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The Influence of the EU Common Agricultural Policy on Agricultural Land Prices

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Abstract

It has been recognized since at least the 1960s that government support programs may influence not only output markets for agricultural commodities but also agricultural factor markets. The most important question in this regard is to what extent government support programs positively influence agricultural land sales and rental prices. Because, if agricultural support capitalizes into land prices to some extent, this will cause the transmission of a (substantial) share of this support to landlords and initial landowners as windfall profits and questions the effects and efficiency of agricultural support measures. The importance of this question is enhanced by high shares of rented agricultural land among total agricultural land in Germany and many other European Union (EU) Member States. Against this background, the aim of this study is to analyze the influence of various agricultural policy instruments applied in the Common Agricultural Policy (CAP) framework of the EU on agricultural land sales and rental prices.

For this purpose, we first perform a meta-regression analysis based on 242 observations from 26 articles on the capitalization of various government support measures in various developed countries into agricultural land sales prices. We then apply spatial econometric methods to more than 7,300 agricultural land sales transactions in 2001 and 2007 in Bavaria to identify the determinants that influence agricultural land sales prices. To investigate the impact of CAP payments on agricultural land rental prices and land allocation on a theoretical basis, we implement a price support policy as well as coupled and decoupled direct payments in a Ricardian land rent model. We then test our theoretical results regarding the influence of decoupled direct payments (historical model) on land rental prices empirically on a dataset of bookkeeping records from more than 3,000 Bavarian farms. Here, we are particularly interested in whether the capitalization of CAP payments into land rental prices differs with respect to the natural conditions (in particular land quality) for farming.

The results obtained from the meta-regression analysis indicate that a 10% decrease in agricultural support will decrease land sales prices somewhere between 3.3% and 5%. By comparison, our empirical results for land sales transactions in Bavaria are slightly lower at 2.7% in 2007 and 0.6% in 2001. In particular, evaluated at mean values and all other characteristics being equal, a reduction in direct payments of 50 €/ha will cause the land sales price to drop by 849 €/ha in 2007 and 280 €/ha in 2001. These results indicate that capitalization in agricultural land prices increased rather than decreased in the course of the Fischler Reform in 2003. Moreover, we find a strong influence of land productivity, urban pressure and land market structure on land sales prices.

Analyzing the bookkeeping records reveals that land rental prices increase at 32 cents per additional euro of decoupled direct payments. This number is at 43 cents per euro in regions with comparably favorable natural conditions, and at 22 cents per euro in areas with less favorable natural conditions. Moreover, we also find considerable capitalization effects of payments for disadvantaged areas, which are 38 cents per euro on average. Agri-environmental payments do not greatly capitalize into land rental prices.

The results of our research help provide a better understanding of the implications of policy instruments, in particular their distributional effects.

Zusammenfassung

Es ist mindestens seit den 1960er Jahren anerkannt, dass Agrarausgleichszahlungen nicht nur die Märkte für landwirtschaftliche Produkte, sondern auch die landwirtschaftlichen Faktormärkte beeinflussen. In diesem Zusammenhang ist die wichtigste Frage, inwieweit die Agrarausgleichszahlungen die Bodenkauf – und Bodenpachtpreise beeinflussen. Ist es nämlich zumindest zu einem gewissen Ausmaß der Fall, dass sich Agrarausgleichszahlungen in den Bodenpreisen kapitalisieren, dann würde damit ein (beträchtlicher) Teil dieser Zahlungen als Marktlagengewinn (windfall profit) den Verpächtern von Agrarland zufallen und das stellt die Effekte und die Effizienz von Agrarausgleichszahlungen infrage. Dies hat eine besondere Bedeutung, weil ein hoher Anteil der gesamten Agrarfläche in Deutschland und in vielen anderen Mitgliedsstaaten der Europäischen Union (EU) von Pächtern und nicht von den eigentlichen Landeigentümern bewirtschaftet wird. Vor diesem Hintergrund ist das Ziel der vorliegenden Arbeit, den Einfluss der verschiedenen, im Rahmen der Gemeinsamen Agrarpolitik (GAP) der EU angewandten agrarpolitischen Instrumente auf die Bodenkauf – und Bodenpachtpreise zu analysieren.

Zu diesem Zweck führen wir in einem ersten Schritt eine Meta-Regressionsanalyse basierend auf 242 Beobachtungen aus 26 Artikeln zum Thema der Kapitalisierung von Agrarausgleichszahlungen in den Bodenkaufpreisen durch. Dann analysieren wir mithilfe räumlich-ökonometrischer Methoden mehr als 7,300 Transaktionen von Agrarland aus den Jahren 2001 und 2007 um die Determinanten landwirtschaftlicher Bodenkaufpreise in Bayern zu identifizieren. Zur Untersuchung der Auswirkungen von GAP-Zahlungen auf die Bodenpachtpreise und die Landallokation auf einer theoretischen Basis, implementieren wir eine Preisstützungsmaßnahme sowie gekoppelte und ungekoppelte Direktzahlungen in ein Landrentenmodell nach Ricardo. Die bezüglich der Kapitalisierung von entkoppelten Direktzahlungen (historisches Modell) in den Bodenpachtpreisen gewonnenen theoretischen Ergebnisse überprüfen wir danach empirisch anhand von Buchführungsabschlüssen von mehr als 3,000 bayerischen landwirtschaftlichen Betrieben. Von besonderem Interesse ist dabei, ob sich EU Agrarausgleichszahlungen in Abhängigkeit von den natürlichen Produktionsbedingungen (in erster Linie die Landqualität) unterschiedlich in den Bodenpachtpreisen kapitalisieren.

Den Resultaten der Meta-Regressionsanalyse zufolge führt eine Senkung der staatlichen Agrarausgleichszahlungen um 10% zu einer Reduktion der Bodenkaufpreise um etwa 3.3% bis 5%. Dazu im Vergleich liegen unsere empirischen Ergebnisse mit 2.7% in 2007 und 0.6% in 2001 etwas darunter. Ausgehend vom Mittelwert und unter sonst gleichen Bedingungen bedeuten diese Ergebnisse, dass eine Reduktion der Direktzahlungen um 50 €/ha eine Senkung der Bodenkaufpreise um 849 €/ha in 2007 und 280 €/ha in 2001 zur Folge hätte. Diese Resultate lassen vermuten, dass die Kapitalisierung in den Bodenkaufpreisen durch die Fischler Reform im Jahr 2003 erhöht anstatt verringert wurde. Des Weiteren zeigen unsere Ergebnisse, dass die Bodenqualität, der urbane Siedlungsdruck und die Struktur des Marktes für Agrarland einen signifikanten Einfluss auf die Bodenkaufpreise haben.

Die Analyse der Buchführungsdaten zeigt, dass die Bodenpachtpreise mit jedem Euro mehr an entkoppelten Direktzahlungen um 32 Cent zunehmen. Dieser Wert ist mit 43 Cent pro Euro in Regionen mit günstigen natürlichen Voraussetzungen für die landwirtschaftliche Produktion höher, und in Regionen mit weniger günstigen natürlichen Produktionsvoraussetzungen mit 22 Cent pro Euro deutlich niedriger. Des Weiteren finden wir mit 38 Cent pro Euro beträchtliche Kapitalisierungseffekte für Zahlungen im Rahmen der Förderung benachteiligter Gebiete. Zahlungen im Rahmen von Agrarumweltprogrammen kapitalisieren sich im Gegensatz dazu nur in einem sehr geringen Ausmaß.

Die Resultate unserer Forschungsarbeiten tragen dazu bei die Auswirkungen der Politikinstrumente, speziell deren Verteilungseffekte, besser zu verstehen.

1 Introduction

1.1 Background and Objectives

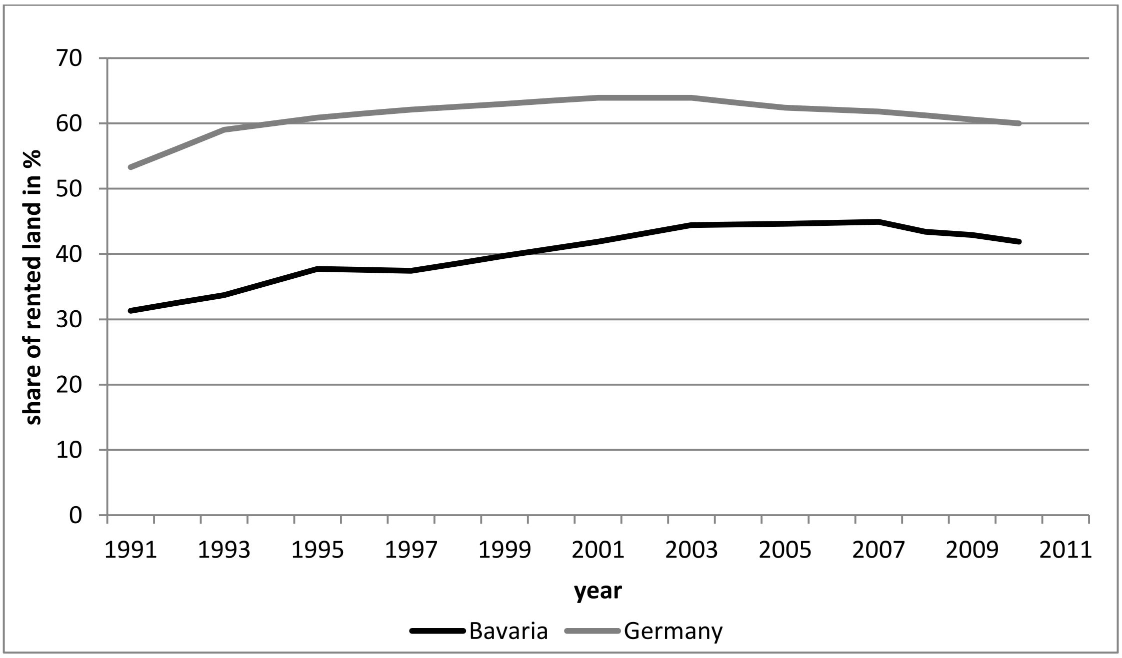
The question of what determines agricultural land prices has occupied economists since the beginning of classical economics (Smith, 1776; Ricardo, 1817; Von Thünen, 1842). Focusing on the United States (US), research on agricultural land prices continued to be carried out in the first half of the 20th century (e.g., Lloyd, 1920; Scofield, 1957). Some of these early studies provided empirical evidence (e.g., Haas, 1922; Ezekiel, 1926; Wallace, 1926 and George, 1941). For example, authors such as Stauber (1937) tried to determine the extent to which changes in expected future land rents and other side speculative issues were responsible for the increases in agricultural land sales prices in the first decades of the 20th century. Others at that time investigated the influence of inflation rates on agricultural land sales prices (e.g., Bean 1938, 1939). Empirical analysis of these issues strongly increased in the 1960s (e.g., Hedrick, 1962; Herdt and Cochrane, 1966; Tweeten and Martin, 1966) and has continued to do so since (e.g., Alston, 1986; Weersink et al., 1999; Salois et al., 2011).

From an economic perspective, land as an input factor in agricultural production is of particular importance due to its rather specific characteristics. The most important characteristic is its limited supply. Additionally, land is heterogeneous in its quality, is distributed in space and is immobile. In the day-to-day farming business, land is particularly important because many government support programs (e.g., area payments, disadvantaged area payments, agri-environmental payments) and many regulations (e.g., maximum livestock numbers) are on a per-hectare basis and thus tied to land. Moreover, the fixed asset land can serve as a loan security for farm investments.

It has been recognized by agricultural economists since at least the 1960s that government support programs may influence not only output markets but also factor markets. Although Floyd (1965) theoretically analyzes the effect of price supports on the returns to land (and labor), others such as Hedrick (1962) and Seagraves (1969) provide the first empirical contributions. For example, the latter investigates the influence of tobacco allotments on agricultural land sales prices. The main question in this regard is to what extent government support programs positively influence agricultural land values. In other words, to what extent do government support programs capitalize into agricultural land values. A high degree of capitalization leads to a (substantial) transmission of support to landlords and initial landowners and has severe consequences on the distributional effects of these support programs. For example, if a farm operator decides to leave the sector and sell his land, he would gain windfall profits from increased land prices.

The importance of this question is reinforced if one considers agricultural land rental markets and an eventual capitalization of agricultural support programs into land rental prices. Currently, a considerable share of agricultural land is cultivated by tenants instead of landowners in many developed countries. Based on data from the Farm Accountancy Data Network (FADN), Swinnen et al. (2009) calculate shares of rented agricultural land to account for at least 60% of the overall agricultural land for eight European Union (EU) Member States (Slovakia, Czech Republic, France, Malta, Belgium, Germany, Hungary and Estonia in descending order) in 2005. In comparison to Germany, Bavarian shares of rented land have been at considerably lower levels over recent decades (Figure 1-1). However, the proportion of rented agricultural land in Bavaria increased from 9% in 1949 to 45% in 2007, and 41.9% of the total Bavarian agricultural land was rented in 2010 (StMELF, 2012).

Figure 1-1: Rented land as a share of total agricultural land in Bavaria and Germany



Source: Authors' presentation based on StMELF (2008, 2012).

Hence, landlords and initial land owners might profit from a (considerable) degree of capitalization of government support programs into land rental prices instead of those actually farming the land. To some extent, this would contradict the objective of the EU

Common Agricultural Policy (CAP) and particularly the most recent reforms that target "support exclusively to active farmers" (European Commission, 2010, p. 3). Against this background, our overall objective in this thesis is to analyze the impact of various agricultural policy instruments applied in the CAP framework of the EU on agricultural land sales and land rental prices.

1.2 Current State of Research

Agricultural land rental and land sales prices are partly determined by the same influence factors. Although the extent of government support, the natural conditions for farming (land productivity), the farm-specific situation and the regional market structure play a role in land rental price and land sales price determination, factors such as urban pressure primarily influence land sales prices but influence rental prices less. The same holds for the rights and obligations attached to the ownership of land. They influence land sales prices to a greater extent than rental prices. With these issues in mind, a comparison of results from studies on the determinants of land sales prices and those concerned with the determinants of land rental prices is inconsistent. Consequently, in the remainder of this chapter and the thesis, we distinguish between agricultural land sales and land rental prices.

The bulk of the economic literature on the influence of government support programs on agricultural land prices in the US focuses on land sales rather than land rental. However, in the last decade, one can observe a rapid growth of studies concerned with the influence of government support on land rental prices (e.g., Roberts et al., 2003; Lence and Mishra, 2003; Kirwan, 2009; Qiu et al., 2010; Goodwin et al., 2011; Hendricks et al., 2012). Although some of these US studies distinguish between various types of support instruments such as deficiency payments, market loss assistance and production flexibility contracts in their empirical analyses, others use the instruments in an aggregated form. In general, coefficient estimates vary considerably not only between studies but also within studies. For example, Roberts et al. (2003) provide coefficient estimates between 0.33 and 1.55 on the capitalization of decoupled direct payments (e.g., production flexibility contracts) into land rental prices for 1997. However, their strongest estimates reveal capitalization rates between 34 and 41 cents per dollar of government payments. When accounting for endogeneity, estimates for 1992 are roughly in line with those obtained for 1997. This is particularly interesting because production subsidies (deficiency payments) were predominant in the earlier time period and decoupled direct payments were more common in the latter. In contrast, Lence and Mishra (2003) find that every dollar of decoupled direct payments gets fully capitalized into land rental prices. Kirwan (2009), Qiu et al. (2010) and Goodwin et al. (2011) obtain capitalization rates that range from 25 cents to 1 dollar per additional dollar of aggregated payments. Hendricks et al. (2012) use a dynamic panel data approach on data from 1990 to 2008 and find that aggregated payments capitalize by 12 cents (37 cents) per additional dollar in the short-run (long-run).

Similar to their US counterparts, studies on the determinants of European land rental prices also emerged relatively late. Because intervention prices and prohibitively high tariffs were most common before the MacSharry Reform in 1992, it was difficult to disentangle their effect on land rental prices. The influence of direct payments applied after the MacSharry Reform was investigated by authors such as Patton et al. (2008) and Breustedt and Habermann (2011). Others were concerned with the question of whether the decoupling of direct payments in the course of the Fischler Reform in 2003 changed the capitalization of government support into land rental prices and therefore consider time periods before and after the Fischler Reform (e.g., Kilian et al., 2012; O’Neill and Hanrahan, 2013; Guastella et al., 2013; Feichtinger et al., 2014).

Using a spatial econometrics approach on data from Lower Saxony (Germany), Breustedt and Habermann (2011) find that land rental prices increase by 38 cents with every additional euro of area payments. Patton et al. (2008) use a dataset that includes the years between 1994 and 2002 to analyze the determinants of land rental prices in North Ireland. Although considering all types of CAP payments, their focus clearly lies on animal payments. Their findings suggest that 41 and 42 pence per pound of beef special premiums and suckler cow premiums, respectively, capitalize in land rental prices. According to their results, sheep annual premiums get fully capitalized. Furthermore, Kilian et al. (2012) find that 41 cents (35 cents) per euro of area payments (animal payments) get capitalized in land rental prices. Applying a dynamic panel data approach, O’Neill and Hanrahan (2013) reveal that 6 to 32 cents of the marginal euro was capitalized into Irish land rental prices in the short-run before the reform. Accordingly, the long-run effects are higher (67 to 90 cents per euro). In contrast to these studies, Guastella et al. (2013) obtain a significant but negative coefficient estimate for the time before the Fischler Reform in their study on Italian land rental prices.

Instead of single farm payments (SFPs), in the course of the 2003 Fischler Reform, single area payments (SAPs) were introduced in the New EU Member States (countries joined the EU after 1995). Thereby, the design of SAPs is similar to that of area payments applied in the EU-15 before the Fischler Reform. Ciaian and Kancs (2012) and Van Herck et al. (2013) give evidence that 13 to 25 cents of the marginal SAP euro end up in Eastern European land rental prices.

Using a generalized propensity score matching approach, Michalek et al. (2014) find rather low average capitalization rates for SFPs of 6% to 10% across several Old EU Member States (countries joined the EU before 1995). The single capitalization rates vary considerably between 3% and 94% for different SFP levels and between different EU Member States. O'Neill and Hanrahan (2013) report a capitalization rate of 7 to 25 (21 to 53) cents per euro of SFPs in the short-run (long-run); this mostly depends on the type of farm considered. These results imply a slight decrease compared to their findings for the time before the Fischler Reform. According to the results of Kilian et al. (2012) and Feichtinger et al. (2014), SFPs capitalize into land rental prices by 61 cents and 47 cents, respectively. Compared to the time before the reform, these results are an increase of 20 cents and 10 cents, respectively. In contrast to these studies, Guastella et al. (2013) cannot confirm a significant influence of SFPs on land rental prices. Varying degrees of capitalization can also be found with respect to disadvantaged area payments. Although they are fully capitalized into land rental prices in the study of Patton et al. (2008), authors such as Kilian et al. (2012) and Feichtinger et al. (2014) provide estimates in a range between 29 and 57 cents.

If government support programs increase annual returns, this must be reflected to some extent in land sales prices. Although numerous studies investigate this influence of government support programs on agricultural land sales prices in North America, the literature on Europe remains scarce.

Studies that measure the influence of US production subsidies and various types of coupled and decoupled direct payments on US agricultural land sales prices include Goodwin and Ortalo-Magné (1992), Just and Miranowski (1993), Barnard et al. (1997), Devadoss and Manchu (2007), Shaik (2007), Goodwin et al. (2003; 2005; 2011) and Shaik et al. (2005; 2006; 2010). According to Latruffe and Le Mouël (2009), empirical studies for the US consistently report government support to be responsible for 12% to 40% of agricultural land price levels. Analogously, Weersink et al. (1999), Vyn et al. (2012) and others empirically confirm that government support positively influences agricultural land sales prices in Canada. At this point, it must be noted that except for Just and Miranowski (1993) all of these studies are included in the meta-regression analysis in chapter 2.

Turning to European studies, Pyykkönen (2005), Duvivier et al. (2005) and Latruffe et al. (2008) analyzed the impact of price support schemes and coupled direct payments on agricultural land sales prices in Finland, Belgium and the Czech Republic, respectively. Applying a spatial econometric approach to data from 1995 to 2002, Pyykkönen (2005) finds capitalization elasticities of 0.212 (1995 - 1999) and 0.602 (2000 – 2002) for CAP direct payments (area payments and animal payments). A capitalization elasticity of 0.212 would imply a 2.1% increase in agricultural land prices with a 10% increase in government support. Analyzing municipality level data between 1980 and 2001, Duvivier et al. (2005) find capitalization elasticities to range from 0.12 to 0.47 and conclude that the MacSharry Reform in 1992 had a positive effect on capitalization. Similarly, Latruffe et al. (2008) find a higher capitalization of area payments than of market price support.

The most recent contributions on European land sales prices include Latruffe et al. (2013), Nilsson and Johansson (2013) and Karlsson and Nilsson (2013). Latruffe et al. (2013) analyze individual agricultural land sales transactions in several French regions from 1994 to 2011. Their results reveal a rather small capitalization of 69 cents per euro of aggregated CAP payments. This number increases to 2.06 euros in nitrate surplus zones. Nilsson and Johansson (2013) use a quantile regression approach on 2007 and 2008 municipality level data from Sweden. They obtain an elasticity of 0.54 for SFPs. These results are not confirmed by Karlsson and Nilsson (2013), who use a dataset of actual sales transactions of mainly small- and medium-sized Swedish farms. However, it must be noted that Karlsson and Nilsson (2013) use total farm values including the farm buildings as their LHS variable instead of the per hectare values of agricultural land without buildings in their analysis.

Here, we provide only an overview and refer to chapter 2 for an extensive summary of the determinants of land sales prices. Apart from our contribution, a very general review on agricultural land markets can be found in Le Mouël (2003). In addition, we refer to OECD (2008) and Latruffe and Le Mouël (2009) as sources for comprehensive reviews on the influence of agricultural support on land prices.

1.3 Outline of the Thesis and Scientific Contribution

Although earlier studies analyzed the influence of agricultural policy measures on agricultural land prices, their results vary considerably. The following chapters provide three distinct studies on the effects of government support programs on agricultural land values. Although the first two contributions concentrate on land sales prices, the third is concerned with rental prices. Although all the chapters contribute to our main topic, they differ in the specific research questions and the theoretical and empirical approaches applied therein.

The first part of chapter 2 provides a review of the empirical literature and the underlying theoretical foundations of the determinants of agricultural land sales prices similar to OECD (2008) and Latruffe and Le Mouël (2009). In contrast to these earlier reviews, we give a systematized overview of the variables used in the empirical analysis and perform a meta-regression analysis. The latter is based on 242 observations from 26 articles and aims to reveal whether various government support measures and other differences (e.g., applied estimation technique, included variables, the proxies for land rents) cause systematic differences in the capitalization rates obtained in earlier studies (so-called primary studies). Although Oltmer and Florax (2001) investigate the determinants of agricultural land sales prices in a general sense in their meta-regression analysis, we specifically focus on the influence of various government support measures. Moreover, we also include more recent studies and therefore analyze the newer policy instruments.

From an empirical perspective, the key challenges in performing a meta-regression analysis are accounting for the correlation between the primary studies and the correlation of the coefficient estimates reported in one primary study (Nelson and Kennedy, 2009). In our study, this problem is enhanced by a highly varying number of coefficient estimates reported in some primary studies. For example, although several studies report only one coefficient estimate on the influence of government support on land sales prices, one study reports as many as 40 estimates. Therefore, we pursue three estimation strategies. In the first strategy, we estimate a simple pooled Ordinary Least Squares (OLS) regression and therefore give all the coefficient estimates (but not the primary studies) equal weights. In the second strategy, we weight the residuals such that every primary study has equal weight. In the third strategy, we take the median estimate of each study and again perform an OLS regression.

In chapter 3, we adopt Fingleton and Le Gallo's (2008) model of the real estate market to agricultural land sales prices. Based on this, we derive a reduced form model of agricultural land sales markets including spatial dependency. This model can be estimated using spatial econometric techniques. As opposed to the prevailing literature, our modelling approach has the advantage of explicitly considering the demand and supply side of the land sales market. In contrast, most prevailing studies derive their empirical model from the net present value approach (NPV) (e.g., Weersink et al., 1999; Duvivier et al., 2005; Latruffe et al., 2008; Vyn et al., 2012). In these studies, the NPV gives the willingness to pay for a particular land given expected future returns from the market, government payments and other potential uses (e.g., conversion to building land). Hence, the NPV approach considers only the demand side of the market. In our empirical model, we analyze a dataset of more than 7,300 actual arm's length transactions of agricultural land sales in the years 2001 and 2007 to identify the factors that influence agricultural land prices in Bavaria. Particular attention is paid to the effect of CAP payments. Given our dataset, we are able to compare the capitalization effect of coupled payments (area payments and animal payments before 2005) with the effect of decoupled payments (SFPs after 2005). In contrast to previous studies of land sales prices, we account for the spatial dimension of land markets and for the endogeneity of the explanatory variables. Each of these issues can potentially lead to biased estimates. Regarding the first, the spatial dimension of land leads to a limited spatial extension of farms and to regional land markets. Applying a general spatial model that includes a spatial lag and a spatial error enables us to consider the fact that spatially closer land markets interact with a higher intensity than do more distant ones. Moreover, we are able to account for unobserved but spatially related factors (e.g., climate) that potentially cause spatial correlated error terms. A crucial issue in this respect is the ex-ante specification of spatial weight matrices because the researcher must exogenously determine what defines neighbors and the weights given to each neighbor. For that reason, we use a distance-based weight matrix and a so-called Gabriel graph as two different approaches. In regard to the second, the endogeneity problem is often caused by reducing the multifaceted interactions of demand and supply in land markets to a single reduced-form price equation, which results in simultaneity problems. Moreover, there is also an "expectation error." This form of measurement error arises when approximating farmers' true expectations of future returns using observed returns (Goodwin et al., 2003; Kirwan, 2009). To account for this, we utilize a two-step estimation strategy as discussed in Kelejian and Prucha (1999; 2010), Arraiz et al. (2010) and Drukker et al. (2011a). Each of the two steps consists of alternating Generalized Method of Moments (GMM) and Two-Stage-Least-Squares (2SLS) estimators. For comparison, we also report non-spatial White heteroscedasticity-consistent OLS and GMM estimates.

Chapter 4 aims to investigate the impact of CAP payments on land rental prices and land allocation. Although Guyomard et al. (2004), Courleux et al. (2008) and Ciaian et al. (2008) analyze the impact of SFPs on land rental prices on a theoretical basis, none of them considers heterogeneous land qualities. Guyomard et al. (2006) consider heterogeneous land quality but focus solely on agri-environmental payments. Although they consider heterogeneous land quality and analyze SFPs, Kilian et al. (2012) provide only a graphical solution. In this chapter, we first develop a Ricardian rent model of one output and two inputs. We then implement the main CAP instruments including SFPs in a historical and a regional model and provide analytical solutions. We next introduce an outside option to examine eventual land allocation changes introduced by various CAP instruments. Thereby, land rents obtained from the outside option are assumed to be independent of land quality.

In the subsequent empirical part, we test our theoretical findings. To do so, we utilize a comprehensive dataset of bookkeeping records from more than 3,000 Bavarian farms. In our empirical implementation, we choose a dynamic panel data model to account for the fact that rental prices depend to some extent on the rental prices paid in the previous period. This allows us to quantify potential inertia in Bavarian land rental prices. Furthermore, we remove individual fixed effects by taking first differences and orthogonal deviations. These models are then estimated by applying a two-step Arellano and Bond (1991) GMM estimation approach. To obtain empirical evidence of whether capitalization differs with respect to land quality, we perform regressions including the same covariates for two subsamples. Although one subsample comprises farms located in areas with comparably favorable natural conditions for farming, the other contains farms located in less favorable areas.

1.3.1 The Candidate's Individual Contribution

Because parts of the thesis are based on joint work, it is necessary to elucidate the candidate's individual contribution to each of the chapters.

The candidate contributed to the meta-analysis in the second chapter by collecting the primary studies, deducing the main determinants of land sales prices from the literature, preparing the dataset and performing the meta-regression analyses. Furthermore, the candidate provided a first draft of the paper including all the tables and graphs. The theoretical part (subchapter 2.2) is based on joint work with the supervisor.

The candidate's contribution to the third chapter comprises preparing the data, performing the spatial regression analyses and providing a draft version of the chapter including all the tables and graphs. The theoretical model (subchapter 3.2) is based on joint work with the supervisor.

The theoretical model in the fourth chapter was jointly developed with the supervisor, but all the analytic results were derived by the candidate. In addition, the candidate contributed most of the data preparation and the draft version of the chapter including all the tables and graphs. The empirical analysis is a joint effort with the supervisor.

2 What do we know about the influence of agricultural support on agricultural land prices?[1]

Abstract

This study gives an overview of the theoretical foundations, the empirical procedures and the derived results of the literature on the determinants of agricultural land prices. A particular interest is given to the effects of government support policies. Almost all empirical studies on the determination of land prices either refer to the net present value method or the hedonic pricing approach. While the two approaches have different theoretical basis, they converge in their empirical implementation. Empirical studies use a broad range of variables to explain land values and we systematize these into six categories. In order to investigate the influence of different measures of government support on land prices, a meta-regression analysis is carried out based on 242 observations from 26 articles. Results indicate that a 10% decrease of agricultural support would decrease land prices by 3.3% to 5%. Therefore, a considerable part of farm subsidies is realized by initial owners of land instead of operating farmers. Results in regard to differences in capitalization for different support measures are ambiguous. Model assumptions, data structure and estimation techniques do have a significant influence on capitalization estimates.

Keywords

Land price, government support, net present value, hedonic pricing approach, meta-regression analysis, capitalization

JEL: Q15, Q18, C83

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[1] This chapter is based on Feichtinger and Salhofer (2013): “What do we know about the influence of agricultural support on agricultural land prices?” published in a special issue of the *German Journal of Agricultural Economics* on “Agricultural Land Markets – Recent Developments and Determinants” edited by Hüttel et al. (2013). We would like to thank the publisher, Deutscher Fachverlag GmbH, and the editors for the permission to reproduce our results.

2.1 Introduction

Eventually, the question of what determines agricultural land values has occupied economists since more than 200 years (Smith, 1776; Ricardo, 1817; von Thünen, 1842) and has been an important research topic in agricultural economics throughout the last century (Lloyd, 1920; Bean, 1938; Scofield, 1957; Klinefelter, 1973; Robison et al., 1985; Shaik et al., 2005). Although, a few econometric contributions date back as early as the late 1930s (George, 1941), regression analysis of land value determinants took off in the 1960s (Hedrick, 1962; Herdt and Cochrane, 1966; Tweeten and Martin, 1966) and continues since then (Traill, 1979; Alston, 1986; Weersink et al., 1999; Salois et al., 2011). Starting in the 1960s agricultural economists began to investigate to what extent agricultural policy measures influence land prices (e.g., Hedrick, 1962; Seagraves, 1969; Vollink, 1978). These first contributions found a significant influence of tobacco and peanut allotments on land prices. Also more than 50 years ago researchers tried to measure the impact of urban pressure on agricultural land prices (e.g., Ruttan, 1961; Scharlach and Schuh, 1962). High inflation rates in the 1970s and partly the 1980s were one cause to investigate the impact of macroeconomic variables on land prices (e.g., Feldstein, 1980; Just and Miranowski, 1993). While all these early studies analyzed land values in the United States (US), investigations for Europe emerged much later and are much scarcer. This applies especially for the impact of the European Union’s (EU) Common Agricultural Policy (CAP) on land prices (e.g., Duvivier et al., 2005; Pyykkönen, 2005; Latruffe et al., 2008; Kilian, 2010).

The overall purpose of this study is to give an overview of this empirical literature and its underlying theoretical foundations. While Le Mouël (2003) and Latruffe and Le Mouël (2009) provide such reviews of the theoretical background and the empirical application, we additionally try to systematize the different influence factors used in empirical analysis so far and apply a meta-analysis to reveal the effects of different government support policies on land prices. Although empirical work on land rental markets has increased substantially over the past ten years (e.g., Roberts et al., 2003; Lence and Mishra, 2003; Goodwin et al., 2005; Kirwan, 2009; Breustedt and Habermann, 2011; Kilian et al., 2012), the focus of our paper is placed on the agricultural land sales market.

The study is structured as follows. Most empirical studies investigating the determinants of agricultural land prices either refer to the net present value method (NPV) or the hedonic pricing approach as a theoretical basis. Therefore, subchapter 2.2 will outline both methods and how they are related. In empirically explaining land prices and their dynamics, researchers have utilized a multitude of different variables. Subchapter 2.3 will review and systematize these determinants. A long discussed question in regard to land prices is the influence of agricultural support measures. The question of how much of government payments will be capitalized into land values will be tackled based on an extensive literature review and a meta-regression analysis in subchapter 2.4. Subchapter 2.5 summarizes our results and draws some conclusions.

2.2 Net Present Value and Hedonic Pricing Approach

According to the NPV model the maximum price a farmer would be willing to pay for a particular piece of agricultural land at time *t* is equal to the summed and discounted expected future stream of earnings from this land. In a very general form we can write

$$L_t = \frac{E_t(R_{t+1})}{(1+r_{t+1})} + \cdots + \frac{E_t(R_{t+i})}{(1+r_{t+1})\ldots(1+r_{t+i})} + \cdots + \frac{E_t(R_{t+n})}{(1+r_{t+1})\ldots(1+r_{t+n})} \qquad (2\text{-}1)$$

where L_t is the NPV or the (maximum) price a farmer would be willing to pay for a unit of land at the end of time period *t*, E_t indicates the expectations at time *t* and r_{t+i} the discount rate in period *t*+*i* applied to returns in period R_{t+i}. In a situation without government intervention R_{t+i} can be interpreted as a Ricardian land rent or residual rent, i.e., the returns to land after costs for all other factors of production, including opportunity costs, have been subtracted (Featherstone and Baker, 1988). Equation (2-1) is general in a sense that we assume different expected land rents and different discount rates for each of the *n* periods. For simplicity, but without any loss of generality let's assume that $r_{t+i} = r$ and $E_t(R_{t+i}) = E_t(R)$ for all $i = 1,2,\ldots n$. Hence, the discount rate and land rents are constant over all *n* periods. Given this and defining $b^i = (1+r)^{-i}$ one derives

$$L_t = \sum_{i=1}^{n} b^i E_t(R) \qquad (2\text{-}2)$$

Additionally, assuming land is a perpetuity ($n = \infty$) and land rents increase (or decrease) at a constant (growth) rate (g) and hence $R_{t+i} = R_t * (1+g)^i$, one derives

$$L_t = \frac{E_t R_{t+1}}{r - g} = \beta E_t R_{t+1} \quad (2\text{-}3)$$

where $\beta = \frac{1}{r-g}$.[2]

Beside the Ricardian land rent, which is created by the “original and indestructible powers of the soils” (Ricardo, 1817), other returns connected to land may capitalize into land prices. This is true to some extent for almost all agricultural support programs. If land is necessary to receive this support, people will take expected future earnings from this support programs into account in their willingness to pay. This has been recognized by agricultural economists at least since Hedrick (1962). Different support measures may capitalize into the land value to a different extent. Following Weersink et al. (1999) government support can be incorporated into the NPV model in the following way:

$$L_t = \beta E_t R_{t+1} + \sum_{j=1}^{m} \beta_{G,j} E_{j,t} G_{j,t+1} \quad (2\text{-}4)$$

where m different types of government support payments G_j capitalize into the land price at a rate of $\beta_{G,j} = \frac{1}{r-g_{G,j}}$. This formulation needs some additional discussion. First, while a perpetual stream of land rents seems a reasonable assumption, this is probably not the case for the stream of government payments. However, it can be argued that one can account for this to some extent through a high negative growth rate $g_{G,j}$. Hence, although government payments are assumed as perpetuities in equation (2-4), they converge to 0 within a few periods if $g_{G,j}$ is close to -1. Expectations and growth rates may differ for different payment types implying different $\beta_{G,j}$. Second, strictly speaking G_j are net returns from government payments not including implied (opportunity) costs. This becomes clear for example in the case of agri-environmental payments, where in many cases additional production costs arise. However, in empirical work these additional costs usually decrease our measure of returns to land R in equation (2-4) rather than G_j. Third, a similar problem exists in the case of policies which directly or indirectly influence returns to land R (e.g., an intervention price, an import quota and a fertilizer tax) rather than G_j. Another important remark in regard to the NPV model is that it basically reflects the willingness to

[2] Equation (2-3) abstracts from some complications including inflation, taxes, credit market imperfections, transactions costs and risk aversion (Just and Miranowski, 1993).

pay and therefore the demand side of the price finding process, or to put it differently, a situation with a fixed amount of land (of a specific quality).

In transferring the theoretical NPV model in equation (2-4) into an empirically estimable model another crucial problem remains. In equation (2-4) land values are based on expectations about the long-run stream of net returns which are unobservable. These problems are discussed in detail by Goodwin et al. (2003). Weersink et al. (1999) show how to solve this problem assuming rational expectations and knowledge of future returns and payments. Abstracting from these problems we can transfer equation (2-4) into the following empirical model:

$$L_i = \alpha + \beta' R_i + \sum_{j=1}^{m} \beta'_{G,j} G_{j,i} + \varepsilon_i \tag{2-5}$$

where α is a constant, β' and $\beta'_{G,j}$ are parameters reflecting β and $\beta_{G,j}$ in equation (2-4), and ε is a white noise error term. We call $\beta_{G,j}$ the capitalization ratio, i.e., the share of payments capitalized into land rental prices (Kilian et al., 2012).

Beside returns to land and government payments, equation (2-5) neglects other factors which may influence land prices. One example is competing demand for land for non-agricultural use, e.g., urban pressure (e.g., Capozza and Helsley, 1989). Another example is the structure of the land market, e.g., market power of only a few land owners willing to sell. One can account for these other factors in equation (2-5) by arguing that those are shifters to the price function and therefore included in the constant α. Hence, equation (2-5) becomes

$$L_i = \sum_{k=1}^{z} \alpha_k X_{k,i} + \beta' R_i + \sum_{j=1}^{m} \beta'_{G,j} G_{j,i} + \varepsilon_i \tag{2-6}$$

where X_k are shift variables with $X_1 = 1$ for all i observations and α_k are z parameters to be estimated. Equation (2-6) is similar to equation (2-3) in Goodwin et al. (2003), who introduce a number of different indicators of urban pressure into the NPV model.

In contrast, the hedonic pricing approach is anchored in consumer theory (Lancaster, 1966), and starts from the assumption that the price of a good (in our case land) can be explained by a set of characteristics (e.g., land quality) affecting it (Rosen, 1974). Very general, and as an estimable function agricultural land price is a function of *y* factors:

$$L_i = \sum_{l=1}^{y} \delta_l Z_{l,i} + \varepsilon_i \quad (2\text{-}7)$$

where Z_l are variables representing characteristics with $Z_1 = 1$ for all i observations. If explanatory variables Z_l include returns from land (or some proxy) R and government payments $G_{j,i}$, the hedonic pricing approach of equation (2-7) and the empirical implementation of the NPV model of equation (2-6) converge to the same empirical model, though based on different theoretical considerations.

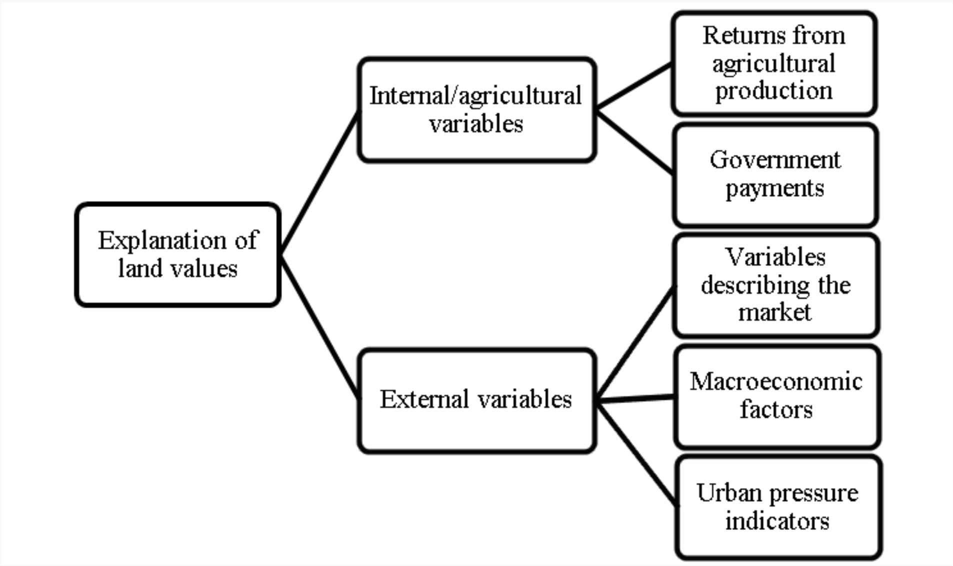
The NPV model has a theoretical basis, which consistently explains the relation between returns from land and government payments on the one hand and the price of land on the other hand. Transferring the NPV model into an empirically estimable function either lacks consistency or involves some strong assumptions. However, in empirical work we cannot find any significant difference between studies referring to the NPV model or the hedonic pricing approach. Both usually use linear regression analysis including different explanatory variables, some of which represent land rents and government payments. This finding implies that we do not have to differentiate studies in regard to their theoretical basis in our meta-regression analysis in subchapter 2.4.

2.3 Explanatory Variables used in Empirical Applications

In an effort to explain what determines land prices as theoretically discussed in the last subchapter, researchers have utilised numerous different variables. One way to structure these variables is depicted in Figure 2-1, where we define two major groups: internal/agricultural variables and external variables.

Agricultural variables are further split into two subgroups. The first one is concerned with returns from agricultural production. Hence, variables in this category usually represent the returns from land R. Since estimates of R are often not available, e.g., because the shadow price of labour is not known, proxies like market revenues, net income or the price of the output are used in empirical work (Table 2-1). Beside those variables which try to approximate R directly utilizing some monetary measure, there are also other non-monetary variables which have a clear influence on returns from land like yields or soil quality. As described in subchapter 2.2, beside returns from land, returns from government payments influence land prices through capitalization. As long as government payments are tied to the price of agricultural production, as in the case of a price support policy, returns to land from production *R* and from government payments *G* are hardly separable. While some studies use total government payments as an explanatory variable of land prices, other split them into different categories (e.g., animal payments and area payments).

Figure 2-1: Variables used in empirical analysis



Source: Authors' presentation.

Beside returns to land and government payments there are other factors which may influence land prices. The influence of some of these factors, in particular interest rate, inflation rate and property tax, can also be explained within the NPV model. Here we systematise these external variables used in the literature into three groups: variables describing the market, macroeconomic factors and urban pressure indicators.

Table 2-1: Examples for variables used to explain land values

Agricultural returns – Monetary variables

- Market revenues (Carlberg, 2002; Barnard et al., 1997; Folland and Hough, 1991; Gardner, 2002; etc.)
- Returns to land (Goodwin et al., 2005 & 2011; Weerahewa et al., 2008)
- Net income (Devadoss and Manchu, 2007)
- Producer price of wheat (Goodwin and Ortalo-Magné, 1992)

Agricultural returns – Non-monetary variables

- Yield (Pyykkönen, 2005; Devadoss and Manchu, 2007; Latruffe et al., 2008)
- Soil quality (Barnard et al., 1997; Kilian, 2010)
- Temperature and precipitation (Barnard et al., 1997)
- Dummy for
  - Irrigation (Barnard et al., 1997)
  - Presence of intensive crops (Barnard et al., 1997)

- Special crops (Pyykkönen, 2005)
- Fraction of cropland (Gardner, 2002)
- Proximity of a port (Folland and Hough, 1991)

Government payments

- Total government payments (Devadoss and Manchu, 2007; Vyn, 2006; Henderson and Gloy, 2008; Shaik et al., 2005)
- One or multiple categories of government support (Goodwin et al., 2003 & 2005; Pyykkönen, 2005)

Variables describing the market

- Manure density (Pyykkönen, 2005)
- Pig density (Duvivier, 2005)
- Farm density (Pyykkönen, 2005)
- Average farm size (Folland and Hough, 1991)
- Size of the agricultural land market (in the case of Duvivier et al., 2005, e.g., the fraction of arable farmland exchanged in a particular district in a particular year)
- Dummy for a specific region

Macroeconomic factors

- Interest rate (Weerahewa et al., 2008; Devadoss and Manchu, 2007)
- Inflation rate (Alston, 1986)
- Property tax rate (Gardner, 2002; Devadoss and Manchu, 2007)
- Multifactor productivity growth (Gardner, 2002)
- Debt to asset ratio (Devadoss and Manchu, 2007)
- Credit availability (Devadoss and Manchu, 2007)
- Unemployment rate (Pyykkönen, 2005)

Urban pressure indicators

- Total population (Devadoss and Manchu, 2007)
- Population density per square kilometre
- Population growth (Gardner, 2002)
- Ratio of population to farm acres (Goodwin et al., 2011)
- Urbanisation categories (Goodwin et al. (2011 & 2005), defined through proximity to an urban centre)
- Rurality – fraction of the population living on farms (Gardner, 2002)
- Dummy variables for metropolitan areas (Henderson and Gloy, 2008)
- Proportion of the labour employed in agriculture (Pyykkönen, 2005)

Source: Authors' presentation.

2.4 Meta-Regression Analysis – Results and Discussion

Recently, the discussion on the capitalization of government support into land prices gained importance through the increasing share of rented agricultural area in most parts of the developed world. Empirical investigation of the capitalization ratio has been conducted at least since Hedrick (1962). However, comparability across studies is limited for several reasons. First, the way agriculture is supported has changed significantly over time in most developed countries. While support was executed through market price support and production subsidies in former times, different kind of direct payments are often dominant these days. Measuring the capitalization effect from market price support is difficult since it cannot be fully dismantled from the influence of land rents (or some proxy). Second, while older studies often use time series, cross sections or panel data is more prominent today. Third, estimation techniques have considerably changed over time. Hence, we apply a meta–regression analysis in order to derive some knowledge about the extent of capitalization of different measures of support and to reveal some structural differences which may influence the capitalization ratio.

Our basic model is an extension of Stanley and Jarrell (1989),

$$b_{ik} = \eta_0 + \sum_{j=1}^{m} \eta_j D_{j,ik} + \sum_{l=1}^{y} \gamma_l Z_{l,ik} + \varepsilon_{ik} \quad (i = 1,2,\dots,n),(k = 1,2,\dots,z) \tag{2-8}$$

where b_{ik} is one of n effects reported in primary study k, η_0, η_j, and γ_l, are parameters to be estimated, $D_{j,ik}$ are dummy variables representing m different categories of government support, $Z_{l,ik}$ are y variables measuring relevant characteristics of an empirical study and explaining its systematic variation from other results in the literature, and ε_{ik} is an error term representing white noise. In our case b_{ik} is the elasticity of land prices with respect to government payments. η_0 may be interpreted as the "true" average value of b_{ik} if we do not distinguish between different government support policies, i.e. use the default category total government payments. However, theoretically there are differences in the capitalization ratio of government payments depending on the measure of support. This is derived from the fact that different government payments have a different impact on land rents R. For example, based on theoretical analysis we would expect that an input subsidy on land implies a larger increase in land rents as does a subsidy on outputs of the same amount (Latruffe and Le Mouël, 2009; Guyomard et al., 2004). Taking this into account, parameters η_j capture the differences of particular support policies to the average situation. Therefore, equation (2-8) is used to test for two different things. First, we try to investigate if we find different support categories to reveal significant different capitalization rates. Second, we try to find out if differences in for example estimation techniques, included variables and differences in proxies for land rents lead to a systematic and significant bias in estimated capitalization elasticities.

As dependent variable, two different measures of capitalization are commonly reported in empirical studies: the (marginal) capitalization ratio $\beta'_{G,j} = \partial L_i / \partial G_{j,i}$, as derived from a linear function and represented in equation (2-5) and the capitalisation elasticity $\mu_{G,j} = (\partial L_i G_{j,i}) / (\partial G_{j,i} L_i)$ derived from a log-linear version of equation (2-5) or calculated from equation (2-5) and some knowledge of average land prices and government payments in the sample. To further illustrate these two measures, we use two results from Kilian (2010) and Goodwin et al. (2003), who report capitalization ratios of 6.74 and 6.55, respectively. Hence, every additional euro (dollar) of support will increase land prices by more than six euros (dollars). This obviously implies the expectation that this support will last for more than 7 years (based on an assumption of a 3% interest rate). Using the mean values of land prices (21,548 EUR/ha and 1,435.59 USD/acre) and government payments (296.39 EUR/ha/year and 13.43 USD/acre/year) in their study samples one can calculate the correspondent capitalisation elasticities of 0.0927 and 0.0613, respectively. Hence, a 1% increase in government payments leads to a 0.0927% (0.0613%) increase in land prices. Accordingly, a 10% decrease in government payments would decrease land prices by 0.927% (or 199.75 EUR/ha) and 0.613% (or 8.8 USD/acre). In the extreme case of a complete abandonment of government payments (decline by 100%) land prices in our examples would decrease by 9.27% (or 1,997.5 EUR/ha) and 6.13% (or 88 USD/acre). Though especially this last result has to be taken with the usual caution of extrapolating estimation results beyond the range in which variables are observed.

In our meta-regression analysis we use the capitalisation elasticity as dependent variable since it provides us with more observations. In addition, Weisensel et al. (1988) and Oltmer and Florax (2001) argue that the use of elasticities is preferable because of avoiding dimensional problems resulting for example from different currencies.

As summarized in Table 2-2, 242 estimations from 26 articles have been included in total. Elasticities vary from -0.408 to 1.184 with a mean elasticity of 0.276. In 96% of the cases the elasticity is a number between 0.002 and 0.789. On average 22 years have been included in the analysis where the mean year of the datasets is 1981 and the mean publishing year 2002.

Table 2-2: Descriptive statistics of the included articles

	Mean	**Maximum**	**Minimum**
Elasticity	0.276	1.184	-0.408
70% Confidence interval of elasticity		0.455	0.071
Year of data	1981	2007	1944
Years included	22	69	1
Publishing year	2002	2010	1982
Citations of articles	15	83	0
Estimates per article	9	40	1
Total number of observations			242
Number of articles			26

Source: Authors’ calculations.

On average every article is cited 15 times (calculated on the basis of the number of citations in www.scholar.google.de). The articles report on average 9.3 different estimates, with a minimum of 1 estimate and a maximum of 40 estimates. A full list of all 26 articles and descriptive statistics can be found in the Appendix Table A1.

About half of the estimates in the investigated studies use total government payments without differentiating between payment categories. Hence, we use this as a base line and introduce dummies if government payments are split into different types. The groups are: market price support (e.g., loan deficiency payments in the US, intervention price in the EU), direct payments (e.g., deficiency payments and crop disaster payments in the US, area and animal payments in the EU) and decoupled direct payments (e.g., counter cyclical payments, production flexibility contract payments and market loss assistance in the US, single farm payments in the EU). These categories are closely related to the Producer Support Estimate (PSE) classification of the Organisation for Economic Co-operation and Development (OECD) and the numbers of observations in each category are listed in Table 2-3. Agri-environmental payments (e.g., conservation reserve program payments in the US, agri-environmental programs in the EU) are not taken into account due to the low number of observations. As discussed in subchapter 2.3, a market price support policy will increase revenues and rents rather than being directly observable as an own variable of government payments. However, market price support was a dominant measure of government support over decades and has to be included into this analysis. Hence, we use estimates of the elasticity of land prices with respect to market revenues as a proxy for the elasticity with respect to market price support.

All utilised *Z* variables are listed in Table 2-3. We distinguish between four different types: model variables, data variables, structural variables and informational variables. Model variables account for differences in the explanatory variables included. One important difference in models to estimate land values is if in accordance with the NPV model land rents are included or some approximation (e.g., market revenues, cash receipts) instead. Hence, we introduce a dummy being 1, if land rents are used and 0 if an approximation is used. Another dummy variable was introduced when non-agricultural variables (e.g., population growth, housing values, etc.) are included in the regression.

Data variables account for differences in the data set. We account for differences in land types and include a dummy variable for arable land. In addition, we include a dummy variable for farm level data versus aggregated data (e.g., county level or province level).

Moreover, studies are either based on US or European data and we introduce a dummy value equal to 1 for Europe. Structural variables account for differences in estimation methods. We include dummies for using multiple equation models versus single equation, for double log specification versus linear specification, for spatial econometrics versus "conventional" procedures, and for including lagged dependent variables versus not using them. Finally, to account for differences in the quality of the study we introduce a dummy accounting if the study is published in a reviewed journal or not. A full list characterizing primary studies can be found in the Appendix Table A2.

Table 2-3: List of independent variables

		I and II		**III**	
Category	**Description**	**Share in %**	**Number of Obs.**	**Share in %**	**Number of Obs.**
Government payment	Market price support	31	73	42	11
	Direct payments	18	42	15	4
	Decoupled direct payments	4	9	8	2
	Total government payments	48	113	35	9
Model variables	Use of proxies, e.g., cash receipts, yield, etc.	76	181	73	19
	Land rent	24	56	27	7
	Only agricultural variables considered	27	63	27	7
	Inclusion of non-agricultural variables	73	174	73	19
Data variables	No diversification, others	77	182	81	21
	Only arable plots considered	23	55	19	5
	Any form of aggregation, e.g., county level	87	207	77	20
	Farm level data	13	30	23	6
	North America	80	189	85	22
	Europe	20	48	15	4
Structural variables	Single equation model	57	134	58	15
	Multiple equation model	43	103	42	11
	Linear function	53	126	58	15
	Double log specification	47	111	42	11
	Spatial econometrics	13	31	12	3
	No application of spatial econometrics	87	206	88	23
	Lagged dependent variable used	2	5	8	2
	No lag of dependent variables	98	232	92	24
	Lagged independent variable used	21	49	23	6
	No lag of independent variable	79	188	77	20
Informational variables	Publication	85	202	81	21
	Not published	15	35	19	5

Source: Authors' calculations.

Common problems in meta-regression analysis are the correlation within and the correlation between primary studies. Use of the same dataset or several articles from the same author are reasons for a correlation between primary studies. Within study correlation is likely to be apparent if more than one estimated value is reported per study. Reasons for reporting more than one estimate are the use of smaller sub-regions of the total dataset, the application of various estimation methods to the same data set or different levels of aggregation. Therefore, Nelson and Kennedy (2009) recommend that some means of adjusting for non-independence of estimates from the same study should be undertaken. According to them, such means are: panel-data methods, weighted least squares and a single estimate per primary study (study-level averages or random selection). In accordance with this, we present three different models, which are labelled I, II and III.

In regard to the first approach, our sample consists of a highly unbalanced panel with some primary studies reporting only one estimate. This does not allow us to use a fixed effects model. In testing whether a random effects model or a pooled regression model is appropriate, a Breusch-Pagan Lagrangian multiplier test (Breusch and Pagan, 1980) was performed. We failed to reject the null hypothesis that variances across articles are zero. Thus we have to reject random effects and instead our model I is a pooled OLS regression treating all estimations equally. Model II follows Johnston et al. (2006), Koetse et al. (2008) and Mrozek and Taylor (2002) and estimates equation (2-8) also as a pooled regression, but weights residual ε_{ik} in the least squares function by $w_{ik} = \frac{1}{n_k}$, where n_k is the number of observations in study k. Therefore, an article with many reported elasticities is given the same weight as an article with very few reported elasticities. Johnston et al. (2006) points out that weighting has the advantage that studies with many observations do not influence the model more than others. According to them a point of criticism has been the arbitrary assumption that studies with many estimates are no more informative than others. Alternative weights of observations, for example weights on the basis of variances or t-values, are not possible in our case due to missing information. Model III uses the median observation of each primary study, what again is arbitrary but has the advantage that the median is robust against extreme outliers. Using the median observation leaves us with a very small number of observations what can lead to a small sample bias.

To correct for outliers we delete observations with values outside economic plausibility (< 0; > 1). Therefore, in models I and II the number of observations reduces to 237. In model

III all observations are between zero and one. In case of an even number of observations the mean of the two median observations was taken. In case that these two observations belong to different support categories we decided to pick the lower of the two median observations. White's heteroscedasticity - consistent standard errors (White, 1980) are utilized in model I and II as a Breusch-Pagan test (Breusch and Pagan, 1979) and a White (1980) test reject the null hypothesis of homoscedasticity. This is not the case for model III.

According to the estimation results in Table 2-4 the constant has a highly significant value of 0.245, 0.355 and 0.297 in the regressions I, II and III, respectively. Hence, with some caution one could interpret those values as the average capitalization elasticities over all types of agricultural support. For example, a 1% change in support implies a 0.245% change in land prices. Analogous, a 10% decrease in government payments would lead to 2.45% lower land prices. Furthermore, one can observe considerable differences with respect to the three different models. Based on our meta-regression analysis we can only confirm a significantly higher capitalization of market price support and direct payments compared to the reference category of total government payments in model I. In regard to the *Z* variables, results show that taking theoretically consistent land rents (returns to land) to explain land values leads to lower elasticities of capitalization at a highly significant level in all models. Hence, taking a proxy for land rents (most often revenues or similar measures) tends to overestimate the capitalization effect. Including non-agricultural variables has a significant negative effect on the estimated capitalization elasticity at least in model II. This seems plausible based on the omitted variable bias. If land rents and potential non-agricultural land use significantly determine land prices, omitting one of them would increase the estimated coefficient of the other. Significantly higher capitalization elasticities are observed if primary studies consider only arable land in II and III. Moreover, if a study is based on aggregated data, we can expect higher capitalization elasticities as compared to farm level data. While a multiple equation model had a significant positive influence on the rate of capitalisation in model I, the double log specification does not influence capitalisation elasticities.

In regard to estimation procedures we find significantly higher elasticities if spatial econometric models are utilised. In addition, the lag of the independent variable or the lag of the dependent variable had negative influence at least in two of the models. Elasticities in published studies are not significantly different from not published work.

Table 2-4: Estimation results of the meta-regression analysis

		I			II			III		
Category	Variable	Coeff.		SE	Coeff.		SE	Coeff.		SE
Government payments	Constant	0.245	***	0.068	0.355	***	0.043	0.297	**	0.104
	Market price support	0.082	***	0.025	-0.012		0.029	0.004		0.057
	Direct payments	0.217	**	0.104	-0.050		0.063	0.189		0.130
	Decoupled direct payments	0.057		0.052	0.096		0.064	0.061		0.118
Model variables	Land rent	-0.157	***	0.044	-0.192	***	0.022	-0.202	***	0.065
	Inclusion of non-agricultural variables	0.006		0.037	-0.130	***	0.034	-0.080		0.067
Data variables	Only arable plots considered	0.028		0.054	0.108	**	0.045	0.141	*	0.074
	Farm level data	-0.093	*	0.047	-0.102	***	0.036	-0.187	**	0.076
	Studies using European data	-0.051		0.081	0.068		0.057	-0.150		0.113
Structural variables	Multiple equation model	0.128	***	0.048	0.032		0.031	0.055		0.057
	Double log specification	0.085		0.053	0.022		0.033	0.015		0.062
	Spatial econometrics	0.066	***	0.051	0.198	***	0.042	0.120		0.069
	Lagged dependent variable used	-0.025		0.071	-0.092		0.089	-0.247	**	0.089
	Lagged independent variable used	-0.109	*	0.054	-0.067	*	0.040	-0.089		0.079
Informational variables	Publication	-0.073		0.048	-0.003		0.026	0.029		0.067
	R-squared	0.361			0.721			0.830		
	Adjusted R-squared	0.321			0.703			0.614		
	F-statistic	8.958			40.927			3.839		
	Mean dependent var	0.281			0.245			0.208		
	Prob. Chi-Square (Breusch P.)	0.000			0.000			0.810		
	Observations	237			237			26		
	Outlier corr. (<0,>1)	yes			yes			no[3]		
	Weighting	no			yes			no		

***p<0,01, **p<0,05, *p<0,10; SE = Standard Error

Source: Authors' calculations.

2.5 Summary and Conclusions

The purpose of this study is to give an overview of the theoretical foundations, empirical procedures and the derived results of the literature identifying the determinants of farmland prices. Almost all studies analysing the determinants of farmland prices either

[3] No outlier correction necessary.

refer to the net present value (NPV) method or to the hedonic pricing approach as a basis of their work. The hedonic pricing approach is anchored in consumer utility theory and assumes that the observed prices of a good (in our case land) are a function of a set of characteristics which define this good. Therefore, empirical models based on the hedonic pricing approach can include a multitude of very different explanatory variables, as long as those refer to characteristics of land. In opposite, the NPV model defines the maximum price somebody (in our case a farmer) would be willing to pay for a particular asset (in our case a piece of agricultural land) as the summed and discounted expected future streams of earnings from this asset. Using this as a starting point we explained some of the developments and extensions of this model. Most important, future streams of earnings go beyond land rents and include rents from government policies. While the NPV approach gives a consistent theoretical explanation for the relation between land prices and probably the most important influence factors, land rents and government payments, it also suffers sever shortcomings if transferred to an estimable empirical model for land price determination. First, since expected future streams of earnings are not observable, one has to either make strong assumptions or is lacking theoretical consistency. Second, the NPV model does not explain what determines land prices beyond expected future earnings and government payments. We have discussed that in the econometric adoption of the NPV model additional explanatory variables can be introduced as some shifters comparable to Goodwin et al.’s (2003) urban pressure indicators. If those shift variables are included, the empirical model based on the NPV approach and the one based on the hedonic pricing approach converge. They are based on different theoretical considerations, but lead to the same econometric regression models.

Subchapter 2.3 discusses how empirical studies used a broad range of variables to explain land prices. We tried to systematise those variables by splitting them into six groups: three groups reflect earnings from land: variables directly or indirectly measuring land rents and variables measuring government payments; three groups measure other influence factors: variables describing market structure, variables describing macroeconomic factors and variables describing pressure from non-agricultural land use.

Finally, in subchapter 2.4 we utilised a meta-regression analysis to investigate if different support policies reveal significantly different degrees of capitalization. Results show that capitalization elasticities of government payments (not distinguishing different types of payments), i.e., the percentage change in land prices, given a 1% change in payments, are somewhere in the range between 1/3 and 1/2. Hence, a decrease of 10% of support would decrease land prices by 3.3% to 5%. This result indicates that a considerable part of farm subsidies is realized by initial owners of land rather than operating farmers.

Our results of the meta-regression analysis are ambiguous and depend on applied estimation procedures. We find a significant difference in the capitalization elasticity for market price support and direct payments compared to average payments using a pooled OLS regression, but not in the other two models which account for non-independence of estimates. Hence, equal weights of observations in a pooled OLS could lead to an overrepresentation of market price support and direct payments compared to decoupled direct payments in the dataset. Moreover, we were not able to verify preceding theoretical results regarding the capitalization of decoupled government payments. Kilian et al. (2012) argue, that decoupled direct payments after the 2003 Reform of the CAP are capitalized into land values to a greater extent as did area and animal payments before, since now all payments are closely linked to land. Though, we derive a small positive coefficient for decoupled payments in all three models, they are not statistically significant. A reason for this result is probably the very small number of observations (9 in models I and II and 2 in model III) from only 5 primary studies (Goodwin et al., 2003; Goodwin et al., 2005; Goodwin et al., 2011; Latruffe et al., 2008; Kilian, 2010) which could verify this theory. Generally the coefficients in model III are less significant than in the other two what may be due to the small sample size.

Results show that model variables, data variables and structural variables have a significant impact on the estimated capitalisation elasticities with respect to government payments. For example, taking theoretically consistent land rents (returns to land) to explain land values, rather than a proxy like market revenues, leads to lower elasticities of capitalization. Hence, taking a proxy significantly overestimates the capitalization. The same is true for not including non-agricultural variables accounting for example for urban pressure. Neglecting these impacts results in a higher capitalization elasticity. In addition, we find a significant influence of the land type, the data type, and estimation techniques on the capitalization elasticity.

In regard to future research our study shows that our theoretical basis for land price models is still weak and needs further development. So far, only land rents and government payments are incorporated in the NPV model in a theoretically consistent way. An existing theoretical extension to non-agricultural use as developed by urban economists Capozza and Helsley (1989) is mostly ignored in the agricultural economics literature. Related to this issue is the spatial dimension of land markets. Though spatial econometric methods have been used in estimating land sales prices (e.g., Hardie et al., 2001; Pyykkönen, 2005) and land rental prices (e.g., Breustedt and Habermann, 2011), a consistent theoretical explanation why we empirically observe spatial dependency does not exist. Moreover, and maybe most important the supply side of the problem is usually ignored.

3 The Common Agricultural Policy and Agricultural Land Prices - A Spatial Econometric Approach for Bavaria

Abstract

We analyze 7,300 agricultural land sales transactions in 2001 and 2007 to identify factors influencing land prices in Bavaria. To account for the importance of space, we utilize a general spatial model with a spatial lag and a spatial error. Our findings confirm significant capitalization of government payments into land prices. A reduction of payments by 50 €/ha would decrease land sales prices by 849 €/ha (280 €/ha) in 2007 (2001). Hence, the 2003 Fischler Reform has increased the capitalization effect. Moreover, we find a strong influence of land productivity, urban pressure and land market structure on land sales prices.

Keywords

agricultural land prices, Common Agricultural Policy, spatial econometrics

JEL: Q15, Q18, C21

3.1 Introduction

It has been recognized by agricultural economists at least since the 1960s (e.g., Floyd, 1965) that government support programs may influence not only output markets but also factor markets. Land is of particular importance due to its fixed supply. The main question is the extent to which government support positively influences agricultural land values.

One of the first efforts in this area was Seagraves (1969), who empirically studied the influence of United States (US) tobacco allotment programs on agricultural land sales prices. More recently, Barnard et al. (1997), Goodwin et al. (2003; 2005; 2011), Shaik et al. (2005), and others have investigated the effect of production subsidies (deficiency payments) and different types of coupled and decoupled direct payments. While numerous studies on agricultural land sales prices exist for the US, literature that focuses on Europe remains scarce. Pyykkönen (2005) analyzed the impact of price support schemes and coupled direct payments on agricultural land sales prices in Finland. Duvivier et al. (2005) performed a similar analysis for Belgium and Latruffe et al. (2008) for the Czech Republic. Based on a meta-regression analysis of 23 studies (for the US and Europe), Feichtinger and Salhofer (2013) provide as a "best guess" that a 10% increase of government support payments will increase agricultural land sales prices by 3.3% to 5%.[4]

Two main empirical challenges in estimating a land price model are the endogeneity of explanatory variables and the spatial dimension of the market. The endogeneity problem is often caused by reducing the multifaceted interactions of demand and supply in land markets to a single reduced-form price equation, which results in simultaneity problems. Moreover, there is also an "expectation error." This form of measurement error arises when approximating farmers' true expectations of future returns using observed returns.

In regard to the second challenge, the spatial dimension of land leads to a limited spatial extension of farms and to regional land markets. A spatial lag model accounts for the fact that spatially closer land markets interact with higher intensity than more distant ones. Moreover, unobserved but spatially related factors (e.g., climate) may cause spatial correlation in the error terms. Neglecting endogeneity and/or spatial relationships can cause biased coefficient estimates.

[4] Feichtinger and Salhofer (2013) also provide an extensive review of the variables used in previous agricultural land price studies. Other related literature reviews on agricultural land prices and the capitalization of government support are Le Mouël (2003) and Latruffe and Le Mouël (2009).

To account for endogeneity, Goodwin et al. (2011) utilized an instrumental variable approach on land sales and rental prices. Kirwan (2009) did the same for rental prices. To account for spatial dependence, Huang et al. (2006) applied a spatial lag model in their analysis of Illinois land sales prices. In solving the problem of spatially correlated error terms, Hardie et al. (2001) and Patton and McErlean (2003) applied spatial error models in their land sales price analyses. To our knowledge, Breustedt and Habermann (2011), with their estimations of agricultural land rental prices in Lower Saxony (Germany), are the only ones who use a general spatial model including a spatial lag and a spatial error and at the same time account for endogeneity in explanatory variables. We use a similar approach and apply it to a rather unique data set of nearly all land sales transactions in Bavaria in 2001 and 2007.

Financial support has been granted to European Union (EU) farmers since the beginning of the 1970s. While the first 20 years were dominated by an intervention price (minimum price) system in combination with protectionist measures (prohibitive high tariffs), this changed under the MacSharry Reform in 1992. Direct payments, mostly coupled to land (area payments) and animal numbers (e.g., slaughter premiums), were introduced in addition to substantial cuts in intervention prices. This reform process was continued in the Agenda 2000 Reform. In 2003, the subsequent Fischler Reform introduced single farm payments (SFPs), which farmers receive by activating their SFP entitlements. Activation of entitlements requires the cultivation of a corresponding number of hectares of eligible land. Hence, SFPs are regarded as decoupled from production decisions, but not necessarily from land values (Kilian et al., 2012). If government support (direct payments as well as price policies or any other measure) is capitalized to some extent into land prices, a (substantial) share of this support is captured by landlords and initial land owners as windfall profits.[5] This contradicts the objective of the EU Common Agricultural Policy (CAP), and in particular of the most recent reforms, to target “support exclusively to active farmers” (European Commission, 2010, p. 3). Against this background, a major aim of this paper is to compare the capitalization of coupled direct payments before the 2003 Fischler Reform with the decoupled payments after the reform.

[5] While here we concentrate on land sales prices, the political interest in the degree of capitalization is boosted by the fact that a considerable share of agricultural land in the EU is farmed by tenants. Based on FADN (Farm Accountancy Data Network) data Ciaian et al. (2012) calculate these shares to be between 18% and 85% in EU-15 member states in 2007.

The paper proceeds as follows: the next subchapter derives a reduced form pricing equation for agricultural land, following Fingleton and Le Gallo (2008). In a second step, we apply a general spatial model empirically, combining a spatial lag model and a spatial error model, to a dataset of more than 7,300 actual arm's length transactions of agricultural land sales in Bavaria. Additionally, we consider endogeneity introduced by the spatially lagged dependent variable and by other explanatory variables.

3.2 Method

Following Fingleton and Le Gallo's (2008) model of real estate prices, we model the observed agricultural land sales price in a specific area as the outcome of the interaction between land supply and demand in an area and the interaction with land markets in neighboring areas. Specifically, the quantity of agricultural land demanded in area i (q_i) is modeled as a linear function

$$q_i = \alpha_0 + \alpha_p\, p_i + \alpha_w \sum_{j \neq i} W_{ij}^D p_j + \sum_{y=1}^{Y} a_y A_{y,i} + \omega_i \qquad (3\text{-}1)$$

where p_i (p_j) is the price of agricultural land in area i (j), W_{ij}^D is a row-standardized spatial weight matrix with zero elements for non-neighbors and zero elements in the diagonal, $A_{y,i}$ are Y demand shifting variables, such as soil quality or distance to the nearest market, ω_i is a stochastic error term with $\omega_i \sim iidN(0, \sigma_\omega^2)$, and all αs are coefficients to be estimated. In accordance with standard economic theory, we assume $\alpha_p \leq 0$. High prices for land in area j, which is in close proximity to area i, will reduce demand for land in that area j. As a consequence, some demand will be displaced from area j to area i. Hence, q_i is positively related to the weighted average of land prices in the surrounding areas ($W_{ij}^D p_j$) and $\alpha_w \geq 0$.

Analogously, the supply of agricultural land (q_i) in area i can be modeled as

$$q_i = \beta_0 + \beta_p\, p_i + \beta_w \sum_{j \neq i} W_{ij}^S p_j + \sum_{z=1}^{Z} \beta_z B_{z,i} + \zeta_i \qquad (3\text{-}2)$$

where W_{ij}^{S} is again a row-standardized spatial weight matrix, $B_{z,i}$ are Z supply-side shifters such as the share of rented land in a municipality,[6] ζ_i is a stochastic error term with $\zeta_i \sim iidN(0, \sigma_\zeta^2)$ and all βs are coefficients to be estimated. In accordance with standard economic theory, we assume $\beta_p \geq 0$. In contrast to the demand-side spillover effect, we assume a negative influence of the weighted average prices in the surrounding areas ($W_{ij}^{S} p_j$) on the quantity supplied in area i (q_i) because high prices in area j cause a displacement of supply from i to nearby j ($\beta_w \leq 0$). In practice, one can think of a larger farmer who prefers to sell a plot in a more expensive corner of his farm than another plot of equal quality in a cheaper corner.

Based on equations (3-1) and (3-2), and the simplifying assumption that $W^E = W^D = W^S$, we can derive a reduced form pricing equation

$$p_i = \gamma_0 + \gamma_w \sum_{j \neq i} W_{ij}^{E} p_j + \sum_{k=1}^{K} \gamma_k X_{k,i} + \varepsilon_i \qquad (3\text{-}3)$$

where $X_{k,i}$ are $K = Y + Z$ variables of demand and supply shifters and all γs are coefficients to be estimated, with $\gamma_0 = \frac{\alpha_0 - \beta_0}{\alpha_p + \beta_p}$, $\gamma_w = \frac{\alpha_w + \beta_w}{\alpha_p + \beta_p}$, $\gamma_k = \frac{\alpha_y}{\alpha_p + \beta_p}$ for demand shifters and $\gamma_k = \frac{-\beta_z}{\alpha_p + \beta_p}$ for supply shifters. Moreover because $\omega_i \sim iidN(0,\sigma_\omega^2)$ and $\zeta_i \sim iidN(0,\sigma_\zeta^2)$ it holds that $\varepsilon_i = \frac{\beta_P \omega_i - \zeta_i}{\alpha_p + \beta_p} \sim iidN(0,\sigma_\varepsilon^2)$. One recognizes equation (3-3) as the well-known spatial lag model of Ord (1975).

Although equation (3-3) accounts for spatial dependence, the potential problem of spatial autocorrelation in the disturbances remains. One reason is the possibility of spatially autocorrelated omitted variables, an inherent problem in land price analysis. To overcome this problem, spatial error processes are typically implemented into the error terms, with the spatial autoregressive model (SAR) and the spatial moving average model (SMA) being the most common specifications. In the SAR model, an assumed shock in area *i* is gradually transmitted to all other areas because all areas are connected to each other to some degree (global autocorrelation). In contrast, a shock is transmitted only to neighboring areas in the SMA model (local autocorrelation). Hence, the range of the effect

[6] Before selling the land, landowners often rent it out for some years. A larger share of rented land may indicate a high number of landowners willing to sell the land.

is much smaller (Anselin, 2003). It seems likely in the case of agricultural land markets that a shock in area i is transmitted to further distant units; therefore, we choose the SAR model for our error term. Moreover, this seems to be consistent with the (global) autoregressive process of our spatial lag formulation.

Including an SAR model, the error term of equation (3-3) becomes

$$\varepsilon_i = \gamma_e \sum_{j \neq i} W_{ij}^E \varepsilon_j + \upsilon_i \,, \tag{3-4}$$

where γ_e is the spatial error coefficient to be estimated, and υ_i is an uncorrelated error term $\upsilon_i \sim iidN(0,\sigma_\upsilon^2)$. While a spatial lag coefficient γ_w has a direct interpretation, a SAR model is implemented to obtain unbiased estimates.[7]

3.3 Data

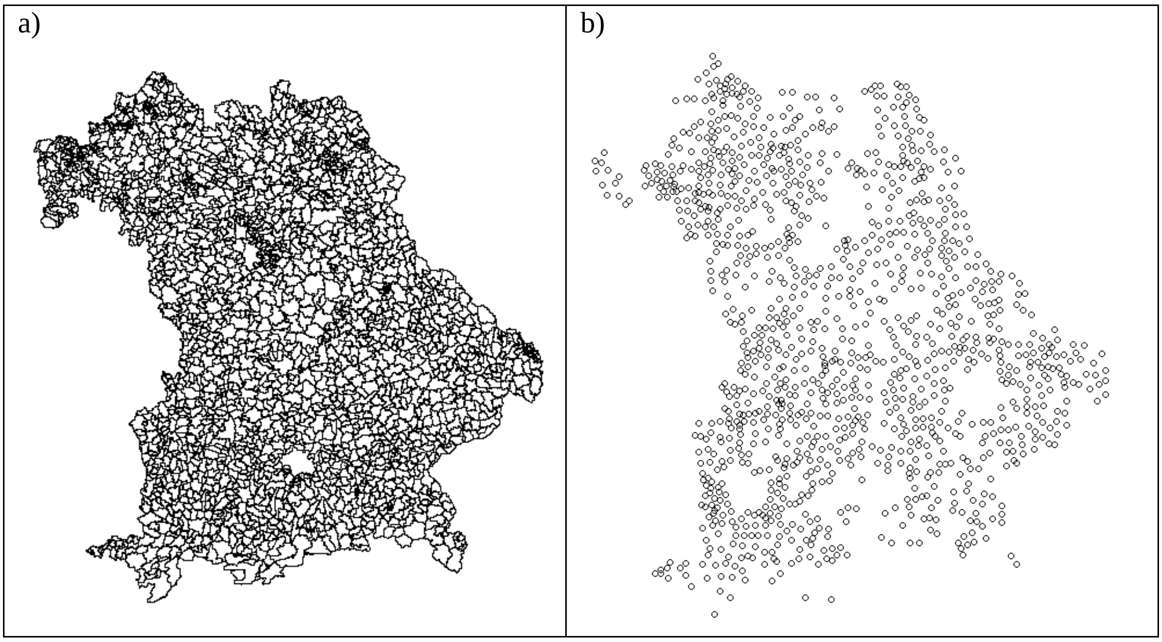
We utilize a comprehensive dataset of almost all arm’s length agricultural land sales transactions in Bavaria for the years 2001 (4,055 transactions) and 2007 (4,574). It includes transaction-specific information on sales price, soil quality, plot size, municipality affiliation and whether a public authority was involved as a seller or buyer. Farm takeovers from descendants are not captured in our data. The amount a successive farmer has to pay to other legal heirs as their compulsory portion of inheritance is usually considerably lower than the farm’s actual market value (van der Veen et al., 2002).

We exclude from our dataset plots already legally converted for housing development, land with a special use, such as excavation areas for gravel or sand, and land that also contains buildings. Furthermore, we try to exclude sales not primarily motivated by agricultural usage. Therefore, we do not consider transacted plots smaller than 0.25 ha. Such plots are more likely to inherit specific rights and easements (e.g., prospective non-agricultural land use) and this may result in price premia difficult to capture in our estimations given the information available. To account for other exceptional circumstances (e.g., agricultural land bought by non-farmers in a scenic area at a high premium or fictitious purchases between closely related persons), we exclude transactions

[7] LeSage (1999) and LeSage and Pace (2009) provide extensive reviews of different spatial models.

at prices lower (higher) than 2,000 (110,324) €/ha.[8] Additionally, we omit transactions with implausible values such as a soil quality index lower than 7 or higher than 85 or a price/soil quality ratio above 20.[9] Taking those restrictions into account, we are left with 7,369 observations for the years 2001 (3,539) and 2007 (3,830). On average, sales transactions took place in approximately 1,200 out of 2056 Bavarian municipalities per year. The shape of Bavarian municipalities and the location of municipalities where transactions took place in 2001 are shown in Figure 3-1. Across both years, at least one transaction took place in 1,567 different municipalities.

Figure 3-1: Bavaria with its municipalities (a) and municipality centroids where transactions took place in 2001 (b)



Source: Authors' presentation.

Descriptive statistics in Table 3-1 show that a plot of agricultural land sells on average for 22,642 €/ha (21,749 €/ha) in 2001 (2007). Public institutions, such as municipalities, are buyers in 22% (13%) of all transactions. Plots bought by the public are often dedicated to infrastructure development in the future or are handed over to a landowner as compensation for land dedicated to develop infrastructure. Public institutions act as sellers in 2.5% (3%) of the sales transactions. State and municipalities own agricultural land mostly for historical reasons. The share accounts for transactions of such land and for sales of plots left over from infrastructure development projects. The dataset does not

[8] Before excluding outliers the average sales price was 25,289 €/ha with a standard deviation of 28,345 €/ha including both years of observation. After accounting for outliers our average sales price drops to 22,198 €/ha with a standard deviation of 14,257 €/ha.

[9] In Germany an index system is used to indicate the soil quality of agricultural land. This index ranges from zero to 100 with values for Bavaria between 7 and 85 (Lfl, 2007).

allow us to distinguish between arable land and grassland, but we do have the soil quality index for each transacted plot available to account for differences in land quality. The soil quality index has an average value of 45.2 and varies between 7.2 and 84. The average transacted plot has a size of approximately 1.70 ha. This variable helps to test if economies of scale of larger plots outweigh higher potential difficulties in financing to purchase them.

Table 3-1: Descriptive statistics for 2001 and 2007 (after excluding outliers)

		No. obs*	Mean/share	SD	Min	Max
			2001			
Sales price	€/ha	3,539	22,642	14,332	2,044	102,260
Public buyer	%	3,539	21.87			
Public seller	%	3,539	3.33			
Soil quality index	pt.	3,539	45.19	13.07	7.18	84.00
Size of a transacted plot	ha	3,539	1.67	2.26	0.25	73.44
Direct payments	€/ha	1,211	261.28	92.21	7.36	469.03
Distance to the next urban center	km	1,211	29.01	14.14	1.00	80.61
Ratio building vs. agricultural land		82	9.43	11.12	2.11	198.24
Price of building plots	€/m^2	82	83.09	66.13	19.21	727.84
Share of rented agricultural area	%	82	44.25	10.47	12.75	77.66
			2007			
Sales price	€/ha	3,830	21,749	14,109	2,026	102,300
Public buyer	%	3,830	12.74			
Public seller	%	3,830	2.45			
Soil quality index	pt.	3,830	45.50	12.67	7.47	84.00
Size of a transacted plot	ha	3,830	1.76	1.94	0.25	31.76
Direct payments	€/ha	1,196	350.31	53.23	122.03	707.74
Distance to the next urban center	km	1,196	29.00	14.62	1.00	72.49
Ratio building vs. agricultural land		86	18.15	20.92	2.58	252.84
Price of building plots	€/m^2	86	71.74	50.01	16.07	331.17
Share of rented agricultural area	%	86	51.38	9.96	19.26	78.17

* A total of 7,369 transactions took place in 1,567 different municipalities and 92 different districts.

Source: Authors' calculations.

In addition to the information from our main data set on sales transactions, we add information at the municipality and district level. We use average direct payments in the respective municipality to account for the fact that agricultural subsidies may capitalize into land values to some extent. The year 2001 represents the time before the Fischler

Reform of the CAP in 2003 and hence includes mainly coupled area and animal payments. The year 2007 represents the time after the Fischler Reform with decoupled single farm payments. On average, producers receive 261 €/ha in 2001 and 350 €/ha in 2007 as direct payments. Low municipality averages, such as the minimum value of 7.36 €/ha (122 €/ha) in 2001 (2007), indicate a comparably high share of milk production on grassland, whereas high values, such as the maximum of 469.03 €/ha (707.74 €/ha), are a sign that arable farming in combination with intensive beef production are predominant.

To broaden the scope of our analysis, we add variables accounting for regional differences in urban pressure (distance to the next urban center, the ratio between the sum of building land sold in the respective year and the preceding two years vs. the farmed agricultural land in the respective year and the sales prices for building plots) and market structure (share of rented agricultural land in total agricultural land). A high ratio of sold building land and farmed agricultural land indicates a progressing urbanization and also a tight agricultural land market. Hence, we expect a positive relationship with land prices. Demand for agricultural land might be increased by farmers who recently sold building land (usually for high prices). Farmers are particularly interested in reinvesting their profits within the next years because that allows them to save on income tax. We relate this to the potential size of the market for agricultural land in the form of including the farmed agricultural land.[10]

3.4 Empirical Implementation

3.4.1 Spatial Weight Matrices and Spatial Tests

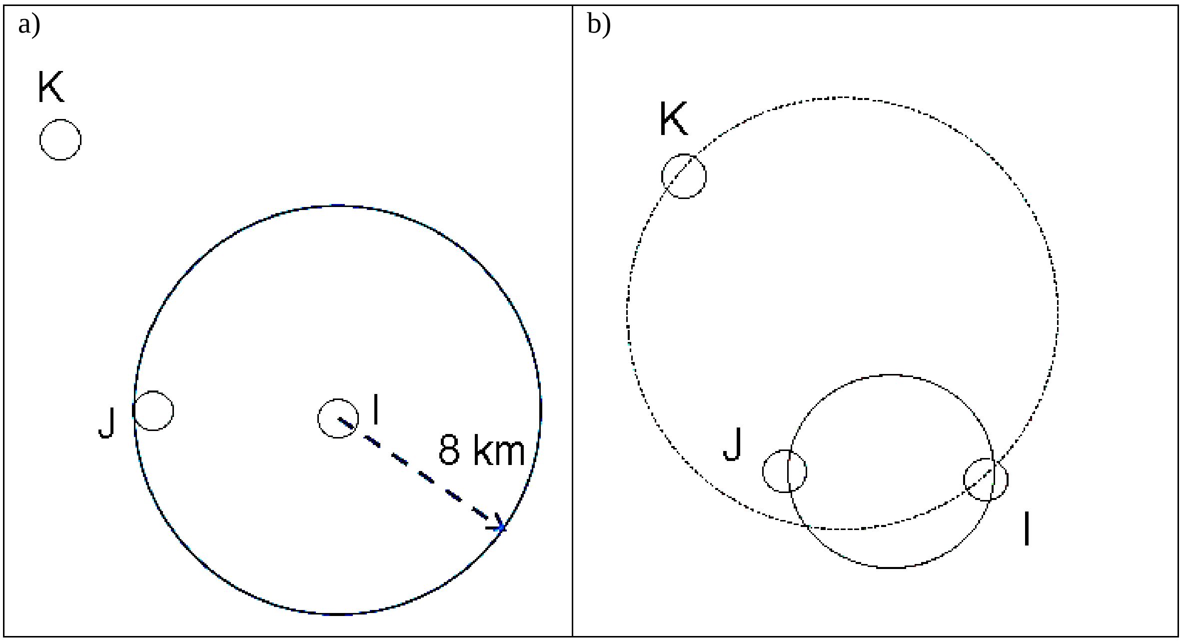
A crucial issue in every spatial econometric analysis is the ex-ante specification of the n x n spatial weighting matrix. The researcher has to determine exogenously what defines neighbors as well as the weights given to each neighbor. In our case, n is the number of transactions of agricultural land in a particular year. Because a land transaction cannot be a neighboring transaction of itself, diagonal elements of the matrix are zero, as are elements for all non-neighbors. In contrast, elements for neighbors are non-zero. In regard to choosing weights of neighbors, the two common approaches used are binary weights assigning a 1 to each neighbor and the inverse distance weight $1/d$, where d is the distance between two units. While in the first approach all neighbors are weighted equally,

[10] Mean and standard deviations of variables based on municipality and district averages are sample weighted because the 7,369 transactions are unequally distributed across municipalities.

geographically closer transactions are weighted stronger than more distant transactions in the second approach. We use binary weights as we lack information on the exact location of a transacted plot within a municipality. For the same reason, we assume municipality centroids as the location of any transacted plot in a municipality.

To determine whether transactions are neighbors, we use two different approaches (Figure 3-2a and Figure 3-2b).[11] In the first, a transacted plot is a neighbor (area *j*) of a transacted plot in question (area *i*) if the municipality centroid of area *j* (*J*) is within a circle of 8 kilometers from the centroid of area *i* (*I*). This is depicted in the left-hand side of Figure 3-2. In some municipalities, multiple transactions take place in one year. Because those transactions are clearly within a circle of 8 kilometers, they are also considered as neighbors. Though not necessarily closer in distance to the transaction in question, they are intuitively closely connected because the flow of information is most likely highest within a municipality.

Figure 3-2: Distance based (a) and Gabriel based (b) neighbor definition



Source: Authors' presentation.

In the second approach, illustrated in the right-hand side of Figure 3-2 and called a Gabriel graph, closed discs are drawn between municipality centroids. Areas *i* and *j* are considered as neighbors if the closed disc between their centroids (*I* and *J*) contains no other

[11] Practical advice in defining neighbors and creating weight matrices can be found in Bivand et al. (2008).

centroids.[12] None of the two definitions implies that *K* is a neighbor of *I*. While in the first case this is due to *K* being outside of an 8 kilometer circle, a closed disc between *I* and *K* containing *J* is the reason in the second case. When using a distance-based neighbor definition, approximately 20 transactions per year have to be dropped from our sample due to a lack of neighbors. The reasons are generally low numbers of sales transactions in the whole region or only a single transaction in a large municipality, with the next municipalities' centroids being further away than 8 kilometers. Advantageously, no transactions have to be dropped when the second approach is used because every area *i* has at least one neighbor area *j* per definition.

Based on those two approaches, we derive two different row-standardized weight matrices with every row summing to one, independent of the actual number of neighbors and whether weights are binary or inverse distances. This implies decreasing impacts of the single transaction with a rising number of neighbors. Moreover, a row-standardized matrix is not symmetric, and a transaction in area *j* may influence a transaction in area *i* differently than in the reverse case. Most importantly, a row-standardized form allows us to interpret the coefficient as the weighted average effect of land prices in the surrounding areas ($W_{ij}^{E}p_j$) on land prices in area *i* (p_i).

Although we give some theoretical justification for a spatial lag model in subchapter 3.2, we also statistically test for spatial autocorrelation in general utilizing a Moran's I test and for spatial autoregressive processes in the dependent variable as well as the residuals utilizing Lagrange Multiplier (LM) tests. In Moran's I tests, positive (negative) values indicate positive (negative) spatial autocorrelation, and values close to zero indicate no autocorrelation. According to Table 3-2, the H_0 of no spatial autocorrelation is rejected at the 99% level for all specifications.[13] To assess the specific form of spatial autocorrelation and to decide whether a spatial error or a spatial lag specification is more appropriate, LM tests are used most frequently. Burridge (1980) proposed a LM test for spatial autoregressive processes in the error term ($H_0\colon \gamma_e = 0$), while Anselin (1988) proposed a LM test for spatial autoregressive processes in the dependent variable ($H_0\colon \gamma_w = 0$).

Also in Table 3-2, depicted LM test results confirm spatial autoregressive processes in the residuals as well as the dependent variable. In such a case, the robust-test versions can be

[12] For an application of the Gabriel graph (first discussed in Gabriel and Sokal, 1969) we refer to Bivand and Brunstad (2006).
[13] A formula for Moran's I test is provided in Florax and de Graaff (2004).

used to determine which autoregressive process is predominant (Anselin et al., 1996).[14] Robust-test version results again confirm spatial autoregressive processes in the residuals as well as the dependent variable for all specifications. Hence, Moran's I and LM tests confirm (on empirical grounds) the use of a general spatial model as in equation (3-3), including a decomposed error term as in equation (3-4).

Table 3-2: Spatial distribution of land transactions as well as general and spatial test results

	2001		2007	
Weight matrix	Distance based	Gabriel	Distance based	Gabriel
No. of observations	3539		3830	
No. of municipalities	1211		1196	
Average no. of neighbors	15.32	18.50	16.06	21.07
Breusch-Pagan test for heteroskedasticity	79.40 ***		111.59 ***	
Jarque – Bera test on normality of errors	12.05 ***		85.99 ***	
Moran's I test	0.265 ***	0.246 ***	0.187 ***	0.155 ***
LM error	1,166.80 ***	1,564.58 ***	663.97 ***	729.21 ***
Robust LM error	142.64 ***	300.29 ***	55.43 ***	116.12 ***
LM lag	1,052.77 ***	1,304.67 ***	681.85 ***	699.13 ***
Robust LM lag	28.61 ***	40.38 ***	73.31 ***	86.04 ***

***p<0.01, **p<0.05, *p<0.10.

Source: Authors' calculations.

3.4.2 Endogeneity in Land Price Analysis and Testing for it

Endogeneity of an explanatory variable, i.e. correlation with the error term, causes biased Ordinary Least Squares (OLS) estimates. According to Wooldridge (2002), endogeneity usually arises for three different reasons: omitted variables, measurement error and simultaneity. In the context of our land price estimations, all three reasons may apply. First, omitted variables are prevalent in applied work. Second, we estimate a reduced-form equation of demand and supply in the agricultural land sales market as well as in related markets. Hence, a simultaneity problem may occur with variables such as the "share of rented agricultural area", the "price of building plots", and also "direct payments". The latter is usually positively correlated with land quality and therefore its price.

Third, and most prominent, land price models may be subject to a measurement error. More specifically, this occurs in the form of an expectation error as being one type of measurement error (Goodwin et al., 2003; Kirwan, 2009). Having incomplete foresight, buyers and sellers of agricultural land have to form some expectations about future market

[14] Formulae for LM tests can be found in Anselin (2001) and for their robust versions in Florax and de Graaff (2004).

returns and government payments. Because we cannot observe the expected values of these monetary streams (the relevant variable), we have to utilize actual values in our estimations and therefore run the risk of a measurement error. This will most likely attenuate the impact of these explanatory variables on land prices.

To detect endogeneity in our analysis and to find appropriate instruments to address this issue, we apply different tests for endogeneity and instrument weakness. The latter is carried out through evaluating the R^2 of the OLS estimates of the first stage of Two-Stage-Least-Squares (2SLS) instrumental variable regressions and the Cragg-Donald (1993) statistic, as proposed by Stock and Yogo (2001).[15] Based on this, we are able to find acceptable instruments for all of our right-hand side (RHS) variables except "public seller" and "public buyer". Therefore, we assume those variables to be exogenous because using weak instruments can lead to biased inferences in instrumental variable estimations. Moreover, this assumption seems reasonable.

For the remaining variables, we extensively test for endogeneity using different combinations of potentially endogenous variables and instruments in two testing procedures. First, we use a Durbin-Wu-Hausman test, as implemented in the software package Eviews 8, to test whether a subset of the endogenous variables is actually exogenous by running a secondary estimation where the test variables are treated as exogenous and by comparing the J-statistic of both estimations. Second, we perform a regression-based test as discussed in chapter 6.2.1 of Wooldridge (2002, pp. 119). In the first stage of this test, all potentially endogenous explanatory variables are regressed on all exogenous variables and all instruments. Subsequently, all residuals obtained in first-stage regressions are each included in separate land price estimations in a second stage. If and only if a residual vector added has no influence on land prices in the second stage estimations, the variable of interest is exogenous. This is commonly tested using a standard t-test, accounting for heteroscedasticity if necessary. We apply this test to all RHS variables (except "public seller" and "public buyer") in different combinations of instruments as well as potentially endogenous variables. We get a strong indication that the "soil quality index" is exogenous. This makes sense given that soil quality is defined by natural conditions that are completely exogenous to our system. However, it does not perfectly fit into the expectation error problem, as the "soil quality index" here serves to

[15] The Cragg-Donald statistic is only valid for 2SLS and other K-class estimators. However, our results of the 2SLS and the GMM estimations are very similar in all respects.

some extent as a proxy for expected future market returns. Moreover, we get mixed indication of endogeneity for the “ratio of building vs. agricultural land”. It is exogenous in 2001 but clearly endogenous in 2007. For all remaining variables, tests clearly indicate an endogeneity problem. Based on these results we decided to treat “public seller”, “public buyer” and the “soil quality index” as exogenous variables while all others were treated as endogenous. The Breusch-Pagan test and the Jarque-Bera test reject normally distributed error terms for both years and give some indication for heteroscedasticity.

3.4.3 Spatial Econometric Model and Instrumentation of Variables

Given all considerations above, our econometric model accounts for endogeneity and heteroscedastic innovations of an unknown form and can be written as

$$\boldsymbol{y} = \boldsymbol{Y}\pi + \boldsymbol{X}\beta + \rho\boldsymbol{W}\boldsymbol{y} + u \qquad (3\text{-}5)$$

$$u = \lambda\boldsymbol{W}\boldsymbol{u} + \epsilon \qquad (3\text{-}6)$$

where $\boldsymbol{y}$ is an $n \times 1$ vector of observations on the dependent variable; $\boldsymbol{Y}$ is an $n \times p$ matrix of observations on p RHS endogenous variables and π is the corresponding $p \times 1$ parameter vector; $\boldsymbol{X}$ is an $n \times k$ matrix of observations on k RHS exogenous variables, and β is the corresponding $p \times 1$ parameter vector; W is a $n \times n$ spatial weighting matrix, and ρ and λ are the corresponding spatial parameters; ϵ is a $n \times 1$ vector of independently but heteroscedastically distributed innovations (Drukker et al., 2011b).

The model is estimated utilizing a two-step estimation strategy as discussed in Kelejian and Prucha (e.g., 1999; 2010), Arraiz et al. (2010) and Drukker et al. (2011a) and as programmed in R by Piras (2010; 2013). Each of the two steps consists of alternating Generalized Method of Moments (GMM) and 2SLS estimators. To take endogeneity from the spatially lagged dependent variable into account, we follow Bivand and Piras (2013) and use all exogenous variables ($\boldsymbol{X}$; “public seller”, “public buyer”, “soil quality index”), their spatial lags ($\boldsymbol{WX}$) and squared spatial lags ($\boldsymbol{W^2X}$) as instruments. In considering endogeneity from the other explanatory variables and therefore to determine $\boldsymbol{Y}$, external instruments are added. In particular, those are two year lags of “direct payments”, the “share of rented agricultural area”, the “ratio of building vs. agricultural land”, a one-year lag of the “price of building plots” and municipality averages of the “livestock units per hectare”, the “size of agricultural land parcels” and the “standard gross margin per farm”. Similar to previous land price studies (e.g., Duvivier et al., 2005; Huang et al., 2006), we use our variables in their logarithmic form, except the share of rented agricultural area, which is in percent and the ratio of sold building land to total farmed agricultural land. However, for comparison reasons, we also estimated our land price model in a linear functional form without obtaining essential deviations from our results.

3.5 Results

Results for the heteroscedasticity-consistent spatial 2SLS/GMM estimator with an endogenous spatial lag and additional endogenous variables as described in the last subchapter are reported in Table 3-3 for 2007 and in Table 3-4 for 2001. In obtaining these results, distance-based spatial weight matrices were used. Highly significant spatial lag and spatial error coefficients in both years indicate the accuracy of our spatial model. Hence, we concentrate on the interpretation of the spatial estimation results, although we also report non-spatial White heteroscedasticity-consistent OLS and GMM estimates for comparison. A spatial lag coefficient of 0.24 (0.33) indicates that agricultural land sales prices in area *i* increase by approximately 0.24% (0.33%) when sales prices in surrounding areas increase by 1%. In addition, all other model coefficient estimates are highly significant except for the “distance to the next urban center” in 2001.

It is important to note that coefficient estimates in a spatial lag model cannot be interpreted analogously to those obtained from models without a spatial lag. For example, a coefficient of 0.1061 for the variable “size of a transacted plot” in 2007 only covers the “initial effect” of a change in the plot size. However, an increase in the plot size and a subsequent increase in agricultural land prices in area *i* will, in turn, spillover to all neighboring areas *j* through the spatial lag parameter and affect agricultural land prices in *j*.[16] Increased prices in area *j* cause a feedback effect, though smaller in size, in area *i*. This feedback effect is included in what is usually defined as the “direct effect” in a spatial model (LeSage and Pace, 2009). Hence, a direct effect gives the average impact over all regions (including feedbacks) of changing a particular explanatory variable in one region. While this might be the appropriate measure to reveal the effect of soil quality index or the size of the transacted plot on land prices, it is not appropriate to discuss the impact of government support payments on land prices because an altered support regime likely causes changes of direct payments in at least many (or most likely all) regions at the same time. Hence, we add the effect of changing direct payments in all neighboring areas *j* on

[16] Please note, because we assume a spatial autoregressive model, the shock spreads further from there.

area *i*, which is called the "indirect effect". "Total effects", obtained by summing direct and indirect effects, essentially report the total average effect of changing direct payments in all regions simultaneously on agricultural land prices.

Table 3-3: Regression results for 2007 using non-spatial OLS, GMM and spatial 2SLS/GMM with a distance based spatial weight matrix

		OLS	**GMM**	**spatial 2SLS/GMM**			
				coeff.	direct	indirect	total
Constant	*coeff.*	5.1998***	5.4920***	4.2916***			
	SE	0.3439	0.4346	0.5810			
Public buyer		0.3414***	0.3368***	0.3023***	0.3050***	0.0975***	0.4025***
		0.0254	0.0280	0.0264	0.0264	0.0317	0.0447
Public seller		0.2279***	0.2214***	0.2072***	0.2084***	0.0669**	0.2753***
		0.0501	0.0591	0.0528	0.0530	0.0280	0.0737
Soil quality index		0.7996***	0.7377***	0.6769***	0.6819***	0.2176***	0.8994***
		0.0306	0.0341	0.0367	0.0358	0.0674	0.0723
Size of a transacted plot		0.0275***	0.0926*	0.1061**	0.1073**	0.0341*	0.1415**
		0.0091	0.0522	0.0484	0.0481	0.0190	0.0640
Direct payments		0.2941***	0.4213***	0.2094**	0.2106**	0.0630***	0.2736***
		0.0610	0.0767	0.0864	0.0869	0.0265	0.1063
Distance to the next urban center		-0.0610***	-0.2410***	-0.1607***	-0.1611***	-0.0490***	-0.2102***
		0.0123	0.0376	0.0501	0.0503	0.0165	0.0599
Ratio building vs. agricultural land		0.1702***	0.1125***	0.1001***	0.1008***	0.0319***	0.1327***
		0.0142	0.0242	0.0264	0.0263	0.0125	0.0349
Price of building plots		0.1006***	0.0917***	0.0499**	0.0501**	0.0153***	0.0655**
		0.0153	0.0191	0.0229	0.0230	0.0078	0.0292
Share of rented agricultural area		-0.0169***	-0.0179***	-0.0132***	-0.0133***	-0.0041***	-0.0174***
		0.0009	0.0011	0.0017	0.0017	0.0011	0.0017
Spatial lag				0.2428***			
				0.0606			
Spatial error				0.1943**			
				0.0805			
Adjusted R-squared		0.4038	0.3547				

***p<0,01, **p<0,05, *p<0,10; SE = Standard Error.

Source: Authors' calculations.

Generally all coefficient estimates in Table 3-3 and Table 3-4 have the expected sign. Very interestingly, involvement of the public authority, either as a buyer or a seller of a plot, increases sales prices quite substantially. The impact at the mean sales price of € 21,749 in 2007 (€ 22,642 in 2001) is estimated to be 4,532 (5,376) €/ha if a public seller and 6,633 (4,963) €/ha if a public buyer is involved. Plots with public authorities involved in the transaction are probably more likely located in more densely populated areas and land is eventually contemplated to prospective infrastructure development. Another possible explanation for this phenomenon could be a downward bias of official land prices when only private parties are involved as buyer and seller to reduce taxes.

Furthermore, our analysis confirms the influence of agricultural factors such as land productivity, of variables describing the regional land market structure and of non-agricultural factors such as urban pressure on agricultural land prices. As expected, the soil quality index has a strong positive impact on land sales prices because it is a relatively direct measure of productivity. An increase in the soil quality index by 1% would increase the sales price by 0.68% (0.60%).[17] In other words, the difference in sales prices between two otherwise exactly equal plots, but one having the average soil quality index of approximately 45.5 (45.2) in 2007 (2001) and the other an index of 10 points higher, is 3,259 (2,985) €/ha. Analogously, evaluated at mean values and all other characteristics being equal, a plot of 3 ha in size is worth 1,638 (2,563) €/ha more than an average sized plot of 1.76 (1.67) ha. A positive influence of plot size makes sense due to lower transaction costs in the transfer and lower operating costs thereafter.

With regards to the influence of government support on land prices, we find that decreasing direct payments by 1% would lead to a decrease in land prices by 0.27% in 2007, but only by 0.06% in 2001. To put this in monetary terms, for land with an average sales value and with average direct payments of 350 €/ha in 2007 and 261 €/ha in 2001, a decrease of direct payments by 50 €/ha will cause the sales price to drop by 849 €/ha and 280 €/ha, respectively. These numbers clearly indicate an increased capitalization of government support payments into agricultural land prices in 2007 compared with 2001.

Agricultural land sales prices clearly increase with increased urban pressure. This is confirmed by the coefficients of all three variables: distance to the next urban center; ratio between sold building land and farmed agricultural land; price of building plots. First, an increase in the distance to the next urban center from an average of 29 (29) km by 10 km to 39 (39) km decreases the price by 1,208 (184) €/ha. Second, an increase in the ratio between sold building land and farmed agricultural land by 1% increases the sales price of land by 0.1% (0.1%). This positive relation can be justified in the following way: a high numerator indicates a high demand for building land, putting pressure on agricultural land

[17] In accordance with our discussion above, we use the direct effects to discuss the impact for all determinants except direct payments.

prices. Moreover, a high number of sold building parcels usually increases farm income and increases farmers' willingness to pay for agricultural land as reinvestment and to save on income tax. A low denominator indicates a potentially small agricultural land market, implying a higher price per hectare. Third, agricultural land use competes for land with other potential usages, in particular housing. Therefore, an increase of the sales price for building land from an average of 72 (83) €/m^2 to e.g., 82 (93) €/m^2 increases the sales price of agricultural land by 152 (336) €/ha.

Table 3-4: Regression results for 2001 using non-spatial OLS, GMM and spatial 2SLS/GMM with a distance based spatial weight matrix

		OLS	GMM	Spatial 2SLS/GMM			
				coeff.	direct	indirect	total
Constant	*coeff.*	6.9206***	6.2228***	3.9200***			
	SE	0.1618	0.2648	0.6384			
Public buyer		0.2562***	0.2822***	0.2156***	0.2192***	0.1050***	0.3242***
		0.0201	0.0220	0.0200	0.0198	0.0323	0.0394
Public seller		0.2605***	0.2891***	0.2341***	0.2374***	0.1140***	0.3515***
		0.0483	0.0529	0.0435	0.0438	0.0411	0.0729
Soil quality index		0.6487***	0.6121***	0.5868***	0.5957***	0.2865***	0.8822***
		0.0301	0.0327	0.0338	0.0335	0.0895	0.0980
Size of a transacted plot		0.0302***	0.2124***	0.1404***	0.1430***	0.0673**	0.2103***
		0.0100	0.0482	0.0525	0.0538	0.0309	0.0787
Direct payments		0.0616***	0.0970***	0.0441*	0.0444*	0.0201*	0.0646*
		0.0163	0.0179	0.0233	0.0234	0.0113	0.0331
Distance to the next urban center		-0.0890***	0.0341	-0.0236	-0.0236	-0.0112	-0.0348
		0.0130	0.0416	0.0459	0.0462	0.0237	0.0691
Ratio building vs. agricultural land		0.0502***	0.1689***	0.0957***	0.0973***	0.0457**	0.1430***
		0.0153	0.0246	0.0296	0.0298	0.0180	0.0430
Price of building plots		0.2055***	0.2343***	0.1215***	0.1234***	0.0565***	0.1799***
		0.0153	0.0218	0.0326	0.0328	0.0156	0.0404
Share of rented agricultural area		-0.0136***	-0.0166***	-0.0104***	-0.0106***	-0.0049***	-0.0155***
		0.0010	0.0013	0.0018	0.0018	0.0013	0.0023
Spatial lag				0.3290***			
				0.0710			
Spatial error				0.2835***			
				0.0740			
Adjusted R-squared		0.3191	0.2303				

***p<0,01, **p<0,05, *p<0,10; SE = Standard Error.

Source: Authors' calculations.

Finally, an increase in the share of rented land from an average of 51% (44%) by 10% points decreases the sales price by 2,884 (2,389) €/ha. A large rental share indicates a busy rental market and increases farmers' potential to acquire land through the rental market as a substitute to buying land. Comparing the estimates of our spatial model to those obtained from non-spatial OLS and GMM regressions shows that signs and significance levels are not markedly different, while coefficient values differ to some extent. Comparing the results for a distance-based weight matrix (Table 3-3 and Table 3-4) with those based on a Gabriel neighbor-weight matrix (Appendix Table A3 and Table A4) reveals slightly stronger spatial effects with other coefficients being relatively comparable.

3.6 Conclusions

The purpose of this study is to investigate the main determinants of agricultural land prices in Bavaria. We therefore empirically analyze a dataset of more than 7,300 arm's length agricultural land sales transactions in 2001 and 2007. In contrast to previous studies of land sales prices, we account for the spatial dimension of land markets and for the endogeneity of explanatory variables. Each of these issues can potentially lead to biased estimates. In regard to the first, we consider spatial dependence as well as spatial autocorrelation in the disturbances by combining a spatial lag model and a spatial error model to a general spatial model. With respect to the second, we apply a spatial 2SLS/GMM estimation strategy (e.g., Kelejian and Prucha, 1999; Kelejian and Prucha, 2010; Arraiz et al., 2010; Drukker et al., 2011a).

Earlier studies (e.g., Barnard et al., 1997; Duvivier et al., 2005) have empirically confirmed the influence of government support payments on agricultural land sales prices. We find a 1% reduction in EU direct payments decreases agricultural land prices by 0.27% in 2007 and by 0.06% in 2001. Evaluated at mean levels, a 50 €/ha reduction of direct payments would therefore imply land prices to decrease by 849 €/ha and 280 €/ha, respectively. Hence, we find a significantly higher capitalization of government support into land prices after decoupling of direct payments in course of the Fischler Reform in 2004. This is in line with theoretical considerations by Courleux et al. (2008), Ciaian et al. (2008) and Kilian et al. (2012), who argue that SFPs, though decoupled from production decisions, are by no means decoupled from land values because land is the crucial and limited factor to receive SFP. For land rental markets, Kilian et al. (2012) and Feichtinger et al. (2014) empirically confirm that the Fischler Reform increases the capitalization effect. Our results also contradict the objective of the CAP, and in particular of the most recent reforms, to target "support exclusively to active farmers" (European Commission, 2010, p. 3). Whether this reform is the only shock responsible for a larger capitalization of government payments in 2007 compared with 2001 needs further inquiry.

Apart from that, we find a substantial influence of land productivity, the regional land market structure and urban pressure on land prices. Furthermore, our spatial results show that land prices increase by approximately 0.24% when land prices in surrounding areas increase by 1%. Based on LfStat (2008; 2013) we find that approximately 0.20% of total Bavarian agricultural land was sold in 2007. This number does not change considerably over the years. Hence, in general, the share of agricultural land sold each year is relatively low. This might entail an unbalanced market structure with a small number of sellers and most likely multiple potential buyers. Accounting for this potential imperfect competition, and its implications on the determinants of agricultural land prices would be worth further investigation in the future.

4 The Influence of the Common Agricultural Policy on Land Rental Prices Considering Heterogeneous Land Quality

Abstract

This study investigates the impact of the Common Agricultural Policy's different support measures with respect to land rental prices and land allocation and explicitly considers heterogeneous land quality in its investigation. Thus, we develop a Ricardian land rent model and test our results empirically on a comprehensive dataset of bookkeeping records from more than 3,000 Bavarian farms. We are able to empirically confirm the theoretical results of significantly higher capitalization of single farm payments (SFPs) into land rental prices in regions with more favorable natural conditions compared with those with less favorable natural conditions (43 and 22 cents per additional euro of SFPs, respectively).

Keywords

agricultural land rental prices, Common Agricultural Policy, heterogeneous land quality, dynamic panel data model

JEL: Q15, Q18, C21

4.1 Introduction

Throughout its history, the European Union (EU) has devoted a considerable share of its budget to the support of farmers through the Common Agricultural Policy (CAP). After decades of price support in the form of intervention prices and coupled direct payments (e.g., area payments that were linked to farmed land), the Fischler Reform of 2003 introduced profound changes by switching to decoupled direct payments, the so-called single farm payments (SFPs). Farmers now own a specific number of SFP entitlements, which can be activated if the farmer owns or rents at least the same amount of eligible hectares of agricultural land. Given the considerable amount spent on this policy, it is of crucial importance to comprehensively understand the impact of CAP measures on input and output markets, farm development and on rural development as a whole. One particularly important question in this regard involves determining the extent to which CAP payments capitalize into land rental prices. When such capitalization occurs, at least part of the transfers simply represent windfall profits for landowners rather than support for active farmers, which clearly contradicts the objective of the CAP to target its "support exclusively to active farmers" (European Commission, 2010, p. 3).

In addition, this question is important because rental shares are at relatively high levels in a number of EU Member States. Swinnen et al. (2009) report that rented agricultural area comprised at least 60% of the total utilized agricultural area (UAA) in eight EU Member States (Slovakia, Czech Republic, France, Malta, Belgium, Germany, Hungary and Estonia in descending order) in 2005.

In light of the foregoing, the objective of our paper is to investigate the impact of CAP payments on land rental prices. Therefore, our work is related to other recent contributions addressing this issue. For example, the influence of coupled direct payments as applied before the Fischler Reform in Old EU Member States (countries joined the EU until 1995) and still present in the New EU Member States (countries joined the EU after 1995) was investigated by Patton et al. (2008), Breustedt and Habermann (2011) and Ciaian and Kancs (2012). Each of these studies finds empirical evidence of capitalization but at different levels.

Courleux et al. (2008), Ciaian et al. (2008) and Kilian et al. (2012) develop theoretical models to analyze the distributional effects of decoupled SFPs. All three papers conclude that SFPs have a considerable effect on land rental prices as long as the number of entitlements emitted is equal to or larger than the eligible hectares in a region or country. Thus, although SFPs are decoupled from production decisions, they are not decoupled from land.

The effect of SFPs on land rental prices has been investigated empirically by Kilian et al. (2012) for Bavaria, O'Neill and Hanrahan (2013) for Ireland, Guastella et al. (2013) for Italy and Michalek et al. (2014) for all EU Member States. Although Kilian et al. (2012) and O'Neill and Hanrahan (2013) find clear evidence that a considerable share of the payments is capitalized into land rental prices, Michalek et al. (2014) find much less evidence of such capitalization and Guastella et al. (2013) entirely reject the hypothesis of a significant capitalization of CAP payments before and after the Fischler Reform.[18]

We contribute to the current literature in two ways. First, we provide strong empirical evidence utilizing a comprehensive dataset regarding an issue that has not been finally decided upon. Second, we explicitly consider heterogeneous land quality in our theoretical and empirical analysis. Differences in the competitiveness and in the distributional effects among regions would ensue if the effect of CAP payments on rental prices changes with land quality. This latter consideration clearly distinguishes our work from the other studies discussed above.

We proceed in our analysis as follows: We first develop an analytical Ricardian land rent model to determine the capitalization of different types of CAP payments into land rental prices on a theoretical basis. We then introduce an outside option that allows us to examine the land allocation between different land uses under different policy settings. Finally, we empirically test our theoretical results regarding the capitalization of SFPs into land rental prices by applying a dynamic panel data model to an extensive dataset of more than 3,000 Bavarian farms over a seven-year period; however, we first discuss our empirical model and data, and we present our results afterward. We finish by drawing some conclusions.

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[18] In addition to the literature for the EU cited herein, there are also empirical studies regarding the effects of US agricultural policies on land rental prices (e.g., Roberts et al., 2003; Lence and Mishra, 2003; Kirwan, 2009; Qiu et al., 2010; Goodwin et al., 2011 and Hendricks et al., 2012). Moreover, there is also literature addressing the effects of agricultural policies on land sales prices. Latruffe and Le Mouël (2009) provide a comprehensive review of this issue.

4.2 Theoretical Model

Ricardo (1817) defines rent as "that portion of the produce of the earth, which is paid to the landlord for the use of the original and indestructible powers of the soil". Thus, Ricardian land rents—which Featherstone and Baker (1988) call residual returns—are the returns to land after the costs for all other factors of production are subtracted.

In our framework, a farm enterprise uses land (M) and an aggregate of non-land inputs (K) to produce one homogeneous output (Q) based on a Cobb-Douglas production technology. In addition to the amount of land and other inputs, land quality has an effect on output quantity. Following Lichtenberg (1989) we assume land quality j can be represented by a scalar that is normalized such that minimal land quality is zero and maximal land quality is one ($0 \leq j \leq 1$).[19] Thus,

$$Q = jK^{\alpha}M^{\beta} \qquad (4\text{-}1)$$

where α and β represent production elasticities.

Dividing both sides of equation (4-1) by M and assuming constant returns to scale ($\alpha + \beta = 1$), we derive,

$$q = jk^{\alpha}, \qquad (4\text{-}2)$$

where $q = Q/M$ is output per hectare and $k = K/M$ is non-land input per hectare. Given $\beta > 0$ and therefore $\alpha < 1$, equation (4-2) is no longer homogenous of degree one.

(Ricardian) land rent per hectare (R) is defined as per hectare revenues (of a specific land quality j) minus per hectare costs,

$$R = pjk^{\alpha} - rk, \qquad (4\text{-}3)$$

where p and r are exogenously determined prices of output and non-land inputs, respectively. Because land is the only fixed factor of production, equation (4-3) also

[19] Similar applications are found in Guyomard et al. (2006), Feng and Babcock (2010) and Martinet (2012).

represents restricted profits per hectare (π) , and therefore $\pi = R$.[20] Maximizing restricted profits by choosing the optimal input quantity k, we derive the input demand function for non-land inputs,

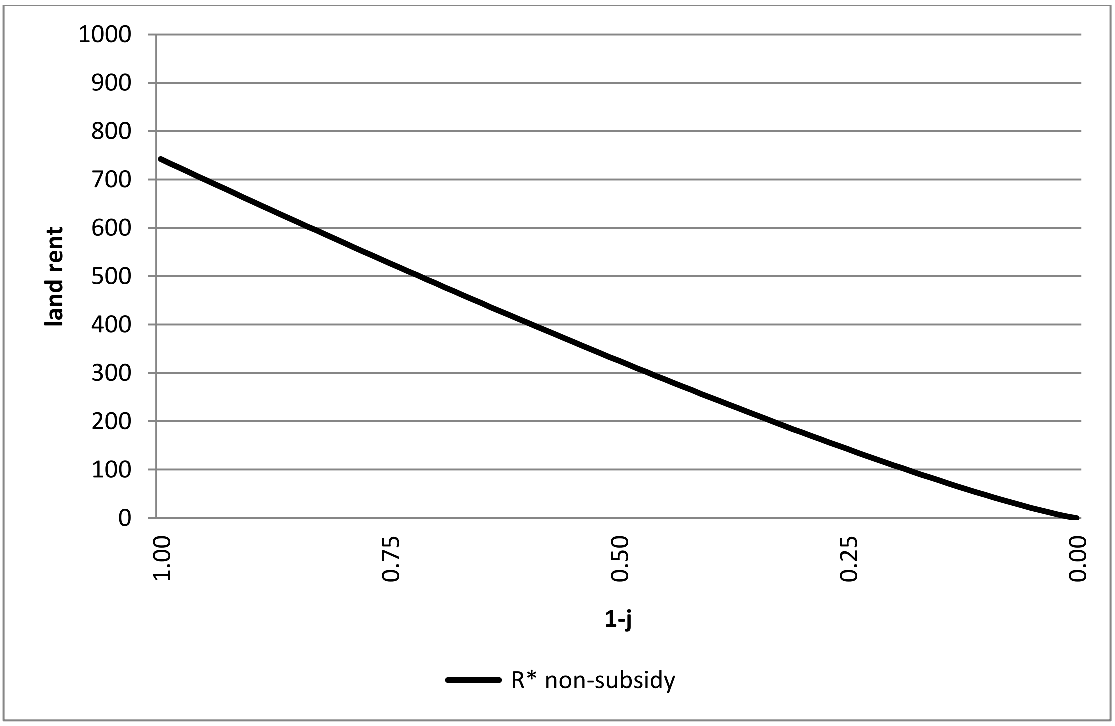
$$k^* = [(\alpha p j)^{-1} r]^{\frac{1}{(\alpha-1)}} \quad (4\text{-}4)$$

Substituting k^* into equation (4-3) gives us the per hectare "indirect" land rent function (R^*) or, equivalently, the per hectare indirect restricted profit function (π^*):

$$\pi^* = R^* = (1-\alpha)(p j r^{-\alpha} \alpha^{\alpha})^{\frac{1}{(1-\alpha)}} \quad (4\text{-}5)$$

In equation (4-5), land rents are determined solely by exogenous variables. Graphically, the land rent function for different land qualities can be drawn as "R^* non-subsidy" in Figure 4-1. For better illustration, the abscissa is labeled with $1 - j$, and therefore, land of maximum quality is located to the left of the graph.

Figure 4-1: Land rent function for different land qualities



Source: Authors' presentation.

[20] Please note that equation (4-3) represents restricted profits no matter if the farmer rents or owns land. In both cases land represents fixed costs. If a farmer has rented land, fixed costs are the per hectare rental price. If one farms his own land, fixed costs are the opportunity costs (forgone receipts) of not renting out the land.

Land rent is strictly positive in regard to land quality j, output price p and non-land input factor share α $\left(\frac{\partial R^*}{\partial j} > 0; \frac{\partial R^*}{\partial p} > 0; \frac{\partial R^*}{\partial \alpha} > 0\right)$ and strictly negative in regard to input price $\left(\frac{\partial R^*}{\partial r} < 0\right)$.

To evaluate the impact of different types of CAP instruments on land rents for different land qualities, the land rent function in equation (4-3) is extended for different policy instruments utilized in the CAP. The corresponding land rent function is given by

$$R^*_{sub} = (1-\alpha)(\bar{p}jr^{-\alpha}\alpha^{\alpha})^{\frac{1}{(1-\alpha)}} + s_l + js_h \quad (4\text{-}6)$$

Before the McSharry Reform in 1992, an intervention price (minimum price) was the most common instrument. Intervention prices were typically set to a level above world market prices by the Council of Agricultural Ministers of the EU. Thus, the price p in equation (4-3) becomes a policy instrument, depicted as $\bar{p}$ in equation (4-6).

One of the main features of the McSharry Reform was to lower intervention prices considerably and to introduce per hectare area payments. This reform process was continued in the Agenda 2000 Reform. Under the assumption that area payments are uniform across all areas, they can be modeled by s_l in equation (4-6).[21]

The 2003 Fischler Reform introduced decoupled SFPs in the EU-15 and SAPs in the New EU Member States. Although SAPs are equal to area payments s_l in our model, modeling the effect of SFPs is more complicated. Farmers receive SFPs by activating entitlements on eligible hectares (one entitlement per ha). Entitlement values were calculated on the basis of direct payments received in the 2000–2002 period (the reference period). However, in calculating entitlement values, EU Member States were allowed to choose between three different models: 1) In the *regional model* (Malta and Slovenia) initially proposed by the Commission, all payments received by the farmers of a certain region during the reference period were summed up and divided by the farmed hectares, which meant that entitlement values were equal within a region but different between regions; however, pursuant to the 2013 reform, all countries have until 2019 to converge to this model; 2) In the *historical model* (Austria, Belgium, France, Greece, Ireland, Italy, Portugal, Scotland, Spain, The Netherlands and Wales), all payments received by a farm

[21] This result was not exactly the case in reality because payments per hectare differed based on historical yields in each region.

during the reference period were summed up and divided by the farmed hectares; thus, entitlement values vary among farms; 3) The *hybrid model* (Luxembourg, Northern Ireland and Sweden) comprises a regional and a historical part; thus, entitlement values are also different among farms but most likely not as different as in the historical model. Some countries began with a hybrid model (Denmark, Finland, Germany and England), but use its dynamic form, i.e., they changed their models stepwise to regional models by 2013.

In theoretically analyzing the impact of SFPs' on land rental prices, Ciaian et al. (2008), Courleux et al. (2008) and Kilian et al. (2012) stress the importance of the following: i) the ratio between the number of entitlements and the available hectares of eligible area to activate them and ii) the implementation model (regional, historical or hybrid). Given the findings of Swinnen et al. (2009) and Salhofer et al. (2009), we only consider those situations in which the number of entitlements is at least equal to the hectares of eligible areas because these situations seem more common in most EU-15 countries—and particularly in Germany and Bavaria (the object of our empirical segment's investigation).[22] Courleux et al. (2008) and Kilian et al. (2012) argue that as long as the number of entitlements is at least equal to the hectares of eligible area, SFPs in the regional model are equivalent to area payments. Thus, s_l also represents SFPs in the regional model.

In contradistinction to SFPs in the regional model, SFPs vary among farms in the historical model. We assume a positive correlation between land quality and entitlement values. This assumption is rationalized by the following: In the course of the Fischler Reform, entitlement values were derived from per hectare averages of direct payments a farm received during the 2000–2002 reference period. The main components of direct payments during the reference period were area payments and slaughter premiums for fattening bulls.[23] Area payments were granted only for arable land and not for grassland. Arable farming and intensive bull fattening tend to be performed on higher quality land. In addition, compensation payments for intervention price cuts for sugar beets during the

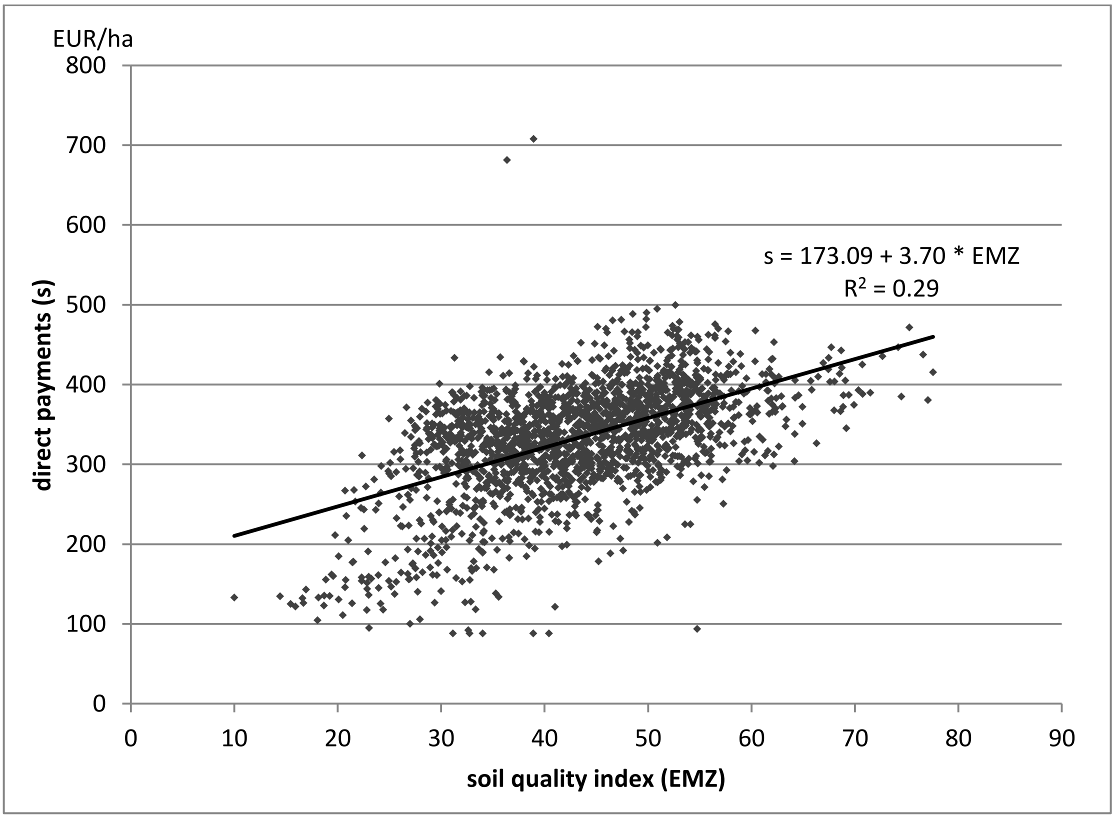
[22] Swinnen et al. (2009) report an entitlement surplus in Finland and reasonably balanced ratios in Belgium, France, Germany, Northern Ireland and Scotland. Moreover, they report a share of inactivated entitlements between 0.9% and 6.8% for all the countries in our study. The fact that not all entitlements are activated indicates a surplus. Salhofer et al. (2009) report a small entitlement surplus for Germany.

[23] At that time, area payments for cereals and corn and slaughter premiums for fattening bulls accounted for the largest share of CAP spending (Gay et al., 2005).

course of the sugar market reform in 2006 were also included in SFPs, and sugar beets are commonly grown on land with a higher quality.[24]

The positive relationship between land quality and SFPs is supported by Figure 4-2. Based on Bavarian data from 2007, it depicts the relationship between the soil quality averages in municipalities and direct payments using a scatter diagram and a regression line. To keep the analysis simple, we assume that SFPs depend on land quality in the form of js_h in equation (4-6).

Figure 4-2: Distribution of per hectare direct payments with respect to soil quality in Bavaria (municipality averages) in 2007 [25]



Source: Authors' presentation.

[24] For the sake of completeness, it must be noted that dairy farmers receive a dairy premium as the users of a considerable share of Middle Europe's grassland. In 2007, it was fully decoupled and equally distributed on farmed hectares.

[25] A "soil quality index" system is widely applied in Germany to describe the natural productivity of land for farming purposes. This "Ertragsmesszahl" (EMZ) ranges from zero to 100. The latter number defines land to be of highest quality.

Table 4-1 summarizes the effects of particular policy measures on land rents. The impact of intervention prices on land rent is positive ($\partial R^*_{sub}/\partial \bar{p} > 0$), and this effect increases with hectare productivity $\frac{\partial R^*_{sub}/\partial \bar{p}}{\partial j} > 0$. Thus, the marginal effect of an increase in the intervention price is greater on higher quality land, which is intuitive because the subsidy is calculated per unit of output, and hectare productivity is greater on high quality land. Area payments and SFPs in the regional model increase land rents by the same amount as the subsidy ($\partial R^*_{sub}/\partial s_l = 1$), and this outcome does not change with the quality of land. SFPs in the historical model also become fully capitalized into land rents ($\partial R^*_{sub}/\partial s_h = j$), but the increase depends on land quality j because the value of the entitlement does. Land quality will positively influence land rents, and this effect increases with land quality ($\frac{\partial R^*_{sub}/\partial s_h}{\partial j} > 0$). We aim to test this last finding in the empirical segment below.

Table 4-1: Comparative statics with respect to different types of CAP instruments and land quality

$\frac{\partial R^*_{sub}}{\partial \bar{p}}$	$(\bar{p}^{\alpha} j r^{-\alpha} \alpha^{\alpha})^{\frac{1}{1-\alpha}} > 0$
$\frac{\partial R^*_{sub}}{\partial s_l}$	1
$\frac{\partial R^*_{sub}}{\partial s_h}$	j
$\frac{\partial R^*_{sub}/\partial \bar{p}}{\partial j}$	$(1-\alpha)^{-1}(\bar{p} j r^{-1} \alpha)^{\frac{\alpha}{1-\alpha}} > 0$
$\frac{\partial R^*_{sub}/\partial s_h}{\partial j}$	1

Source: Authors‘ calculations.

Whereas this analysis is concerned with the effects of different CAP instruments on land rents under a given land use, farmers in most cases face more than one production possibility and therefore must decide how to allocate their land. To analyze the effect of different types of CAP payments under alternative land uses, we introduce an outside option, *o*. We assume that the per hectare land rent of this outside option is independent of land quality. Our model may describe in a stylized way, for example, the fact that high quality land can be used for crop farming where rents vary considerably with land quality and extensive grassland farming as an outside option where land quality does not play a (considerable) role. Beginning with two different land uses, this model can be extended arbitrarily.

We follow Lichtenberg (1989) and assume that the number of hectares with a particular land quality j is denoted by $g(j)$. For analytical convenience, the distribution is assumed to be uniform and continuous. Although the total amount of land available to a farmer is again fixed in the short run, the farmer can freely allocate land between the two options. Thus, the farmer maximizes total rents (or total restricted profits) (Π) by optimally allocating land between the two different utilizations. Let $0 \leq m \leq 1$ be the amount of land allocated to the outside option and $1 - m$ to the initial use; farmer's maximization problem then becomes,

$$\max_{j} \Pi = \int_0^m (o + js_h + s_r)\, g(j)dj + \int_m^1 ((1-\alpha)(\bar{p}jr^{-\alpha}\alpha^{\alpha})^{\frac{1}{(1-\alpha)}} + js_h + s_r + s_l)\, g(j)dj$$

$$= om + a\bar{p}^{\frac{1}{1-\alpha}} r^{\frac{\alpha}{\alpha-1}} \left[1 - m^{\frac{2-\alpha}{1-\alpha}}\right] + s_l(1-m) + s_r + \frac{s_h}{2} \qquad (4\text{-}7)$$

with $a = (1-\alpha)^2(2-\alpha)^{-1}\alpha^{\frac{\alpha}{1-\alpha}} \geq 0$. Recall that equation (4-6) introduced the same variable (s_l) for area payments and SFPs in a regional model. However, here we assume that the outside option is eligible for SFPs (s_r) in the regional model but not for area payments (s_l). This assumption is consistent with the CAP history in which area payments introduced with the McSharry Reform were only assigned to land devoted to the production of certain crops (such as cereals and corn), but not to other uses (such as grassland).

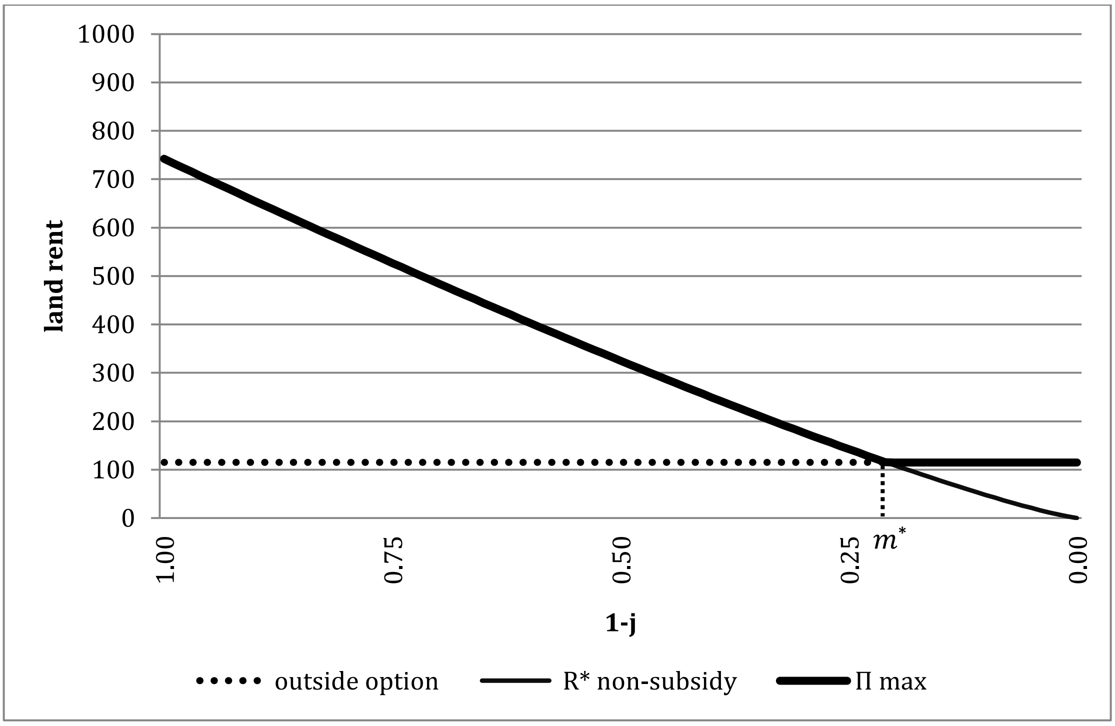
The m that maximizes total restricted rents in equation (4-7) is given by

$$m^* = \bar{a}(o - s_l)^{1-\alpha}\bar{p}^{-1}r^{\alpha} \qquad (4\text{-}8)$$

with $\bar{a} = \alpha^{-\alpha}(1-\alpha)^{\alpha-1}$.

Figure 4-3 shows the land rent function of our main land use (R^* non-subsidy) and of the outside option. The intersection of both functions determines the optimal land allocation. An outcome of $m^* = 0.21$ (as in our stylized) case indicates that 79% of the land is devoted to our main land use and 21% of the land is devoted to be used pursuant to an outside option.

Figure 4-3: Land allocation with an outside option



Source: Authors' presentation.

The behavior of m^* with respect to different exogenous variables is presented in Table 4-2. Whereas m^* increases with higher land rents from the outside option (o) and a higher price of non-land inputs (r), it decreases with higher area payments (s_l) and higher intervention prices ($\overline{p}$), which is true as long as $o > s_l$. In the reverse case, $o < s_l$, m^* would be zero in any event, and all land would be devoted to our main land use. Moreover, neither regional (s_r) nor historical (s_h) SFPs influence land allocation.

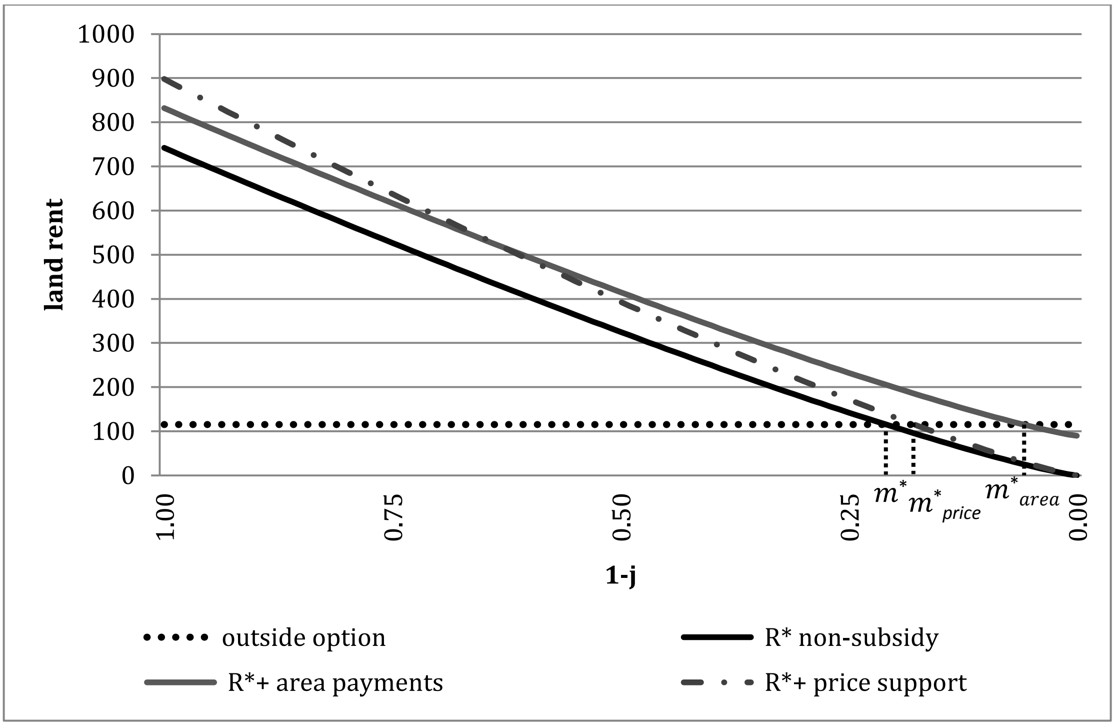
Table 4-2: Comparative statics of land use (m^*) with respect to different variables

$\frac{\partial m^*}{\partial o}$	$\overline{a}\,\overline{p}^{-1}\,r^{\alpha}\,(o - s_l)^{-\alpha}(1-\alpha) > 0$
$\frac{\partial m^*}{\partial r}$	$\overline{a}\,\overline{p}^{-1}\,r^{\alpha-1}\,(o - s_l)^{1-\alpha}\alpha > 0$
$\frac{\partial m^*}{\partial s_l}$	$-\,\overline{a}\,\overline{p}^{-1}\,r^{\alpha}\,(o - s_l)^{-\alpha}(1-\alpha) < 0$
$\frac{\partial m^*}{\partial \overline{p}}$	$-\,\overline{a}\,\overline{p}^{-2}\,r^{\alpha}\,(o - s_l)^{1-\alpha} < 0$

Source: Authors' calculations.

Figure 4-4 compares the land allocation after a change from a price support policy to area payments, which reflects the McSharry Reform to a certain extent. A price policy supports high quality land to a great extent. Therefore, the rent curve will rotate rather than shift. Rotation increases with a higher per-output price and a higher impact of land quality on productivity. By contrast, a uniform payment for each hectare will shift the rent curve. Therefore, area payments will tend to decrease the amount of land dedicated to the outside option (in our stylized case, from $m^* = 0.21$ or $m^*_{price} = 0.18$ to $m^*_{area} = 0.06$).

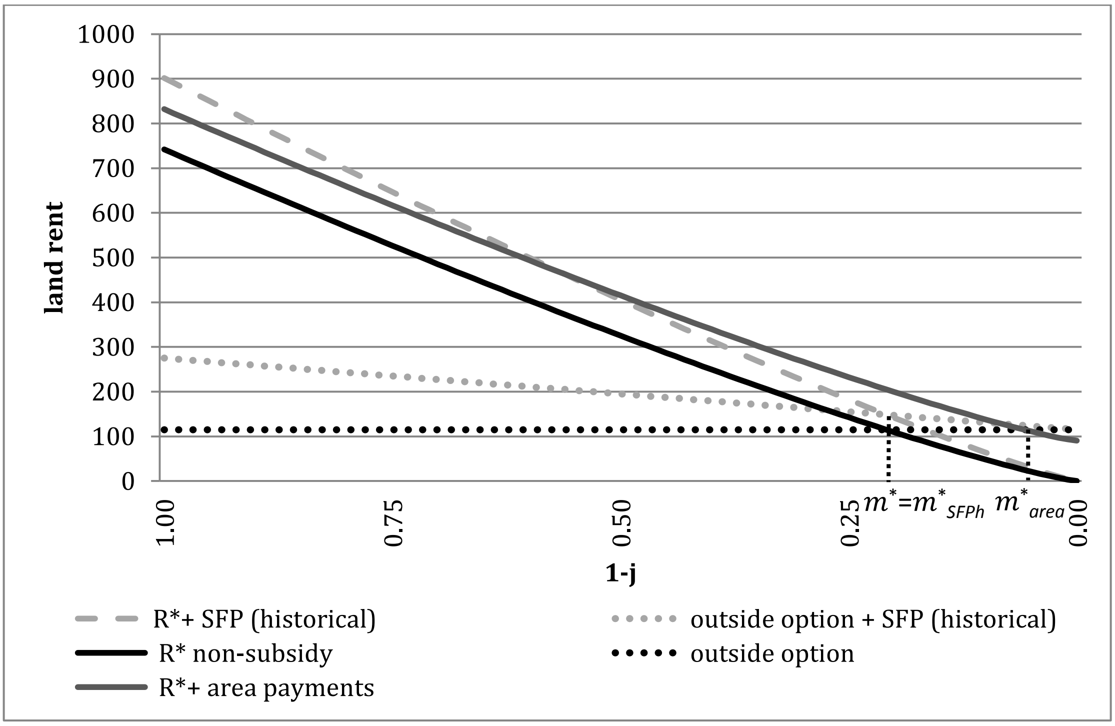
Figure 4-4: Impacts of the McSharry Reform on land allocation



Source: Authors' presentation.

As discussed above, during implementation of the Fischler Reform, EU-15 Member States were able to choose between a regional, a historical and a hybrid model. Figure 4-5 shows in a stylized way the impact of opting for a historical model on land allocation. Compared with the situation before the reform ($m^*_{area} = 0.06$), more land would be used via the outside option ($m^*_{SFPh} = 0.21$). It is important to note, that land allocation after the reform equals the non-subsidy case ($m^* = m^*_{SFPh}$). Thus, land allocation is not affected even if subsidization depends on land quality.

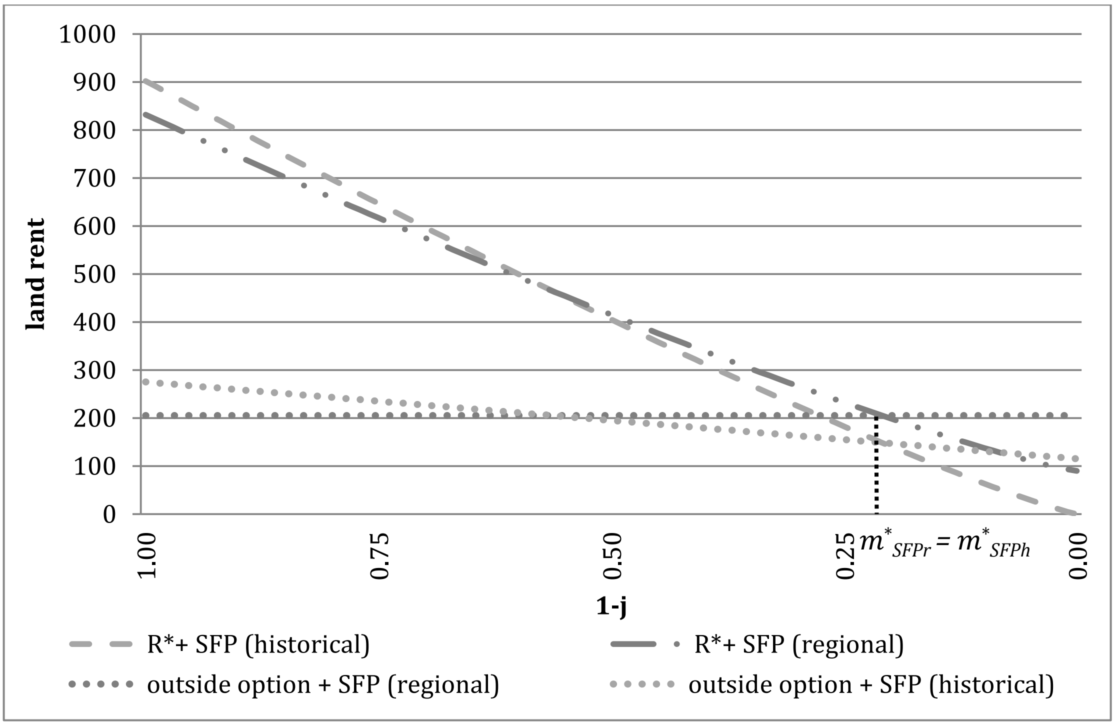
Figure 4-5: Impacts of the Fischler Reform on land allocation



Source: *Authors' presentation.*

Figure 4-6 compares land allocation in the historical model with the regional model, which is important for countries with a dynamic hybrid model (Denmark, Finland, Germany and England) in which the payments are gradually transformed from farm individual payments to regionally uniform payments. Moreover, the same process will occur in countries still operating under a historical model (Austria, Belgium, France, Greece, Ireland, Italy, Portugal, Scotland, Spain, The Netherlands and Wales). According to the CAP 2014–2020 program, it is mandatory for these countries to switch to a full regional model no later than 2019. However, our results indicate that land allocation is not affected by this transition ($m^*_{SFPh} = m^*_{SFPr} = 0.21$).

Figure 4-6: Impact of a transition to the regional model on land allocation



Source: Authors' presentation.

4.3 Empirical Model

According to our theoretical model, land rent and therefore rental prices (r) are mainly determined by net returns from the market (m) and government policy in the form of decoupled direct payments (s), for example. It can be argued that changes in m or s do not instantaneously change the rental price r because of multiple-year rental contracts and/or other forms of transaction costs causing inertia (Hendricks et al., 2012), which can be modeled in a simple form with Nerlove's (1958) partial adjustment model: $r_t - r_{t-1} = \rho(r^*_t - r_{t-1})$, with r^*_t being the equilibrium rental price and ρ being the adjustment coefficient. ρ = 1 represents a full (instantaneous) adjustment, whereas 0 < ρ < 1 implies a partial adjustment. With that in mind, we define a dynamic panel data model in the form of,

$$r_{it} = \gamma + \theta r_{it-1} + \gamma_m m_{it} + \sum_{l=1}^{L} \gamma_l \, s_{lit} + \sum_{e=1}^{E} \lambda_e \, x_{eit} + \sum_{t=1}^{T-1} \epsilon_t \, d_t + u_{it} \quad (4\text{-}9)$$

with $u_{it} = +v_i + \varepsilon_{it}$

where r_{it} is the average per-hectare rental price farm *i* pays during time period *t*. r_{it-1} is the rental price paid in the previous time period $t{-}1$, m_{it} are the net returns from the market, s_{lit} are the per-hectare averages of L different types of CAP payments a farm receives, x_{eit} are *E* covariates to control for observed farm specific conditions, d_t are $T{-}1$ time dummies to absorb year specific shocks (e.g., weather, key interest rate, …) that influence all farm operations and u_{it} is an error term. The two components of this error term, $v_i \sim IID(0, \delta_v^2)$ and $\varepsilon_{it} \sim IID(0, \delta_\varepsilon^2)$, are independent of one another and among themselves (Baltagi, 2013). $\theta = (1 - \rho)$, all γs, λs and ϵs are coefficients to be estimated. Whereas these coefficients capture short-run effects, long-run effects are calculated by dividing the respective coefficient by the adjustment coefficient $\rho = (1 - \theta)$.

The inclusion of the lagged rental price (r_{it-1}) in combination with unobserved heterogeneity (v_i) introduces two problems. First, due to the presence of the lagged dependent variable on the RHS we have autocorrelation because r_{it-1} is correlated with ε_{it-1}, ε_{it-2} etc. Second, r_{it} is a function of v_i, and because the same is true for r_{it-1}, it is also correlated with ε_{it}. Therefore, the OLS estimator is inconsistent and upward biased (Bond, 2002). Furthermore, Nickell (1981) showed that the within transformation does not solve the problem for the fixed-effects (FE) estimator. r_{it-1} remains correlated with $\bar{\varepsilon}_i$ because it includes ε_{it-1}. The estimator remains inconsistent as the number of individuals N increases, but becomes consistent as the number of time periods T grows larger (Roodman, 2009). The FE estimator is typically downward biased.

Alternative transformations to address unobserved individual effects include first-differences, $\Delta r_{it} = r_{it} - r_{it-1}$ (Anderson and Hsiao, 1982; Holtz-Eakin et al., 1988; Arellano and Bond, 1991) and forward orthogonal deviations, $\tilde{r}_{it} = r_{it} - \frac{1}{T-t)} \sum_{t+1}^{T} r_{it}$ (Arellano, 1988; Arellano and Bover, 1995). We concentrate here on first-differences, but the results for forward orthogonal deviations are presented in the Appendix. The transformed model can be written as,[26]

It is important to note that the lagged dependent variable $\Delta r_{it-1} = r_{i,t-1} - r_{it-2}$ and the error term $\Delta\varepsilon_{it} = \varepsilon_{it} - \varepsilon_{it-1}$ after this transformation remain correlated because $r_{i,t-1}$ is correlated with ε_{it-1}. However, as suggested by Anderson and Hsiao (1982), we are then able to use $\Delta r_{it-2} = r_{it-2} - r_{it-3}$ or r_{it-2} as instruments for Δr_{it-1} because they are not correlated with $\Delta\varepsilon_{it} = \varepsilon_{it} - \varepsilon_{it-1}$. Using instruments at their levels has the advantage of saving one time period. Anderson and Hsiao's (1982) two-stage least squares (2SLS) estimator is consistent as $N \to \infty$ but is only efficient if $T = 3$. In all cases of $T > 3$, efficiency can be improved. Although r_{it-2} is the only instrument available in period $t = 3$, the number of available instruments increases dynamically. For example, the vectors r_{it-2} and r_{it-3} can be utilized as instruments in period $t = 4$; in a general sense, $r_{it-2}, \dots, r_{iT-2}$ can be utilized in period T. Holtz-Eakin et al. (1988) and Arellano and Bond (1991) applied the generalized method of moments (GMM) approach developed by Hansen (1982) to exploit this additional information in dynamic panel data problems.

In our analysis, we apply Arellano and Bond's (1991) two-step GMM estimation approach that accounts for a heteroskedastic error structure. The GMM estimator is given by,

$$\hat{\sigma} = (\Delta X' Z W_N Z' \Delta X)^{-1} \Delta X' Z W_N Z' \Delta r \qquad (4\text{-}10)$$

with

$$W_N = \left(\frac{1}{N} \sum_{i=1}^{N} Z_i' \widehat{\Delta v}_i \widehat{\Delta v}_i' Z_i \right)^{-1}$$

Where $\sigma = (\theta, \gamma_m, \gamma_1 \dots, \gamma_l, \lambda_1, \dots, \lambda_e, \epsilon_1, \dots, \epsilon_{T-1})$ is a vector of parameters to be estimated, ΔX denotes the stacked N(T − 2)×(2 + L + E + T − 1) matrix of observations of $\Delta X_{it} = (\Delta r_{it-1}, \Delta m_{it}, \Delta s_{1it}, \dots, \Delta s_{Lit}, \Delta x_{1it}, \dots, \Delta x_{Eit}, d_t, \dots, d_{T-1})$, W_N is a weighting matrix and $Z = (Z_1, \dots, Z_N)$ is the stacked N(T − 2)×y matrix of observations of instruments with y as the numbers of moment conditions. In the weighting matrix $\widehat{\Delta v}_i$, there might be consistent estimates of the first-differenced residuals obtained from a preliminary consistent estimator, i.e., the first-step Arellano and Bond estimator.

[26] All estimations presented in this paper include time dummy variables in their levels. However, transforming them does not significantly alter our results.

By dynamically increasing the instruments, the model becomes overidentified. The basic specification test in this regard is the Sargan (1958)/Hansen (1982) test of overidentifying restrictions (or J test) for GMM, which can also be applied in this context (Arellano and Bond, 1991). To obtain a consistent estimator, Arellano and Bond (1991) stress the importance of no serial correlation in the levels and proposed a test for the lack of serial correlation based on the GMM residuals. In this regard, it is important to note that first-order serial correlation is apparent in estimation in differences by construction because $\varepsilon_{i,t-1}$ is part of $\Delta\varepsilon_{it}$ and of $\Delta\varepsilon_{i,t-1}$. Therefore, the assumption that there is no serial correlation in the disturbances $\varepsilon_{i,t}$ can also be confirmed by testing for the absence of second-order serial correlation in the first differenced residuals (Bond, 2002).

Apart from the discussion above, other potential sources of endogeneity remain.[27] For example, Kirwan (2009), Breustedt and Habermann (2011), Hendricks et al. (2012) and other studies stress the importance of expectation errors in land rental price analysis. Essentially being one form of measurement error, expectation errors arise because rental prices are negotiated before the growing season; with that, tenants must form some expectations about future market returns and CAP payments. As the true factor influencing rental prices, expectations are not observable to us, and therefore we must utilize actual values in our estimations. If actual values are different than expected values, biased coefficient estimates ensue. Because the value of SFP entitlements was exactly given and known for the 2005–2013 period, we do not anticipate any expectation error in this regard. However, this result might be different for market returns and an endogeneity problem might also occur with other explanatory variables. In general, one could use the same procedure of dynamic instruments as described by r_{it-1} for all other endogenous variables. Rather than testing for the endogeneity of different subsets as might be performed by a Durbin-Wu-Hausman test, we follow Baum et al. (2003) and use a difference-in-Sargan test to investigate the exogeneity of a subset of variables. In particular, the test uses the difference between two Sargan statistics: one for the (restricted, fully efficient) regression using the entire set of over-identifying restrictions and the other for the (unrestricted, inefficient but consistent) regression using a smaller set of restrictions in which a specified set of instruments is removed from the total set. Based

[27] In general, Wooldridge (2002) defines omitted variables, measurement error and simultaneity as the common sources of endogeneity. Transformations such as first differencing expediently eliminate an omitted variable bias associated with u_i (Baum, 2006). However, sources such as time-varying omitted variables remain.

on these tests, we finally assume that all explanatory variables are exogenous, except the lagged rental price.

4.4 Data

Our empirical model is applied to a comprehensive dataset of bookkeeping records from more than 4,000 Bavarian farms. This dataset forms the basis for the Bavarian part of the EU’s Farm Accountancy Data Network (FADN). In addition to land rental prices, the dataset includes information regarding land use, production, farm structure and the demographics of the persons involved in the farm operation. The sample is stratified with respect to legal form, farm type (agriculture, viniculture, horticulture and forestry), farm size and geographical region. However, very small farms and part-time farms are underrepresented. The reporting period is the financial year, which starts July 1 and ends June 30 of each year. We refer to the financial year 2005/06, for example, as the year 2005.

Historical SFPs were introduced in Germany in 2005. Beginning in 2010, all individual entitlement values were gradually transformed to a uniform value of € 354.55 in 2013. The transformation was progressive. For example, if a farmer owned an entitlement with a value of € 500 in 2009, it was decreased by € 144.46 over the next 4 years. In 2010, the value was decreased by 10% (€ 14.45), in 2011 by 20% (€ 28.89), in 2012 by 30% (€ 43.34) and 2013 by 40% (€ 57.78). If the initial entitlement value was less than € 354.55, it was gradually increased.

Table 4-3 presents descriptive statistics for the years 2005–2011. Our dependent variable is constructed in the following manner. Our dataset comprises information on farmed and owned land of each farm. We first subtract owned from farmed hectares to obtain a measure of net rented land. Subsequently, we divide a farm’s total expenditures for renting land by net rented land. To control for outliers and data problems, we cut off observations indicating specific farming or rental situations or unexplainably high or low values. In particular, we exclude farms specialized in viniculture, horticulture and forestry and those with negative rental prices and average rental prices of more than 3,000 €/ha. We also exclude farms with revenues greater than 12,000 €/ha. Moreover, farms are excluded when their CAP payments exceed 1,000 €/ha for SFPs, 2,500 €/ha for agri-environmental payments and 250 EUR/ha for disadvantaged area payments. Finally, we do not consider smallholder farming of less than five hectares of agricultural land and farms renting less than one hectare. To avoid gaps in our panel data, we completely exclude a farm from all estimations if one of the criteria discussed above is met in one particular year. Our final dataset is an unbalanced panel of 18,805 observations from 3,010 farms. Thus, the average farm reports data for 6.2 out of 7 years.

Table 4-3: Descriptive statistics for the total sample

	total sample			
Variable	**Mean**	**SD**	**Max**	**Min**
Rent (€/ha)	255.24	164.21	2,983.86	0.97
Market revenues (€/ha)	2,941.47	1,635.75	11,816.39	0.00
Single farm payments (€/ha)	350.13	94.82	997.31	0.00
Agri-environmental payments (€/ha)	61.24	80.96	699.27	0.00
Disadvantaged area payments (€/ha)	39.67	42.65	228.93	0.00
Ratio of cropland	0.66	0.32	1.00	0.00
Ratio of sugar beet area	0.02	0.05	0.49	0.00
Ratio of potato area	0.01	0.05	0.57	0.00
Ratio of corn area	0.04	0.10	0.97	0.00
Ratio of wheat area	0.15	0.15	0.94	0.00
Ratio rapeseed	0.05	0.08	0.90	0.00
Farm size	58.73	38.86	519.38	6.17
Ratio of owned land	0.45	0.24	0.98	0.00
Ratio of family labor	0.96	0.10	1.00	0.21
Dummy parttime	0.09	0.29	1.00	0.00
Dummy young farmer	0.13	0.34	1.00	0.00
Dummy female	0.03	0.17	1.00	0.00
Dummy agr. skilled farm operator	0.59	0.49	1.00	0.00
Dummy agr. high-skilled farm operator	0.32	0.47	1.00	0.00
Observations	18805			

SD = Standard deviation.

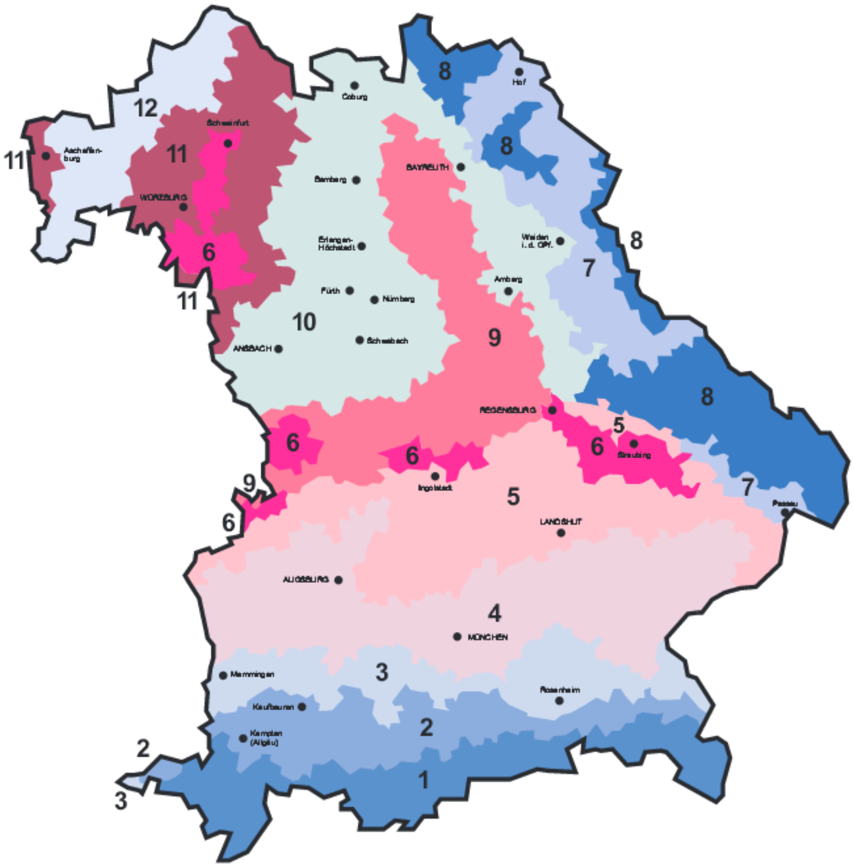
Source: Authors‘ calculations.

The average rental price is 255 €/ha. In accordance with our theoretical model, the rental price is determined by market returns and government payments. In regard to the first, we use market revenues, with an average value of 2,941 €/ha, as a proxy for market returns. Moreover, we include three types of CAP payments: SFPs, agri-environmental payments and disadvantaged area payments. Farms in our sample received an average of 350 €/ha of SFPs, 61 €/ha of agri-environmental payments and 40 €/ha of disadvantaged area payments.

We include two types of variables to account for farm heterogeneity. Ratios of cropland and specific crops (sugar beet, potato, corn, wheat and rapeseed) are used to describe at least to some extent a farm's specific natural production conditions. In addition, we account for different economic conditions of the farm and for the socio-economic conditions of the farm holder and her family. On average, the farms in our sample cultivate 59 hectares, own 45% of the farmed land and 96% of their labor comes from family members. Only 9% of the farm holders work part-time. We also include a dummy for farms operated by young farmers (13%) born later than 1970 and a dummy if the farm is operated by a woman (3%). Finally, we include two dummies that account for the educational level of the farmer. Whereas the default is not to have finished (yet) any specific agricultural education, the first dummy accounts for skilled labor and the second for further agricultural education.

We perform regressions for the entire sample and for two different subsamples to obtain empirical evidence about whether capitalization differs with respect to land quality. The criterion used to assign farms to a subsample consists of the eleven defined agricultural production regions in Bavaria (Figure 4-7). These regions are demarcated in Wittmann (1983) and LfB (1984) based on natural conditions (e.g., soil quality, altitude and climate) for farming in a specific area. Although our first subsample, “high quality land”, contains farms located in highly productive regions such as the tertiary hills and the Gäu (regions 3 - 6), the second subsample, “low quality land”, includes less favorable areas such as the Bavarian Alps (1) and its foothills (2), the Bavarian Forest (7, 8) and less productive areas in the north (11, 12). Not clearly belonging to either of the two subsamples, we omit farms located in agricultural regions 9 and 10 from our analysis.

Figure 4-7: Classification of Bavarian agricultural regions



Source: StMELF (2012) according to Wittmann (1983) and LfB (1984)

High quality land: Agricultural regions 3 – 6.

Low quality land: Agricultural regions 1, 2, 7, 8, 11 and 12.

Analogous to the descriptive statistics for the total sample, Table 4-4 describes the two subsamples of areas characterized by high and low quality land. As expected, rental rates, market revenues and SFPs are smaller, on average, in areas with low land quality. The opposite is true for agri-environmental payments and disadvantaged payments because in areas with less favorable natural conditions, a higher share of land is covered by these programs. Cash crops are clearly more important in regions with high quality land. However, excluding certain minor differences, farm characteristics are pretty comparable between regions.

Table 4-4: Descriptive statistics for subsamples of high quality and low quality land

	high quality land*				low quality land**			
Variable	**Mean**	**SD**	**Max**	**Min**	**Mean**	**SD**	**Max**	**Min**
Rent (€/ha)	352.60	181.95	2,983.86	0.97	207.01	124.33	2,065.98	3.84
Market revenues (€/ha)	3,605	1,834	11,816	13	2,625	1,343	11,648	0
Single farm payments (€/ha)	381.82	114.19	997.31	0.00	325.89	78.97	806.55	0.00
Agri-environmental payments (€/ha)	40.25	68.55	699.27	0.00	87.45	93.67	622.88	0.00
Disadvantaged area payments (€/ha)	5.76	13.09	112.82	0.00	71.91	46.75	228.93	0.00
Ratio of cropland	0.77	0.27	1.00	0.00	0.46	0.36	1.00	0.00
Ratio of sugar beet area	0.04	0.07	0.49	0.00	0.01	0.03	0.31	0.00
Ratio of potato area	0.02	0.07	0.57	0.00	0.00	0.02	0.41	0.00
Ratio of corn area	0.09	0.15	0.97	0.00	0.00	0.02	0.50	0.00
Ratio of wheat area	0.23	0.15	0.93	0.00	0.07	0.12	0.93	0.00
Ratio rapeseed	0.04	0.08	0.62	0.00	0.04	0.07	0.59	0.00
Farm size (ha)	56.87	37.55	519.38	6.17	54.77	36.52	352.60	11.10
Ratio of owned land	0.50	0.24	0.98	0.00	0.45	0.23	0.98	0.00
Ratio of family labor	0.95	0.13	1.00	0.21	0.98	0.08	1.00	0.21
Dummy part-time	0.09	0.28	1.00	0.00	0.06	0.25	1.00	0.00
Dummy young farmer	0.14	0.34	1.00	0.00	0.13	0.34	1.00	0.00
Dummy female	0.03	0.16	1.00	0.00	0.03	0.17	1.00	0.00
Dummy skilled operator	0.59	0.49	1.00	0.00	0.62	0.49	1.00	0.00
Dummy highly-skilled operator	0.31	0.46	1.00	0.00	0.31	0.46	1.00	0.00
Observations	6917				6788			

SD = Standard deviation.
* High quality land: Agricultural regions 1 – 6;
** Low quality land: Agricultural regions 1, 2, 7, 8, 11 and 12.

Source: Authors' calculations.

In our estimations, we also utilize rental prices for 2000–2004 as additional instruments in our regression analysis.

4.5 Results

The results for the two-step dynamic GMM (Arellano-Bond) estimator are depicted in Table 4-5. According to the p-value of an Arellano-Bond test, the null hypothesis of no first-order serial correlation is rejected (as expected). However, the hypothesis of no second-order serial correlation in first difference residuals cannot be rejected. Therefore, the essential assumption in the Arellano-Bond model that the disturbances are serial uncorrelated seems to hold. Moreover, according to the results of the Sargan test, the null hypothesis that the over-identifying restrictions are valid cannot be rejected. Thus, loosely spoken, there is no evidence for any misspecification.

The coefficient with respect to the lagged variable is significant but relatively small (0.05), which indicates a high adjustment coefficient (ρ = 0.95) and implies a relatively fast adjustment of rental prices to changes in market conditions or subsidies, for example. In fact, our adjustment coefficient is considerably higher than the 0.33 of Hendricks et al. (2012) for Kansas and the values between 0.3 and 0.49 as estimated by O'Neill and Hanrahan (2013) for Ireland. Rental prices in Bavaria increase in the short-run by 0.9 cents per additional euro of market revenues. Therefore, we can calculate the slightly higher long-run effect as 0.9/(0.95) = 1 cent per additional euro of market revenues.

Most importantly, we find that land rental prices are significantly influenced by CAP payments. According to our results, every additional euro given as SFPs to farmers increases land rental prices by 32 (31) cents in the long-run (short-run), which is within the range of 21 to 53 cents per euro SFP as obtained by O'Neill and Hanrahan (2013) for different farming systems (e.g., dairying, cattle, sheep, ….). They are also of similar magnitude as the 37 cents per additional Dollar of aggregated payments obtained by Hendricks et al. (2012).

Our results are lower than the capitalization rates obtained by Kilian et al. (2012) and Feichtinger et al. (2014); and each of these also investigated Bavarian land rental prices. The first use cross-sectional municipality level data and find that 61 cents per additional euro of SFPs will capitalize into land rental prices; in contrast to them the second use a static panel data approach and find a capitalization rate of 47 Cents. Michalek et al. (2014) use a generalized propensity score matching approach and apply it to an extensive dataset that includes all EU Member States to find comparably low average capitalization rates between 4% (Greece) and 18% (Portugal). However, these capitalization rates vary considerably between 3% and 94% for different SFP levels and among different EU Member States. In contrast to our results and those of the studies mentioned above, Guastella et al. (2013) are not able to find any significant influence of SFPs on Italian land rental prices.

Furthermore, agri-environmental payments capitalize with 5 cents per euro in the long-run, which is a considerably lower extent of capitalization into land rental prices than SFPs that can be rationalized by the fact that the main purpose of these payments is to compensate for additional costs that arise in the course of providing environmental services. Moreover, this result is consistent with results obtained in earlier studies. For example, Lence and Mishra (2001) do not confirm US Conservation Reserve Program payments to influence cash rental rates in Iowa. Kilian et al. (2012) find a negative influence of agri-environmental payments on land rental prices. O'Neill and Hanrahan (2013) obtain coefficient estimates near zero for EU second pillar payments. The latter consist of agri-environmental payments and spending on rural development.

Table 4-5: Dynamic GMM (Arellano-Bond) and fixed effects OLS results for the total sample

	total sample					
	dynamic GMM (Arellano-Bond)			**fixed effects**		
Variable	coeff.		SE	coeff.		SE
Constant				-310.225	***	62.393
Lagged rent (€/ha)	0.050	***	0.017	0.034		0.040
Market revenues (€/ha)	0.009	***	0.002	0.013	***	0.002
Single farm payments (€/ha)	0.306	***	0.040	0.421	***	0.054
Agri-environmental payments (€/ha)	0.044	*	0.026	0.066	**	0.032
Disadvantaged area payments (€/ha)	0.357	***	0.099	0.433	***	0.119
Ratio of cropland	52.041		40.903	131.920	**	58.084
Ratio of sugar beet area	443.003	***	92.513	325.579	***	101.452
Ratio of potato area	379.419	***	115.817	342.038	**	144.267
Ratio of corn area	124.456	***	36.102	73.410	**	30.895
Ratio of wheat area	92.077	***	18.005	75.742	***	24.421
Ratio rapeseed	79.547	***	21.114	68.838	***	24.858
Farm size	4.785	***	0.765	3.230	***	0.695
Farm size squared	-0.011	***	0.002	-0.007	***	0.002
Ratio of owned land	476.163	***	65.694	257.630	***	53.972
Ratio of family labor	-32.543	*	19.227	-26.526		23.301
Dummy parttime	0.739		21.616	27.652		26.446
Dummy young farmer	67.422	***	19.359	44.863	**	17.620
Dummy female	66.313	**	26.269	38.845		29.241
Dummy skilled operator	-22.760		18.735	-35.278	*	20.949
Dummy highly-skilled operator	-3.044		20.773	-7.514		21.171
Farms	3,010			3,010		
Observations	15,709			16,085		
Cross-section fixed effects	First differences			Dummy variables		
Period fixed effects	Dummy variables			Dummy variables		
Adjusted R-squared				0.80		
Instrument rank for J-statistic	55.00					
Sargan test – Prob. (J-statistic)	0.872					
Arellano-Bond test – Prob. AR(1)	0.000					
Arellano-Bond test – Prob. AR(2)	0.514					

***p<0,01, **p<0,05, *p<0,10; SE = Standard Error; Time dummys are suppressed for brevity.

Source: Authors' calculations.

By contrast, our capitalization rates for disadvantaged area payments are considerably higher at 38 cents per additional euro over the long run. We explain this large difference by the fact that no significant obligations are tied to such payments. Our results are somewhat higher than the 19–29 cents of Kilian et al. (2012), slightly lower than the results of Feichtinger et al. (2014), but much lower than the result of Patton et al. (2008), who report a full capitalization of disadvantaged areas payments.

We use several crop ratios to describe differences in land productivity. As expected, all these variables reveal positive coefficients because these crops are typically planted on relatively productive soil in climatically and topographically advantaged regions; this set of circumstances is particularly true for sugar beet and potato. However, these coefficient estimates might also include policy effects because both crops were highly subsidized. Moreover, demand for corn increased considerably in the last decade as a result of increased installation of biogas plants.

Apart from that, our results reveal that rental prices are significantly influenced by the size of a farm, as measured by its UAA. Although the direct effect is positive, the second-order effect is negative and indicates a reverse U-shaped relation. This can be explained by two countervailing effects: i) economies of scale posit that profitability increases with size; and ii) farming occurs in space, and with that an increased size implies nonlinear transportation costs within a farm. We find the reversal point at which paid rental prices begin to decrease with size at 217 ha. Furthermore, an additional percentage point of owned land as a share of total farmed land increases land rental prices by 5.02 €/ha. Farms with a high share of owned land most likely face fewer financial constraints and can pay a higher price. Alternatively, a high ratio of owned land might indicate limited availability of rental area for the farm.

In addition, we are not able to confirm the influence that the ratio of family labor has on land rental prices in most of our regressions, which might be due to a lack of sufficient variation in our data because family labor is prevalent in Bavarian agriculture. Moreover, we are not able to report significant differences in rental prices when farms are operated only as part-time facilities. This type of finding is notable because there is some evidence in the literature that part-time farmers are less efficient than full-time farmers (e.g., Alvarez and Arias, 2004). If this circumstance is representative, our result might indicate a cross-subsidization of agriculture from non-agricultural income sources because otherwise part-time farmers would not be able to bid up to the offers of full-time farmers.

All other things equal, rental prices paid by young farmers are 71 €/ha higher than those paid by the rest over the long run. At the beginning of their careers, young farmers tend to invest in their farms more rapidly and therefore might operate proactively in the rental market. Our results also indicate that female farm operators pay a higher rental price than their male counterparts. Finally, we are not able to confirm significant differences in rental prices with respect to the level of agricultural education. Table 4-5 also presents the results of the FE model. As expected, the lagged variable is downward biased. All variables share the same sign with their GMM counterparts. Capitalization effects are slightly higher, but otherwise the results are relatively similar.

Table 4-6 represents the results for the two-step dynamic GMM (Arellano-Bond) estimator for our two subsamples of areas with high and low quality land. Again, the assumption that the disturbances are serial uncorrelated cannot be rejected for both samples. The same is true for the null hypothesis that the over-identifying restrictions are valid.

Notably, the adjustment coefficient $\rho = (1 - \theta)$ is 0.85, compared with 0.97 it is smaller for rental prices in areas with lower quality land. In other words, it takes land rental prices a longer timeframe to adjust to shocks on low quality land than on high quality land. This finding might be explained by differences in rental contract durations.

As predicted by our theoretical model, SFPs capitalize to a much more significant extent into land rental prices in regions with comparably favorable natural conditions: in the long-run at 43 cents per euro on high quality land and at 22 cents on low quality land. The results for agri-environmental payments are similar in both samples. Whereas disadvantaged area payments do not play an important role in areas with high quality land, they are capitalized at 48 cents per euro on low quality land.

Most coefficients for crop ratios are highly significant in areas with high quality land and much less significant in areas with low quality land, which partly reflects their small shares in areas with low quality land. The coefficients of all other farm specific variables are partly different in their value but are similar with regard to their signs and significance.

For comparison reasons, we also apply the dynamic GMM estimations that utilize forward orthogonal deviations as a transformation method to the total sample and the two subsamples (Table A5). In the case of forward orthogonal deviations, the Arellano-Bond test for lack of serial correlation does not exist. However, based on the Sargan test, we cannot reject the null hypothesis that the over-identifying restrictions are valid. The results are similar to the first differenced model. The most important deviation is most likely that the capitalization of disadvantaged area payments is even higher than in the first difference model.

Table 4-6: Dynamic GMM (Arellano-Bond) results for the subsamples of high quality and low quality land

	dynamic GMM (Arellano-Bond)					
	high quality land			**low quality land**		
Variable	coeff.		SE	coeff.		SE
Lagged rent (€/ha)	0.028	*	0.016	0.149	***	0.035
Market revenues (€/ha)	0.008	***	0.003	0.008	***	0.003
Single farm payments (€/ha)	0.416	***	0.066	0.189	***	0.036
Agri-environmental payments (€/ha)	0.060		0.057	0.054	*	0.030
Disadvantaged area payments (€/ha)	0.231		0.358	0.408	***	0.104
Ratio of cropland	109.563		70.945	18.727		43.575
Ratio of sugar beet area	436.217	***	98.184	256.349	**	119.801
Ratio of potato area	440.910	***	141.868	123.052		176.614
Ratio of corn area	121.260	***	38.619	-126.223	*	73.424
Ratio of wheat area	123.080	***	30.256	58.803	**	23.110
Ratio rapeseed	90.269	***	34.605	54.442		51.106
Farm size	5.111	***	1.547	5.000	***	0.742
Farm size squared	-0.013	***	0.005	-0.012	***	0.002
Ratio of owned land	490.105	***	77.916	385.290	***	56.368
Ratio of family labor	-22.088		33.172	-39.669		30.084
Dummy parttime	27.124		36.830	-65.776	**	27.936
Dummy young farmer	54.329	*	32.748	42.325	***	13.517
Dummy female	26.981		66.475	33.132	*	17.130
Dummy skilled operator	-30.143		51.567	-21.546		13.617
Dummy highly-skilled operator	1.027		49.336	-24.242		19.658
Farms	1,112			1,084		
Observations	5,769			5,674		
Cross-section fixed effects	First differences			First differences		
Period fixed effects	Dummy variables			Dummy variables		
Instrument rank for J-statistic	55			55		
Sargan test – Prob. (J-statistic)	0.387			0.503		
Arellano-Bond test – Prob. AR(1)	0.000			0.000		
Arellano-Bond test – Prob. AR(2)	0.987			0.661		

***p<0,01, **p<0,05, *p<0,10; SE = Standard Error; Time dummys are suppressed for brevity.

Source: Authors‘ calculations.

4.6 Conclusions

The objective of this paper is to investigate the impact of different types of CAP instruments on land rental prices and land allocation. For that purpose, in our first step, we develop a Ricardian rent model of one output and two inputs and include the main CAP measures that have been applied in the most recent decades. In the second step, we introduce an outside option to examine the influence of CAP instruments on land allocation. We then empirically test the results obtained regarding the influence of SFPs in a historical model on land rental prices using a comprehensive dataset of bookkeeping records from more than 3,000 Bavarian farms. In contrast with previous studies, we specifically consider heterogeneous land quality in our analysis.

The theoretical results show that area payments and SFPs in a regional model become fully capitalized into land rents. In other words, every additional euro transferred to farmers as CAP payments increases land rents equally. SFPs in a historical model also become fully capitalized, but here the increase depends on land quality. Our results reveal that SFPs in a historical model become more strongly capitalized on higher quality land than on lower quality land. It should be stressed that these results are based on the assumption of a Cobb-Douglas production technology with an elasticity of the substitution of unity between land and non-land inputs.

According to our theoretical results, land allocation shifts from the use with an outside option (e.g., extensive grassland) to our main land use (e.g., cereals) during the course of the McSharry Reform. However, in this respect it would be necessary to account for other policy instruments being in force at that time. One of these would be the set aside instrument in its compulsory (15% of total crop area) and voluntary form. If one has the goal to hold as much land as possible in production, then an input subsidy on land that is designed to be independent of land quality is the favorable instrument. Even more efficient would be focusing subsidization only on low quality land, as is the case with disadvantaged area payments. Furthermore, our results demonstrate that a transition from area payments to SFPs in a historical model leads to increased land use via the outside option. In contrast with area payments, land allocation in a historical model and a regional model equals the non-subsidy case, which holds even when subsidies depend on land quality, such as with SFPs in a historical model.

According to our empirical results, 32 cents per additional euro of CAP payments capitalize into land rental prices. Bearing in mind that 41.9% of total Bavarian agricultural land was rented in 2010 (StMELF, 2012), a considerable share of support is captured by landlords rather than active farmers, which clearly contradicts the objective of the CAP to target "support exclusively to active farmers" (European Commission, 2010, p. 3). Most importantly, we are able to empirically confirm our theoretical results that capitalization of SFPs in a historical model depends on land quality. Whereas 43 cents of each euro translates into land rental prices in regions with comparably favorable natural conditions, this number becomes 22 cents per euro (which is considerably lower) in areas with less favorable natural conditions. Thus, high quality land becomes, in relative terms, more expensive than low quality land. This result biases the competitiveness of farms on a regional level and the question “who profits from CAP payments?” will thus be answered differently based on the region considered. Whereas landlords owning high quality land benefit to a considerably larger extent from CAP payments than landlords owning low quality land, the reverse holds for tenants. Those tenants farming in regions with less favored natural conditions are supported to a higher extent than is expected.

Further empirical results show that young farmers born after 1970 pay a significantly higher rental price compared with other farm operators. This result is particularly notable because the CAP 2014–2020 program is designed to give young farmers a 25% increase in their SFPs.

Although we consider numerous issues, we face certain limitations in our analysis. For example, we do not consider spatial relationships. Although we know the district a specific farm is located in, our dataset lacks information regarding the respective municipality or its exact coordinates.[28] Because we only consider farms renting more than 1 ha and exclude farms limiting themselves to operating exclusively on their own land, we run the risk of a potential bias from a nonrandom selection of the sample (“sample selection bias”). However, Kirwan (2009) and Ciaian and Kancs (2012) do not confirm a significant sample selection bias in their land rental price analyses.

[28] Our first tests offered evidence that our geographical measurements are not sufficiently precise.

5 Discussion

The objective of this thesis is to analyze the impact of government support programs on agricultural land values. Although earlier studies provide theoretical and empirical investigations into this topic, the insights gained so far are not conclusive. For that reason, we provide three distinct studies on the influence of various agricultural policy instruments on agricultural land sales and land rental prices.

In chapter 2, we give an overview of the theoretical foundations, the empirical procedures and the derived results of the literature on the determinants of agricultural land sales prices. A particular focus is given to the effects of government support policies. Almost all studies that analyze the determinants of farmland prices refer to either the NPV method or the hedonic pricing approach as a basis of their work. The hedonic pricing approach is anchored in consumer utility theory and assumes that the observed prices of a good (in our case land) are a function of a set of characteristics that define this good. In contrast, the NPV model defines the maximum price somebody (in our case a farmer) would be willing to pay for a particular asset (in our case a piece of agricultural land) as the summed and discounted expected future streams of earnings from this asset. We show that, although these two approaches have a different theoretical basis, they converge in their empirical implementation. In contrast to earlier reviews on this topic, we give a systematized overview of the variables used in the empirical analysis and are the first to perform a meta-regression analysis. The results obtained from the latter indicate that a 10% decrease in agricultural support will decrease land sales prices somewhere between 3.3% and 5%. Therefore, a considerable part of farm subsidies is realized by the initial owners of land instead of the operating farmers. However, we are not able to verify earlier theoretical (e.g., Guyomard et al., 2004; Courleux et al., 2008; Ciaian et al., 2008; Kilian et al. 2012) and empirical (e.g., Goodwin et al.; 2003; Kilian et al., 2012; Feichtinger et al., 2014) results that various types of government support measures capitalize into land prices to various extents. Nevertheless, our results show that model assumptions, data structure and estimation techniques can lead to a systematic and significant bias in the estimated effects of support measures on agricultural land sales prices. Most importantly, taking theoretically consistent land rents (returns to land) to explain land values rather than a proxy like market revenues leads to lower elasticities of capitalization. Hence, caution must be taken if one compares the results obtained in various studies. Moreover, our results also confirm the importance of applying appropriate estimation methods to obtain consistent results.

The purpose of chapter 3 is to theoretically and empirically model the interactions of agricultural land markets in Bavaria. In doing so, we adopt a model developed by Fingleton and Le Gallo (2008) for the real estate market to the agricultural land sales market. This allows us to account for spatial dependency in this market. In contrast to previous studies, our modelling approach explicitly considers the demand and supply side of the land sales market. In the subsequent empirical part, we apply a general spatial model, which combines a spatial lag model and a spatial error model, to a dataset of more than 7,300 actual arm's length transactions of agricultural land sales in the years 2001 and 2007. As opposed to prevailing studies on land sales prices, we account for the spatial dimension of land markets and the endogeneity of the explanatory variables.

Our results reveal that a 1% reduction in EU direct payments decreases agricultural land prices by 0.27% in 2007 and by 0.06% in 2001. Evaluated at mean levels, a 50 €/ha reduction in direct payments would imply land prices decreases of 849 €/ha and 280 €/ha, respectively. Hence, we find a significantly higher capitalization of government support into land prices after the decoupling of direct payments in the course of the Fischler Reform. This estimate regarding CAP payments before the reform is somewhat lower than the capitalization elasticities between 0.12 to 0.60 as obtained by Pyykkönen (2005) and Duvivier et al. (2005). Our capitalization elasticities with respect to SFPs (after the reform) are lower than the 0.54 of Nilsson and Johansson (2013). However, they are considerably higher than the 69 cents per euro obtained by Latruffe et al. (2013) for aggregated CAP payments and their 2.06 euros per euro of the same payments when only considering nitrate surplus regions. Apart from that, we find a substantial influence of land productivity, the regional land market structure and urban pressure on land prices. Interestingly, the involvement of the public authority, as either a buyer or a seller of a plot, substantially increases sales prices. The impact at the mean sales price of € 21,749 in 2007 (€ 22,642 in 2001) is estimated to be 4,532 (5,376) €/ha if a public seller and 6,633 (4,963) €/ha if a public buyer is involved. An explanation for this result might be that public authorities involved in the transaction are most likely located in more densely populated areas and that land is eventually contemplated to prospective infrastructure development. Another possible explanation for this phenomenon could be a downward bias of official land prices when only private parties are involved as buyer and seller to reduce taxes. Furthermore, our spatial results show that land prices increase by approximately 0.24% when land prices in surrounding areas increase by 1%. Therefore, not including the spatial interactions in an econometric model might underestimate the impact of payments on agricultural land prices.

Chapter 4 aims to investigate the impact of CAP payments on land rental prices and land allocation on a theoretical and an empirical basis. Therefore, we add additional evidence to a very recently expanding branch of the literature (e.g., Breustedt and Habermann, 2011; Kilian et al., 2012; O'Neill and Hanrahan, 2013; Guastella et al., 2013; Feichtinger et al., 2014). As opposed to all the other contributions, we account for the heterogeneity of land. We develop a Ricardian land rent model that includes land quality. We then implement the main CAP instruments including SFPs in a historical and a regional model and provide analytical solutions for their impact on land rental prices. We next introduce an outside option to analyze the effect of various types of CAP payments on land allocation between various uses. For example, our model may describe the allocation between cropland and grassland in a very stylized way. In the empirical part, we test our theoretical findings on a dataset of bookkeeping records from more than 3,000 Bavarian farms over 7 years. In accounting for potential inertia, i.e., the fact that rental prices depend to some extent on the rental prices paid in the previous period, we use dynamic panel data methods (Arellano and Bond, 1991). We conduct estimations for the whole sample and for subgroups with various land qualities.

Our theoretical results show that area payments and SFPs in a regional model are fully capitalized into land rents. SFPs in a historical model are also fully capitalized, but the extent of capitalization depends on land quality. In other words, SFPs in a historical model are capitalized into land rental prices to a greater extent for high-quality land than low-quality land. Furthermore, land allocation between various uses (e.g., crops) in the historical and the regional model does not differ from the non-subsidy case. This holds even if subsidies depend on land quality as with SFPs in a historical model. The rational and main driving force for this finding is the fact that SFP entitlements can be activated on both land uses.

The empirical results show that, in the long-run, 43 cents per euro of SFPs in a historical model end up in Bavarian land rental prices in regions with favorable natural conditions for farming. In contrast, only 22 cents per euro end up in Bavarian land rental prices in areas with less favorable natural conditions. Using the overall sample, every additional euro spent as SFPs increases land rental prices by 32 cents. This is within the range of 21 to 53 cents per euro obtained by O'Neill and Hanrahan (2013) for SFPs. Our results are considerably higher than the average capitalization rates of 4% (Greece) to 18% (Portugal) obtained by Michalek et al. (2014). However, these capitalization rates vary considerably between 3% and 94% for different SFP levels and between different EU Member States. Their result is also in contrast to our findings regarding the capitalization of various land qualities. In particular, Michalek et al. (2014, p. 279) find that "farms with low-value entitlements channel a substantially higher share of the SPS to landowners than farms with high-value entitlements." Given that support levels are usually positively correlated with land quality, this is not in line with our findings. The capitalization rates obtained by Kilian et al. (2012) and Feichtinger et al. (2014), which both also investigate Bavarian land rental prices, are comparable though higher than ours. Although the first study uses cross-sectional municipality level data and finds 61 cents per additional euro of SFPs to capitalize into land rental prices, the second study uses a dataset similar to ours and finds a capitalization rate of 47 cents. In discussing the results of the latter, it is important to note that they focus on cropland and do not account for inertia in rental prices or heterogeneous land quality in their analysis. In contrast to our results and those of the studies mentioned above, Guastella et al. (2013) are not able to confirm that SFPs significantly influence Italian land rental prices.

Moreover, we find considerable capitalization effects of payments for disadvantaged areas, which are 38 cents per euro on average. Agri-environmental payments do not capitalize into land rental prices to a very significant extent. Apart from the influence of government support programs, our results reveal the influence of market returns in determining land rental prices. This is also in line with our theoretical model. Moreover, young farmers born later than 1970 pay a significantly higher rental price compared to the other farm operators. This is particularly interesting because the new CAP 2014-2020 program is designed to give young farmers a 25% top up in their SFPs. Hence, one might argue that a considerable share of this top up will be captured by initial land owners.

In general, the results from these three studies confirm that CAP payments significantly capitalize into agricultural land sales and land rental prices. As shown above, this is in line with most of the prevailing literature. Moreover, the magnitudes of most of our coefficient estimates comply with the theoretical expectations. Most importantly, a significant capitalization has severe consequences on the distributional effects of government support programs. Although a seller of agricultural land gains windfall profits from increased land prices, a landlord renting out his land gains from increased rental prices. The latter is particularly important because a considerable share of agricultural land is cultivated by tenants instead of landowners in many developed countries. Hence, our results clearly contradict the objective of the EU Common Agricultural Policy (CAP) and particularly the most recent reforms to target "support exclusively to active farmers" (European Commission, 2010, p. 3).

Furthermore, our results reveal a significantly higher capitalization of SFPs (historical model) into rental prices in regions with comparably favorable natural conditions than in those with less favorable natural conditions. Putting it differently, high-quality land becomes relatively more expensive than low-quality land. This biases the competitiveness of farms on a regional level, and the question "who profits from CAP payments?" is to be answered differently depending on the region considered. Although landlords who own high-quality land benefit to a considerably larger extent from CAP payments than do landlords who own low-quality land, the reverse holds for tenants. Those of the latter farming in regions with less favored natural conditions get supported to a higher extent than is most likely expected.

Relating our results regarding the capitalization of CAP payments into land prices to the new CAP 2014-2020 program, we expect changes in the magnitude of capitalization effects and changes in the distributional effects. Most importantly, in implementing the CAP 2014-2020 program all the EU Member States are expected to move toward a full regional model until 2019. This is crucial for many EU Member States because the bulk of them still apply a historical model (Austria, Belgium, France, Greece, Ireland, Italy, Portugal, Scotland, Spain, The Netherlands and Wales) or a static hybrid model (e.g., Luxembourg, North Ireland). In a regional model, all the entitlements in a region (e.g., Bavaria) have equal values. Hence, during the implementation process, the values of high-grade entitlements are decreased, and the values of low-grade entitlements are increased. Moreover, if a farm operator faces an entitlement deficit, he will be able to request new entitlements. Considering that land quality correlates with entitlement values and reissues of entitlements will predominantly play a role in grassland regions, the transition to the CAP 2014-2020 program shifts CAP payments from areas dominated by arable farming and bull fattening to extensive dairy farming areas.

In discussing the impacts of the future CAP 2014-2020 program on the capitalization rates, we are able to identify some tendencies, but this is aggravated by the fact that none of the preceding studies provide evidence on the capitalization or CAP payments in a regional model. Relying on our theoretical and empirical results, we would expect that low-quality land becomes relatively more expensive than high-quality land through the CAP 2014-2020 reform. Another novelty not discussed so far is the so-called “greening of the CAP.” The greening-component is similar in design to the cross-compliance mechanism, but it has more demanding obligations for farmers. For example, from 2015 on, farmers must establish ecological compensation areas on at least 5% of their total cropland. If a famer has not fulfilled the requirements, their CAP direct payments can be reduced by up to thirty percent. Because additional costs arise with greening for farmers, we expect a decreasing effect on capitalization rates of SFPs.

Although we considered numerous issues regarding the specific characteristics of land sales and land rental markets and applied various data sets and econometric methods, we face several limitations in our analyses. First, in our meta-regression analysis in chapter 2, we address a highly varying number of coefficient estimates reported in some of the primary studies. For example, although several studies report only one coefficient estimate on the influence of government support on land sales prices, one study reports as many as 40 estimates. This aggravates problems caused by correlation between primary studies and correlation of coefficient estimates reported in one primary study, which are common in meta-regression analyses (Nelson and Kennedy, 2009). Second, in our analysis of the influence factors that determine land sales prices in Bavaria in chapter 3, we use data from the years 2007 and 2001. Our findings suggest that CAP payments capitalize to a considerably higher extent into land sales prices after the Fischler Reform in 2003. Whether the reform is the only determinate for this result needs further inquiry. Third, our analysis of agricultural land sale prices is based on cross-sectional data. Therefore, we lack the possibility, as with panel data, to remove unobserved heterogeneity. Fourth, although we consider with more than 7,300 arm’s length land sales transactions, which is (almost) all the transactions in 2007 and 2001, the share of total Bavarian agricultural land remains 0.20% per year, which is relatively low (LfStat, 2008; 2013). This might entail an unbalanced market structure with a small number of sellers and most likely a higher number of potential buyers. Accounting for this potential imperfect competition and its implications on the determinants of agricultural land prices would be worth further investigation. Fifth, we do not consider spatial relationships in our land rental price analysis in chapter 4 because our dataset lacks exact location coordinates of farms or at least information on the municipality of specific farms. However, our results in chapter 3 suggest that spatial interactions might be important. Sixth, because we consider only farms that rent more than 1 ha and exclude farms that limit themselves to operate exclusively on their own land, we run the risk of a potential bias from a nonrandom selection of the sample ("sample selection bias"). However, Kirwan (2009) and Ciaian and Kancs (2012) do not confirm a significant sample selection bias in their land rental price analyses.

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7 Appendix

Table A1: List of articles and the reported capitalization elasticities included in the meta-regression analysis

Author	Title	Article	Mean	Median[29]	Max	Min.	Std. Dev.	Obs.
Barnard et al., 1997	Evidence of Capitalization of Direct Government Payments in to U.S. Cropland Values	1	0.265	0.215	0.690	0.120	0.180	8
Carlberg, 2002	Effects of Ownership Restrictions on Farmland Values in Saskatchewan	2	0.043	0.030	0.520	-0.408	0.423	4
Devadoss and Manchu, 2007	A comprehensive analysis of farmland value determination: a county-level analysis	3	0.020	0.020	0.020	0.020		1
Duvivier et al., 2005	A Panel Data Analysis of the determinants of farmland price: An application to the effects of the 1992 CAP Reform in Belgium	4	0.299	0.285	0.469	0.121	0.100	28
Folland and Hough, 1991	Nuclear Power Plants and the Value of Agricultural Land	5	0.386	0.384	0.427	0.355	0.033	6
Goodwin and Ortalo-Magné, 1992	The Capitalization of Wheat Subsidies into Agricultural Land Values	6	0.380	0.380	0.380	0.380		1
Goodwin et al., 2003	What's wrong with our models of agricultural land values?	7	0.076	0.061	0.130	0.020	0.049	5
Goodwin et al., 2005	Landowners' Riches: The Distribution of Agricultural Subsidies	8	0.111	0.042	0.233	0.028	0.086	6
Goodwin et al., 2011	The Buck Stops Where? The Distribution of Agricultural Subsidies	9	0.041	0.032	0.134	0.007	0.042	8
Hardie et al., 2001	The Joint Influence of Agricultural and Nonfarm Factors on Real Estate Values: An Application to the Mid-Atlantic Region	10	0.474	0.460	0.605	0.405	0.077	5
Henderson and Gloy, 2008	The Impact of Ethanol Plants on Cropland Values in the Great Plains	11	0.302	0.296	0.372	0.270	0.032	8
Kilian, 2010	Die Kapitalisierung von Direktzahlungen in landwirtschaftlichen Pacht- und Bodenpreisen - Theoretische und empirische Analyse der Fischler-Reform der Gemeinsamen Agrarpolitik	12	0.282	0.093	0.472	0.093	0.268	2
Latruffe et al., 2008	Capitalisation of the government support in agricultural land prices in the Czech Republic	13	0.205	0.070	0.890	0.040	0.296	10
Pyykkönen, 2005	Spatial Analysis of Factors Affecting Finnish Farmland Prices	14	0.412	0.344	0.835	0.166	0.256	8
Runge and Halbach, 1990	Export Demand, U.S. Farm Income and Land Prices: 1949 - 1985	15	0.322	0.253	1.184	0.051	0.208	40
Sandrey et al., 1982	Determinants of Oregon Farmland Values: a Pooled Cross-Sectional, Time Series Analysis	16	0.228	0.228	0.228	0.228		1
Shaik et al., 2005	The Evolution of Farm Programs and their contribution to agricultural land values	17	0.256	0.242	0.397	-0.040	0.136	14
Shaik et al., 2006	Farm programs and agricultural land values	18	0.281	0.274	0.543	0.099	0.119	31
Shaik, 2007	Farm Programs and Land Values in Mountain States: Alternative Panel Estimators	19	0.429	0.441	0.608	0.224	0.125	15
Shaik et al., 2010	Did 1933 New Deal Legislation Contribute to Farm Real Estate: Temporal and Spatial Analysis	20	0.378	0.303	0.875	0.103	0.230	18
Taylor and Brester, 2005	Noncash Income Transfers and Agricultural Land Values	21	0.100	0.100	0.100	0.100		1
Veeman et al., 1993	Price Behaviour of Canadian Farmland	22	0.384	0.380	0.470	0.260	0.083	5
Vyn, 2006	Testing for Changes in the Effects of Government Payments on Farmland Values in Ontario	23	0.130	0.130	0.184	0.075	0.077	2
Weerahewa et al., 2008	The Determinants of Farmland Values in Canada	24	0.060	0.060	0.060	0.060		1
Weersink et al., 1999	The Effect of Agricultural Policy on Farmland Values	25	0.008	0.008	0.013	0.002	0.004	10
Weisensel et al., 1988	Where are Saskatchewan Farmland Prices Headed	26	0.088	0.275	0.284	-0.342	0.295	4
Total			**0.276**	**0.208**	**1.184**	**-0.408**	**0.198**	**242**

Source: Authors' calculations.

[29] Median as it is used in model III.

Table A2: Overview of primary study characteristics[30]

	Market price support	Direct payments	Decoupled direct payments	Total payments	Land rent	Inclusion of non-agricultural variables	Only arable plots considered	Farm level data	Studies using European data	Multiple equation model	Double log spec.	Spatial econometrics	Lagged dependent variable used	Lagged independent variable used	Publication
Barnard et al., 1997				✓		✓					✓				✓
Carlberg, 2002	✓									✓	✓		✓	✓	✓
Devadoss and Manchu, 2007				✓	✓	✓									✓
Duvivier et al., 2005		✓			✓	✓	✓		✓		✓				✓
Folland and Hough, 1991	✓					✓					✓				✓
Goodwin and Ortalo-Magné, 1992				✓							✓				✓
Goodwin et al., 2003	✓	✓	✓	✓		✓		✓							✓
Goodwin et al., 2005	✓		✓	✓	✓	✓	✓	✓							
Goodwin et al., 2011	✓	✓	✓	✓	✓	✓		✓							✓
Hardie et al., 2001	✓					✓				✓		✓			✓
Henderson and Gloy, 2008	✓			✓		✓	✓								
Kilian, 2010		✓	✓			✓	✓	✓	✓						✓
Latruffe et al., 2008	✓	✓	✓			✓	✓		✓		✓			✓	✓
Pyykkönen, 2005		✓				✓	✓	✓	✓		✓	✓			✓
Runge and Halbach, 1990	✓			✓							✓				✓
Sandrey et al., 1982	✓					✓				✓	✓				✓
Shaik et al., 2005				✓		✓				✓					✓
Shaik et al., 2006				✓		✓				✓					✓
Shaik, 2007	✓			✓		✓				✓					✓
Shaik et al., 2010	✓			✓		✓				✓		✓		✓	
Taylor and Brester, 2005	✓					✓		✓							✓
Veeman et al., 1993	✓									✓	✓			✓	✓
Vyn, 2006				✓	✓					✓				✓	
Weerahewa et al., 2008				✓	✓	✓				✓					
Weersink et al., 1999				✓	✓					✓				✓	✓
Weisensel et al., 1988	✓						✓				✓		✓	✓	✓

Source: Authors' calculations.

[30] Most articles present more than one estimate, which may have different characteristics. Therefore characteristics of single estimates can deviate from Appendix Table A2.

Table A3: Regression results for 2007 using spatial 2SLS/GMM with a Gabriel neighbor spatial weight matrix

		spatial 2SLS/GMM			
		coeff.	direct	indirect	total
Constant	*coeff.*	3.9044 ***			
	SE	0.5803			
Public buyer		0.2997 ***	0.3021 ***	0.1244 ***	0.4266 ***
		0.0265	0.0268	0.0376	0.0512
Public seller		0.2162 ***	0.2170 ***	0.0897 **	0.3067 ***
		0.0522	0.0529	0.0354	0.0804
Soil quality index		0.6720 ***	0.6767 ***	0.2775 ***	0.9541 ***
		0.0365	0.0365	0.0774	0.0799
Size of a transacted plot		0.0989 **	0.0996 **	0.0408 *	0.1404 **
		0.0480	0.0478	0.0234	0.0684
Direct payments		0.2149 **	0.2154 **	0.0839 **	0.2992 ***
		0.0848	0.0851	0.0334	0.1108
Distance to the next urban center		-0.1697 ***	-0.1699 ***	-0.0676 ***	-0.2375 ***
		0.0452	0.0455	0.0209	0.0581
Ratio building vs. agricultural land		0.0827 ***	0.0837 ***	0.0340 **	0.1177 ***
		0.0251	0.0251	0.0136	0.0356
Price of building plots		0.0355	0.0355	0.0136	0.0491
		0.0224	0.0228	0.0092	0.0310
Share of rented agricultural area		-0.0123 ***	-0.0124 ***	-0.0050 ***	-0.0174 ***
		0.0017	0.0017	0.0011	0.0017
Spatial lag		0.2904 ***			
		0.0610			
Spatial error		0.1683 **			
		0.0792			

***p<0,01, **p<0,05, *p<0,10; SE = Standard Error.

Source: Authors' calculations.

Table A4: Regression results for 2001 using spatial 2SLS/GMM with a Gabriel neighbor spatial weight matrix

		Spatial 2SLS/GMM			
		coeff.	direct	indirect	total
Constant	*coeff.*	3.4648 ***			
	SE	0.6487			
Public buyer		0.2188 ***	0.2220 ***	0.1452 ***	0.3673 ***
		0.0197	0.0199	0.0434	0.0502
Public seller		0.2308 ***	0.2342 ***	0.1536 ***	0.3877 ***
		0.0430	0.0434	0.0541	0.0846
Soil quality index		0.5815 ***	0.5900 ***	0.3870 ***	0.9770 ***
		0.0329	0.0329	0.1161	0.1235
Size of a transacted plot		0.1199 **	0.1221 **	0.0782 **	0.2002 **
		0.0490	0.0497	0.0372	0.0814
Direct payments		0.0420 *	0.0426 *	0.0264 *	0.0689 *
		0.0231	0.0236	0.0154	0.0374
Distance to the next urban center		-0.0581	-0.0595	-0.0392	-0.0986
		0.0449	0.0458	0.0337	0.0775
Ratio building vs. agricultural land		0.0755 ***	0.0767 ***	0.0492 **	0.1259 ***
		0.0282	0.0288	0.0222	0.0473
Price of building plots		0.0963 ***	0.0977 ***	0.0602 ***	0.1579 ***
		0.0325	0.0327	0.0184	0.0456
Share of rented agricultural area		-0.0088 ***	-0.0090 ***	-0.0057 ***	-0.0147 ***
		0.0018	0.0018	0.0015	0.0026
Spatial lag		0.3975 ***			
		0.0718			
Spatial error		0.3045 ***			
		0.0768			

***p<0,01, **p<0,05, *p<0,10; SE = Standard Error.

Source: Authors' calculations.

Table A5: Dynamic GMM results for different land qualities using orthogonal deviations as transformation method

	dynamic GMM (Arellano-Bond)								
	total land			**high quality land**			**low quality land**		
Variable	coeff.		SE	coeff.		SE	coeff.		SE
Lagged rent (€/ha)	0.061	***	0.018	0.038	**	0.016	0.183	***	0.036
Market revenues (€/ha)	0.012	***	0.002	0.015	***	0.003	0.009	***	0.002
Single farm payments (€/ha)	0.342	***	0.034	0.425	***	0.053	0.228	***	0.038
Agri-environmental payments (€/ha)	0.073	***	0.023	0.088	*	0.046	0.046	*	0.024
Disadvantaged area payments (€/ha)	0.565	***	0.091	0.753	***	0.282	0.420	***	0.088
Ratio of cropland	100.115	***	37.846	127.677	**	51.405	65.855		40.491
Ratio of sugar beet area	384.128	***	103.811	308.225	***	112.820	253.378	**	119.469
Ratio of potato area	268.581	***	103.383	229.472		147.229	-6.837		146.150
Ratio of corn area	91.708	***	26.620	72.128	**	28.698	-24.673		46.885
Ratio of wheat area	96.423	***	18.684	94.684	***	33.484	81.076	***	18.040
Ratio rapeseed	70.087	***	19.449	80.504	**	35.454	54.292		35.719
Farm size	2.903	***	0.476	3.670	***	0.985	2.587	***	0.465
Farm size squared	-0.006	***	0.001	-0.007	**	0.003	-0.005	***	0.002
Ratio of owned land	221.579	***	37.422	189.574	***	53.804	197.126	***	34.288
Ratio of family labor	-8.723		15.638	8.441		26.096	-13.359		24.736
Dummy parttime	21.652		22.464	25.419		34.670	0.044		16.366
Dummy young farmer	41.066	***	12.696	36.272		22.318	29.504	***	9.931
Dummy female	35.406		22.096	-0.818		48.318	13.315		17.825
Dummy skilled operator	-29.021	*	16.601	-34.098		39.892	-9.436		12.592
Dummy highly-skilled operator	-4.694		17.254	-14.519		34.790	-12.877		17.620
Farms	3,010			1,112			1,084		
Observations	15,709			5,769			5,674		
Cross-sec. fixed eff.	Orthogonal dev.			Orthogonal dev.			Orthogonal dev.		
Period fixed effects	Dummy variables			Dummy variables			Dummy variables		
Instrument rank for J-statistic	55			55			55		
Sargan test – Prob. (J-statistic)	0.773			0.262			0.263		

***p<0,01, **p<0,05, *p<0,10; SE = Standard Error; Time dummys are suppressed for brevity.

Source: Authors' calculations.