What Do We Know about the Influence of Agricultural Support on Agricultural Land Prices?

Was wissen wir über den Einfluss von Agrarstützungen auf die Bodenpreise?

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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 systematise 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.

Key Words

land price; government support; net present value; hedonic pricing approach; meta-regression analysis; capitalization

Zusammenfassung

Das Ziel dieser Arbeit ist die Zusammenfassung der theoretischen Grundlagen, der empirischen Anwendungen und der bisherigen Ergebnisse hinsichtlich der Literatur zu den Determinanten landwirtschaftlicher Bodenpreise. Spezielles Augenmerk liegt auf der Wirkung von landwirtschaftlichen Stützungsprogrammen. Nahezu alle bisherigen Arbeiten berufen sich auf die Barwertmethode oder das hedonische Preismodell als theoretische Grundlage für die empirische Analyse. Trotz der methodologischen Unterschiede dieser beiden Ansätze ist ihre empirische Implementation sehr ähnlich. In den empirischen Studien wird eine große Bandbreite an Erklärungsvariablen genutzt. Dieser Artikel teilt diese Vielzahl an Variablen in sechs Kategorien ein. Um die Unterschiede im Einfluss verschiedener Stützungsmaßnahmen auf die Bodenpreise zu untersuchen, wird eine Meta-Regressionsanalyse, basierend auf 242 Beobachtungen aus 26 Artikeln, durchgeführt. Die Resultate deuten darauf hin, dass eine Senkung der landwirtschaftlichen Stützungsprogramme um 10 % eine Reduktion der landwirtschaftlichen Bodenpreise um etwa 3.3 % bis 5 % mit sich bringt. Demnach fließt ein beachtlicher Teil der Agrarstützungen an die ursprünglichen Landeigentümer anstatt an praktizierende Landwirte. Über eine unterschiedliche Kapitalisierung verschiedener Stützungsprogramme kann keine klare Aussage getroffen werden. Modellannahmen, die Art der Daten und die Schätzmethode haben einen signifikanten Einfluss auf die geschätzte Kapitalisierung.

Schlüsselwörter

Bodenpreise; Agrarstützungen; Barwertmethode; hedonisches Preismodell; Meta-Regressionsanalyse; Kapitalisierung

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 analysed land values in the U.S., 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 systematise 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, section 2 will outline both methods and how they are related. In empirically explaining land prices and their dynamics, researchers have utilised a multitude of different variables. Section 3 will review and systematise 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 capitalised into land values will be tackled based on an extensive literature review and a meta-regression analysis in section 4. Section 5 summarises our results and draws some conclusions.

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

$$(1)\quad L_t = \frac{E_t(R_{t+1})}{(1+r_{t+1})} + \cdots + \frac{E_t(R_{t+i})}{(1+r_{t+1})\ldots(1+r_{t+i})} + \cdots + \frac{E_t(R_{t+n})}{(1+r_{t+1})\ldots(1+r_{t+n})}$$

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 (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

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

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[1]

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

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

[1] Equation (3) abstracts from some complications including inflation, taxes, credit market imperfections, transactions costs and risk aversion (JUST and MIRANOWSKI, 1993).

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:

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

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 (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 (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 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 (4) into an empirically estimable model another crucial problem remains. In Equation (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 (4) into the following empirical model:

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

where α is a constant, β' and $\beta'_{G,j}$ are parameters reflecting β and $\beta_{G,j}$ in Equation (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 (5) neglects other factors which may influence land prices. One example is competing demand for land for non-agricultural use, i.e. 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 (5) by arguing that those are shifters to the price function and therefore included in the constant α. Hence, Equation (5) becomes

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

where X_k are shift variables with $X_1 = 1$ for all i observations and α_k are z parameters to be estimated. Equation (6) is similar to Equation (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:

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

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 (7) and the empirical implementation of the NPV model of Equation (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 section 4.

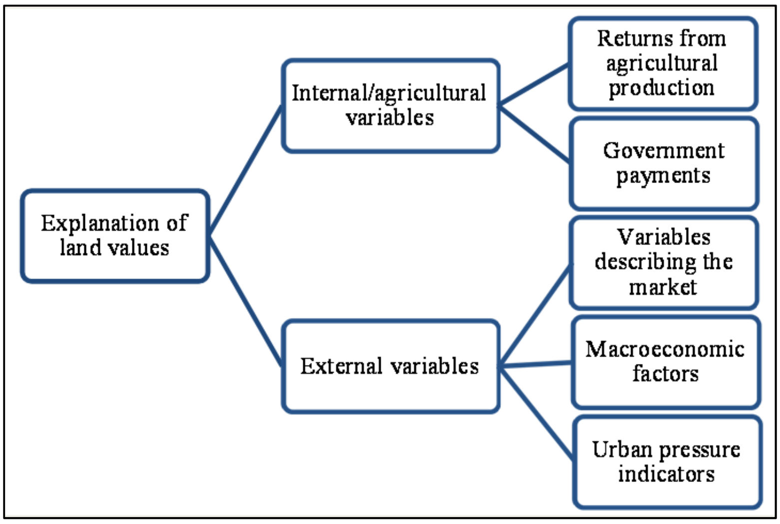
3 Explanatory Variables used in Empirical Applications

In an effort to explain what determines land prices as theoretically discussed in the last section, researchers have utilised numerous different variables. One way to structure these variables is depicted in Figure 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 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 section 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).

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.

Figure 1. Variables in empirical analysis



Source: authors' presentation

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),

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

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

Table 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 and 2010; 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
o Irrigation (BARNARD et al., 1997)
o Presence of intensive crops (BARNARD et al., 1997)
o 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 and 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., 2010)
– Urbanisation categories (GOODWIN et al. (2010 and 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

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 (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 (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 (5) or calculated from Equation (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, 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. On average every article is cited 15 times (calculated on the basis of the number of citations in http://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.

Table 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' calculation

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 PSE classification of the OECD and the numbers of observations in each category are listed in Table 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 section 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 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.

Table 3. List of independent variables

Category	Description	I and II		III	
		Share in %	Number of Observations	Share in %	Number of Observations
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' calculation

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.

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 subregions 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 (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 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 4. Estimation results of the meta-regression analysis

		I			II			III		
Category	**Variable**	**Coeff.**		**SE**	**Coeff.**		**SE**	**Coeff.**		**SE**
	Constant	0.245	***	0.068	0.355	***	0.043	0.297	**	0.104
Government payments	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[1]		
	Weighting	no			yes			no		

***p<0,01, **p<0,05, *p<0,10; SE = Standard Error
[1] No outlier correction necessary.
Source: authors' calculation

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 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.

Section 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 section 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., 2010; 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.

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Appendix

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

Author	Title	Article	Mean	Median[1]	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. (2010)	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**

[1] Median as it is used in model III.
Source: authors' calculation

Table A2. Overview of primary study characteristics[1]

	Market price support	Direct pay-ments	Decoupled direct payments	Total pay-ments	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 econo-metrics	Lagged dependent variable used	Lagged independent variable used	Publica-tion
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. (2010)	✓	✓	✓	✓	✓	✓		✓							✓
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)	✓						✓				✓		✓	✓	✓

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

Source: authors' presentation