Transition to Sustainable Agriculture

The Economic Viability of Certified Animal Production

Lina Wendel Örtqvist

Degree project/Independent project • 30 credits
Swedish University of Agricultural Sciences, SLU
Faculty of Natural Resources and Agricultural Sciences/Department of Economics
Agriculture Programme – Economics and Management
Degree project/SLU, Department of Economics, 1611 • ISSN 1401-4084
Uppsala 2024

Transition to Sustainable Agriculture. The Economic Viability of Certified Animal Production

Lina Wendel Örtqvist

Supervisor:	**Pia Nilsson, Swedish University of Agricultural Science, Department of Economics**
Examiner:	Robert Hart, Swedish University of Agricultural Sciences, Department of Economics

Credits:	30 credits
Level:	Second cycle, A2E
Course title:	Master Thesis in Economics
Course code:	EX0907
Programme/education:	Agriculture Programme - Economics and Management
Course coordinating dept:	Department of Economics
Place of publication:	Uppsala
Year of publication:	2024
Copyright:	All featured images are used with permission from the copyright owner.
Title of series:	Degree project/Department of Economics, SLU
Part number:	1611
ISSN:	1401-4084

Keywords:	Animal certification; Valued Added; spatial spillovers; Two-Way Fixed-effects model

Swedish University of Agricultural Sciences
Faculty of Natural Resources and Agricultural Sciences
Department of Economics

Abstract

This study investigates the influence of certification schemes: EKO, KRAV, and IPSigill, on the economic performance of animal production, thereby addressing a research gap on the well-explored subject of organic farming.

While previous research has explored the economic benefits associated with organic farming, the economic benefits of other certification schemes remains less studied. This study examines the clustering effects associated with EKO, KRAV, and IPSigill certifications on the economic performance of animal production. Using a combination of primary and secondary data, I employ two-way fixed-effect models to analyze how the regional concentration of certified producers influence the value added of animal production over a ten-year period (2010-2020) across Swedish harvest areas. By calculating a localization quotient for EKO, KRAV and IPSigill certified producers, I assess whether regional specialization is correlated with increased value added.

The findings reveal a statistically significant and positive association between certification clustering and economic performance among certified animal producers, highlighting the spillover benefits associated with certification concentration beyond organic farming. This study contributes to the literature by expanding the discussion on the economic performance and agglomeration effects of certification schemes by including additional certifications such as EKO, KRAV and IPSigill. The results provide valuable insights to farmers, certification organizations, and policymakers to promote sustainable practices and enhance economic viability in agriculture.

Keywords: Animal certification; Valued Added; spatial spillovers; Two-Way Fixed-effects model

Table of contents

List of tables

Appendix

Abbreviations

AFC	Arable and Forage Crops
Arcsinh	Hyperbolic Sine Function
FAO	Food and Agriculture Organization
FAW	Farm Animal Welfare
FE	Fixed-Effect
GDPR	General Data Protection Regulation
GHG	Greenhouse Gas
HHI	Herfindahl-Hirschman Index
LQ	Localization Quotient
RE	Random Effects
SBA	Swedish Board of Agriculture
SDG	Sustainable Development Goals
SLU	Swedish University of Agricultural Sciences
TWFE	Two-Way Fixed-Effects
UN	United Nations
VA	Value Added
VA/LU	Value Added per Labor Units

1. Introduction

In the global pursuit of sustainable development, 17 Sustainable Development Goals (SDG) has been established by the United Nations (UN). Goal 12 *"Responsible Consumption and Production Patterns"* underscores the need for sustainable practices in food production (UNDP, 2023). This goal serves as a guiding framework for countries and is particularly crucial for animal production as it faces severe environmental challenges. Animal production is a significant producer of greenhouse gas (GHG) emissions, accounting for a substantial portion of all agricultural emissions (Herrero & Thornton, 2013; Gerber et al. 2013). Sweden, historically known for integrating livestock into food production (Tunón & Sandell, 2021), is facing severe challenges in fulfilling sustainability goals. Specifically, the adoption of modern farming practices, extensive land use for grain production and intensive animal production with stable-raised animals has depleted diversity and endangered many ecosystem services, previously provided by livestock grazing on semi-natural pastures (Hessle & Kumm, 2011; Williams & Hedlund, 2013; Tamburini, et al. 2020). Despite ongoing efforts to maintain and restore these areas, the continuing loss of biodiversity raises significant concerns (Tunón & Sandell, 2021).

Certification schemes, such as organic farming, can play a key role in mitigating these environmental problems, by using methods designed to reduce the adverse environmental impacts of agriculture. Organic practices are designed to align with principles of sustainable development (EU Commission, 2018; Mockshell & Villarino, 2019; Grovermann et al. 2020) and can offer prospects for improved rural livelihoods when implemented effectively (Crowder & Reganold, 2015). In the scientific literature, there is a significant interest in understanding farmer's uptake of sustainable practices and the economic consequences of uptake (Thompson et al. 2024). Still, we have limited understanding of the extent that different certification schemes influence farm economic outcomes, which is key to understanding economic incentive formation and transitional dynamics (Carlisle et al. 2019).

The purpose of this study is to examine how the uptake of different certification schemes among animal producers influences the value added (VA) of production. Although there exist studies with a similar focus, they often build on qualitative or cross-sectional approaches (c.f. Ravaglia, Famiglietti & Valentino, 2018; Garber et al. 2022) and results often apply to certain geographically delimited areas (c.f.

Holzer, 1998; Fredriksen & Langer, 2004; Läpple, 2010; Schneider et al. 2012; Marian & Thøgersen, 2015). This study takes a different approach by examining how change in the regional concentration of producers enrolled in certification schemes influences the VA of production.[1] The analysis is performed using two-way fixed-effects (TWFE) models to address change over time (2010-2020) and regions (harvest areas) across the Swedish geography. The model used in this study accounts for time-invariant heterogeneity within regions and over time, which is key in robust analysis of longitudinal data (Stock & Watson, 2019).

This study uses a localization quotient (LQ) to measure the extent that animal producers enroll in three types of certification schemes: EKO, KRAV, and IPSigill. The rationale is to examine if growth in the regional specialization of certified animal production is associated with growth in the VA of production. This is highly relevant from a policy perspective as a positive association would signal a spill-over effect (Cohen & Levinthal, 1990) suggesting that certified producers can benefit from co-location, i.e. that more producers will adopt certification given the opportunity to observe, learn and share information and knowledge with those that have already adopted certification.

The main contribution of this study to the existing literature is the combination of different types of certifications systems in the analysis. While most previous studies have focused on organic production, denoted here as EKO (e.g. Bolwig et al. 2009; Mendoza, 2004; Ssebunya et al. 2019; Tran & Goto, 2019), this study includes two additional certification schemes in the analysis: KRAV and IPSigill. EKO is the fundamental organic certification that adheres to EU organic standards (EU Commission, 2018). KRAV, while also organic, imposes rules that are more stringent than the EU standards (Krav, 2024). Additionally, IPSigill, although not organic, prioritizes sustainability through semi-natural pasture rules (Sigill, 2023). The contribution of this study is enabled via collection of unique primary data on the uptake of KRAV and IPSigill certification among animal productions, collected specifically for the purpose of this study.

The results of this study provide support for the knowledge spillover (or agglomeration hypothesis), showing a robust positive relationship between the net value added of certified animal production and the concentration of certified animal productions. Results are robust to the inclusion of common production factors, such as access to land, labor, and capital, and to regional change in land use patterns, such as the availability of semi-natural pasture. However, the use of TWFE modelling limits the ability to draw cause-and-effect relationship between the dependent and explanatory variables (Kuroki & Pearl, 2014).

---

[1] This study uses the harvest area level to define regions. There are 120 harvest areas in Sweden and their borders are defined to reflect natural preconditions for agriculture (Jordbruksverket 2, 2022). The terms regional and harvest area are used interchangeably.

Farmers bear a significant responsibility of providing food and meeting the dietary demands of a growing population. In light of this critical role, they often face financial struggles, exacerbated by declining EU dairy and beef production and the prospect of increased imports (Hocquette, 2018) as well as rising production costs, fluctuating feed- and energy prices. Therefore, sustainability and organic goals need to make sense for the farmers economically. This requires that sustainable organic interventions and certification schemes are systematically assessed in terms of economic viability, which is the purpose of the present study. The results of this study are relevant for farmers, certification organizations, and policymakers, particularly in the context of Sweden's new sustainable Food Strategy, extending until 2030, which has set ambitious targets for the promotion of sustainable and organic certified food production (Jordbruksverket, 2022; Jordbruksverket rapport, 2023).

The rest of this study is organized in the following: Section 2 provides the background and a review of the relevant literature, covering the relevant articles to enhance the understanding of the research field. Section 3 outlines the theoretical arguments that underlie the investigation. Section 4 specifies the data and methodologies used in this study, and Section 5 is dedicated to results and empirical findings. Section 6 conducts an analysis of the results and provides a thorough discussion. Lastly, possible implications for policy and future research concludes the study.

2. Literature Review

2.1 The necessity of sustainability certifications

Sustainability certifications in agriculture are crucial for several reasons. The agricultural sector, particularly livestock production, is a significant contributor to greenhouse gas (GHG) emissions. Gerber et al. (2013) estimated that beef and dairy cattle production alone contributes to 41% and 20% of agricultural sector GHG emissions, respectively. Forecasts indicate that consumer demand for livestock products will double by 2050 (Garnett, 2008). Beef production, in particular, has been identified as yielding the highest GHG emissions per kilogram of food, with considerable variability across various production systems (Morgensen et al. 2014; Morgensen et al. 2015). Additionally, livestock production utilizes nearly 80% of global agricultural land (FAO, 2010; Nguyen et al. 2010), raising concerns about land-use change and impacts on soil carbon balance (Cederberg et al. 2013; Vellinga et al. 2004).

Adoption of sustainable production methods can help mitigate these environmental impacts. For example, sustainable practices have shown to reduce emissions (Reganold & Wachter, 2016), decrease water usage (Chartzoulakis & Bertaki, 2015), and promote healthy soil ecosystems (Zhang et al. 2020). These benefits are achieved through the implementation of practices such as harnessing natural cycles, restricting pesticides and manure, and adopting self-sufficiency strategies (Jordbruksverket, 2023). Studies by Kumm (2005), Hessle & Kumm (2011) and Kumm (2007) indicate that livestock grazing, utilized on semi-natural pastures, can positively contribute to biodiversity. This emphasizes the potential role of sustainable and organic certifications to help mitigate the environmental challenges that stems from agriculture and animal production.

In Sweden, animal productions follow EU regulations and strict national rules for welfare and environmental standards. Even non-certified productions prioritizes the welfare of the animals with proper housing, nutrition, and veterinary care (EU Commission, 1998). The certifications analyzed in this thesis are EKO; KRAV and IPSigill. EKO follows the EU organic production standards, aiming for environmental protection, biodiversity, and consumer trust (EU Commission, 2018). Organic productions must use natural resources in a way that minimally impacts the environment while maintaining a high self-sufficiency. KRAV, another organic certification, surpasses EU standards in animal welfare and environmental requirements (Krav, 2024). Svenskt Sigill, not strictly organic, strives for sustainability. The IPSigill[2] semi-natural pasture beef certification mandates animals graze on semi-natural pasture for at least half of the grazing period. These productions also hold the IP beef & milk certification for improved food safety, animal welfare, reduced environmental impact, and fairer working conditions (Sigill, 2023).

2.2 The growing trend of organic and certified farming

The increasing adoption of organic and certified practices is driven by various factors, including profitability, aligning with microeconomic profit maximization theory (Debertin 2012). Certifications such as EKO, KRAV, and IPSigill, offer economic incentives such as access to premium markets with price premiums, resulting in higher payments per kilo of meat. Additionally, participation in organic and sustainability programs may make the productions eligible for government subsidies (Jordbruksverket, 2024).

Recent literature supports these growing trends in organic farming (Willer & Lernoud, 2019), and offer insights into sustainable practices and economic viability within the agricultural sector. Organic farming entails the application of many agroecological principles and is formalized by certain standards to certify compliance with these principles (Mockshell & Villarino, 2009). Under the right conditions, organic certifications can create sustainable rural livelihoods and profitability for farmers (Crowder & Reganold, 2015). Farmer's decisions to adopt certification are influenced by various factors, including gender, off-farm income, education level, positive attitudes, and normative and moral obligations (Sapbamer & Tammachai, 2021). However, accurately measuring these factors can be challenging, especially when relying on secondary data.

Research evaluating sustainability production standards has highlighted various aspects. Meemken & Qaim (2018) assessed them for gender equality, while Ibanez & Blackman (2016) evaluated them for the adoption of good agricultural practices, and Schreibermachers et al. (2012) for pesticide use reduction. Several studies have examined the economic effects of organic production standards across different income settings, consistently demonstrating financial advantages (c.f. Bolwig et al. 2009; Mendoza, 2004; Ssebunya et al. 2019; Tran & Goto, 2019)

A meta-study evaluating the competitiveness of organic farming suggests that profitability and benefit-cost ratios are higher for certified organic farms compared

---

[2] Throughout the paper, the certification "Svenskt Sigill – IPSigill semi natural pasture beef", is referred to as "IPSigill" to streamline its name.

to non-certified farms (Crowder & Reganold, 2015). Van Der Ploeg et al. (2019) examined agroecology's economical potential in the EU. Analyzed data included various certified organic cases, further supporting the profitability of organic production. Grovermann et al. (2020), found evidence that organic certification in the EU results in increased gross margins for dairy productions, improved technical efficiency, and significant profit increases.

Furthermore, studies by Garber et al. (2022) and Schneider et al. (2012) offer insights into the profitability and feasibility of certification programs. Garber et al. (2022) found that Virginia Quality Assured (VQA) – certified cattle were significantly more profitable due to faster turnover and reduced feed costs. Schneider et al. (2012) conducted a qualitative study and cluster analysis in Brazil, assessing the feasibility of implementing a geographic certification for label sheep productions in certain clustered areas, identifying potential benefits under correct preconditions as well as challenges.

Fredriksen & Langer (2004) provide insights into the spatial distribution of organic farms. By using localization quotients (LQs) they analyzed the geographical distribution of organic farms in Denmark at both county and parish levels. They highlighted various factors influencing adoption and diffusion across different regions including, regional specialization, policy interventions, market dynamics and local factors.

However, there is research that suggests that achieving profitability through certifications can present challenges. For instance, Johansson (2009) revealed limitations and challenges with fairtrade certification, such as price premiums not fully reaching the farmers. This emphasizes the need for critical assessment of certifications and how they affect profitability, tailored to specific contexts. In the Swedish agricultural landscape, studies by Kumm (2005), Hessle & Kumm (2011) and Hessle et al. (2017) highlights the economic challenges and opportunities facing sustainable animal production, particularly beef production. These investigations underscore the importance of environmental subsidies and income support in promoting the financial sustainability of beef productions. Similarly, Ahmed et al. (2020) emphasize the initial profitability challenges associated with farm animal welfare (FAW) measures, while also recognizing their long-term benefits for both farmers and society at large.

Examining sustainable crop production, Manevska & Malmström (2022) discovered the positive correlation between crop diversity, organic farming, and farm efficiency. They also underscore the importance of environmental support and agricultural subsidies in enhancing technological advancement and efficiency on Swedish farms.

The literature review provides insights into sustainable agriculture, emphasizing environmental challenges in animal production and advocating for biodiversity promotion and GHG reduction. It underscores the potential for mitigation through sustainable and organic certification schemes, with research indicating potential profitability opportunities in organic production.

However, the review highlights a significant gap in understanding the economic performance of certification clustering, particularly within the Swedish context. This highlights the necessity for further exploration into the economic viability and clustering dynamics of certified animal productions in Sweden, recognizing the transformative potential of clustering analyses and localization quotients (LQ).

The earlier literature mainly focuses on organic farming. Therefore, this study contributes to the literature by broadening the scope and enhancing the discussion within the literature of economic performance and clustering effects of certification schemes, through the inclusion of certifications such as EKO, KRAV and IPSigill.

3. Theoretical Framework

The theory of externalities examines how activities affect third parties not directly involved in a transaction (Ayres & Kneese, 1969; Lewis et al. 2008). One significant motivation for adopting certification stems from the possibility of producers to gain from externalities arising from sharing, matching, and learning activities (Cohen & Levinthal, 1989). Animal productions can gain from the impact of social capital on and absorptive capacity from the adoption of new production methods (Micheels & Nolan, 2016). Animal productions can also learn from each other on how to mitigate negative production externalities which are costs not fully reflected in market prices, such as climate change, land-use change and biodiversity loss. Certification is aimed at mitigating these negative externalities and instead produce positive externalities. Yet, this might require learning-by-doing and learning-by-observing others engaged in similar efforts. For instance: biodiversity enhancement through livestock grazing on semi-natural pastures (c.f. Kumm, 2005; Hessle & Kumm, 2011; Kumm, 2007) and the reduction of environmental toxin through restricted pesticide use (Jordbruksverket, 2023).

Another possible source of learning stems from government initiatives and policies that aim to support sustainable agricultural practices. Various policy instruments are employed to reduce the climate impact of food production and consumption. Including taxes, subsidies, restrictions, and consumer influence, and measures like nudges and advisory services (AgriFood, 2020). Yet, there is not much evidence on the role of policy in providing animal productions the resources (such as social capital and knowledge networks) to improve their absorptive capacity. A common finding in the literature is that both agglomeration effects and policy measures are important and that for policy measures to be effective it requires knowledge about the extent of diffusion associated with production (Läpple, 2010). Localization theory suggests that similar economic activities tend to cluster together geographically. This is due to factors such as the availability of resources, skilled labor, infrastructure, as well as historical reasons (North, 1955). The impact of clustering can lead to development of specialized knowledge, networks, and economies of scales within regions. It can also lead to the adoption of innovation in agriculture (Micheels & Nolan, 2016) and to adoption of organic farming practices (Läpple, 2010; Läpple and Van Rensburg, 2011). The main theoretical assertion tested in this study is if certified animal producers gain economically from clustering together.

To assess how the spatial concentration of certified animal productions influences economic outcomes, this study utilizes localization quotients (LQs) in line with Fredriksen & Langer (2004). This is a common method for measuring the degree of regional specialization, typically in a sectoral or spatial context (Eliasson & Westerlund, 2003). In this study, the calculated LQ compares the portion of certified EKO, KRAV, and IPSigill farms in the animal production sector within a specific harvest area to the total number of farms in that harvest area, divided by the same ratio at the national level. Essentially, the LQ measures the extent to which animal productions enroll in the three types of certification schemes. Measuring the spatial concentration of economic activities is crucial for effective localization strategies because such concentration could foster job creation and growth of the sector as a whole. This study uses value added (VA) to measure economic growth of the sector, a measure widely utilized in agricultural studies to measure economic performance (Nilsson et al. 2022; Ilic, 2010).

The LQ is utilized in the two-way fixed-effect (TWFE) models as the key explanatory variable, to examine if the growth in the regional specialization of certified animal productions is associated with growth in the VA in production. From a policy perspective, this is highly relevant as a positive association would signal a spill-over effect (Cohen & Levinthal, 1990).

4. Data and Methodology

4.1 Data sources and collection

This study utilizes both primary and secondary data. The secondary data comprise firm financial accounts and land-use data for the period 2010-2020. The economic data are sourced from Statistics Sweden's (SCB) FEK database ("Företagens Ekonomi"). The Land Parcel Identification System (LPIS) governed by the Swedish Board of Agriculture (SBA) provides information on the relevant land-uses (e.g. land devoted to semi-natural pasture). A third source of secondary data is from SBA and contains information on firms enrolled in the first certification scheme of focus in this study, EKO, which is the fundamental organic certification. Due to the confidentiality rules regarding microdata (GDPR), individual firm-level data could not be accessed for this analysis. Instead, firm-level data from the sources described above is analyzed at the aggregated harvest area level, as described further below.

In the process of data collection, the primary focus was on animal producers, specifically targeting beef, dairy, sheep, goat, and mixed productions. A key challenge in this study was how to distinguish those animal producers enrolled in the remaining two certification schemes of focus in this study: 'KRAV' and 'IPSigill'. There is no official database that can be used to identify these producers. In order to identify them, I collected primary data from websites and compiled a dataset of producers enrolled in IPSigill and KRAV certification, which I then asked SCB to match to the secondary data using the collected organizational numbers. This matching was conducted by SCB, and the data accessed for this study is the aggregated version of the primary data, retrieved from their Microdata Online System (Mona) after matching with other microdata. Since students are restricted from having access to Mona, I received the data in aggregated form from my thesis supervisor.

Another challenge encountered during the primary data collection was how to determine the exact year of entry for the KRAV and IPSigill certified producers. Despite efforts to reach out to the producers for clarification, responses were limited. Consequently, in cases where the year of entry was missing for KRAV in the collected data. I assumed that productions joined KRAV simultaneously with their enrollment in EKO. Fortunately, for IPSigill certified productions, I was able to obtain most of the relevant enrollment years directly from the producers themselves. However, it is important to acknowledge the absence of precise entry years in many instances, which represents a limitation of this study. Although in many cases, entry into EKO and KRAV do occur in the same year.

The primary data consists of 1370 producers of which 90% could be matched to FEK with the collected organization numbers. The approach to combine primary and secondary data to obtain a comprehensive list of animal producers enrolled in different certifications systems is the first of its kind, which is also a contribution of this study.

4.2 Variables

The dependent variable used in the analysis is the net value added[3] (VA) of production aggregated at the harvest area level. Following the previous literature, this is defined as the difference between the value of production and the costs of intermediate consumption and fixed capital consumption, i.e. depreciation (c.f. Lu & Dudensing, 2015; Nilsson et al. 2022).

The study primarily focuses on two main production orientations: beef and dairy aggregated into a single group, and mixed productions. In certain models, dairy, beef, and mixed producers are all aggregated into one group. Producers adopting EKO, KRAV or IPSigill certifications were also aggregated into one group in the estimations.

Explanatory variables

The explanatory variable of focus in this analysis is a localization quotient (LQ) which measures the concentration of certified animal production within specific harvest areas relative to the overall concentration of certified animal production in Sweden. The quotient is calculated in the following:

$$Cert_{st} = LQ_{js} = \frac{S_{js}/S_s}{S_{jn}/S_n} \qquad (1)$$

where, S_{js} is the number of certified producers s in sector j in harvest area s, S_s is the total number of farms in harvest area s, S_{jn} is the number of certified animal producers in sector j in Sweden (n) and S_n is the total number of farms in Sweden (n). As outlined in the theory, this quotient offers insights into the economic potential of the spatial concentration of certified production and is assess against

---

[3] See Table A3 in the appendix for a correlation matrix demonstrating the interrelationship among economic indicators, supporting the selection of value added as the dependent variable to address multicollinearity issues.

net VA in the empirical model. This approach resembles Fredriksen & Langer, (2004) on the localization of organic farms in Denmark, who found major variations in concentrations of organic farmers across regions, suggesting that localization factors are crucial in the context of organic conversion.

A set of control variables are included to account for additional factors that influence the net VA of production. Additionally, LQs for concentration of semi-natural pastures and mixed productions[4] were included to control for their influence on certification uptake. Temporal variables, such as a meat price index and a measure of population density, were also included to account for fluctuations in production costs and accessibility to markets. Lastly, the Herfindahl-Hirschman (HHI) index was included to control for crop diversity by measuring the concentration of land use in semi-natural pasture, ley, and arable and forage crops (AFC).

Table 1 presents the dependent variables and their definitions and data sources, and Table 2 outlines the explanatory variables of interest alongside the control variables used in the empirical analysis.

Table 1. Definition of dependent variables used in the empirical analysis.

Variable	Definition	Source
VALU_animal_all	The net value added per labor unit (VA/LU) of all animal producers (Dairy, Beef, Sheep, Goat and Mixed)[5] in the harvest area (HA), weighted with the total number of animal producers in the harvest area.	SCB/FEK
VALU_DairyBeef_all	Calculated as above but only for dairy and beef production.	SCB/FEK
VALU_Mix_all	Calculated as above but only for mixed production.	SCB/FEK
VALU_DairyBeef_Mix_cert	The net VA/LU of all certified dairy, beef, and mixed producers in the harvest area weighted with the total number of all animal producers in the harvest area.	SCB/FEK
VALU_DairyBeefMix _noncert	The net VA/LU of all non-certified dairy, beef, and mixed producers, in the harvest area weighted with the total number of all animal producers in the harvest area.	SCB/FEK

---

[4] See Table A1 & A2 in the appendix for a correlation matrix demonstrating the interrelationship among LQs for certified animal production and dairy, beef, and mixed productions, and EKO crop productions. Since, the correlations is relatively high a corresponding LQ for crop productions was excluded in the final model.

[5] Dairy: SNI 1410, Beef: SNI: 1420, Sheep and Goat: SNI 1450, Mixed: SNI 1500.

Table 2. Definition of explanatory variables used in the empirical analysis.

Variable[6]	Definition	Source
LQ_certanimal	LQ calculated for the aggregated group of EKO, KRAV, and IPSigill certified animal producers (defined by Eq. 1).	SBA
LQ_Mix	LQ calculated wrt. the number of employees in mixed production.	SBA
LQ_pasture	LQ calculated wrt. hectares of semi-natural pasture.	SBA
Capital_all_firm	Total value of material and immaterial assets (building. Land, machinery) in possession of animal producers divided by the total number of animal producers (dairy, beef, & mixed).	SCB/FEK
Land_DairyBeef Mix_firm	Total hectares of land (owned, rented by animal producers) divided by the total number of animal producers.	SBA/LPIS
Meat_priceindex	Meat price index. For fluctuations in production costs.	SBA
Pop_density	Number of people per km^2 in the harvest area.	SCB
HHI	Herfindahl-Hirschman index $HHI = s_1^2 + s_2^2$ measures the concentration of land used for semi-natural pasture, ley, & arable and forage crops as an indicator of crop-livestock integration. in the harvest area.	SBA/LPIS

4.3 Summary Statistics

The summary statistics presented in Table 3 below, show that the average value added (VA) across different productions was 143 thousand SEK over the period (2010-2020), with the highest average VA found among the non-certified producers. The lowest average VA is found among the certified producers. This low average VA is likely due to higher labor usage in certified production (Finley et al. 2018) than non-certified production (Morison et al. 2005) and the weighting by the total number of animal firms to avoid size effects.

---

[6] All variables are defined at harvest area level if nothing else is indicated.

The summary statistics further show that the number of observations for the variables varies between 1092 and 1121, indicating that the dataset is slightly unbalanced, due to missing data for some variables. This could introduce complexities in the analysis, potentially leading to biased estimates if not properly addressed. Robust standard errors are employed to adjust for the variability in the data sample (Stock & Watson, 2019).

Table 3. Descriptive Statistics

Variable	Obs	Mean	Std. Dev	Min	Max
VALU_animal_all	1,092	143.0791	94.82475	-113	1944
VALU_DairyBeef_all	1,092	124.2921	91.48866	-113	1944
VALU_Mix_all	1,092	167.5878	115.3246	-34	1345
VALU_DairyBeefMix_cert	1,092	30.15213	63.66629	-113	1944
VALU_DairyBeefMix_noncert	1,092	239.6864	121.9046	-49	1345
LQ_certanimal	1,092	0.9575732	0.7230346	0	10.2809
LQ_Mix	1,121	1.065463	0.5766453	0	6.162482
LQ_Pasture1	1,094	1.087016	.9052709	0	7.011104
Capital_all_firm	1,121	6.28e+08	6.93e+08	0	3.63e+09
Land_DairyBeefMix_firm	1,092	86.01769	47.48454	0	5.684061
Meat_priceindex	1,110	100.2011	6.47279	86.94	111.33
Pop_density	1,110	1624.968	2652.211	130.0792	19367.5
HHI	1,094	0.6420255	0.1362491	0.5	1

4.4 Empirical model

To analyze the influence of change in the concentration of EKO, KRAV and IPSigill certified production on value added (VA) among animal producers (both certified and non-certified) a two-way fixed-effect[7] (TWFE) method is employed. The TWFE model accounts for both time-invariant heterogeneity within regions and temporal effects, which are important given the likely presence of unobserved factors in longitudinal observational data (Stock & Watson, 2019).

Harvest areas may systematically differ from each other in factors such as natural preconditions for agriculture (e.g. soil quality and climatic conditions) and access to markets. These differences can vary both over time and within harvest areas and

---

[7] See Table A4 in the appendix for Hausman test results favoring the fixed-effects model over the random effects model for this dataset and analysis.

could significantly influence the adoption of certifications. Therefore, the model includes both yearly dummies and harvest area fixed-effects.

The baseline model used in this study is specified as follows:

$$VA_{st} = \alpha_s + \theta Cert_{st} + \gamma LQ_{st} + \eta Capital_{st} + \lambda LAND_{st} + \beta X_{st} + \mu_s + \tau + \varepsilon_{st} \quad (2)$$

where $VA_{st} = (\frac{VA/LU}{firms})_{st}$

In this model, VA_{st} denotes the value added of animal production (defined in Table 1), in harvest area s at time t. The variable $Cert_{st}$ aggregates EKO, KRAV, and IPSigill certifications as a group, representing all certified productions. As mentioned, this variable measure the degree of certification concentration across harvest areas in the form of a localization quotient as defined in section 4.2. The vector LQ_{st} includes additional localization quotients for factors influencing the animal sectors competitiveness, such as the spatial concentration of mixed production and semi-natural pasture.

$Capital_{st}$ and $Land_{st}$ are included to measure and control for structural change in terms of capital intensity and farm size. The vector X_{st} encompasses temporal control variables, including a meat price index, population density and the HHI index, to control for fluctuations in production costs, accessibility to markets and crop-livestock integration. The harvest area fixed-effects are represented by μ_s and the time-specific fixed-effects are represented by τ. Lastly, ε_{st} denotes the error term.

4.3.1 Variable transformations

Examination of scatter plots of the residuals[8] for the variables revealed heteroscedasticity. To address this issue, the independent variables were transformed into natural logarithmic (log) form.

Log transformation changes the interpretation of the coefficients in the regression models: now, the coefficient on an explanatory variable represent the percentage change in the dependent variable for a one-unit change in the explanatory variable.

For the dependent variables, the inverse hyperbolic sine (arcsinh) transformation was employed to address negative minimum values present in the data[9] and to provide a more comprehensive treatment of outliers. The arcsinh transformation function for VA_{st} is formulated as follows:

$$\text{arcsinh}(VA_{st}) = \ln(VA_{st} + \sqrt{VA_{st}^2 + 1}) \quad (6)$$

---

[8] See Figure A1 in the appendix for illustrated residual plots.

[9] See Table 3 in the results section for descriptive statistics for min and max values.

This function behaves like a logarithm for large VA_{st} (positive or negative) and behaves like a linear function for small values of VA_{st} (Zhang et al. 2000). This also allows to compress extreme values while preserving the central values relatively unchanged, which diminishes both positive and negative tails.

The logarithmic and arcsinh transformation improved homoscedasticity, as the spread of the residuals appears more evenly. Despite this, the residual plots still indicated heteroscedasticity. To address this issue all models are estimated with robust standard errors clustered at the harvest area level (Stock & Watson, 2008).

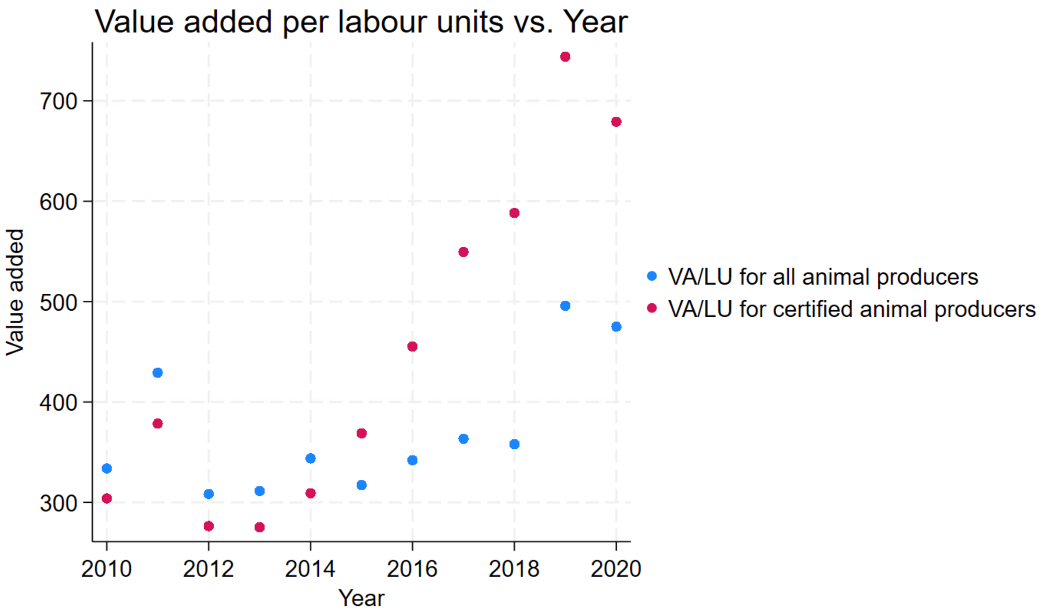
5. Results

5.1 Temporal and spatial trends in certified animal production in Sweden (2010-2020)

The temporal trend of value added (VA) in animal production from 2010 to 2020 observed in the data is illustrated in Figure 1. The graph shows the time trends for all animal productions regardless of their certification status (red plots), and certified EKO, KRAV, and IPSigill animal productions (blue plots). The figure provides a visual representation of the volatility of economic development within the animal production sector.

Between 2010 and 2014, all productions demonstrated a rising VA. Beginning in 2015, the VA for certified productions surpassed all productions. In 2020, certified productions experienced a decline, aligning more closely with the VA of all productions. This coincided with the start of the COVID-19 pandemic, which could suggest potential economic repercussions.

Figure 1. Time trend graph



The x-axis: the years from 2010 to 2020, the y-axis: the VA in thousands of crowns.

Figure 2a and 2b presents the results of cluster analysis performed to examine the geographical distribution of the localization quotient (LQ) for certified animal production at the harvest area level for 2010 and 2020. I performed the analysis using the Getis-Ord method (Getis & Ord, 1992), which considers both the LQ values, and the proximity of harvest areas based on Euclidean distance. These maps highlight the presence of statistically significant spatial autocorrelation in certified animal production.

High LQ areas surrounded by other high LQ areas are shown in varying shades of red, indicating significant clustering. Conversely, areas with low LQs surrounded by similar areas are shaded blue, while yellow areas indicate random distributions with no significant clustering. The maps reveal significant clusters in central Sweden, with an expansion over time, suggesting a growing co-localization of certified animal producers in Sweden.

Figure 2a-b. Graphical illustration of spatial certification clusters.

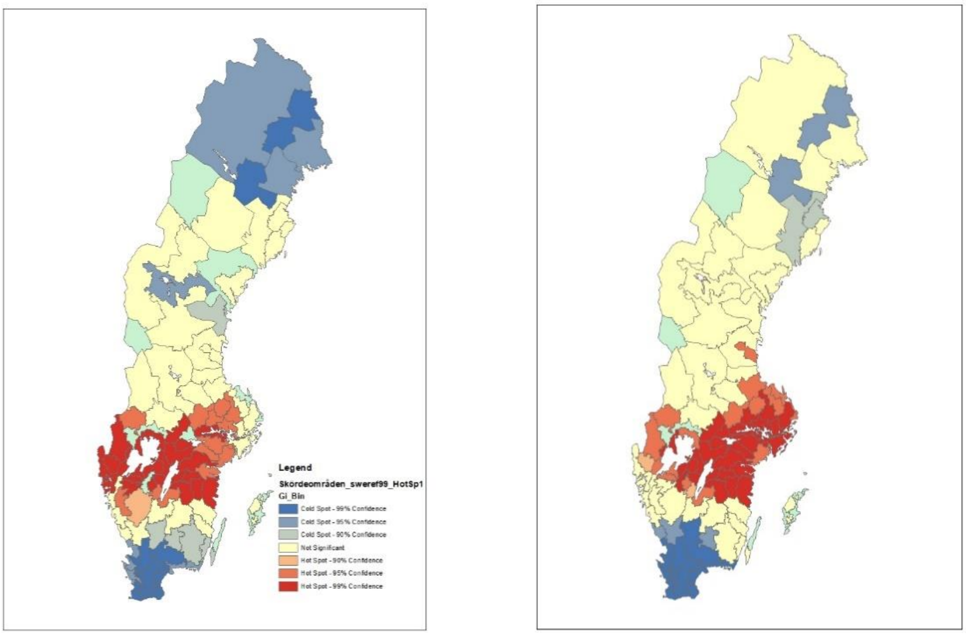


Fig. 2a. 2010 *Fig. 2b. 2020*

The analysis of Figure 1 and Figure 2a-b show that both the value added (VA) among certified producers and the concentration of certification have grown over time.

5.2 Empirical approach and results

The estimated models in this study uses different dependent variables for each of the five estimated models, while maintaining consistent key explanatory and control variables across all models.

Model 1 examines how a change in certification concentration influences economic performance among animal producers and the sector as a whole, with the dependent variable being “VALU_animal_all". Models 2 and 3 examine within-sector heterogeneity, with the dependent variables "VALU_DairyBeef_all" and "VALU_Mix_all," respectively. Models 4 and 5 investigate how the degree of certification influences value added (VA) among non-certified and certified producers, with the dependent variables "VALU_DairyBeefMix_cert" and "VALU_DairyBeefMix_noncert", respectively. [10]

Residual plots[11] for models 1, 4, and 5 were conducted to assess the TWFE model assumptions and the necessity of robust standard errors. For each model, two sets of residual plots were generated: one with the dependent and explanatory variables in their original, untransformed, form and one with the arcsinh-transformed dependent variables and logged explanatory variables. The residual plots revealed violations of the assumption of homoscedasticity in the TWFE model for the untransformed values across all models. However, the residual plots of the arcsinh and logged values showed improvements in homoscedasticity, exhibiting more evenly spread distributions of the residuals. Therefore, the logged and arcsinh transformation was utilized in all of the estimated models to address the issue of negative values. Nevertheless, while there were improvements in homoscedasticity, heteroscedasticity was still evident. This observation further supports the use of robust[12] standard errors in the models to account for potential heteroscedasticity (Stock & Watson, 2008).

5.3 Baseline regression results

Table 4 presents the results of three estimated TWFE models, encompassing all productions regardless of their certification status. Model 1 focuses on all animal (dairy, beef, sheep, goat and mixed) productions, while models 2 and 3 address specialized dairy and beef productions and mixed productions, respectively. The key independent variable of interest, lnLQ_certanimal, which is the main variable used to test the stated hypotheses regarding spill over effects.

Model 1 produced 14 out of 19 significant variables, with an R^2 value of 0.6806, indicating that the model explains 68.06% of the variance in the dependent variable by the independent variables. The F-statistic test $F(94{,}906) = 67.52\ P = 0.0000$ indicates overall statistical significance of the model. The coefficient for lnLQ_certanimal is insignificant. As a result, it is not possible to confirm a relationship between the spatial concentration of certified animal production and the overall VA by all animal producers.

---

[10] See Table 1 for dependent variables definitions.

[11] See Figure A1 in the appendix for illustrated residual plots.

[12] All equations are estimated with robust standard errors clustered at the harvest area level.

Model 2 and 3 resulted in 13/19 and 5/19 significant variables, respectively. However, the coefficient for lnLQ_certanimal is insignificant in both models. Consequently, the aspect of heterogeneity within the sector remains unanswered. Further investigation is needed to explore the relationship between the spatial concentration of certified animal production on the overall VA by all animal producers, and heterogeneity within the sector.

Table 4. Two-way FE Results for all productions.

VALU	(1) Coef (Std.err)	(2) Coef (Std.err)	(3) Coef (Std.err)
lnLQ_certanimal	0.0535 (0.0342)	-0.0229 (0.0320)	-0.0285 (0.0419)
lnLQ_Mix	-0.1240* (0.0645)	-0.1416** (0.0700)	0.0104 (0.0980)
lnLQ_pasture1	-0.2584* (0.1292)	0.0970 (0.2303)	-0.1261 (0.1346)
lnCapital_all_firm	0.2053*** (0.0704)	0.1525** (0.0639)	0.3581** (0.1179)
lnLand_all_firm	0.4842*** (0.1207)	0.4501** (0.2086)	0.1793 (0.1928)
lnMeat_priceindex	0.0462 (0.0729)	0.0138 (0.0764)	0.0224 (0.0888)
lnPop_density	-0.0328 (0.0301)	-0.0343 (0.0357)	0.0747 (0.0475)
lnHHI	-0.2130 (0.3133)	-0.3605 (0.3903)	-0.9826** (0.3670)
2011	1.667*** (0.4671)	1.3008** (0.4210)	2.8089*** (0.7928)
2012	-0.1022*** (0.0192)	-0.1524*** (0.0189)	-0.0472 (0.0378)
2013	-0.0865*** (0.0234)	-0.1234*** (0.0238)	-0.0482 (0.0331)
2014	-0.0540** (0.0223)	-0.0888*** (0.0224)	0.0296 (0.0344)
2015	-0.2768*** (0.0235)	-0.1915*** (0.0255)	-0.0312 (0.0381)
2016	-0.2320*** (0.0279)	-0.1296*** (0.0291)	-0.0207 (0.0429)
2017	-0.1991*** (0.0301)	-0.0656** (0.0290)	-0.0625 (0.0575)
2018	-0.2606*** (0.0368)	-0.1272*** (0.0354)	0.0029 (0.0499)
2019	1.4407*** (0.4399)	1.2229** (0.3984)	2.8143*** (0.7463)
2020	1.3539*** (0.4344)	1.1335** (0.3937)	2.8086*** (0.7396)
Constant	0.5068 (1.1396)	1.1146 (1.3821)	-1.52501 (1.8977)
Obs	1019	1019	1019
R-squared	$R^2 = 0.6806$	$R^2 = 0.6420$	$R^2 = 0.6255$
F-test	$F(18, 94) = 141.57$	$F(18,94) = 124.47$	$F(18,94) = 107.69$
P-value	$P = 0.0000$	$P = 0.0000$	$P = 0.0000$

*Significance levels: *** 99% (p<0.01), **95% (p<0.05), *90% (p<0.10).*

Table 5 presents the results of two estimated TWFE models: model 4 includes certified dairy, beef, and mixed productions, while model 5 includes non-certified dairy, beef, and mixed productions. These models address how the degree of certification concentration influences VA among non- versus certified producers.

Model 4 produced 11 out of 19 significant variables, with an R^2 value of 0.6068, explaining 60.68% of the variance in the dependent variable by the independent variables. The F-statistic test $F(94{,}906) = 14.42\ P = 0.0000$ indicates overall statistical significance of the model. The coefficient of interest, lnLQ_certanimal, is 0.8767 in model 4, suggesting a positive and significant relationship between VA (among certified animal producers) and the spatial concentration of certification. This result is statistically significant at the 99% confidence level. Results further show that model 5 produced 12/19 significant variables but exhibits an insignificant coefficient for lnLQ_certanimal. A relationship can thus not be confirmed, indicating the presence of spill over effects among certified animal producers.

Table 5. Two-way FE Results for certified and non-certified productions.

VALU	(4) Coef	(Std.err)	(5) Coef	(Std.err)
lnLQ_certanimal	0.8767***	(0.0804)	-0.0260	(0.0246)
lnLQ_Mix	-0.0181	(0.1810)	-0.0750	(0.0654)
lnLQ_pasture1	-0.1247	(0.2945)	-0.0391	(0.1583)
lnCapital_all_firm	0.5102***	(0.1942)	0.2398*	(0.0719)
lnLand_all_firm	-0.1887	(0.3000)	0.2043	(0.1814)
lnMeat_priceindex	-0.1062	(0.1672)	-0.0169	(0.0745)
lnPop_density	-0.0478	(0.0610)	0.0604	(0.0397)
lnHHI	-0.7754	(0.9913)	-0.6596**	(0.2982)
2011	3.8680***	(1.3092)	1.967***	(0.4879)
2012	-0.1279**	(0.0519)	-0.1107***	(0.0188)
2013	-0.1050*	(0.0582)	-0.1157***	(0.0231)
2014	-0.0734	(0.0639)	-0.0430*	(0.0241)
2015	-0.7130***	(0.0734)	-0.1188***	(0.0233)
2016	-0.7910***	(0.0851)	-0.1018***	(0.0261)
2017	-0.8250***	(0.0815)	-0.0767**	(0.0329)
2018	-0.9040***	(0.0923)	-0.0703**	(0.0336)
2019	3.1299**	(1.2420)	1.9463***	(0.4638)
2020	3.0454**	(1.2316)	1.9241***	(0.4556)
Constant	-1.9514	(2.7057)	0.9911	(1.1701)
Obs	1019		1019	
R-squared	$R^2 = 0.6068$		$R^2 = 0.7259$	
F-test	$F(18, 94) = 77.03$		$F(18, 94) = 162.02$	
P-value	$P = 0.0000$		$P = 0.0000$	

*Significance levels: *** 99% (p<0.01), **95% (p<0.05), *90% (p<0.10).*

Control variables

The control variables show varying statistical significance and signs across all five models. Capital consistently produced significant and positive coefficients. This outcome was quite expected and aligns well with fundamental economic theory on the growing role played by capital intensity in agriculture: an increase in assets generally leads to improvements in economic indicators (Petrick & Kloss, 2018; Gutierrez, 2002). The consistent positive associations between capital and VA strengthens the confidence of the models as it confirms a key empirical regularity.

Furthermore, the year dummies mostly yield negative coefficients across the models, indicating declining trends in net VA. In 2018, characterized by adverse weather conditions including heat and drought, significant negative coefficients were consistently observed in models 1, 2, 4, and 5. The summer drought of 2018 not only led to a poor harvest but also resulted in long slaughter queues and significant costs for Swedish agriculture (Grusson, et al. 2021; Rende, 2019). As a result, profitability in 2019 for several agricultural productions was impacted. Additionally, the COVID-19 pandemic further strained the economy in 2020 (Uğur & Buruklar, 2021).

However, despite the challenges faced in 2018 and the subsequent impact of the COVID-19 pandemic in 2020, both 2019 and 2020 displayed significant and positive coefficients across all models. This suggests that these years were particularly favorable for animal producers in Sweden, aligning with Lin & Zhang's (2020) research indicating that the COVID-10 negatively impacted smaller agricultural firms rather than larger ones.

Robustness checks

To further evaluate the influence of the years 2018, 2019, 2020 on the previous findings, a robustness check was performed on model 4 by excluding these years in the TWFE regression. The results from 2010-2017 are presented in Table 6. The coefficient for lnLQ_certanimal remains statistically significant at the 99% confidence level and increases slightly from 0.8767 to 0.8980, with a marginally higher standard error. Similarly, the capital coefficient, significant at the 90% confidence level, decreases from 0.5102 to 0.3942, also with a slightly higher standard error. The year dummies, included to control for year-specific effects, prove statistically significant for most years. Excluding 2018-2020 enhances the robustness of the earlier findings, emphasizing the consistency of the results.

Building upon the spatial analysis results in Figure 2a-b, which highlighted significant clustering of certified animal production in central Sweden, a second robustness check was conducted. This check, also presented in Table 6, aimed to determine whether certification concentration has a greater influence on VA for certified animal production in the South regions compared to the North (c.f.

Nordborg et al. 2017; Eckersten et al. 2012). Utilizing the SBA map[13], the South (encompassing both South and Central Sweden) and the North harvest areas were compared. The results indicate a significant and positive influence at the 99% confidence level, with slightly higher values observed in the South (0.8795) compared to the North (0.7645). This finding aligns with the spatial analysis and further supports the robustness of Model 4's results for lnLQ_certanimal.

Table 6. Two-way FE Results for model 4: LHS: 2010-2017, Mid: South, RHS: North.

VALU	**2010-2017** (4) Coef (Std.err)	**South** (4) Coef (Std.err)	**North** (4) Coef (Std.err)
lnLQ_certanimal	0.8980*** (0.1009)	0.8795*** (0.1099)	0.7645*** (0.1250)
lnLQ_Mix	0.0670 (0.1872)	0.1573 (0.2119)	-0.4587 (0.2963)
lnLQ_pasture1	-0.3785 (0.3313)	0.1546 (0.4163)	-0.1048 (0.4167)
lnCapital_all_firm	0.3942* (0.2179)	0.3814** (0.1862)	1.3047** (0.5301)
lnLand_all_firm	0.2093 (0.3776)	-0.1315 (0.3689)	-0.2842 (0.5210)
lnMeat_priceindex	0.0276 (0.1753)	-0.1153 (0.1632)	-0.1738 (0.4381)
lnPop_density	0.1134 (0.0795)	-0.0318 (0.0611)	-0.2268 (0.2583)
lnHHI	-1.7387* (0.9622)	0.2969 (1.3707)	-2.5716** (0.9595)
2011	3.0203 ** (1.4723)	3.0134** (1.2520)	9.1185** (3.5839)
2012	-0.0977* (0.0519)	-0.1342** (0.0587)	-0.1349 (0.0986)
2013	-0.0570 (0.0586)	-0.0719594 (0.0580)	-0.2560** (0.1206)
2014	-0.0271 (0.0640)	-0.0596 (0.0675)	-0.1698 (0.1534)
2015	-0.6637*** (0.0775)	-0.6797*** (0.0695)	-0.7753*** (0.1667)
2016	-0.7404*** (0.0878)	-0.7301*** (0.0851)	-1.0061*** (0.1968)
2017	-0.7741*** (0.0883)	-0.7324*** (0.0856)	-1.2194*** (0.1644)
2018		-0.8685*** (0.0958)	-1.1051*** (0.1860)
2019		2.3034* (1.1882)	8.2672** (3.4374)
2020		2.2269* (1.1829)	8.1283** (3.3932)
Constant	-3.9742 (3.0791)	-0.0657 (2.7160)	-11.9304 (8.0538)
Obs	759	792	227
R-squared	$R^2 = 0.6444$	$R^2 = 0.5975$	$R^2 = 0.6706$
F-test	$F(15,94) = 68.65$	$F(18,71) = 63.13$	$F(18,22) = 136.79$
P-value	$P = 0.0000$	$P = 0.0000$	$P = 0.0000$

*Significance levels: *** 99% (p<0.01), **95% (p<0.05), *90% (p<0.10).*

---

[13] See Figure A2 in the appendix for the SBA map illustrating the Southern and Northern harvest areas.

6. Analysis and Discussion

The results of this study indicate a positive relationship between the clustering of certification schemes and economic performance in certified animal production. These findings contribute to the literature on organic farming (Läpple, 2010; Crowder & Reganold, 2015; Van Der Ploeg et al. 2019; Grovermann et al. 2020), and to the policy discussion on the importance of sustainability certification and their potential to strengthen economic viability in agriculture. Through the analysis, this study examined how the uptake of different certification schemes among animal producers influence the value added (VA) of production using a longitudinal approach. A contribution to the literature is the analysis of heterogeneity in the economic implications of certification concentration within the animal sector. There is still not much empirical evidence on within-industry heterogeneity as most studies tend to study farms in specific sectors (often dairy alone) or in aggregated terms (c.f. Doole & Pannell, 2012; Chang, 2013; Wimmer & Sauer, 2016; Weersink, 2018).

The findings of this study lend support to theories on agglomeration benefits, suggesting that clustering of certified productions enhances economic performance. These results are broadly in line with the evidence presented in Läpple, (2010) and Läpple and Van Rensburg, (2011), and supports the idea that clustering and knowledge diffusion (i.e. matching-sharing-learning mechanisms) can enhance adoption of organic farming practices.

The findings also closely align with Micheels & Nolan, (2016), who argue that the spatial concentration of certified animal production has the potential to foster knowledge spillovers, resource sharing, and adoption of innovation in agriculture—and thereby contribute to increased efficiency and productivity in the sector. The positive effect of certification on VA also resonates with insights from studies such as Van der Ploeg et al. (2019) and Grovermann et al. (2020) demonstrating the profitability of organic and certified production practices. Thus, this finding provides further evidence of the economic advantages of certification in animal production.

The findings regarding model 4 and the observed significance of the coefficient of the certification quotient (*lnLQ_certanimal)* underscore the influence of certification concentration on the VA of certified animal production. This could suggest that there are beneficial spillovers between the different certified (EKO, KRAV, and IPSigill) production practices (Cohen & Levinthal, 1990), emphasizing the systematic effects of sustainable agricultural practices on the economic performance of certified producers. If this is the case, it resonates with Crowder & Reganold, (2015), who emphasize the economic benefits and improved rural livelihoods of adopting sustainable agricultural practices when implemented effectively and under “right” conditions.

The robustness checks for Model 4 validates the initial findings. Excluding 2018-2020 from Model 4 did not diminish the significance of key coefficients, reaffirming robustness. Regional analysis reveals slightly higher certification concentration effects in the South (and Central) compared to the North of Sweden, aligning with previous research on regional disparities (c.f. Nordborg et al. 2017; Eckersten et al. 2012) and the spatial analysis of high concentration of certification schemes in Central Sweden (see Figure 2a-b). These findings stress the importance of considering geographic and climatic factors in assessing certification program efficacy.

The findings of this study are relevant for various stakeholders, including farmers, certification organizations, and policymakers, especially within initiatives such as Sweden’s Sustainable Food Strategy, which advocates for sustainable and organically certified food production methods (Jordbruksverket, 2022). Building on the insights of Fredriksen & Langer (2004), who identified the influence of policy interventions on the geographical distribution of organic farms, this study suggests a strategic approach for policymakers. By incentivizing localized certification efforts and encouraging the clustering of certified productions in specific harvest areas, policymakers can potentially realize economic benefits for certified animal productions while promoting sustainability (Cohen & Levinthal, 1990). Certification organizations could also promote certification clustering in specific regions to encourage producers to adopt certifications. This approach aligns with the findings of Schneider et al. (2012), who also highlighted the potential of geographical certification under suitable conditions.

While this study provides valuable insights, it also has limitations. Efforts to include diverse productions were challenging, leading to a comprehensive list of certified productions being difficult and time-consuming to compile. Consequently, only IPSigill-certified beef under semi-natural pasture grazing from Svenskt Sigill was included, which limited the dataset's scope. Another significant limitation is the difficulty in obtaining accurate entry years for KRAV-certified productions; using entry years for EKO, while often correct, may not accurately reflect KRAV’s entry timeline.

Despite efforts to adhere to TWFE model assumptions, reliance on secondary data sources could introduce biases or measurement errors, significantly impacting the robustness of the findings. The observational nature of the TWFE study prevents drawing causal inferences, hindering the establishment of cause-and-effect relationships between variables (Kuroki & Pearl, 2014). The main reason why the observed correlation does not show causal relationships is probably due to crucial factors being excluded, *omitted variable bias* and *endogeneity*, where an explanatory variable correlates with the error term which create non-causal correlations if unobserved factors influence both certification and VA.

If farm-level data was available, it could have been utilized to address causality by creating a control group with similar uncertified producers and utilizing difference in difference modelling to draw causal inferences. However, due to GDPR I was unable to use micro-data. Acknowledging this limitation is crucial as it affects the overall validity of the study's conclusions.

Additionally, the TWFE method assumes adequate control of all relevant time-varying factors. However, ensuring each pertinent variable is accounted for in practical applications remains challenging, potentially leading to omitted variable bias and skewing results (Stock & Watson, 2019). Therefore, its application requires critical evaluation within these constraints.

While the fixed effects models utilized in this study offer valuable insights into the correlation between certification concentration and economic performance in certified animal production, there are opportunities to tailor the methodology more specifically to the context of this thesis. For instance, exploring the feasibility of instrumental variable (IV) regression analysis, as proposed by Bowden & Turkington (1990), could address potential endogeneity concerns effectively. IV regression uses instrumental variables that are correlated with the endogenous explanatory variable but not with the error term, thus providing unbiased estimates of causal effects under certain conditions. However, Kubitza and Krishna (2020) underscore the importance of carefully selecting IVs. Recognizing the complexity of this task, the TWFE approach was still selected, and the study remained observational. Nonetheless, future research could explore the applicability of IV regression or other causal inference models to further examine the causal relationship between certification concentration and economic outcomes in animal production.

Conclusion

This study provides important insights into how certification schemes influence the economic performance of animal production, contributing valuable knowledge to the ongoing conversation about sustainability certifications and their economic viability. The findings reveal that a high concentration of certified animal productions tends to result in better economic outcomes, supporting the agglomeration hypothesis that clustering benefits economic performance. These results align with previous studies highlighting the profitability of sustainable and organic certification practices.

The relevance of this study’s findings extends from academia to farmers, certification organizations, and policymakers, suggesting that focusing on localized certification efforts in certain regions could enhance economic growth and sustainability in certified animal production. This study is particularly relevant to policy discussions such as Sweden’s sustainable Food Strategy, which promotes sustainable and organic certified food production methods.

However, the study has limitations, including reliance on secondary data, potential measurement errors, and the observational nature preventing causal inference. The scope of the dataset also limits the analysis.

Future research should explore several key areas that remain unanswered in this thesis. One focus should be the relationship between the spatial concentration of animal production and VA along with examining the heterogeneity within the sector and the influence of certification on VA among non-certified producers. Additionally, future studies should aim to encompass all certified IPSigill productions and broaden the scope to include various agricultural sectors such as crops, pigs, hens, and other livestock. Investigating the cause-and-effect relationships and the underlying mechanisms behind the relationship between certification concentration and value added (VA) in animal production, using instrumental variables as well as qualitative and longitudinal approaches, would also be valuable.

References

AgriFood. (2020*). Märkning av livsmedel för ett bättre klimat - vad tycker konsumenten?* Policy Brief Nummer 2020:3 [2024-03-25]

Ahmed, H., Alvåsen, K., Berg, C., Hansson, H., Hultgren, J., Röcklingsberg H., Emanuelsson U. (2020). *Assessing economic consequences of improved animal welfare in Swedish cattle fattening operations using a stochastic partial budgeting approach,* Livestock Science, Vol 232, 103920, ISSN 1871-1413, https://doi.org/10.1016/j.livsci.2020.103920. [2024-02-05]

Ayres, R. U., & Kneese, A. V. (1969). *Production, Consumption, and Externalities.* The American Economic Review. 59(3), 282–297. http://www.jstor.org/stable/1808958 [2024-05-13]

Bolwig, S., Gibbon, P., Jones, S. (2009). *The economics of smallholder organic contract farming in tropical Africa.* World Development, Vol. 37, Is. 6, P. 1094-1104, https://doi.org/10.1016/j.worlddev.2008.09.012 [2024-03-04]

Bowden, R. J., & Turkington, D. A. (1990). *Instrumental variables (No. 8).* Cambridge university press. [2024-06-03]

Carlisle, L., Montenegro de Wit, M., DeLonge, M. S., Iles, A., Calo, A., Getz, C., et al. (2019). *Transitioning to sustainable agriculture requires growing and sustaining an ecologically skilled workforce*. Frontiers in Sustainable Food Systems, 3, 96. https://doi.org/10.3389/fsufs.2019.00096 [2024-04-29]

Cederberg, C., Henriksson M., Berglund M. (2013). *An LCA researcher's wish list – data and emission models needed to improve LCA studies of animal production.* Animal, 7, 212-219, https://doi.org/10.1017/S1751731113000785. [2024-02-16]

Chang, H. H. (2013). *Heterogeneity in development.* In Proceedings. Retrieved from https://api.semanticscholar.org/CorpusID:153835139 [2024-05-24]

Chartzoulakis, K., & Bertaki, M. (2015). *Sustainable Water Management in Agriculture under Climate Change,* Agriculture and Agricultural Science Procedia, 4, 88-98, https://doi.org/10.1016/j.aaspro.2015.03.011. [2024-04-29]

Cohen, W.M., & Levinthal, D.A. (1989). *Innovation and Learning the Two Faces of R & D,* The Economic Journal, 99, 397, 569–596, https://doi.org/10.2307/2233763 [2024-05-13]

Cohen, W. M., & Levinthal, D. A. (1990). *Absorptive capacity: A new perspective on learning and innovation.* Administrative science quarterly, 35(1), 128-152. https://www.jstor.org/stable/2393553 [2024-04-29]

Crowder, D. W., & Reganold, J. P. (2015). *Financial competitiveness of organic agriculture on a global scale.* Proceedings of the National Academy of Sciences of the United States of America, 112, 7611–7616. https://doi.org/10.1073/pnas.1423674112 [2024-03-04]

Debertin, D. (2012). *Agricultural Production Economics*. Second edition, University of Kentucky. [2024-02-13]

Doole, G. J., & Pannell, D. J. (2012). *Empirical evaluation of nonpoint pollution policies under agent heterogeneity: Regulating intensive dairy production in the Waikato Region of New Zealand.* Food Groups eJournal. Retrieved from https://doi.org/10.1111/j.1467-8489.2011.00565.x [2024-05-24]

Eckersten, H., Herrmann, A., Kornher, A., Halling, M. A., Sindhøj, E., & Lewan, E. (2012). *Predicting silage maize yield and quality in Sweden as influenced by climate change and variability.* Acta Agriculturae Scandinavica, Soil & Plant Science, 151-165. https://doi.org/10.1080/09064710.2011.585176 [2024-05-24]

Eliasson, K., & Westerlund, O. (2003). *Regionala tillväxtindikatorer - teoretiska aspekter, begrepp och empiriska illustrationer*. Institutet för tillväxtpolitiska studier. A2003:004 [2024-04-16]

EU Commission. (1998) *Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes,* OJ L 221, 8.8.1998, p. 23–27. Version: 14/12/2019. http://data.europa.eu/eli/dir/1998/58/oj [2024-05-07]

EU Commission. (2018). *Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation*. (EC) No 834/2007 version: 21/02/2023. http://data.europa.eu/eli/reg/2018/848/oj [2024-05-07]

FAO. (2010). The *State of Food and Agriculture: Livestock in the balance.* Report by the Food and Agriculture Organization of the United Nations. FAO, Rome (180pp.). http://www.fao.org/3/a-i0680e.pdf [2024-02-16]

Finley, L. C., Chappell, M. J., Thiers, P., & Moore, J. (2018). *Does organic farming present greater opportunities for employment and community development than conventional farming? A survey-based investigation in California and Washington.* Agroecology and Sustainable Food Systems, 42, 552-572. https://doi.org/10.1080/21683565.2017.1394416 [2024-05-22]

Fredriksen, P., & Langer, V. (2004). *Localisation and concentration of organic farming in the 1990s – the Danish Case.* Department of Policy Analysis, National Environmental Research Institute Denmark. https://doi.org/10.1111/j.0040-747X.2004.00338.x [2024-04-02]

Garber, B., Alwang, J., Norton, G.W., Bovay, J. (2022). *Beef and the Bottom Line: The Effect of Value-Added Certification on Feeder Cattle Profitability,* Journal of Agricultural and Applied Economics. doi:10.1017/aae.2021.33. [2024-04-30]

Garnett, T. (2008). *Cooking up a storm. Food, greenhouse gas emissions and our changing climate.* Food Climate Research Network. Centre for Environmental Strategy, University of Surrey, UK. 155 pp. http://www.unscn.org/layout/modules/resources/files/Cooking_up_a_Storm.pdf [2024-02-16]

Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., et al. (2013). *Tackling climate change through livestock A global assessment of emissions and* *mitigation opportunities.* Food and Agriculture Organization of the UN (FAO), Rome. http://www.fao.org/docrep/018/i3437e/i3437e.pdf [2024-02-09]

Getis, A., & Ord, J. K. (1992). *The analysis of spatial association by use of distance statistics.* Geographical Analysis, 24(3), 189-206. https://doi.org/10.1111/j.1538-4632.1992.tb00261.x [2024-05-31]

Grovermann, C., Quiédeville, S., Muller, A., Leiber, F., Stolze, M., Moakes, S. (2020). *Does organic certification make economic sense for dairy farmers in Europe? – A latent class counterfactual analysis.* Agricultural Economics. 2021; 52:1001–1012. https://doi.org/10.1111/agec.12662 [2024-03-04]

Grusson, Y., Wesström, I., & Joel, A. (2021). *Impact of climate change on Swedish agriculture: Growing season rain deficit and irrigation need.* Agricultural Water Management, 251. https://doi.org/10.1016/j.agwat.2021.106858 [2024-05-23]

Gutierrez, L., (2002). *Why is agricultural labour productivity higher in some countries than others?* Agri. Econ. https://doi.org/10.22004/AG. ECON.26431. [2024-05-23]

Hausman, J.A., & Taylor W.E. (1981). *A generalized specification test.* Econ Letters. 8(3) 239-245 https://doi.org/10.1016/0165-1765(81)90073-2 [2024-03-17]

Herrero, M., & Thornton, P. (2013). *Livestock and global change: Emerging issues for global food systems.* PNAS, 110 (52) 20878–20881 https://doi.org/10.1073/pnas.132184411 [2024-02-26]

Hessle, A., Bertilsson J., Stenberg, B., Kumm, K-I., Sonesson, U. (2017). *Combining environmentally and economically sustainable dairy and beef production in Sweden,* Agricultural Systems, Volume 156, 2017, Pages 105-114,ISSN 0308-521X, https://doi.org/10.1016/j.agsy.2017.06.004. [2024-02-06]

Hessle, A., & Kumm, K-I. (2011). *Use of beef steers for profitable management of biologically valuable semi-natural pastures in Sweden.* Journal for Nature Conservation, Volume 19, Issue 3, 131-136, https://doi.org/10.1016/j.jnc.2010.10.002. [2024-02-05]

Hocquette, J., Ellies-Oury, M., Lherm, M., Pineau, C., Deblitz, C., Farmer, L. (2018). *Current situation and future prospects for beef production in Europe — A review,* Asian-Australas J Anim Sci. 31(7):1017-1035. doi: 10.5713/ajas.18.0196. [2024-02-09]

Holzer, Q.B. (1998). *Beef quality assurance and perceptions of a feeder calf certification for Montana producers.* Agricultural Education Montana State University. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=0fd4ed3ae08746273b6ee6092db178958ad0f2d2 [2024-05-02]

Ibanez, M., & Blackman, A. (2016). *Is eco-certification a win–win for developing country agriculture? Organic coffee certification in Colombia.* World Development, Volume 82, Pages 14-27, ISSN 0305-750X, https://doi.org/10.1016/j.worlddev.2016.01.004. [2024-03-04]

Ilic, M. (2010). *Economic value added as a modern performance indicator.* Journal: Perspectives of Innovation in Economics and Business. Volume 6, pp: 94-97. https://doi.org/10.15208/PIEB.2010.90 [2024-05-07]

Johansson, H. (2009). *Vad uppnås med rättvisemärkning?* RAPPORT 2009:1, AgriFood Economics Centre [2024-03-25]

Jordbruksverket 2. (2022). *Normskördar 2022.* https://jordbruksverket.se/om-jordbruksverket/jordbruksverkets-officiella-statistik/jordbruksverkets-statistikrapporter/statistik/2022-06-10-normskordar-2022#h-Kartor [2022-05-20]

Jordbruksverket. (2022). *Livsmedelsstrategi för Sverige.* https://jordbruksverket.se/mat-och-drycker/livsmedelsstrategi-for-sverige [2024-02-05]

Jordbruksverket rapport. (2023). *Uppföljning och utvärdering av livsmedelsstrategin – Årsrapport 2023.* Rapport 2023:6, Jordbruksverket. https://webbutiken.jordbruksverket.se/sv/artiklar/ra243.html [2024-02-05]

Jordbruksverket. (2023). *Om ekologisk produktion.* https://jordbruksverket.se/jordbruket-miljon-och-klimatet/ekologisk-produktion [2024-02-29]

Jordbruksverket. (2024). *Det här är SAM ansökan.* https://jordbruksverket.se/stod/jordbruk-tradgard-och-rennaring/sam-ansokan-och-allmant-om-jordbrukarstoden/det-har-ar-sam-ansokan [2024-04-11]

Krav. (2024). *Lättläst.* https://www.krav.se/lattlast/ [2024-02-29]

Kubitza, C., & Krishna, V. V. (2020*). Instrumental variables and the claim of causality: Evidence from impact studies in maize systems.* Global Food Security, 26, 100383. https://doi.org/10.1016/j.gfs.2020.100383 [2024-06-03]

Kumm K.-I. (2005). *Economically sustainable preservation of grazing dependent biodiversity in Sweden with Canadian ranching systems.* Department of Animal Environment and Health, Skara: SLU. Sweden. Outlook on Agriculture 34(4):255-260 https://doi.org/10.5367/000000005775454742 [2024-02-07]

Kumm, K.-I. (2007). *Lönsam betesdrift genom stora sammanhängande marker.* Department of Animal Environment and Health, Skara: SLU. Sweden. ISSN 1652-2885 https://www.slu.se/globalassets/ew/org/inst/hmh/hmh-pdf/rapport_16.pdf [2024-03-25]

Kuroki, M., & Pearl, J. (2014). Measurement bias and effect restoration in causal inference. Journal: Biometrika. Vol: 101 pp: 423–437 DOI:10.1093/BIOMET/AST066 [2024-05-03]

Lewis, D., Barham, B., Zimmer, K. (2008). *Spatial Externalities in Agriculture: Empirical Analysis, Statistical Identification, and Policy Implications,* World Development, https://doi.org/10.1016/j.worlddev.2007.10.017. [2024-04-24]

Lin, B., & Zhang, Y. Y. (2020). *Impact of the COVID-19 pandemic on agricultural exports.* Journal of Integrative Agriculture. Available: https://doi.org/10.1016/S2095-3119(20)63430-X [2024-05-23]

Lu, R., & Dudensing, R. (2015). *What do we mean by value-added agriculture?* Choices, 30(4), 1-8. English, Journal article. The Magazine of Food, Farm, and Resources Issues, American Agricultural Economics Association, http://www.jstor.org/stable/choices.30.4.05 [2024-04-29]

Läpple, D. (2010). *Adoption and abandonment of organic farming: an empirical investigation of the Irish drystock sector.* Journal of agricultural Economics, 61(3), 697-714. https://doi.org/10.1111/j.1477-9552.2010.00260.x [2024-05-13]

Läpple, D., & Van Rensburg, T. (2011*). Adoption of organic farming: Are there differences between early and late adoption?.* Ecological economics, 70(7), 1406–1414. https://doi.org/10.1016/j.ecolecon.2011.03.002. [2024-05-13]

Manevska, G., & Malmström, N. (2022). *Mot en miljövänlig växtodling - hur påverkas gårdens ekonomi?* Policy Brief 2022:4 AgriFood Econ Centre [2024-03-25]

Marian, L., & Thøgersen, J. (2015). *Adding more value to added-value. An exploration of consumers' perceptions and attitudes towards improved animal welfare standards in organic meat production processes.* Agricultural and Food Sciences, Aarhus University, Denmark. https://pure.au.dk/portal/en/publications/adding-more-value-to-added-value-an-exploration-of-consumers-perc-2 [2024-04-29]

Meemken, E., & Qaim, M. (2018). *Can private food standards promote gender equality in the small farm sector?* Journal of Rural Studies, Vol 58, Pages 39-51, https://doi.org/10.1016/j.jrurstud.2017.12.030. [2024-03-04]

Mendoza, T. C. (2004*). Evaluating the benefits of organic farming in rice agroecosystems in the Philippines.* Journal of Sustainable Agriculture, 24, 93–115. http://dx.doi.org/10.1300/J064v24n02_09 [2024-03-04]

Micheels, E.T., & Nolan, J.F. (2016). *Examining the effects of absorptive capacity and social capital on the adoption of agricultural innovations: A Canadian Prairie case study,* Agricultural Systems, Volume 145, Pages 127-138, ISSN 0308-521X, https://doi.org/10.1016/j.agsy.2016.03.010. [2024-05-13]

Mockshell, J., & Villarino, E. J. (2019). *Agroecological intensification: Potential and limitations to achieving food security and sustainability.* In Encyclopedia of Food Security and Sustainability (pp. 64–70). Amsterdam, Netherlands: Elsevier. https://doi.org/10.1016/b978-0-08-100596-5.22211-7 [2024-03-04]

Morgensen, L., Kristensen, T., Nguyen. T., Knudsen, M., Hermansen, J. (2014). *Carbon footprint of cattle feeds – a method to include contribution from soil carbon changes and use of cattle manure*. Journal of Cleaner Production, Vol 73, pp 40-51, https://doi.org/10.1016/j.jclepro.2014.02.023. [2024-02-16]

Morgensen, L., Kristensen T., Nielsen N.I., Spleth, B., Spleth P., Henriksson M., et al. (2015). *Greenhouse gas emissions from beef production systems in Denmark and Sweden.* Livestock Science 174, 126–143. https://doi.org/10.1016/j.livsci.2015.01.021. Elsevier B.V. [2024-02-16]

Morison, J. I. L., Hine, R., & Pretty, J. (2005). *Survey and Analysis of Labour on Organic Farms in the UK and Republic of Ireland.* Intern. Journal of Agri. Sustainability, 3, 24-43. https://doi.org/10.1080/14735903.2005.9684742 [2024-05-22]

Nguyen, T., Hermansen, J.E., Morgensen, L. (2010). *Environmental con- sequences of different beef production systems in the EU*. Journal of Cleaner Production, Vol. 18, is. 8, p 756-766, https://doi.org/10.1016/j.jclepro.2009.12.023. [2024-02-16]

Nilsson, P., Bommarco, R., Hansson, H., Kuns, B., Schaak, H. (2022). *Farm performance and input self-sufficiency increases with functional crop diversity on Swedish farms,* Ecological Economics, Vol 198, https://doi.org/10.1016/j.ecolecon.2022.107465. [2024-04-29]

Nordborg, M., Sasu-Boakye, Y., Cederberg, C., & Berndes, G. (2017). *Challenges in developing regionalized characterization factors in land use impact assessment:*

Impacts on ecosystem services in case studies of animal protein production in Sweden. The International Journal of Life Cycle Assessment, 22(3), 328-345. https://doi.org/10.1007/s11367-016-1158-x [2024-05-24]

North, D.C. (1955). *Location theory and regional economic growth.* Journal of political economy, 63(3), 243-258. https://doi.org/10.1086/257668 [2024-05-13]

Petrick, M., Kloss, M. (2018). *Identifying agricultural factor productivity from micro-data: a review of approaches with an application to EU countries.* German J. Agricult. Econ. 67, 67–79. 10.22004/ag.econ.309975 [2024-05-23]

Ravaglia, P., Famiglietti, J., Valentino, F. (2018). *Chapter Three - Certification and Added Value for Farm Productions, Advances in Chemical Pollution,* Environmental Management and Protection, Elsevier, Volume 2, 63-108, https://doi.org/10.1016/bs.apmp.2018.03.003. [2024-04-29]

Reganold, J.P., & Wachter, J.M. (2016). *Organic agriculture in the twenty-first century.* 2055–0278 https://doi.org/10.1038/nplants.2015.221 [2024-04-29]

Regeringen. (2017). *En Livsmedelsstrategi för Sverige – fler jobb och hållbar tillväxt i hela landet.* Regeringens proposition 2016/17:104. Stockholm. [2024-03-08]

Rende, S. (2019). *What can be learnt from the 2018 drought and how to adapt Swedish agriculture to a changing climate.* https://stud.epsilon.slu.se/14966/ [2024-05-23]

Sapbamrer, R., & Thammachai, A. (2021). *A systematic review of factors influencing farmers' adoption of organic farming.* Sustainability. Advance online publication. https://doi.org/10.3390/SU13073842 [2024-06-26]

Schneider, S., Siegmund-Schultze, M., Holanda Júnior, E. V., Alves, F. S. F., Valle Zárate, A. (2012). *Is a geographical certification a promising production and commercialization strategy for smallholder sheep farming in Ceará, Brazil?* Journal of Agriculture, Food Systems, and Community Development, 2(2),107–127. http://dx.doi.org/10.5304/jafscd.2012.022.013 [2024-05-02]

Schreibermachers, P., Schad, I., Tipraqsa, P., Williams, P.M., Neef, A., Riwthong, S., et al. (2012). *Can public GAP standards reduce agricultural pesticide use? The case of fruit and vegetable arming in northern Thailand.* Agriculture and Human Values, *29,* 519–529. https://doi.org/10.1007/s10460-012-9378-6 [2024-03-04]

Sigill. (2023). *Tillval naturbeteskött.* https://www.sigill.se/omraden-och-regler/not-och-mjolk/tillval-naturbeteskott/ [2024-02-08]

Ssebunya, B., Morawetz, U., Schader, C., Stolze, M., Schmid, E. (2019). *Group membership and certification effects on incomes of coffee farmers in Uganda.* European Review of Agri. Economics. DOI:10.1093/erae/jby022 [2024-03-04]

Stock, J. H., & Watson, M. W. (2008). *Heteroskedasticity-Robust Standard Errors for Fixed Effects Panel Data Regression.* Econometrica, 76(1), 155-174. https://www.jstor.org/stable/4502057 [2024-05-08]

Stock J.H., & Watson M. W. (2019). *Introduction to Econometrics.* Edition 4. James H. Stock, Harvard University, Mark W. Watson, Princeton University. [2024-02-16]

Tamburini, G., Bommarco, R., Wanger, T. C., Kremen, C., Van Der Heijden, M. G., Liebman, M., et al. (2020). *Agricultural diversification promotes multiple ecosystem services without compromising yield.* Science advances, 6(45), DOI: 10.1126/sciadv.aba17 [2024-04-29]

Thompson, B., Leduc, G., Manevska-Tasevska, G., Toma, L., Hansson, H. (2024). *Farmers' adoption of ecological practices: A systematic literature map.* Journal of Agri Econ, 75, 84-107. https://doi.org/10.1111/1477-9552.12545 [2024-04-29]

Tran, D., & Goto, D. (2019). *Impacts of sustainability certification on farm income: Evidence from small-scale specialty green tea farmers in Vietnam.* Food Policy, Elsevier, 83,70-82. https://doi.org/10.1016/j.foodpol.2018.11.006 [2024-03-04]

Tunón, H., & Sandell, K. (2021*). Biologisk mångfald, naturnyttor, ekosystemtjänster. Svenska perspektiv på livsviktiga framtidsfrågor.* CBM:s skriftserie 121, SLU Centrum för biologisk mångfald, Uppsala & Naturvårdsverket, Stockholm. urn:nbn:se:kau:diva-86401 [2024-02-05]

Uğur, A., & Buruklar, T. (2021). *Effects of Covid-19 pandemic on agri-food production and farmers.* Food Sci. Technol. https://doi.org/10.1590/fst.19821 [2024-05-23]

UNDP. (2023). *Om globala målen.* https://www.globalamalen.se/om-globala-malen/ [2024-02-05]

Van der Ploeg, J. D., Barjolle, D., Bruil, J., Brunori G., Madureira, L.M.C., Dessein, J., Drag, Z., et al. (2019). *The economic potential of agroecology: Empirical evidence from Europe.* Journal of Rural Studies, Vol 71, 46-61, https://doi.org/10.1016/j.jrurstud.2019.09.003. [2024-03-04]

Vellinga, T.V., Blonk, H., Marinussen Zeist, W.J.V., Boer, I.J.M., Starmans, D. (2013). *Methodology Used in Feed Print: A Tool Quantifying Green- house Gas Emissions of Feed Production and Utilization.* Report No 674. Wageningen UP Livestock Research. 108pp. https://edepot.wur.nl/254098 [2024-02-16]

Weersink, A. (2018). *The growing heterogeneity in the farm sector and its implications.* Canadian Journal of Agricultural Economics/Revue Canadienne D'Agroeconomie, 66(1), 27-41. https://doi.org/10.1111/cjag.12163 [2024-05-24]

Willer, H., & Lernoud, J. (2019). *The World of Organic Agriculture. Statistics and emerging trends.* Switzerland Research Inst. of Organic Agriculture. Germany – Organics International. https://orgprints.org/id/eprint/33355/ [2024-03-04]

Williams, A., Börjesson, G., Hedlund, K. (2013). *The effects of 55 years of different inorganic fertiliser regimes on soil properties and microbial community composition.* Soil Biology and Biochemistry, 67, 41–46. https://doi.org/10.1016/j.soilbio.2013.08.008 [2024-04-29]

Wimmer, S., & Sauer, J. (2016). *Diversification versus specialization: Empirical evidence on the optimal structure of European dairy farms.* Doi: 10.22004/ag.econ.244882 [2024-05-24]

Zhang, J., Van der Heijden, M., Zhang, F., Bender, F. (2020). *Soil biodiversity and crop diversification are vital components of healthy soils and agricultural sustainability.* Frontiers of Agricultural Science and Engineering, 7(3):236. https://doi.org/10.15302/j-fase-2020336 [2024-04-29]

Zhang, M., Fortney, J.C., Tilford, J.M. (2000). *An Application of the Inverse Hyperbolic Sine Transformation - A Note.* Health Services & Outcomes Research Method 1, 165–171. https://doi.org/10.1023/A:1012593022758 [2024-05-08]

Popular science summary

In a world grappling with food security and environmental challenges, the necessity for sustainable agricultural practices has never been more crucial. Sustainable agriculture is not only possible but essential, offering benefits to the environment as well as economic and social aspects.

This study explored sustainable farming to understand the economic implications of certification clusters. While organic farming has long been examined for its financial benefits, this research extends beyond the organic label to uncover the economic potential of other certification schemes: EKO, KRAV, and IPSigill within a Swedish context. Utilizing a combination of primary and secondary data, I investigated the economic viability of certification clustering among Swedish harvest areas from 2010 to 2020. The focus was on the regional (harvest area) concentration of certified animal production and its influence on economic performance.

The findings revealed a positive correlation between certification clustering and economic viability in certified animal productions. Areas with a higher concentration of certified animal productions experienced notable economic growth, showcasing the transformative potential of sustainability certifications.

What does this mean for farmers, certification organizations, and policymakers?

It offers a guide for decision-making towards economic viability and environmental sustainability. By focusing on localized certification efforts and harnessing the power of clustering, we can pave the way for a more sustainable and profitable future for animal producers.

This study provides valuable insights into the transformative potential of sustainable farming practices and unlocks economic opportunities within the industry. Together, we can build a more prosperous, resilient, and sustainable agricultural future for generations to come.

Acknowledgements

The completion of this thesis wouldn’t have been possible without the support I received from multiple individuals. Thus, I want to express my deepest gratitude to them. Their guidance, encouragement, and assistance have been immensely valuable in shaping both the academic quality of my work and my personal development.

Firstly, I am deeply thankful to my supervisor, Pia Nilsson. Her mentorship has been vital in shaping the direction and quality of this research. Pia has an impressive ability to brainstorm and produce incredibly valuable ideas. She has encouraged me to step outside of my comfort zone and realize my potential, which has been invaluable for me. I am incredibly grateful to have had the privilege to have her as my supervisor. Pia, thank you for your support, expertise, and dedication to my academic growth.

I am also indebted to Julia Marcopoulos, Product Owner at “Sigill Kvalitetssystem AB’, for her help with questions regarding certification schemes and farmer memberships. Thank you for providing valuable insights about IPSigill. Furthermore, Anna Jamiesson, Executive Director of “Naturbeteskött i Sverige” and Vice Chairman of “Sveriges Nötköttsproducenter”, thank you for your expertise in semi-natural pasture questions and many suggestions regarding earlier research and reviewing my thesis to identify areas for improvement.

A special acknowledgment goes to Ella-li Jennersjö, my dear friend and mentor, who has consistently provided guidance, motivation, and inspiration. Our weekly meetings and her ongoing support have been invaluable throughout this journey. Last but not least, I want to extend warm thanks to my friends and family who have supported me not only during my master thesis but also throughout my university studies. Their support has carried me through difficult times, and without them, I wouldn't be the person I am today.

Thank you all for your consistent support.

Uppsala, June 2024
Lina Wendel Örtqvist

Appendix

Table A1. Correlation Matrix LQ for Dairy, Beef & Mix productions

	arcsinhVALU_animal_all	lnLQ_dairybeef	lnLQ_mix
arcsinhVALU_animal_all	1.0000		
lnLQ_dairybeef	0.7726	1.0000	
lnLQ_mix	-0.0352	0.1871	1.0000

Table A2. Correlation Matrix LQ for Animal Certifications and EKO Crops

	lnLQ_certanimal	lnLQ_ekocrops
lnLQ_certanimal	1.0000	
lnLQ_ekocrops	0.6143	1.0000

Table A3. Correlation Matrix Economic Indicators

	VA	NM	RE	OM	VA/LU
VA	1.0000				
NM	0.9085	1.0000			
RE	0.7937	0.8542	1.0000		
OM	0.9167	0.9395	0.7973	1.0000	
VA/LU	0.9333	0.9460	0.8157	0.9787	1.0000

Value Added, Net Margin, Return on Equity, Operation Margin, Value Added per Labor Unit.

Table A4. Hausman testing the fit of Fixed Effects and Random Effects models.

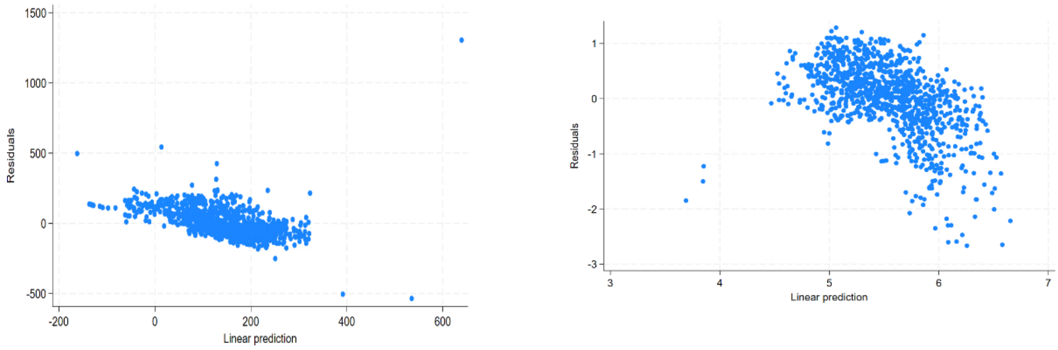
	Coef. (b) FE model	Coef. (B) RE model	(b-B) difference	$\sqrt{\left(diag(V_b - V_B)\right)}$ std- err.
lnLQ_certanimal	0.0535	0.1006	-0.0471	0.0078
lnLQ_mix	-0.1235	-0.1810	0.0574	0.0219
lnCapital_all_firm	0.2053	0.2784	-0.0731	0.0181
lnLand_all_firm	0.4942	0.0466	0.4477	0.0753
lnLQ_pasture1	0.2284	0.1224	-0.3508	0.0689
lnMeat	0.0462	0.0345	0.0117	0.0082
lnPop_dens_ratio	-0.0328	0.0080	-0.0408	0.0286
lnHHI	-0.2130	-0.3921	0.1791	0.1992
2011	1.6686	2.2505	-0.5819	0.1199
2012	-0.1022	-0.1225	0.0203	0.0030
2013	-0.0865	-0.1214	0.0348	0.0050
2014	-0.0540	-0.1008	0.0468	0.0062
2015	-0.2768	-0.3100	0.0333	0.0053
2016	-0.2320	-0.2683	0.0363	0.0057
2017	-0.1991	-0.2335	0.0345	0.0059
2018	-0.2604	-0.2964	0.0358	0.0069
2019	1.4407	2.0116	-0.5709	0.1141
2020	1.3540	1.9186	-0.5646	0.1128

The Hausman test[14] results. The rejection of the null hypothesis in favor of the systematic difference in coefficient suggests that the FE model provides a better fit for the data.

---

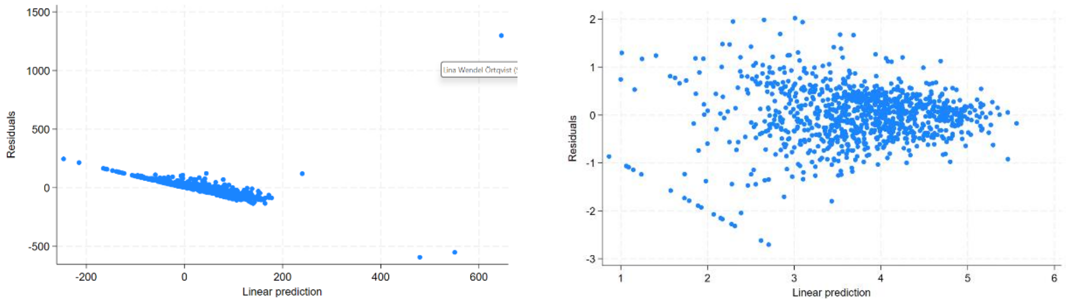
[14] The results of the test show that b is consistent under H_0 and H_a. B is inconsistent under H_a and efficient under H_0. The test of H_0 shows that the difference in coefficients is not systematic.
$chi^2(11) = 131.53 \; Prob > chi^2 = 0.0000$

Figure A1. Residual plots LHS: original values, RHS: transformed values.



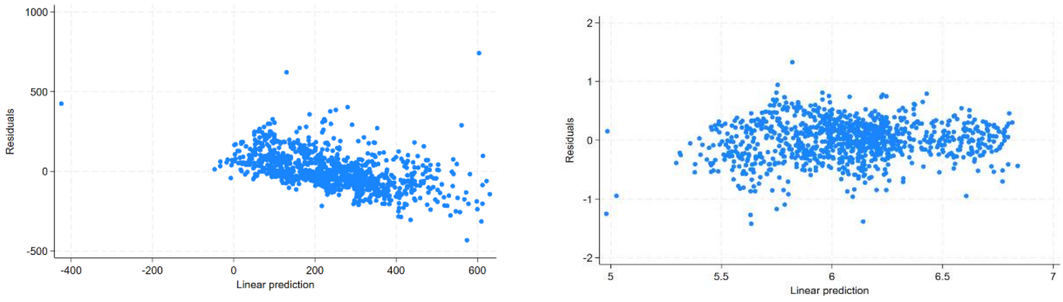
1.1 Original

1.1 Logged + arcsinh



2.1 Original

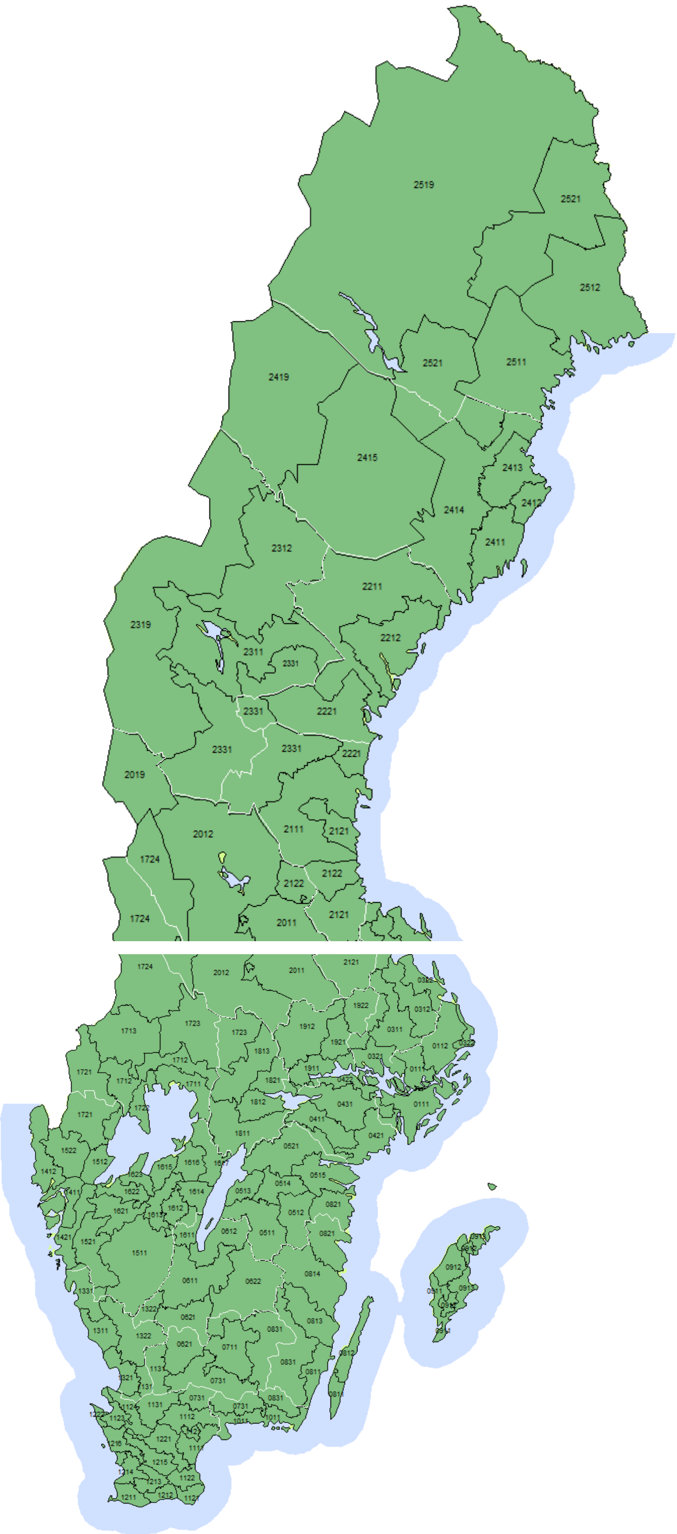
2.1 Logged + arcsinh



2.2 Original

2.2 Logged + arcsinh

Figure A2. Map over Sweden's Northern and Southern Harvest Areas



The illustration of Northern and Southern harvest regions, along with their respective codes, is referenced and endorsed for inclusion in this thesis by the Swedish Board of Agriculture (Jordbruksverket 2, 2022).

Publishing and archiving

Approved students' theses at SLU are published electronically. As a student, you have the copyright to your own work and need to approve the electronic publishing. If you check the box for **YES**, the full text (pdf file) and metadata will be visible and searchable online. If you check the box for **NO**, only the metadata and the abstract will be visible and searchable online. Nevertheless, when the document is uploaded it will still be archived as a digital file. If you are more than one author, the checked box will be applied to all authors. You will find a link to SLU's publishing agreement here:

- https://libanswers.slu.se/en/faq/228318.

☒ YES, I/we hereby give permission to publish the present thesis in accordance with the SLU agreement regarding the transfer of the right to publish a work.

☐ NO, I/we do not give permission to publish the present work. The work will still be archived, and its metadata and abstract will be visible and searchable.