinking Organic Farming in the Post-Socialist Context: Lessons from Bulgaria, *EuroChoices*, vol. 17, no. 1, pp. 40-45

Mzoughi, N. (2011). Farmers Adoption of Integrated Crop Protection and Organic Farming: do moral and social concerns matter?, *Ecological Economics*, vol. 70, no. 8, pp. 1536-1545

Offermann, F., Nieberg, H. & Zander, K. (2009). Dependency of Organic Farms on Direct Payments in Selected EU Member States: Today and tomorrow, *Food Policy*, vol. 34, no. 3, pp. 273-279

Padel, S., Lampkin, N. & Foster, C. (1999). Influence of Policy Support on the Development of Organic Farming in the European Union, *International Planning Studies*, vol. 4, no. 3, pp. 303-315

Padel, S., Röcklinsberg, H. & Schmid, O. (2009). The Implementation of Organic Principles and Values in the European Regulation for Organic Food, *Food Policy*, vol. 34, no. 3, pp. 245-251

Pakes, A. (1979). Aggregation Effects And Panel Data Estimation Problems: An investigation of the R&D intensity decision, *National Bureau of Economic Research Working Paper Series*, vol. No. 344, pp. 168-173

Parra López, C. & Calatrava Requena, J. (2005). Factors Related to the Adoption of Organic Farming in Spanish Olive Orchards, *Spanish Journal of Agricultural Research*, vol. 3, no. 1, pp. 5-16

Parras-Alcántara, L. & Lozano-García, B. (2014). Conventional Tillage versus Organic Farming in Relation to Soil Organic Carbon Stock in Olive Groves in Mediterranean Rangelands (Southern Spain), *Solid Earth*, vol. 5, no. 1, pp. 299-311

Pickett, J. A. (2013). Food Security: Intensification of Agriculture Is Essential, for Which Current Tools Must Be Defended and New Sustainable Technologies Invented, *Food and Energy Security*, vol. 2, no. 3, pp. 167-173

Pietola, K. S. & Lansink, A. O. (2001). Farmer Response to Policies Promoting Organic Farming Technologies in Finland, *European Review of Agricultural Economics*, vol. 28, no. 1, pp. 1-15

Rader, R., Birkhofer, K., Schmucki, R., Smith, H. G., Stjernman, M. & Lindborg, R. (2014). Organic Farming and Heterogeneous Landscapes Positively Affect Different Measures of Plant Diversity, *Journal of Applied Ecology*, vol. 51, no. 6, pp. 1544-1553

Rahmann, G., Ardakani, M. R., Bàrberi, P., Boehm, H., Canali, S., Chander, M., David, W., Dengel, L., Erisman, J. W., Galvis-Martinez, A. C., Hamm, U., Kahl, J., Köpke, U., Kühne, S., Lee, S. B., Løes, A. K., Moos, J. H., Neuhof, D., Nuutila, J. T., Olowe, V., Oppermann, R., Rembiałkowska, E., Riddle, J., Rasmussen, I. A., Shade, J., Sohn, S. M., Tadesse, M., Tashi, S., Thatcher, A., Uddin, N., von Fragstein und Niemsdorff, P., Wibe, A., Wivstad, M., Wenliang, W. & Zanoli, R. (2017). Organic Agriculture 3.0 Is Innovation with Research, *Organic Agriculture*, vol. 7, pp. 169-197

Rogers, E. M., Singhal, A. & Quinlan, M. M. (2019). Diffusion of Innovations, in D. W. Stacks, M. B. Salwen & K. C. Eichhorn (eds.) *An Integrated Approach to Communication Theory and Research*, 3rd Edn., Abingdon: Routledge, chap. 31

Rollan, À., Hernández-Matías, A. & Real, J. (2019). Organic Farming Favours Bird Communities and Their Resilience to Climate Change in Mediterranean Vineyards, *Agriculture, Ecosystems and Environment*, vol. 269, pp. 107-115

Rønningen, K., Renwick, A. & Burton, R. (2012). Western European Approaches to and Interpretations of Multifunctional Agriculture - And Some implications of a possible neo-productivist turn, *Research in Rural Sociology and Development*, vol. 18, pp. 73-92

Salhi, S., Grolleau, G., Mzoughi, N. & Sutan, A. (2012). How Can Positional Concerns Prevent the Adoption of Socially Desirable Innovations?, *Journal of Economic Issues*, vol. 46, no. 3, pp. 799-808

Sanders, J. (2011). Use and Efficiency of Public Support Measures Addressing Organic Farming, Johann Heinrich von Thünen Institut (vTI) – Institute of Farm Economics, Available at: https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cmef/farmers-and-farming/use-and-efficiency-public-support-measures-addressing-organic-farming_en

Sattler, C. & Nagel, U. J. (2010). Factors Affecting Farmers' Acceptance of Conservation Measures - A case study from North-Eastern Germany, *Land Use Policy*, vol. 27, no. 1, pp. 70–77.

Schneeberger, W., Darnhofer, I. & Eder, M. (2002). Barriers to the Adoption of Organic Farming by Cash-Crop Producers in Austria, *American Journal of Alternative Agriculture*, vol. 17, no. 1, pp. 24-31

Schultz, T. W. (1964). Transforming Traditional Agriculture, New Haven: Yale University Press

Serebrennikov, D., Thorne, F., Kallas, Z. & McCarthy, S. N. (2020). Factors Influencing Adoption of Sustainable Farming Practices in Europe: A systemic review of empirical literature, *Sustainability (Switzerland)*, vol.12, no. 22, article no. 9719

Seufert, V., Ramankutty, N. & Mayerhofer, T. (2017). What Is This Thing Called Organic? – How organic farming is codified in regulations, *Food Policy*, vol. 68, pp. 10-20

Stolze, M. & Lampkin, N. (2009). Policy for Organic Farming: Rationale and Concepts, *Food Policy*, vol. 34, no. 3, pp. 237-244

Tiffin, R. & Balcombe, K. (2011). The Determinants of Technology Adoption by UK Farmers Using Bayesian Model Averaging: The cases of organic production and computer usage, *Australian Journal of Agricultural and Resource Economics*, vol. 55, no. 4, pp. 579-598

Trewavas, A. (2001). Urban Myths of Organic Farming, *Nature*, vol. 410, pp. 409-410

Tuck, S. L., Winqvist, C., Mota, F., Ahnström, J., Turnbull, L. A. & Bengtsson, J. (2014). Land-Use Intensity and the Effects of Organic Farming on Biodiversity: A hierarchical meta-analysis, *Journal of Applied Ecology*, vol. 51. no. 3, pp. 746-755

Van Bussel, L. G. J., Ewert, F. & Leffelaar, P. A. (2011). Effects of Data Aggregation on Simulations of Crop Phenology, *Agriculture, Ecosystems and Environment*, vol. 142, no. 1–2, pp.75-84

Willock, J. (1999). The Role of Attitudes and Objectives in Farmer Decision Making: Business and environmentally-oriented behaviour in Scotland, *Journal of Agricultural Economics*, vol. 50, no. 2, pp. 286-303

Wilson, G. (2001). There and Back Again ? Exploring the (un) changed natural and mental landscapes of European agriculture, *Transactions of the Institute of British Geographers*, vol. 26, no. 1, pp. 77-102

Wilson, G. A. (2007). Multifunctional Agriculture: A transition theory perspective, Wallingford, Available at: https://www-cabi-org.ludwig.lub.lu.se/cabebooks/ebook/20073109026 [Accessed 5 December 2020]

What is Organic Farming? (2020). SARE, Available at: https://www.sare.org/publications/transitioning-to-organic-production/what-is-organic-farming/ [Accessed 23 November, 2020]

Zander, K., Nieberg, H. & Offermann, F. (2008). Financial Relevance of Organic Farming Payments for Western and Eastern European Organic Farms, *Renewable Agriculture and Food Systems*, vol. 23, no. 1, pp. 53-61

Appendix A – Data and methods

Table 11: Metadata of used variables

Variable	Source	NUTS0	NUTS2
Outcome variable			
organic percentage	Eurostat	2001-2016, annual[86]	2005, 2007, 2010, 2013, 2016
Country control variables			
GDP / capita	Eurostat	2001-2016, annual	-
agri. GDP percent	Eurostat	2001-2016, annual	-
agri. lab. percent	WBOD	2001-2016, annual	-
Farm structural characteristics			
avg. farm size	Eurostat - FSS	2005, 2007, 2010, 2013, 2016	2005, 2007, 2010, 2013, 2016
avg. farm size^2	Eurostat - FSS	2005, 2007, 2010, 2013, 2016	2005, 2007, 2010, 2013, 2016
land ownership	Eurostat - FSS	2005, 2007, 2010, 2013, 2016	2013, 2016
livestock density	Eurostat - FSS	2005, 2007, 2010, 2013, 2016	2005, 2007, 2010, 2013, 2016
permanent grassland	Eurostat - FSS	2005, 2007, 2010, 2013, 2016	2013, 2016
permanent crops	Eurostat - FSS	2005, 2007, 2010, 2013, 2016	2013, 2016
dairy cattle density	Eurostat - FSS	2005, 2007, 2010, 2013, 2016	2005, 2007, 2010, 2013, 2016
labour intensity	Eurostat - FSS	2005, 2007, 2010, 2013, 2016	2005, 2007, 2010, 2013, 2016
fam. labour intensity	Eurostat - FSS	2005, 2007, 2010, 2013, 2016	2005, 2007, 2010, 2013, 2016
off-farm main	Eurostat - FSS	2005, 2007, 2010, 2013, 2016	2013, 2016
off- farm sec.	Eurostat - FSS	2005, 2007, 2010, 2013, 2016	2013, 2016
soil erosion	Eurostat	2000, 2010, 2016	2000, 2010, 2016
Farmer demographic characteristics			
avg. age	Eurostat - FSS	2005, 2007, 2010, 2013, 2016	2005, 2007, 2010, 2013, 2016
avg. age^2	Eurostat - FSS	2005, 2007, 2010, 2013, 2016	2005, 2007, 2010, 2013, 2016
female ratio	Eurostat - FSS	2005, 2007, 2010, 2013, 2016	2005, 2007, 2010, 2013, 2016
farmer training	Eurostat - FSS	2005, 2010, 2013, 2016	2013, 2016
Organic markets & infrastructure			
HS food percent	Eurostat	2001-2016 annual	-
organic PCC	FiBL	2001-2016 annual	-
organic retail volume	FiBL	2001-2016 annual	-
Societal attitudes			
env. importance	ESS	2004, 2006, 2010, 2012, 2016	-
green vote ratio	ESS	2004, 2006, 2010, 2012, 2016	-
green closeness	ESS	2004, 2006, 2010, 2012, 2016	-
legal trust level	ESS	2004, 2006, 2010, 2012, 2016	-

Source: Eurostat, FiBL database, World Bank Open Data, ESS (rounds 2-5 & 7).

[86] On the country level, yearly organic data collection is a member state obligation as per regulation 889/2008.

The tables below present the specifications described in-text in 4.2. For both levels, the first row displays the variables included in the "core" specification. Subsequent rows present only the variables that are added to the core in each additional regression (non-cumulatively).

Table 12: Breakdown of regression specifications at NUTS0 level

Specification	CC	FS	FC	OM	SA	# of OBS
Core	GDP / capita agri. lab. perc. agri. GDP perc.	avg. farm size avg. farm size2 land ownership perm. grassland permanent crops livestock density dairy c. density labour intensity family lab. int. off-farm main off-farm sec soil erosion	female ratio	HS food percent	-	124
2	-	-	-	organic PCC org. retail vol.	green vote perc. green closeness env. importance legal trust level	84
3	-	-	farmer training avg. age avg. age2	organic PCC org. retail vol.	green vote perc. green closeness env. importance legal trust level	60
RC 1			farmer training avg. age avg. age2			83
RC2				organic PCC org. retail vol.		102
RC3					green vote perc. green closeness env. importance legal trust level	99

Source: author's own work.

Table 13: Breakdown of regression specifications at NUTS2 level

Specification	CC	FS	FC	OM	SA	# of OBS
Core	GDP / capita agri. lab. percent agri. GDP percent	avg. farm size avg. farm size2 livestock density soil erosion	female ratio	HS food percent	-	1193
#2		dairy cattle density labour intensity fam. labour intensity	avg. age avg. age2	organic PCC org. retail volume	green vote ratio green closeness env. importance legal trust	599
#3		dairy cattle density labour intensity fam. labour intensity permanent grassland permanent crops off-farm main off-farm sec. land ownership	avg. age avg. age2 farmer training	organic PCC org. retail volume	green vote ratio green closeness env. importance legal trust level	255
RC1	-	-	-	organic PCC org. retail volume	-	1133
RC2	-	-	-	-	green vote ratio green closeness env. importance legal trust level	1060
RC3	-	dairy cattle density labour intensity fam. labour intensity	-	-	-	992
RC4	-	-	avg. age avg. age2	-	-	908
RC5	-	dairy cattle density labour intensity fam. labour intensity off-farm main off-farm sec. permanent grassland permanent crops	-	-	-	393
RC6	-	-	avg. age avg. age2 farmer training	-	-	385

Source: author's own work.

Appendix B – Additional maps of European organic acreage expansion

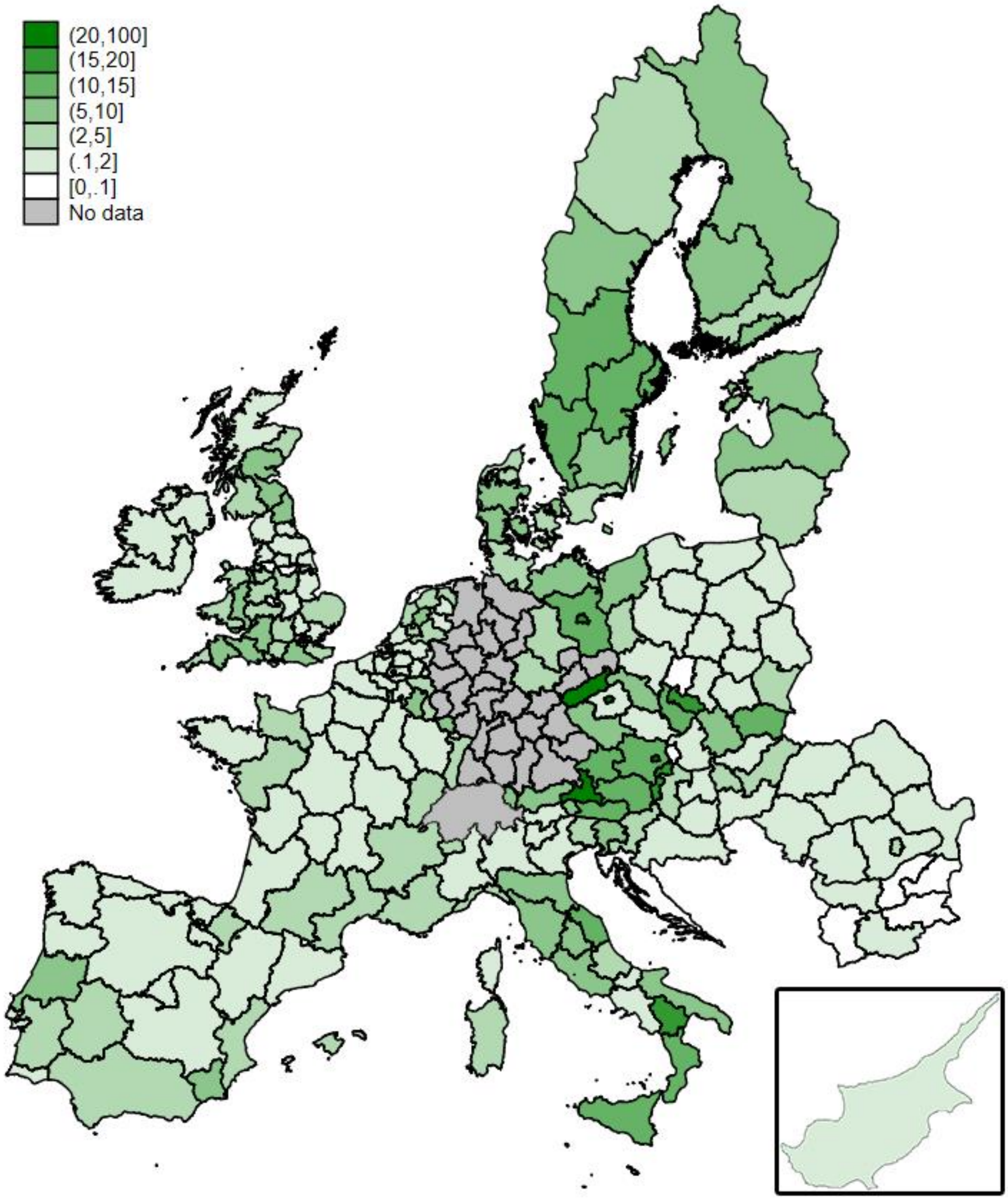

Figure 8: Organic acreage percentages by NUTS2 regions in Europe in 2007. Source: author's visualization based on the Eurostat agricultural database and Eurostat GISCO Geodata.

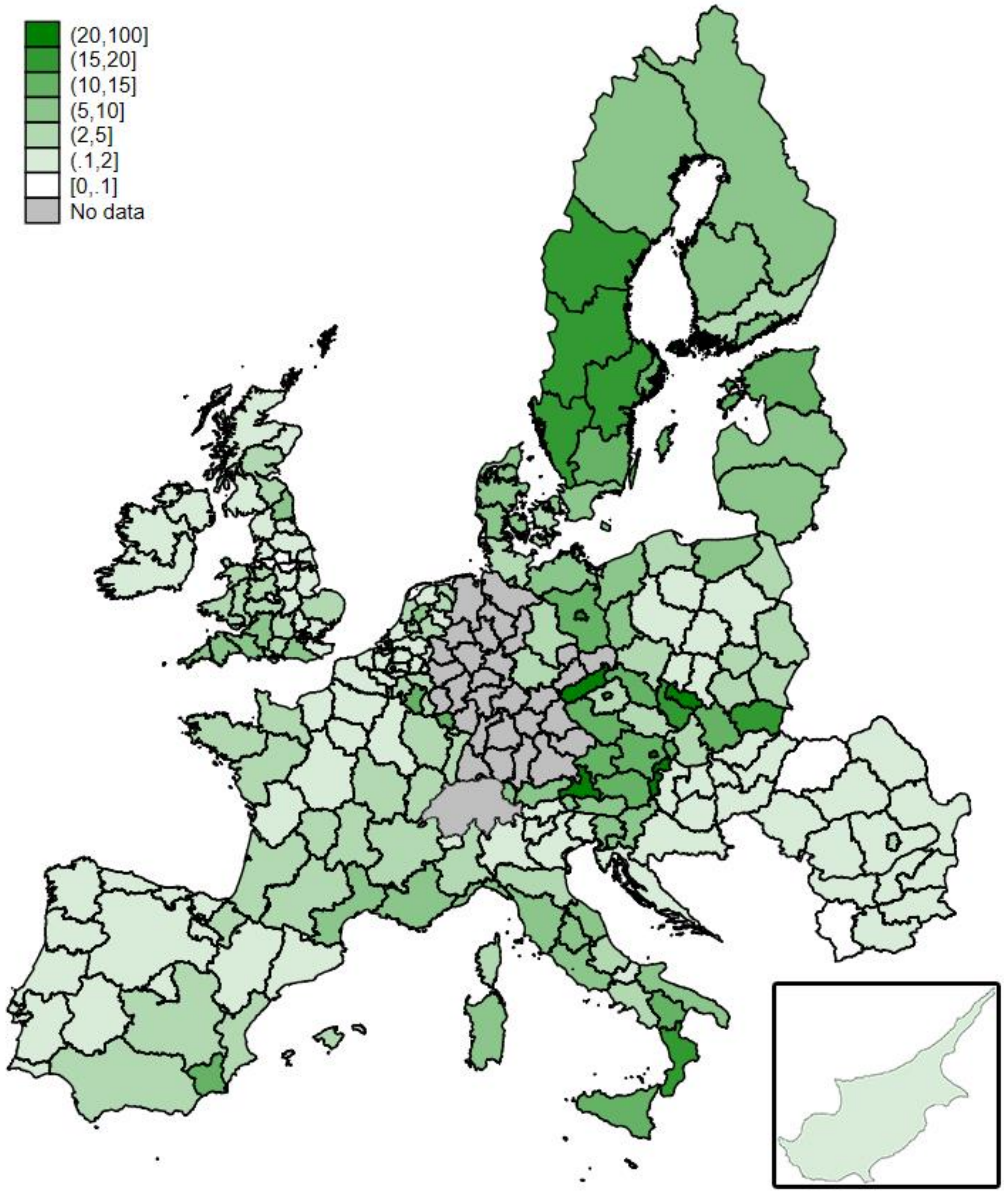

Figure 9: Organic acreage percentages by NUTS2 regions in Europe in 2010. Source: author's visualization based on the Eurostat agricultural database and Eurostat GISCO Geodata.

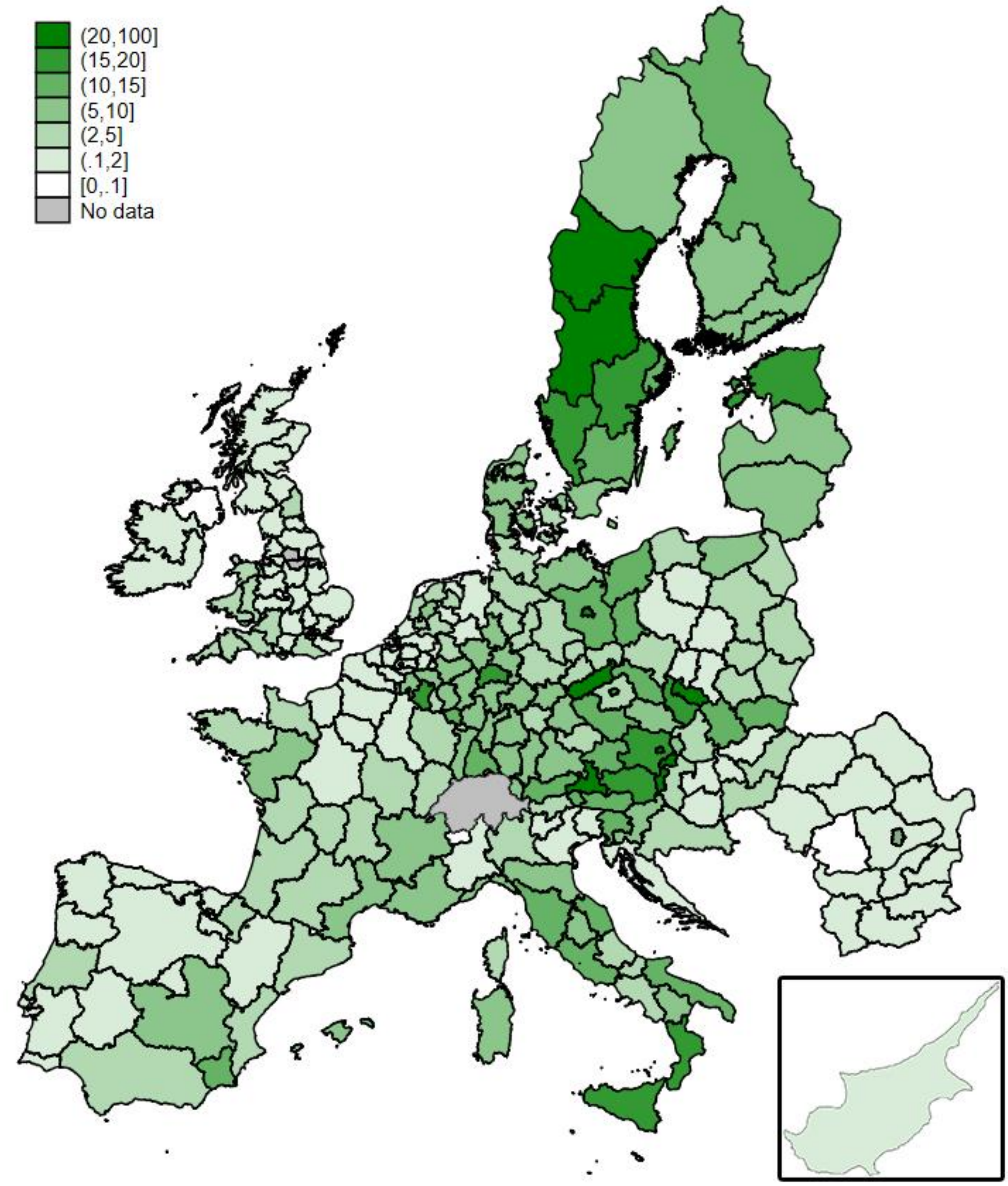

Figure 10: Organic acreage percentages by NUTS2 regions in Europe in 2013. Source: author's visualization based on the Eurostat agricultural database and Eurostat GISCO Geodata.

Appendix C - Full regression outputs

Table 14: Full regression output of the first main specification at NUTS0 level

N0S1

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	.2198916	.0908294	2.42	0.023	.032825	.4069582
agri. lab. percent (%/100)	-.3387828	.1776018	-1.91	0.068	-.7045606	.026995
agri. GDP percent	.5529633	.5091575	1.09	0.288	-.4956663	1.601593
avg. farm size (acres)	.0364936	.0731136	0.50	0.622	-.1140868	.187074
avg. farm size2 (acres)	.0000641	.0003512	0.18	0.857	-.0006591	.0007873
land ownership (%/100)	-3.35106	4.879257	-0.69	0.499	-13.40008	6.697957
permanent grassland (%/100)	-15.95587	8.413503	-1.90	0.070	-33.28381	1.372061
permanent crops(%/100)	-92.28452	32.31136	-2.86	0.009	-158.831	-25.73803
livestock density (head / ha)	3.152438	3.112867	1.01	0.321	-3.258633	9.563509
dairy cattle density (head/ha)	-21.90182	12.13272	-1.81	0.083	-46.88963	3.085986
labour intensity (AWU/ha)	-22.97285	53.05428	-0.43	0.669	-132.2402	86.29448
fam. labour intensity (AWU/ha)	-16.06377	122.2661	-0.13	0.897	-267.8756	235.748
off-farm main (%/100)	1.099181	3.893052	0.28	0.780	-6.91871	9.117071
off-farm sec. (%/100)	2.830689	3.12357	0.91	0.373	-3.602424	9.263803
soil erosion (%/100)	-.2158991	.3304396	-0.65	0.519	-.8964522	.4646541
female ratio (%/100)	-14.9478	16.81212	-0.89	0.382	-49.57301	19.67742
HS food percent (%/100)	.5708379	.4563884	1.25	0.223	-.3691117	1.510787
_cons	9.508823	11.63892	0.82	0.422	-14.46199	33.47964
N_obs	124					
N_groups	26					
R-squared						
within	0.0586					
between	0.5772					
overall	0.0379					

Source: author's calculations.

Table 15: Full regression outputs of the second main specification at NUTS0 level

N0S2

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	.2435061	.12281	1.98	0.061	-.0126712	.4996834
agri. lab. percent (%/100)	-.2725281	.3659428	-0.74	0.465	-1.035871	.4908152
agri. GDP percent	-1.706481	1.714215	-1.00	0.331	-5.282271	1.869309
avg. farm size (acres)	-.0234927	.0586582	-0.40	0.693	-.1458514	.0988661
avg. farm size2 (acres)	.0001607	.0003047	0.53	0.604	-.0004749	.0007963
land ownership (%/100)	5.18327	4.587513	1.13	0.272	-4.386114	14.75266
permanent grassland (%/100)	-19.39157	14.67917	-1.32	0.201	-50.01178	11.22864
permanent crops(%/100)	38.29382	52.31218	0.73	0.473	-70.82746	147.4151
livestock density (head / ha)	-.7425102	2.759947	-0.27	0.791	-6.499659	5.014639
dairy cattle density (head/ha)	-11.7282	6.138344	-1.91	0.070	-24.53257	1.076158
labour intensity (AWU/ha)	-77.66574	84.78044	-0.92	0.371	-254.5146	99.18316
fam. labour intensity (AWU/ha)	141.2993	153.1322	0.92	0.367	-178.1288	460.7274
off-farm main (%/100)	-3.538044	4.555228	-0.78	0.446	-13.04008	5.963996

off-farm sec. (%/100)	-.5283202	2.992081	-0.18	0.862	-6.769693	5.713052
soil erosion (%/100)	-.3689576	.6221899	-0.59	0.560	-1.666823	.9289077
female ratio (%/100)	41.03893	29.10584	1.41	0.174	-19.67479	101.7527
HS food percent (%/100)	.4873471	.4973765	0.98	0.339	-.5501622	1.524856
organic PCC (€)	.0580941	.0241802	2.40	0.026	.0076551	.1085331
organic retail volume (million €)	-.5540676	.4497039	-1.23	0.232	-1.492134	.3839984
green vote ratio (%/100)	8.367533	14.74925	0.57	0.577	-22.39886	39.13393
green closeness (%/100)	6.609163	17.71893	0.37	0.713	-30.35188	43.5702
legal trust level (1-10)	-.6164965	.5746467	-1.07	0.296	-1.815188	.5821954
env. importance (1-4)	-1.860259	1.70946	-1.09	0.289	-5.426129	1.705611
_cons	11.51165	17.61067	0.65	0.521	-25.22357	48.24686
N_obs	84					
N_groups	21					
R-squared						
within	0.7244					
between	0.0306					
overall	0.0539					

Source: author's calculations.

Table 16: Full regression outputs of the third main specification at NUTS0 level

N0S3

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	.1719487	.1137365	1.51	0.147	-.0661046	.4100019
agri. lab. percent (%/100)	-.1101633	.8010987	-0.14	0.892	-1.786882	1.566556
agri. GDP percent	-2.118135	1.340917	-1.58	0.131	-4.924706	.6884363
avg. farm size (acres)	.3792308	.1121094	3.38	0.003	.1445831	.6138785
avg. farm size2 (acres)	-.0015677	.0004622	-3.39	0.003	-.0025351	-.0006003
land ownership (%/100)	14.77551	5.333508	2.77	0.012	3.612346	25.93867
permanent grassland (%/100)	-17.31147	13.49068	-1.28	0.215	-45.54779	10.92486
permanent crops(%/100)	75.18512	81.46811	0.92	0.368	-95.3296	245.6998
livestock density (head / ha)	-2.114478	2.865378	-0.74	0.470	-8.111782	3.882827
dairy cattle density (head/ha)	-10.6216	7.614603	-1.39	0.179	-26.55915	5.315944
labour intensity (AWU/ha)	-78.59458	77.90897	-1.01	0.326	-241.6599	84.47077
fam. labour intensity (AWU/ha)	259.9875	149.7975	1.74	0.099	-53.54223	573.5172
off-farm main (%/100)	-6.444608	6.84643	-0.94	0.358	-20.77435	7.885134
off-farm sec. (%/100)	3.188339	2.556732	1.25	0.228	-2.162963	8.53964
soil erosion (%/100)	-.4694463	.5409276	-0.87	0.396	-1.601621	.6627283
female ratio (%/100)	36.43801	19.43208	1.88	0.076	-4.233813	77.10983
HS food percent (%/100)	-.3113708	.5397396	-0.58	0.571	-1.441059	.8183171
organic PCC (€)	.0187285	.0192774	0.97	0.343	-.0216195	.0590765
organic retail volume (million €)	.2161442	.4730572	0.46	0.653	-.7739759	1.206264
green vote ratio (%/100)	-27.57888	19.39241	-1.42	0.171	-68.16765	13.0099
green closeness (%/100)	19.70156	21.82324	0.90	0.378	-25.975	65.37811
legal trust level (1-10)	-.6259052	.681091	-0.92	0.370	-2.051445	.7996347
env. importance (1-4)	-5.385318	1.881718	-2.86	0.010	-9.323799	-1.446837
avg. age (years)	-11.17592	5.82141	-1.92	0.070	-23.36027	1.008435
avg. age2 (years)	.1061049	.0571127	1.86	0.079	-.0134334	.2256432
farmer training	5.277111	1.745817	3.02	0.007	1.623074	8.931148

_cons	300.7723	162.9087	1.85	0.080	-40.19948	641.7442
N_obs	60					
N_groups	20					
R-squared						
within	0.8817					
between	0.0313					
overall	0.0661					

Source: author's calculations.

Table 17: Full regression outputs of the first RC specification at NUTS0 level

N0RC1

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	.0674407	.068452	0.99	0.335	-.0741631	.2090445
agri. lab. percent (%/100)	-.4299903	.1469651	-2.93	0.008	-.7340107	-.1259699
agri. GDP percent	-.3202096	.61401	-0.52	0.607	-1.590386	.9499668
avg. farm size (acres)	.4265895	.0669507	6.37	0.000	.2880914	.5650876
avg. farm size2 (acres)	-.0015861	.0003105	-5.11	0.000	-.0022284	-.0009438
land ownership (%/100)	1.825665	5.416275	0.34	0.739	-9.378753	13.03008
permanent grassland (%/100)	2.402855	8.380595	0.29	0.777	-14.93373	19.73944
permanent crops(%/100)	-13.96802	30.9152	-0.45	0.656	-77.92098	49.98493
livestock density (head / ha)	3.675426	2.129397	1.73	0.098	-.7295673	8.08042
dairy cattle density (head/ha)	-19.31473	5.562999	-3.47	0.002	-30.82267	-7.806788
labour intensity (AWU/ha)	12.43409	42.88292	0.29	0.774	-76.27599	101.1442
fam. labour intensity (AWU/ha)	21.26655	93.58688	0.23	0.822	-172.3327	214.8658
off-farm main (%/100)	8.373173	5.683225	1.47	0.154	-3.383474	20.12982
off-farm sec. (%/100)	-5.900635	3.403547	-1.73	0.096	-12.94141	1.140139
soil erosion (%/100)	-.1842235	.309617	-0.60	0.558	-.824715	.4562681
female ratio (%/100)	-5.448295	14.37165	-0.38	0.708	-35.17833	24.28174
HS food percent (%/100)	-.002056	.331787	-0.01	0.995	-.6884097	.6842977
farmer training	4.301212	.8994119	4.78	0.000	2.440637	6.161788
avg. age (years)	-2.340828	1.716501	-1.36	0.186	-5.891681	1.210025
avg. age2 (years)	.0251319	.01838	1.37	0.185	-.0128899	.0631538
_cons	40.12994	41.81286	0.96	0.347	-46.36655	126.6264
N_obs	83					
N_groups	24					
R-squared						
within	0.7687					
between	0.0137					
overall	0.0466					

Source: author's calculations.

Table 18: Full regression outputs of the second RC specification at NUTS0 level

N0RC2

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	.1266244	.0722754	1.75	0.093	-.0228887	.2761375
agri. lab. percent (%/100)	-.2145737	.2055376	-1.04	0.307	-.6397606	.2106132

agri. GDP percent	-.0213232	.9772486	-0.02	0.983	-2.042916	2.00027
avg. farm size (acres)	-.0247939	.054519	-0.45	0.654	-.1375751	.0879873
avg. farm size2 (acres)	.0002782	.0002664	1.04	0.307	-.0002729	.0008293
land ownership (%/100)	3.498599	4.386393	0.80	0.433	-5.575346	12.57254
permanent grassland (%/100)	-15.40289	9.034346	-1.70	0.102	-34.09186	3.286082
permanent crops(%/100)	-66.5265	42.07494	-1.58	0.128	-153.5651	20.51215
livestock density (head / ha)	1.05067	2.735904	0.38	0.704	-4.608979	6.710318
dairy cattle density (head/ha)	-13.82535	10.21785	-1.35	0.189	-34.9626	7.311887
labour intensity (AWU/ha)	-53.22848	51.4941	-1.03	0.312	-159.7521	53.29519
fam. labour intensity (AWU/ha)	63.08161	122.1799	0.52	0.611	-189.6667	315.83
off-farm main (%/100)	-1.949367	5.739886	-0.34	0.737	-13.82323	9.924491
off-farm sec. (%/100)	.0075504	2.606145	0.00	0.998	-5.383672	5.398773
soil erosion (%/100)	-.1284719	.4482592	-0.29	0.777	-1.055767	.7988229
female ratio (%/100)	23.62499	18.79793	1.26	0.221	-15.2615	62.51148
HS food percent (%/100)	.1812107	.3191131	0.57	0.576	-.4789251	.8413465
organic PCC (€)	.0461175	.0266762	1.73	0.097	-.0090664	.1013013
organic retail volume (million €)	-.0914346	.5251711	-0.17	0.863	-1.177834	.9949646
_cons	8.11792	11.68119	0.69	0.494	-16.04645	32.28229
N_obs	102					
N_groups	24					
R-squared						
within	0.6175					
between	0.0096					
overall	0.1276					

Source: author's calculations.

Table 19: Full regression outputs of the third RC specification at NUTS0 level

N0RC3

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	.3387536	.0975684	3.47	0.002	.1373823	.5401249
agri. lab. percent (%/100)	-.5021567	.3225343	-1.56	0.133	-1.167835	.1635213
agri. GDP percent	-1.55355	.9573701	-1.62	0.118	-3.529465	.4223648
avg. farm size (acres)	-.0148085	.0497701	-0.30	0.769	-.1175289	.0879119
avg. farm size2 (acres)	.000155	.0002609	0.59	0.558	-.0003834	.0006934
land ownership (%/100)	-1.676791	5.887016	-0.28	0.778	-13.827	10.47341
permanent grassland (%/100)	-26.2857	9.865465	-2.66	0.014	-46.64702	-5.92438
permanent crops(%/100)	-61.40091	66.03274	-0.93	0.362	-197.6858	74.88397
livestock density (head / ha)	-.1171836	2.740975	-0.04	0.966	-5.774279	5.539911
dairy cattle density (head/ha)	-18.62898	8.08049	-2.31	0.030	-35.30629	-1.951664
labour intensity (AWU/ha)	-63.93923	62.91396	-1.02	0.320	-193.7873	65.90881
fam. labour intensity (AWU/ha)	35.25254	149.302	0.24	0.815	-272.8917	343.3967
off-farm main (%/100)	2.445445	3.078688	0.79	0.435	-3.908655	8.799544
off-farm sec. (%/100)	2.504639	3.111293	0.81	0.429	-3.916754	8.926032
soil erosion (%/100)	-.0965297	.4450222	-0.22	0.830	-1.01501	.8219509
female ratio (%/100)	-7.242889	22.76586	-0.32	0.753	-54.22932	39.74354
HS food percent (%/100)	.9678503	.3789	2.55	0.017	.1858392	1.749861
green vote ratio (%/100)	30.31133	16.53956	1.83	0.079	-3.824639	64.4473
green closeness (%/100)	-18.82076	20.3914	-0.92	0.365	-60.90654	23.26501

legal trust level (1-10)	-.1448625	.5855093	-0.25	0.807	-1.353294	1.063569
env. importance (1-4)	-.4328725	2.123416	-0.20	0.840	-4.815388	3.949643
_cons	10.42697	15.31384	0.68	0.502	-21.17924	42.03319
N_obs	99					
N_groups	25					
R-squared						
within	0.6698					
between	0.1795					
overall	0.2162					

Source: author's calculations.

Table 20: Full regression outputs of the first main specification at NUTS2 level

N2S1

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	.5319648	.0894397	5.95	0.000	.3557851	.7081445
agri. lab. percent (%/100)	-.1904612	.0998335	-1.91	0.058	-.3871148	.0061924
agri. GDP percent	.447726	.1640303	2.73	0.007	.1246166	.7708354
avg. farm size (acres)	.0223756	.0191169	1.17	0.243	-.0152811	.0600323
avg. farm size2 (acres)	-.0000426	.0000728	-0.58	0.559	-.000186	.0001009
livestock density (head / ha)	.3992728	.9177549	0.44	0.664	-1.408535	2.20708
soil erosion (%/100)	-.1308466	.1104586	-1.18	0.237	-.3484295	.0867364
female ratio (%/100)	12.34206	8.259874	1.49	0.136	-3.928368	28.61248
HS food percent (%/100)	.4209145	.1672581	2.52	0.012	.091447	.7503819
_cons	-15.26877	4.52296	-3.38	0.001	-24.17816	-6.359372
N_obs	1091					
N-groups	243					
R-squared						
within	0.2793					
between	0.0033					
overall	0.0109					

Source: author's calculations.

Table 21: Full regression outputs of the second main specification at NUTS2 level

N2S2

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	.2765004	.1235273	2.24	0.026	.0327796	.5202212
agri. lab. percent (%/100)	.0040537	.1895309	0.02	0.983	-.369893	.3780004
agri. GDP percent	.0355652	.5321965	0.07	0.947	-1.014465	1.085595
avg. farm size (acres)	.0139189	.0292718	0.48	0.635	-.0438347	.0716725
avg. farm size2 (acres)	.0001115	.0001441	0.77	0.440	-.0001728	.0003957
livestock density (head / ha)	-2.930494	1.515903	-1.93	0.055	-5.921389	.0604017
soil erosion (%/100)	-.1828963	.1824205	-1.00	0.317	-.542814	.1770214
female ratio (%/100)	24.94548	12.51538	1.99	0.048	.2524751	49.63848
HS food percent (%/100)	-.1628425	.2361302	-0.69	0.491	-.6287302	.3030452
dairy cattle density (head/ha)	.4266839	4.8356	0.09	0.930	-9.114012	9.96738
labour intensity (AWU/ha)	-29.5901	17.04324	-1.74	0.084	-63.21662	4.036415
fam. labour intensity (AWU/ha)	46.28543	28.60198	1.62	0.107	-10.14661	102.7175

avg. age (years)	-.1343206	.7630507	-0.18	0.860	-1.639829	1.371188
avg. age2 (years)	.0006609	.0086457	0.08	0.939	-.0163972	.017719
organic PCC (€)	.0830319	.0169423	4.90	0.000	.0496044	.1164593
organic retail volume (million €)	-.8903081	.3071283	-2.90	0.004	-1.496276	-.2843404
green vote ratio (%/100)	.5709974	11.25322	0.05	0.960	-21.63173	22.77373
green closeness (%/100)	2.267374	10.57545	0.21	0.830	-18.59812	23.13287
legal trust level (1-10)	-.915681	.5241995	-1.75	0.082	-1.949933	.1185709
env. importance (1-4)	-4.176725	.8805008	-4.74	0.000	-5.913963	-2.439486
_cons	22.49773	17.83129	1.26	0.209	-12.68363	57.67908
N_obs	599					
N-groups	184					
R-squared						
within	0.4734					
between	0.0442					
overall	0.0749					

Source: author's calculations.

Table 22: Full regression outputs of the third main specification at NUTS2 level

N2S3

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	1.496953	1.063096	1.41	0.161	-.6038542	3.59776
agri. lab. percent (%/100)	2.7312	3.215548	0.85	0.397	-3.623117	9.085517
agri. GDP percent	-11.30947	8.208972	-1.38	0.170	-27.5314	4.912467
avg. farm size (acres)	-.0621522	.1914874	-0.32	0.746	-.4405548	.3162504
avg. farm size2 (acres)	.0004288	.0011624	0.37	0.713	-.0018683	.0027259
livestock density (head / ha)	-1.956716	1.487481	-1.32	0.190	-4.896162	.9827294
soil erosion (%/100)	.5447598	.8297974	0.66	0.513	-1.095022	2.184541
female ratio (%/100)	16.52453	11.08153	1.49	0.138	-5.373937	38.42299
HS food percent (%/100)	.626637	.735072	0.85	0.395	-.8259553	2.079229
dairy cattle density (head/ha)	10.97178	7.90552	1.39	0.167	-4.650496	26.59405
labour intensity (AWU/ha)	-22.54661	17.86671	-1.26	0.209	-57.85342	12.76021
fam. labour intensity (AWU/ha)	6.519519	52.14429	0.13	0.901	-96.52398	109.563
permanent grassland (%/100)	15.01268	12.38655	1.21	0.227	-9.464659	39.49003
permanent crops (%/100)	133.224	36.68045	3.63	0.000	60.73897	205.7091
off-farm main (%/100)	9.518576	8.515402	1.12	0.265	-7.308902	26.34605
off-farm sec. (%/100)	7.299586	10.06707	0.73	0.470	-12.59418	27.19336
land ownership (%/100)	-1.782689	7.15784	-0.25	0.804	-15.92746	12.36208
avg. age (years)	1.011603	.6529643	1.55	0.123	-.2787341	2.301941
avg. age2 (years)	-.0122004	.007673	-1.59	0.114	-.0273632	.0029624
farmer training	1.72099	2.814168	0.61	0.542	-3.84015	7.282129
organic PCC (€)	-.0124725	.0384076	-0.32	0.746	-.0883707	.0634256
organic retail volume (million €)	2.46374	1.504975	1.64	0.104	-.510275	5.437755
green vote ratio (%/100)	-146.038	89.17585	-1.64	0.104	-322.2604	30.1844
green closeness (%/100)	30.06341	39.20457	0.77	0.444	-47.40962	107.5365
legal trust level (1-10)	-5.209598	3.960477	-1.32	0.190	-13.03599	2.616789
env. importance (1-4)	15.74942	14.85766	1.06	0.291	-13.61114	45.10997
_cons	-101.9512	53.48758	-1.91	0.059	-207.6492	3.746831
N_obs	255					

N-groups	149
R-squared	
within	0.7726
between	0.0688
overall	0.0779

Source: author's calculations.

Table 23: Full regression outputs of the first RC specification at NUTS2 level

N2RC1

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	.1540793	.0637527	2.42	0.016	.0284794	.2796792
agri. lab. percent (%/100)	-.1801937	.0892188	-2.02	0.045	-.3559645	-.0044228
agri. GDP percent	.6713008	.3164104	2.12	0.035	.0479375	1.294664
avg. farm size (acres)	.0235143	.018308	1.28	0.200	-.0125545	.059583
avg. farm size2 (acres)	-.0000713	.0000763	-0.94	0.351	-.0002216	.0000789
livestock density (head / ha)	-.8033442	.8210625	-0.98	0.329	-2.420928	.8142394
soil erosion (%/100)	-.1590219	.1285211	-1.24	0.217	-.4122226	.0941787
female ratio (%/100)	21.08842	9.374061	2.25	0.025	2.620487	39.55635
HS food percent (%/100)	-.1759529	.1558175	-1.13	0.260	-.4829305	.1310247
organic PCC (€)	.0751869	.0145965	5.15	0.000	.0464301	.1039437
organic retail volume (million €)	-.2229068	.2995614	-0.74	0.458	-.8130757	.3672622
_cons	.6372892	2.940297	0.22	0.829	-5.15542	6.429999
N_obs	1032					
N-groups	236					
R-squared						
within	0.3990					
between	0.0288					
overall	0.0490					

Source: author's calculations.

Table 24: Full regression outputs of the second RC specification at NUTS2 level

N2RC2

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	.7414354	.0951377	7.79	0.000	.5540278	.9288429
agri. lab. percent (%/100)	-.1908066	.1478123	-1.29	0.198	-.4819755	.1003624
agri. GDP percent	-1.527115	.5045824	-3.03	0.003	-2.521069	-.5331598
avg. farm size (acres)	.0079974	.0167476	0.48	0.633	-.024993	.0409877
avg. farm size2 (acres)	5.02e-06	.0000616	0.08	0.935	-.0001163	.0001263
livestock density (head / ha)	.0209045	1.050197	0.02	0.984	-2.047833	2.089642
soil erosion (%/100)	.0766051	.1582071	0.48	0.629	-.2350401	.3882503
female ratio (%/100)	9.423595	9.811312	0.96	0.338	-9.903279	28.75047
HS food percent (%/100)	.6600864	.2173936	3.04	0.003	.2318523	1.088321
green vote ratio (%/100)	20.14766	9.158646	2.21	0.029	2.106444	38.18887
green closeness (%/100)	2.28226	8.28166	0.28	0.783	-14.03142	18.59594
legal trust level (1-10)	-1.918353	.3805543	-5.04	0.000	-2.66799	-1.168716
env. importance (1-4)	-1.460623	.9471756	-1.54	0.124	-3.326423	.4051767
_cons	-10.33176	5.913385	-1.75	0.082	-21.98027	1.316761

N_obs	961
N-groups	242
R-squared	
within	0.3504
between	0.1428
overall	0.1554

Source: author's calculations.

Table 25: Full regression outputs of the third RC specification at NUTS2 level

N2RC3

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	.4428082	.0767462	5.77	0.000	.2914908	.5941257
agri. lab. percent (%/100)	-.2385417	.0949394	-2.51	0.013	-.4257299	-.0513534
agri. GDP percent	.5525709	.1700317	3.25	0.001	.217326	.8878158
avg. farm size (acres)	.0089916	.0205239	0.44	0.662	-.0314746	.0494578
avg. farm size2 (acres)	.0000572	.0001	0.57	0.568	-.00014	.0002543
livestock density (head / ha)	.0632213	1.031438	0.06	0.951	-1.970425	2.096867
soil erosion (%/100)	-.113685	.103414	-1.10	0.273	-.3175823	.0902123
female ratio (%/100)	19.06798	6.623946	2.88	0.004	6.007806	32.12816
HS food percent (%/100)	.5053185	.1958806	2.58	0.011	.1191083	.8915286
dairy cattle density (head/ha)	-1.236215	4.379312	-0.28	0.778	-9.870734	7.398304
labour intensity (AWU/ha)	-2.121236	8.305637	-0.26	0.799	-18.49714	14.25466
fam. labour intensity (AWU/ha)	-12.98393	20.29925	-0.64	0.523	-53.00716	27.0393
_cons	-14.00588	4.527253	-3.09	0.002	-22.93209	-5.079675
N_obs	983					
N-groups	205					
R-squared						
within	0.2819					
between	0.0103					
overall	0.0256					

Source: author's calculations.

Table 26: Full regression outputs of the fourth RC specification at NUTS2 level

N2RC4

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	.4006022	.0910084	4.40	0.000	.2212729	.5799314
agri. lab. percent (%/100)	-.1791217	.1027	-1.74	0.082	-.3814888	.0232454
agri. GDP percent	-.0199924	.432128	-0.05	0.963	-.8714875	.8315026
avg. farm size (acres)	.0859816	.0244368	3.52	0.001	.0378297	.1341335
avg. farm size2 (acres)	-.0001914	.0000809	-2.37	0.019	-.0003509	-.000032
livestock density (head / ha)	.7418799	.907883	0.82	0.415	-1.047076	2.530836
soil erosion (%/100)	-.1078126	.1129377	-0.95	0.341	-.3303529	.1147278
female ratio (%/100)	18.35763	10.10224	1.82	0.071	-1.548532	38.26379
HS food percent (%/100)	.3340387	.1588614	2.10	0.037	.0210073	.6470702
avg. age (years)	-1.308488	.6019948	-2.17	0.031	-2.4947	-.1222754
avg. age2 (years)	.0133314	.006642	2.01	0.046	.0002435	.0264194
_cons	18.68321	14.68616	1.27	0.205	-10.25542	47.62184

N_obs	820
N-groups	228
R-squared	
within	0.3080
between	0.0032
overall	0.0121

Source: author's calculations.

Table 27: Full regression outputs of the fifth RC specification at NUTS2 level

N2RC5

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	.4775779	.094074	5.08	0.000	.292068	.6630877
agri. lab. percent (%/100)	-.0928885	.1807946	-0.51	0.608	-.4494076	.2636305
agri. GDP percent	.257651	.7078875	0.36	0.716	-1.138273	1.653574
avg. farm size (acres)	.0460304	.0547808	0.84	0.402	-.061995	.1540559
avg. farm size2 (acres)	-.0001244	.0001783	-0.70	0.486	-.000476	.0002271
livestock density (head / ha)	.2425098	1.7376	0.14	0.889	-3.183963	3.668982
soil erosion (%/100)	-.3484589	.4945988	-0.70	0.482	-1.323786	.6268684
female ratio (%/100)	20.95153	9.554988	2.19	0.029	2.109509	39.79355
HS food percent (%/100)	.2124206	.3409257	0.62	0.534	-.4598701	.8847113
dairy cattle density (head/ha)	-9.882615	5.505188	-1.80	0.074	-20.73861	.9733775
labour intensity (AWU/ha)	20.59384	22.17664	0.93	0.354	-23.13752	64.32521
fam. labour intensity (AWU/ha)	-58.42513	43.18831	-1.35	0.178	-143.5906	26.74034
off-farm main (%/100)	12.07536	5.638172	2.14	0.033	.9571324	23.19359
off-farm sec. (%/100)	9.170212	3.267527	2.81	0.006	2.72679	15.61363
permanent crops (%/100)	64.39644	28.03502	2.30	0.023	9.112595	119.6803
permanent grassland (%/100)	-4.216608	10.53809	-0.40	0.689	-24.99725	16.56404
_cons	-12.03471	11.12139	-1.08	0.281	-33.9656	9.896181
N_obs	386					
N-groups	200					
R-squared						
within	0.4730					
between	0.0073					
overall	0.0184					

Source: author's calculations.

Table 28: Full regression outputs of the sixth RC specification at NUTS2 level

N2RC6

organic percentage (%)	**Coef.**	**R. Std. Err.**	**t**	**P>t**	**95% Confidence Interval**	
GDP / capita (1000 €)	.6290555	.1278925	4.92	0.000	.3769448	.8811663
agri. lab. percent (%/100)	.0837243	.3129069	0.27	0.789	-.5330998	.7005485
agri. GDP percent	.8442343	.9943306	0.85	0.397	-1.11586	2.804329
avg. farm size (acres)	-.0652061	.082982	-0.79	0.433	-.228786	.0983738
avg. farm size2 (acres)	.0002347	.0002953	0.79	0.428	-.0003474	.0008168
livestock density (head / ha)	-1.878575	.9542235	-1.97	0.050	-3.759608	.002458
soil erosion (%/100)	-.0257608	.504223	-0.05	0.959	-1.019721	.9681993
female ratio (%/100)	21.47645	11.50605	1.87	0.063	-1.205101	44.15799

HS food percent (%/100)	-.1526315	.3017927	-0.51	0.614	-.7475465	.4422835
avg. age (years)	-1.012144	.6154629	-1.64	0.102	-2.225388	.2010997
avg. age2 (years)	.0104453	.0067715	1.54	0.124	-.0029032	.0237937
farmer training	1.946407	2.394514	0.81	0.417	-2.773829	6.666642
_cons	10.8353	17.08101	0.63	0.527	-22.836	44.5066
N_obs	381					
N-groups	212					
R-squared						
within	0.3775					
between	0.1747					
overall	0.1975					

Source: author's calculations.

Appendix D – Validity checks

Variable distributions, NUTS0

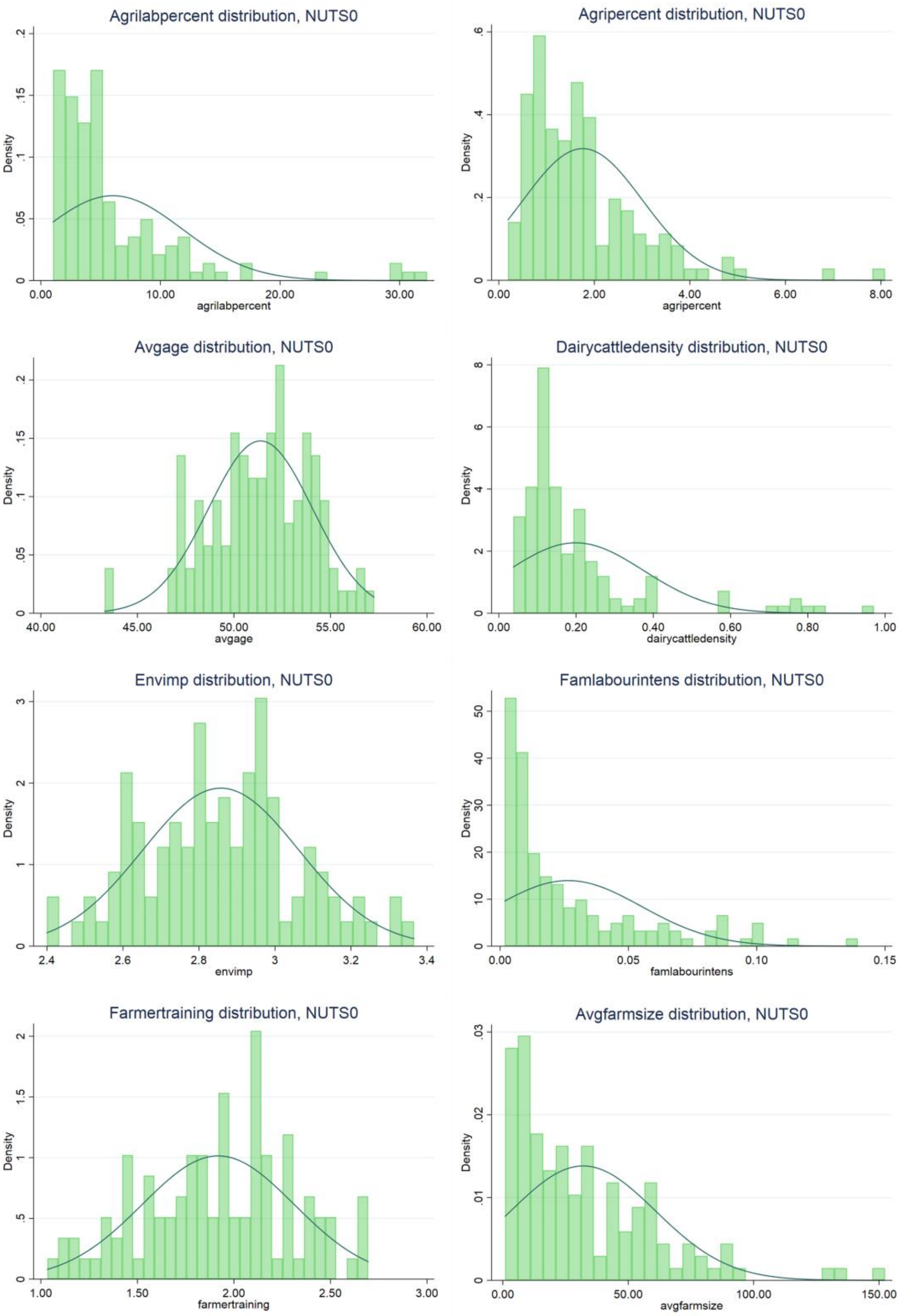

Figure 11: Variable distributions at NUTS0 level, #1. Source: author's visualization based on Eurostat, World Bank Open Data, FiBL database, ESS (rounds 2-5 & 7).

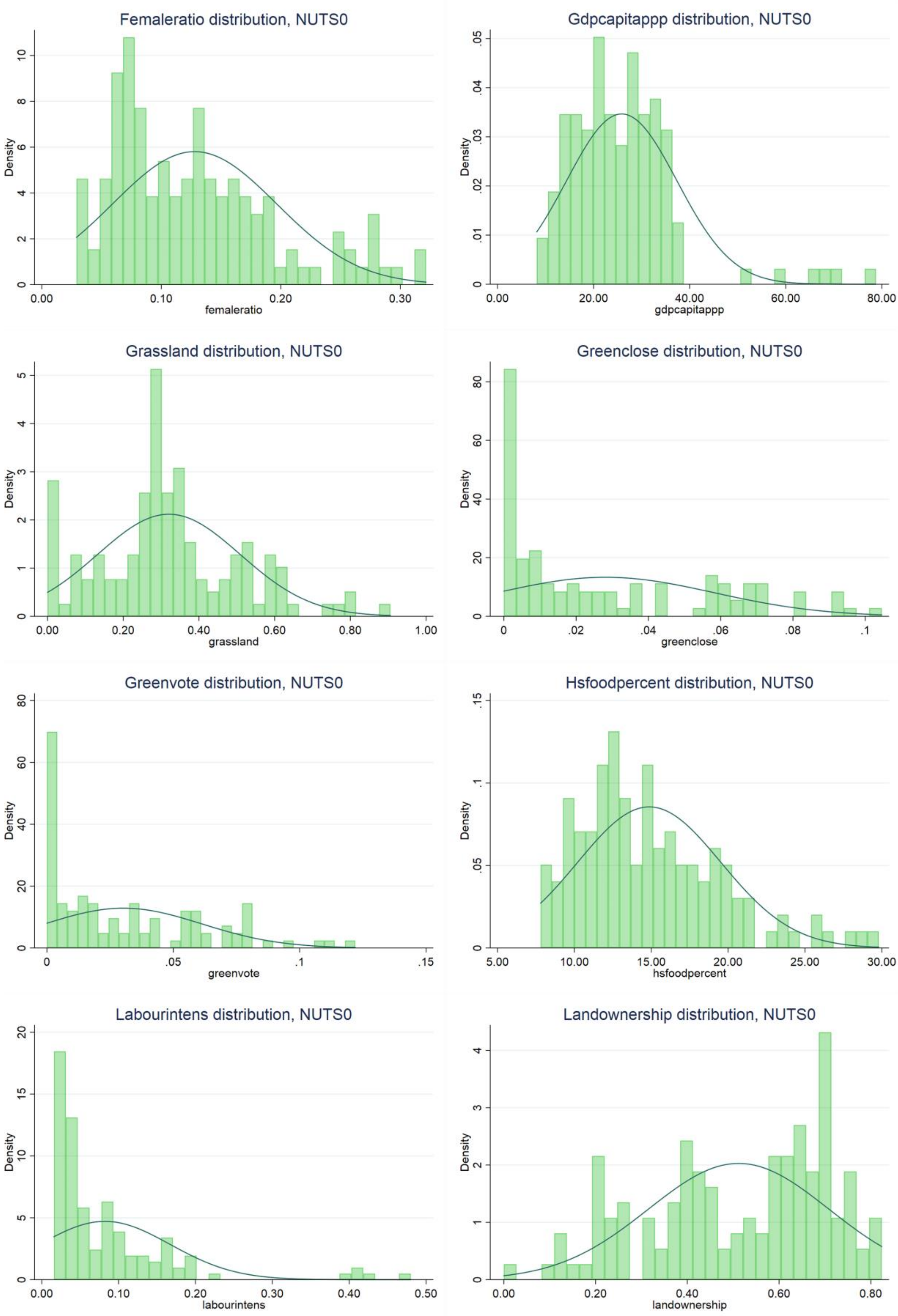

Figure 12: Variable distributions at NUTS0 level, #2. Source: author's visualization based on Eurostat, World Bank Open Data, FiBL database, ESS (rounds 2-5 & 7).

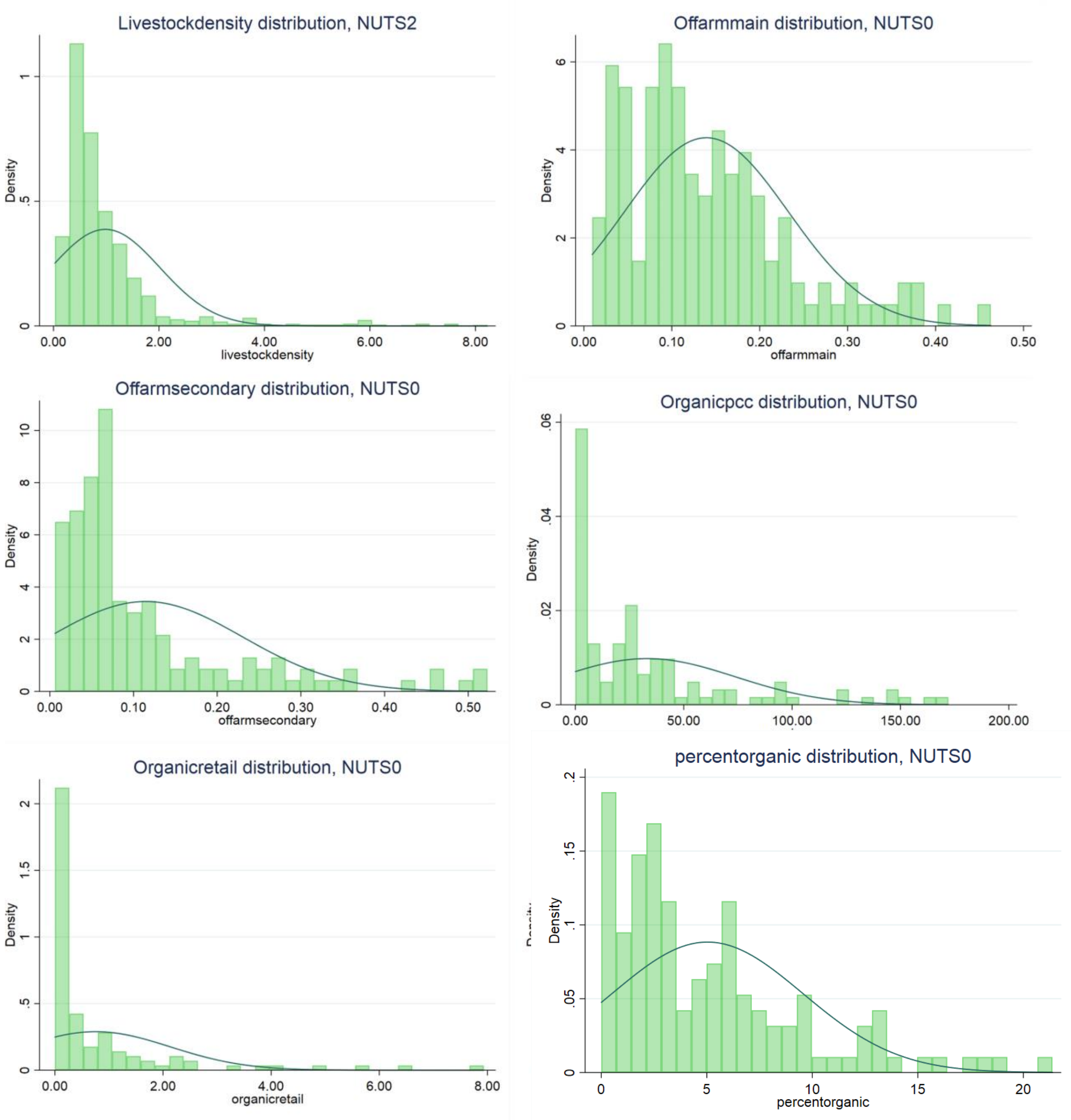

Figure 13: Variable distributions at NUTS0 level, #3. Source: author's visualization based on Eurostat, World Bank Open Data, FiBL database, ESS (rounds 2-5 & 7).

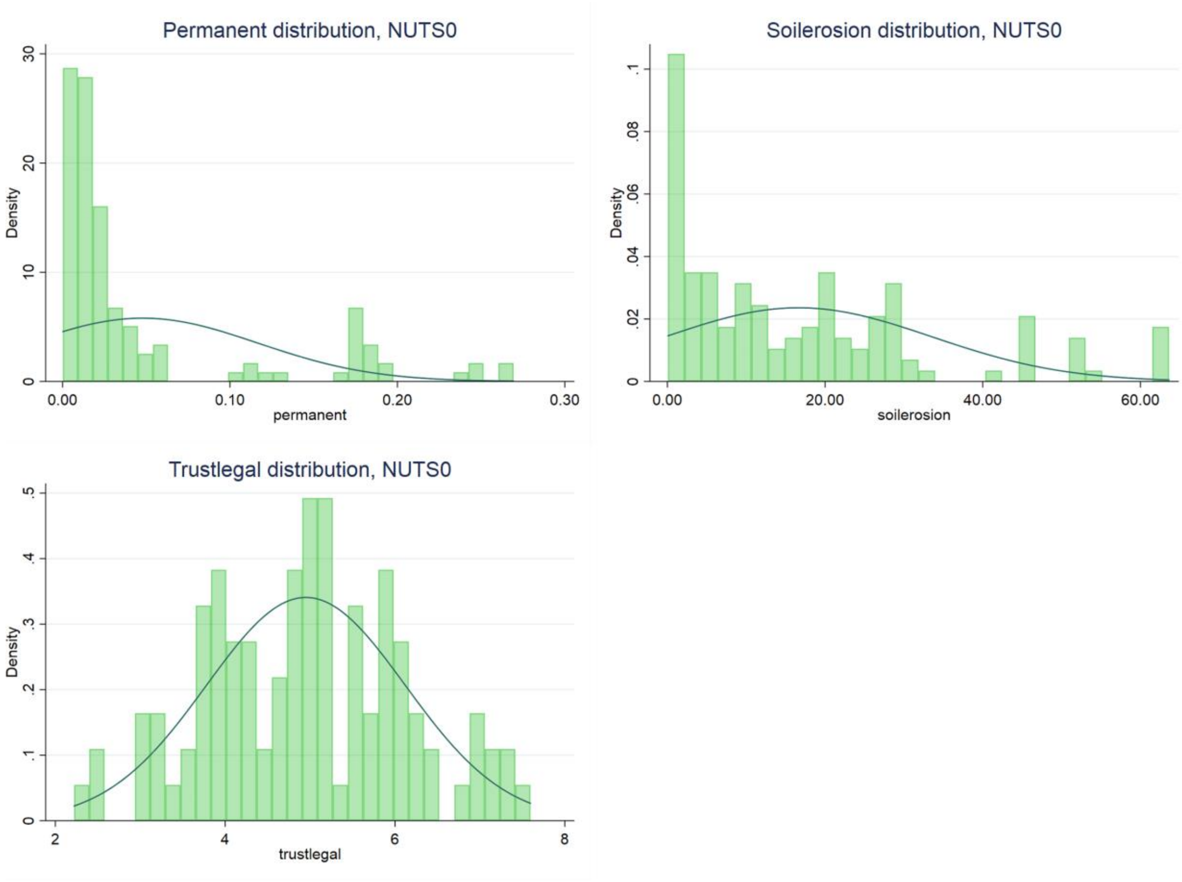

Figure 14: Variable distributions at NUTS0 level, #4. Source: author's visualization based on Eurostat, World Bank Open Data, FiBL database, ESS (rounds 2-5 & 7).

Variable distributions, NUTS2 level

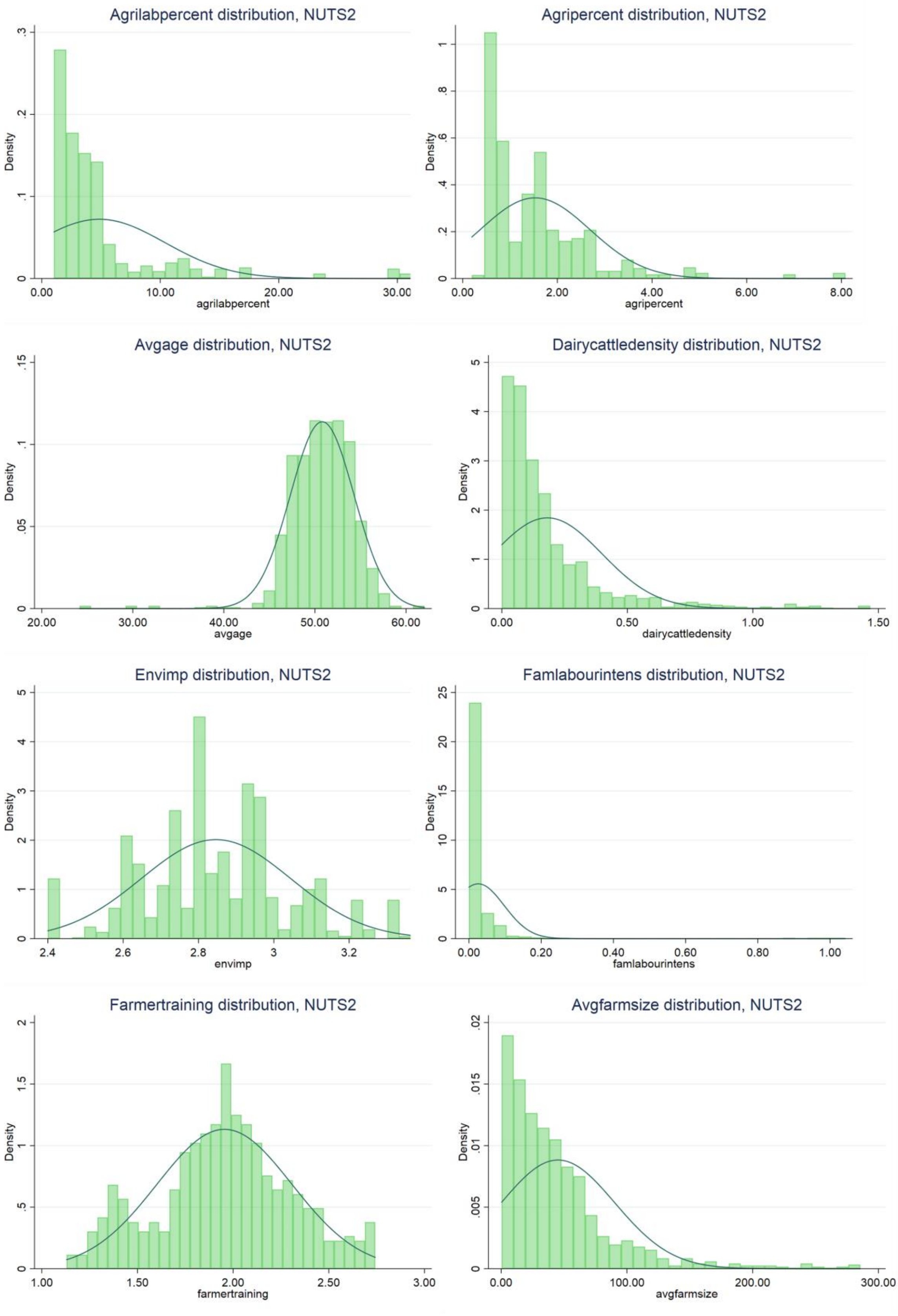

Figure 15: Variable distributions at NUTS2 level, #1. Source: author's visualization based on Eurostat, World Bank Open Data, FiBL database, ESS (rounds 2-5 & 7).

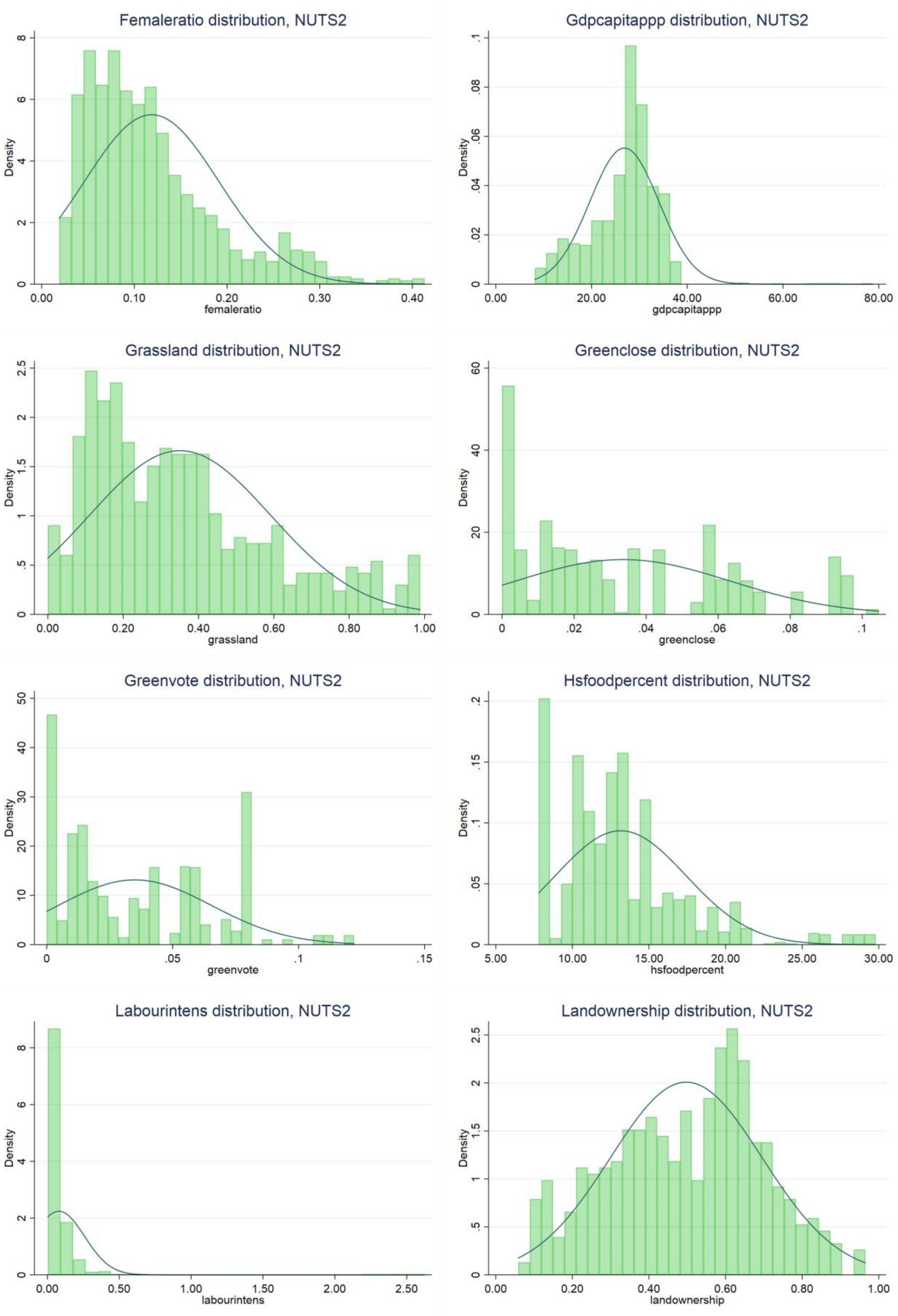

Figure 16: Variable distributions at NUTS2 level, #2. Source: author's visualization based on Eurostat, World Bank Open Data, FiBL database, ESS (rounds 2-5 & 7).

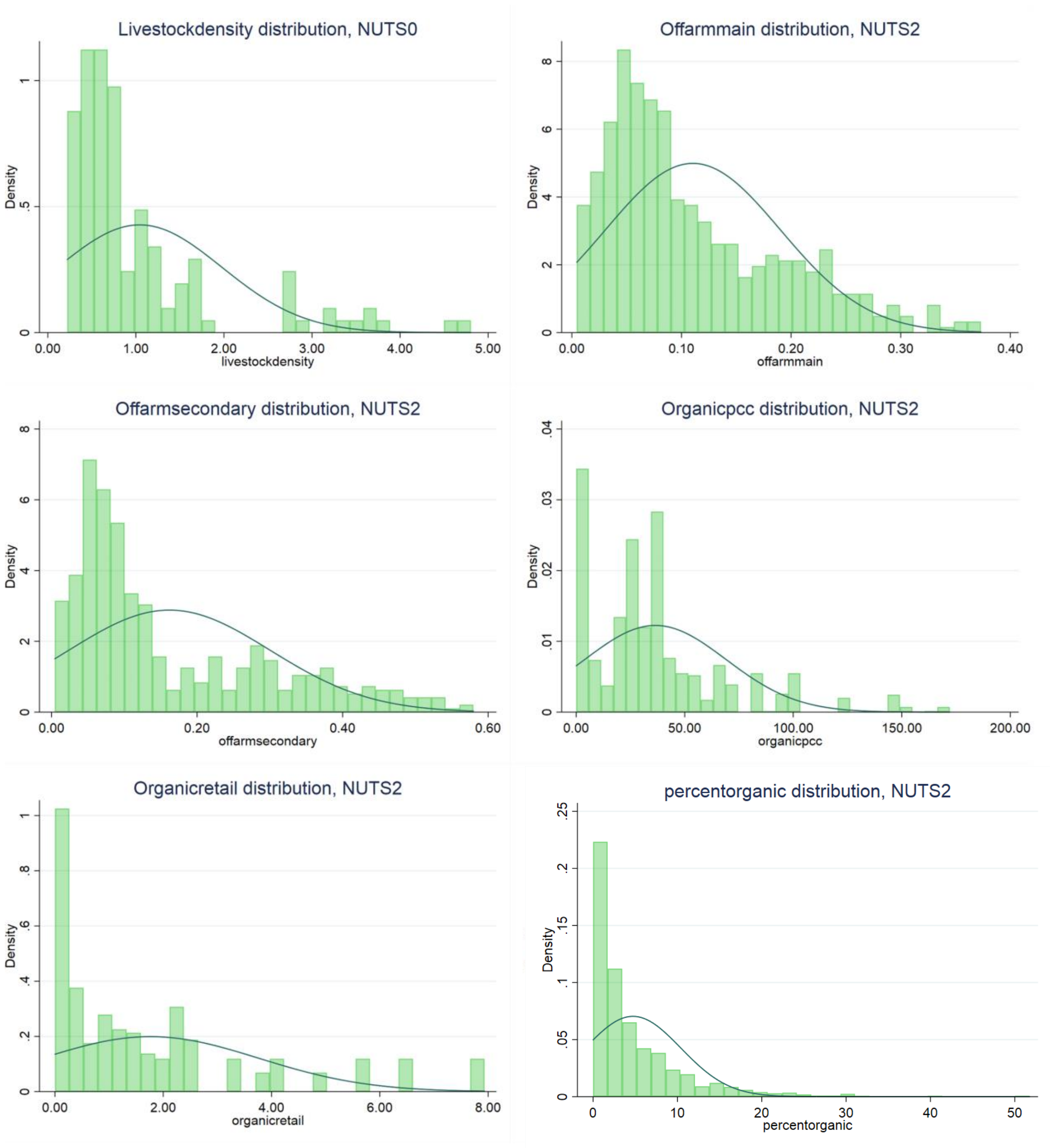

Figure 17: Variable distributions at NUTS2 level, #3. Source: author's visualization based on Eurostat, World Bank Open Data, FiBL database, ESS (rounds 2-5 & 7).

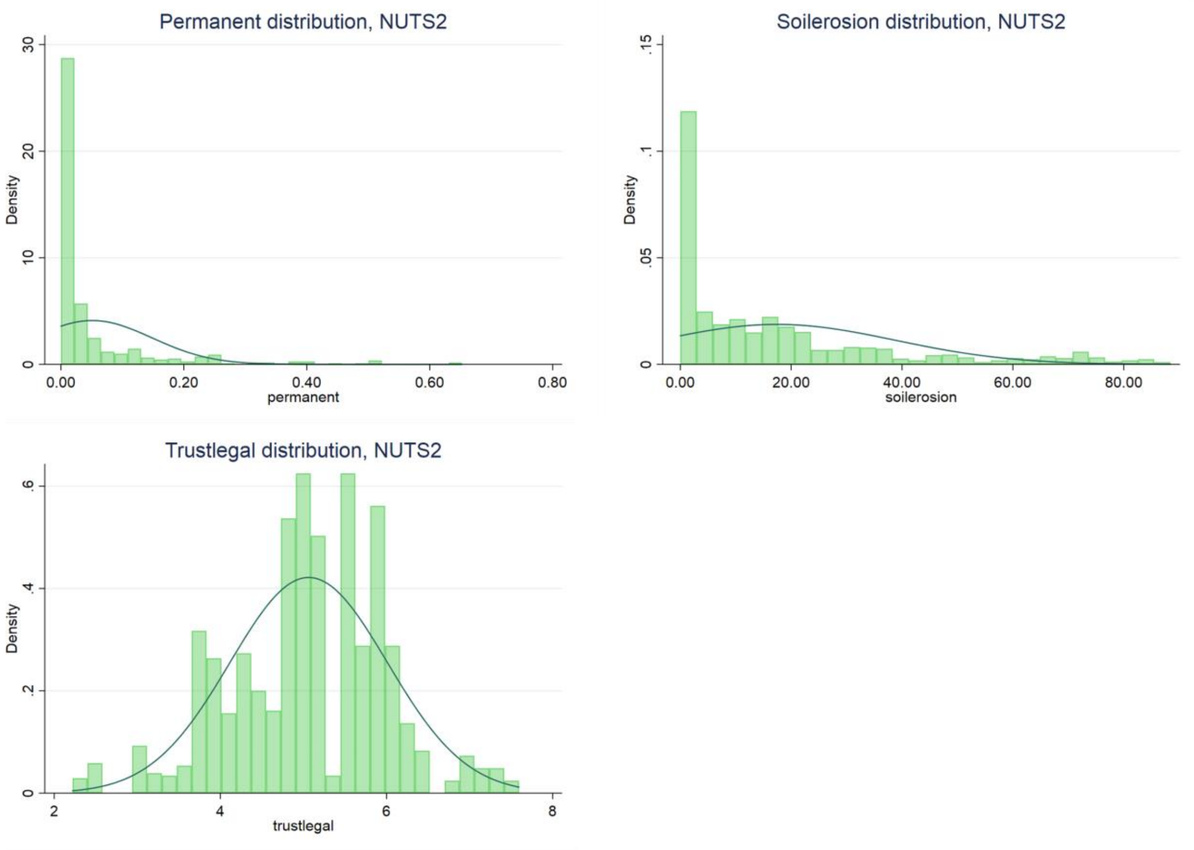

Figure 18: Variable distributions at NUTS2 level, #4. Source: author's visualization based on Eurostat, World Bank Open Data, FiBL database, ESS (rounds 2-5 & 7).

Residual normality histograms, main specifications

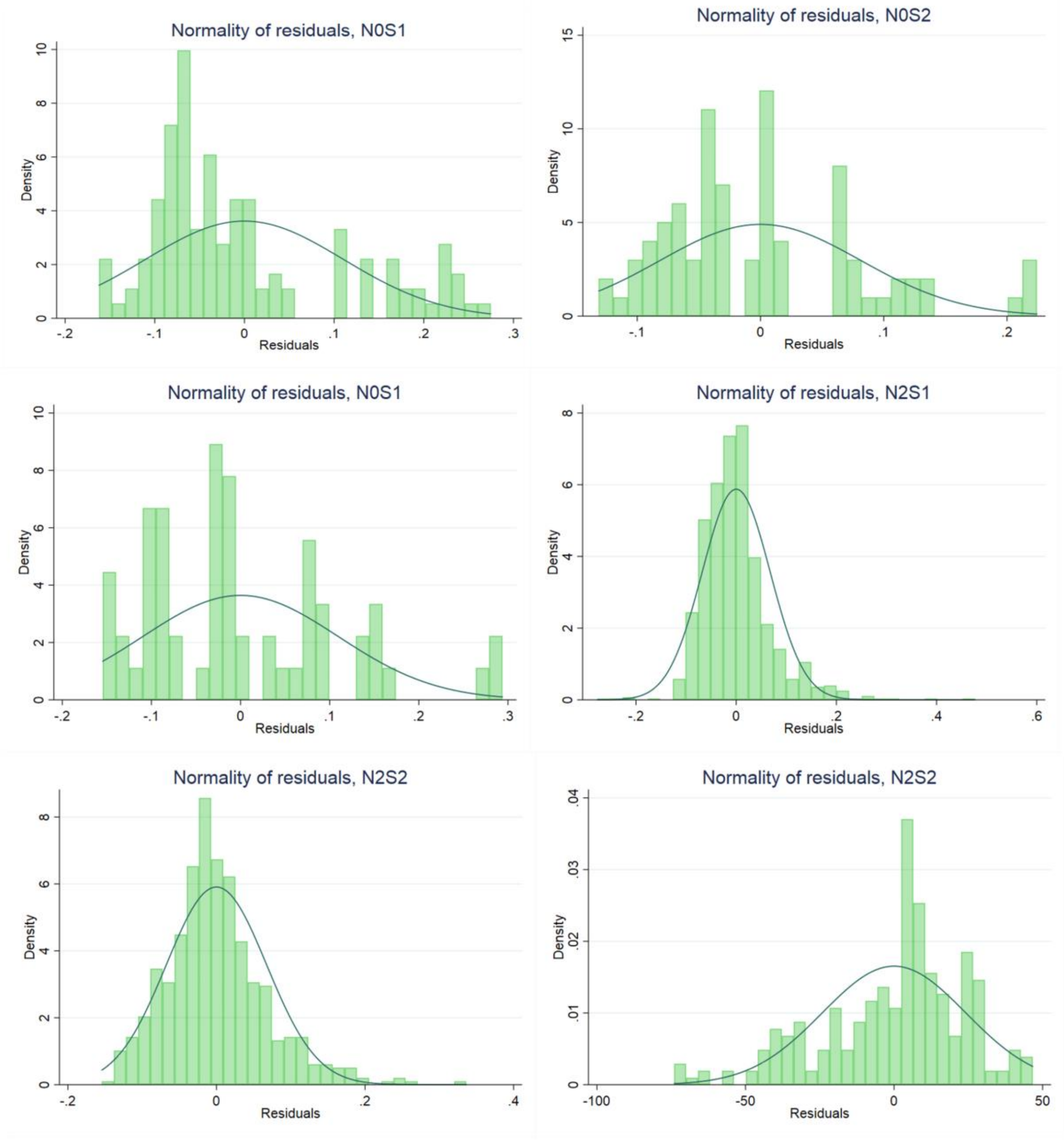

Figure 19: Residual normality histograms of main specifications. Source: author's calculations.

Q-Q normality plots, main specifications

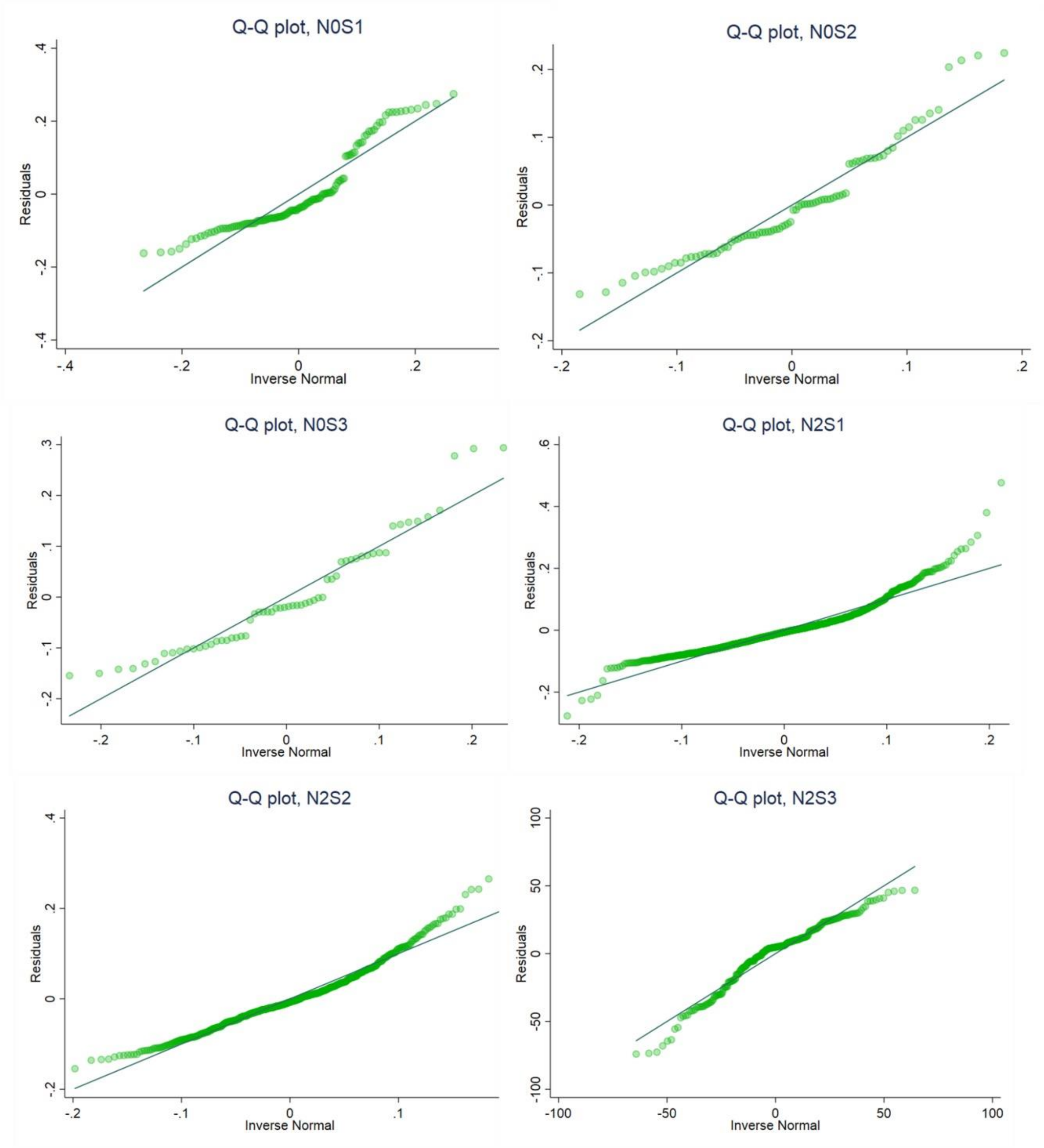

Figure 20: Q-Q residual normality plots of main specifications. Source: author's calculations.

Serial correlation graphs, main specifications

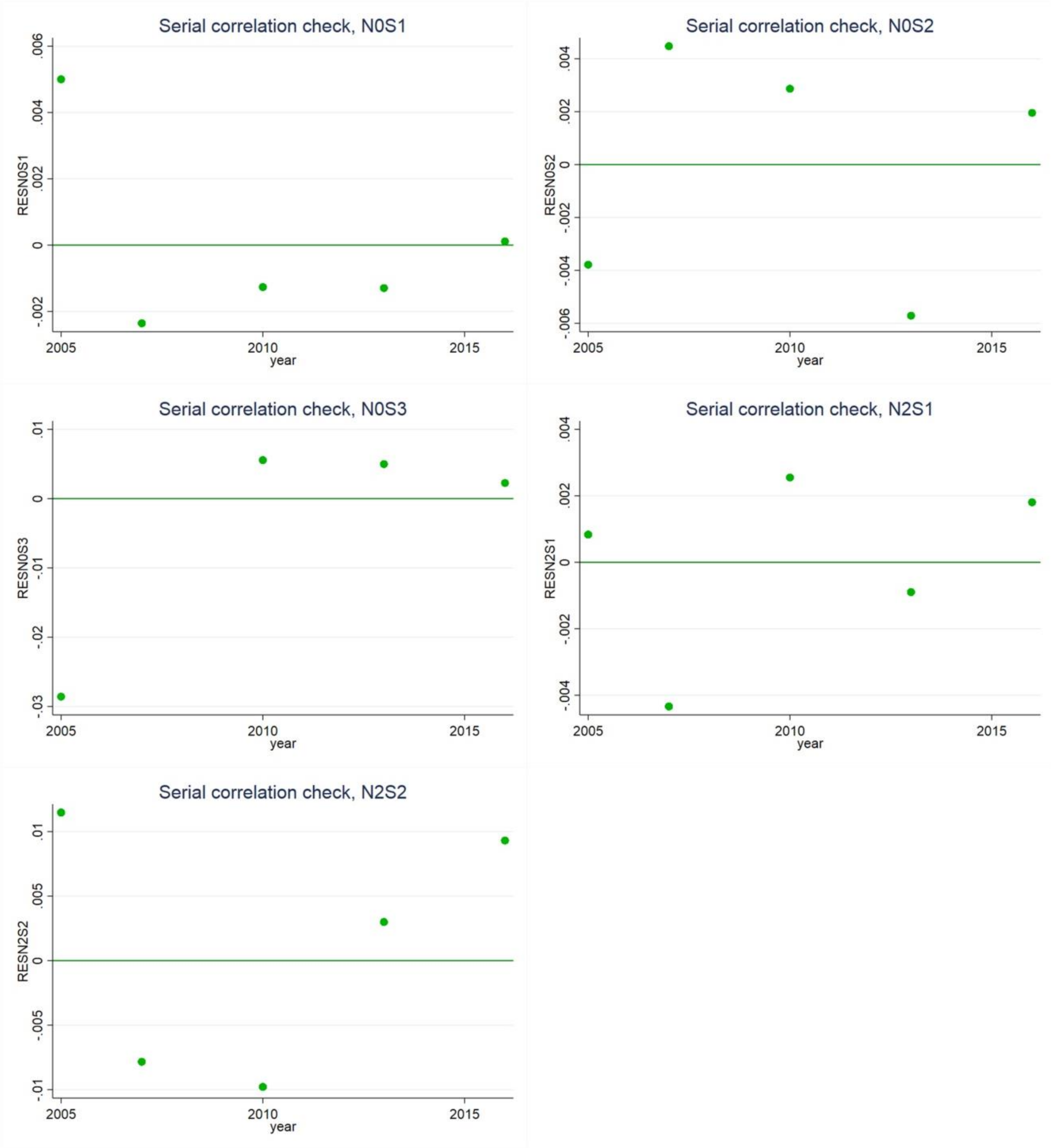

Figure 21: Serial correlation graphs of residuals averaged by year, main specifications. Source: author's calculations.

Appendix E – Samples of cited econometric studies

Table 29: Samples of cited econometric studies

Samples of cited econometric studies	
Burton, R. & Y. (1999)	237 (86 organic) horticultural UK farms, 1996
Burton, R. & Y. (2003)	237 (86 organic) horticultural UK farms, 1996
Chatzimichael, G. & T. (2014)	210 olive farms on Crete; 72 grain farms in Germany, 2006-2007
Chmielinski et al (2019)	6229 Polish farms, 2009-2016
Dinis et al. (2015)	352 organic farms in Italy and Portugal, 2010-2012
Gardebroek (2006)	227 (43 organic) Dutch farms, 1990-1999
Genius, P. & T. (2006)	237 multi-crop farms in Crete, 1995-1999
Kallas, S. G. (2010)	130 (26 organic) vineyards in Catalonia
Kaufmann, S. F. (2009)	4823 (230 organic) farms in Latvia and Estonia, 2005
Läpple & K. (2013)	193 conventional Irish drystock farmers, 2008
Läpple & K. (2015)	597 (165 organic) Irish drystock farmers, 2008
Läpple & V. R. (2011)	546 drystock dairy farms in Ireland, 2008
Läpple (2010)	546 (341 organic, 41 ex-organic) drystock dairy farms in Ireland, 2008
Mzoughi (2011)	243 (38 organic) fruit and vegetable farms in Eastern Fance, 2008-2009
P. López & C. R. (2005)	322 (161 organic) olive orchards in Spain, 2000-2001
Pietola & L. (2001)	Finnish farms (unspecified number and type) , 1994-1997
Schneeberger, D. & E. (2002)	6586 (71 organic) farms in Austria, 1999
Tiffin & B. (2011)	237 (86 organic) horticultural UK farms, 1996

Source: surveyed literature.