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The Valuation of Agricultural Land and the Influence of Government Payments

ABSTRACT

This study gives an overview of the theoretical foundations, empirical procedures and derived results of the literature identifying determinants of land prices. Special attention is given to the effects of different government support policies on land prices. Since almost all empirical studies on the determination of land prices refer either to the net present value method or the hedonic pricing approach as a theoretical basis, a short review of these models is provided. While the two approaches have different theoretical bases, their empirical implementation converges. Empirical studies use a broad range of variables to explain land values and we systematise those 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. Our results reveal a significantly higher rate of capitalisation for decoupled direct payments and a significantly lower rate of capitalisation for agri-environmental payments, as compared to the rest of government support. Furthermore, the results show that taking theoretically consistent land rents (returns to land) and including non-agricultural variables like urban pressure in the regression implies lower elasticities of capitalisation. In addition, we find a significant influence of the land type, the data type and estimation techniques on the capitalisation rate.

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The Valuation of Agricultural Land and the Influence of Government Payments

Paul Feichtinger and Klaus Salhofer*

Factor Markets Working Paper No. 10/December 2011

1. Introduction

The question of what determines agricultural land values has occupied economists for 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 as far back as the late 1930s (George, 1941), empirical analysis of land value determinants took off in the 1960s (Hedrick, 1962; Herdt & Cochrane, 1966; Tweeten & Martin, 1966) and continues since then (Traill, 1979; Alston, 1986; Weersink et al., 1999; Salois et al., 2011). The overall purpose of this study is to give an overview of this empirical literature and its underlying theoretical foundations. Of particular interest are 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. Lence & Mishra, 2003; Kirwan, 2009; Breustedt & Habermann, 2011), most studies investigate the sales market. For this reason the focus of this working paper is placed on the agricultural land sales market.

The paper 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, Chapter 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. Chapter 3 will review and systematise these determinants. A long-discussed question in regard to land prices is the influence of agricultural support (Hedrick, 1962). The question of how much government payments will be capitalised into land values will be tackled based on an extensive literature review and a meta-regression analysis in Chapter 4. Chapter 5 summarises our results and draws some conclusions.

2. Net Present Value and Hedonic Pricing Approach

Most studies analysing the determinants of land sales prices either refer to the net present value (NPV) method or to the hedonic pricing approach as a basis of their work. Therefore, we will review both methods and explain their differences and their similarities.

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

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

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

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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, i.e. the returns to land after the costs for all other factors of production, including opportunity costs, have been subtracted (Featherstone & Baker, 1988). Equation (1) is general in a sense that we assume different 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 $i = 1,2, \dots n$. Hence, the discount rate and returns are constant over all n periods. Given this and defining $b^i = (1+r)^{-i}$, one derives

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

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

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

where $\beta = \frac{1}{r-g}$, the capitalisation rate of Ricardian land rents into the value of land.

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

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

where m different types of government support payments G_j capitalise 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 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 capitalisation rates $\beta_{G,j}$. Second, strictly speaking, G_j should be 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 that directly or indirectly influence the agricultural product price (e.g. an intervention price, an import quota or tax) by increasing R rather than G_j. Hence, although we can theoretically distinguish between returns from land and returns from government policy, this is tricky in empirical work. 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.

In transferring the theoretical outcome of the 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:

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

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.

Besides returns to land, other factors may influence the land price not included in the NPV model. One example is competing demand for land for non-agricultural use, i.e. urban pressure. Another example is the structure of the 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. Or one could rewrite equation (5) to

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

where X_k are shift variables with $X_1 = 1$ for all i observations and α_k are z parameters to be estimated. Equation (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 generally, and as an estimable function, agricultural land price is a function of y factors:

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

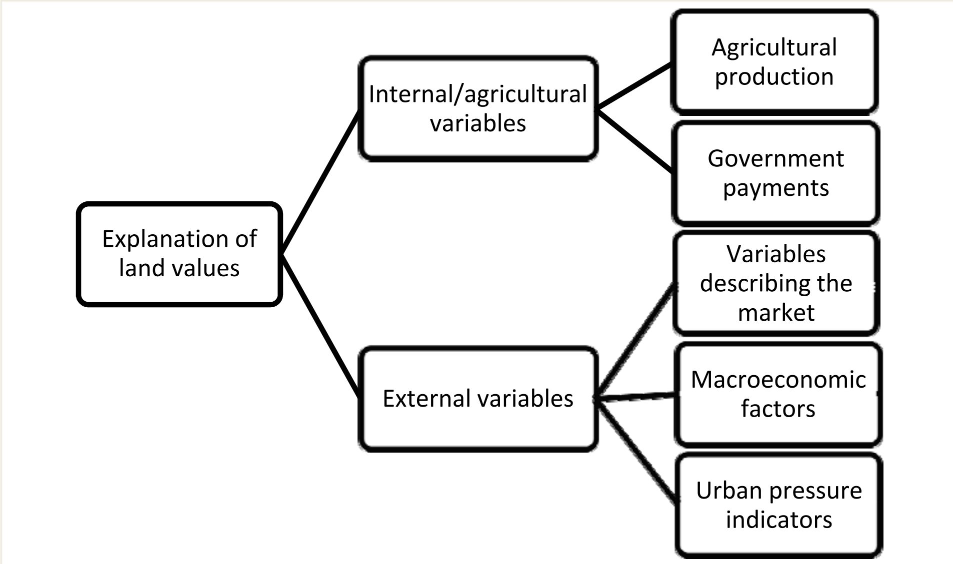
where Z_l are variables representing characteristics with $Z_1 = 1$ for all i observations. If explanatory variables Z_l include returns from land (or some proxy) R and government payments $G_{j,i}$, the hedonic pricing approach of equation (7) and the empirical implementation of the NPV model of equation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

The NPV model has a theoretical basis, which consistently explains the relationship between returns from land and government payments on the one hand and the price of land on the other. 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 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.

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.

Figure 1. Variables in empirical analysis



Source: Authors' own configuration.

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 utilising 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 Chapter 2, beside returns from land, returns from government payments influence land prices through capitalisation. 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).

Besides returns to land and government payments, there are other factors that 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 1. Examples for variables used to explain land values

Agricultural returns - Monetary variables

- Market revenues (Carlberg, 2002; Barnard et al., 1997; Folland & Hough, 1991; Gardner, 2002; etc.)
- Returns to land (Goodwin et al., 2005 & 2010; Weerahewa et al., 2008)
- Net income (Devadoss & Manchu, 2007)
- Producer price of wheat (Goodwin & Ortalo-Magné, 1992)

Agricultural returns – Non-monetary variables

- Yield (Pyykkönen, 2005; Devadoss & 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 & Hough, 1991)

Government payments

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

Variables describing the market

- Pig density (Duvivier et al., 2005)
- Manure density (Pyykkönen, 2005)
- Farm density (Pyykkönen, 2005)
- Average farm size (Folland & 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 & Manchu, 2007)
- Inflation rate (Alston, 1986)
- Property tax rate (Gardner, 2002; Devadoss & Manchu, 2007)
- Multifactor productivity growth (Gardner, 2002)
- Debt to asset ratio (Devadoss & Manchu, 2007)
- Credit availability (Devadoss & Manchu, 2007)
- Unemployment rate (Pyykkönen, 2005)

Urban pressure indicators

- Total population (Devadoss & 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 & 2005, defined through proximity to an urban centre)
- Rurality – fraction of the population living on farms (Gardner, 2002)
- Dummy variables for metropolitan areas (Henderson & Gloy, 2008)
- Proportion of the labour employed in agriculture (Pyykkönen, 2005)

Source: Authors' own compilation.

4. Government Payments in Empirical Land Price Estimations

Recently, the discussion of capitalisation 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 capitalisation rate has been applied 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 kinds of direct payments are often dominant these days. Measuring the capitalisation effect from market price support is difficult since it can't 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 are 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 estimated rates of capitalisation of different measures of support and to reveal some structural differences that may influence the estimated rate of capitalisation.

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

$$b_{ik} = \beta_0 + \sum_{j=1}^{m} \beta_j D_{j,ik} + \sum_{l=1}^{y} \alpha_l Z_{l,ik} + \varepsilon_{ik} \quad (i = 1, 2, \ldots, n), (k = 1, 2, \ldots, z) \qquad (8)$$

where b_{ik} is one of n effects reported in the primary study k, β_0, β_j, and α_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. β_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, there are theoretical differences in the capitalisation rate 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 & Le Mouël, 2009; Guyomard et al., 2004). Taking this into account, parameters β_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 capitalisation 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 capitalisation rates.

A common problem in meta-regression analysis is the correlation within and between primary studies. Uses of the same dataset or several articles from the same author are reasons for correlations between primary studies. In many cases more than one estimated value is reported per study. Examples for differences in those estimations are the use of smaller sub-regions of the total dataset, the application of various estimation methods or different levels of aggregation. In the meta-regression analysis at hand the number of estimates per article is unbalanced and in several cases more than one estimate is drawn from the primary study. Not in all cases did the Z variables account for the differences in estimates from the same study. Therefore, Nelson & Kennedy (2009) recommend that some means of adjusting for non-independence of estimates from the same study should be undertaken. Examples of such means are a single estimate per primary study (study-level averages or random selection), panel-data methods, and weighted least squares. Our sample consists of a relatively small number of primary studies (k = 26) with a highly unbalanced number of observations ($1 \leq i \leq 40$). Therefore, utilising only a single estimate per study would leave us with rather small number of observations, while a panel data approach is problematic because the data is so highly unbalanced. Hence, we follow Johnston et al. (2006), Koetse et al. (2008) and Mrozek & Taylor (2002) and estimate equation (8) as pooled regression, but weight 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. That studies with many estimates are no more informative than others is an arbitrary assumption and has been a point of criticism (Johnston et al., 2006). However, not weighting observations would give a very high weight to a very few studies.

As dependent variable, two different measures of capitalisation are possible. First, a marginal capitalisation rate $\beta'_{G,j} = \partial L_i / \partial G_{j,i}$, as derived from a linear function as represented in equation (4). Second, a 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 (4) or calculated. Since utilising the latter provides us with more observations, our dependent variable is the elasticity of land prices with respect to government payments. Hence, a value of for example 0.5 indicates that a 1% increase in government payments leads to a 0.5% increase in land prices. In those cases where only the coefficient was reported, the elasticities have been calculated on the mean level of land prices and government payments.

As summarised in Table 2, 246 estimations from 26 articles have been included in total. Estimated elasticities vary from -0.40 to 1.184 with a mean elasticity of 0.271. In 70% of the cases the elasticity is a number between 0.061 and 0.455. On average, 22 years have been included in the analysis where the mean year of the datasets is 1982 and the mean publishing year 2002. Each article is cited an average of 15 times (calculated on the basis of the number of citations in www.scholar.google.de). The articles reported on average 19 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 Table 3.[1]

Table 2. Descriptive statistics of the included articles

	Mean	**Maximum**	**Minimum**
Elasticity	0.271	1.184	-0.408
70% confidence interval of elasticity		0.455	0.061
Year of data	1982	2007	1944
Years included	22	69	1
Publishing year	2002	2010	1982
Citations of articles	15	83	0
Estimates per article	19	40	1
Total number of observations			246
Number of articles			26

Source: Authors' own compilation.

[1] Table A.1 in the Appendix gives a description of the research design and the main results of a selection of work conducted in the field.

Table 3. List of articles included in the meta-regression analysis

Author	Article	Number	Mean	Max	Min.	Std. Dev.	Obs.
Henderson & Gloy, 2008	The Impact of Ethanol Plants on Cropland Values in the Great Plains	1	0.302	0.372	0.270	0.032	8
Weisensel et al., 1988	Where are Saskatchewan Farmland Prices Headed	2	0.088	0.284	-0.342	0.295	4
Folland & Hough, 1991	Nuclear Power Plants and the Value of Agricultural Land	3	0.386	0.427	0.355	0.033	6
Hardie et al., 2001	The Joint Influence of Agricultural and Nonfarm Factors on Real Estate Values: An Application to the Mid-Atlantic Region	4	0.474	0.605	0.405	0.077	5
Sandrey et al., 1982	Determinants of Oregon Farmland Values: a Pooled Cross-Sectional, Time Series Analysis	5	0.228	0.228	0.228		1
Carlberg, 2002	Effects of Ownership Restrictions on Farmland Values in Saskatchewan	6	0.043	0.520	-0.408	0.423	4
Shaik, 2007	Farm Programs and Land Values in Mountain States: Alternative Panel Estimators	7	0.429	0.608	0.224	0.125	15
Kilian, 2010	Die Kapitalisierung von Direktzahlungen in landwirtschaftlichen Pacht- und Bodenpreisen - Theoretische und empirische Analyse der Fischler-Reform der Gemeinsamen Agrarpolitik	8	0.169	0.472	-0.056	0.272	3
Goodwin et al., 2010	The Buck Stops Where? The Distribution of Agricultural Subsidies	9	0.041	0.134	0.007	0.042	8
Taylor & Brester, 2005	Noncash Income Transfers and Agricultural Land Values	10	0.100	0.100	0.100		1
Weerahewa et al., 2008	The Determinants of Farmland Values in Canada	11	0.060	0.060	0.060		1
Pyykkönen, 2005	Spatial Analysis of Factors Affecting Finnish Farmland Prices	12	0.412	0.835	0.166	0.256	8
Shaik et al., 2006	Farm programs and agricultural land values	13	0.281	0.543	0.099	0.119	31
Goodwin et al., 2003	What's wrong with our models of agricultural land values?	14	0.057	0.130	-0.037	0.064	6
Goodwin et al., 2005	Landowners' Riches: The Distribution of Agricultural Subsidies	15	0.079	0.233	-0.020	0.094	8
Shaik et al., 2005	The Evolution of Farm Programs and their contribution to agricultural land values	16	0.256	0.397	-0.040	0.136	14
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	17	0.299	0.469	0.121	0.100	28
Latruffe et al., 2008	Capitalisation of the government support in agricultural land prices in the Czech Republic	18	0.205	0.890	0.040	0.296	10
Devadoss & Manchu, 2007	A comprehensive analysis of farmland value determination: a county-level analysis	19	0.020	0.020	0.020		1
Weersink et al., 1999	The Effect of Agricultural Policy on Farmland Values	20	0.008	0.013	0.002	0.004	10
Barnard et al., 1997	Evidence of Capitalization of Direct Government Payments in to U.S. Cropland Values	21	0.265	0.690	0.120	0.180	8
Shaik et al., 2010	Did 1933 New Deal Legislation Contribute to Farm Real Estate: Temporal and Spatial Analysis	22	0.378	0.875	0.103	0.230	18
Runge & Halbach, 1990	Export Demand, U.S. Farm Income and Land Prices: 1949 - 1985	23	0.322	1.184	0.051	0.208	40
Veeman et al., 1993	Price Behaviour of Canadian Farmland	24	0.384	0.470	0.260	0.083	5
Goodwin & Ortalo-Magné, 1992	The Capitalization of Wheat Subsidies into Agricultural Land Values	25	0.380	0.380	0.380		1
Vyn, 2006	Testing for Changes in the Effects of Government Payments on Farmland Values in Ontario	26	0.130	0.184	0.075	0.077	2
Total			**0.271**	**1.184**	**-0.408**	**0.200**	**246**

Source: Authors' own compilation.

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), 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) and agri-environmental payments (e.g. conservation reserve programme payments in the US, agri-environmental programmes in the EU). These categories are closely related to the OECD PSE classification and the numbers of observations in each category are listed in Table 4. 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 in 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.

Table 4. List of independent variables

Category	Description	Share in %	Number of observations
Government payment classification based on OECD PSE categories	Market price support	31	76
	Direct payments	17	43
	Decoupled direct payments	4	9
	Agri-environmental payments	2	4
	Total government payments	46	114
Model variables	Use of proxies, e.g. cash receipts, yield, etc.	76	188
	Land rent	24	58
	Only agricultural variables considered	27	67
	Inclusion of non-agricultural variables	73	179
Data variables	No diversification	74	181
	Only arable plots considered	24	59
	Special forms of plots	2	6
	Any form of aggregation, e.g. county level	86	212
	Farm level data	14	34
	North America	80	197
	Europe	20	49
Structural variables	Single equation model	57	141
	Multiple equation model	43	105
	Linear function	55	135
	Double log specification	45	111
	Spatial econometrics	13	31
	No application of spatial econometrics	87	215
	Lagged dependent variable used	3	8
	No lag of dependent variables	97	238
	Lagged independent variable used	21	52
	No lag of independent variable	79	194
Informational variables	Publication	85	209
	Not published	15	37

Source: Authors' own compilation.

All utilised Z variables are listed in Table 4. 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 having been considered in the study. For this, we choose to include a dummy variable when estimations are based on arable land (which is corn, wheat and soybean dominated). In addition, studies are either based on US or European data and we use a dummy to account for the two different regions. Finally, we include a dummy variable for farm level data versus aggregated data (e.g. county level or province level). Structural variables account for differences in estimation methods. We include dummy variables 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.

According to the estimation results in Table 5 the constant has a highly significant value of 0.388. Hence, with some caution one could interpret this as average capitalisation elasticity over all types of agricultural support. A 1% change in support implies a 0.388% change in land prices. Based on our meta-analysis we cannot confirm a significant difference in capitalisation of market price support and direct payments compared to the reference category of total government payments. In contrast, decoupled direct payments seem to capitalise at a significantly higher rate into land values. Furthermore, the results indicate that agri-environmental payments are capitalised into land at a lower rate than the reference category of total government payments.

Table 5. Estimation results of the meta-regression analysis

Category	Variable	Coefficient	Std. Error	t-Statistic
Government payments	Constant	0.388 ***	0.047	8.17
	Market price support	0.018	0.035	0.53
	Direct payments	0.058	0.064	0.92
	Decoupled direct payments	0.143 **	0.063	2.28
	Agri-environmental payments	-0.184 **	0.071	-2.59
Model variables	Land rent	-0.184 ***	0.031	-5.89
	Inclusion of non-agricultural variables	-0.148 ***	0.033	-4.42
Data variables	Only arable plots considered	0.094 **	0.038	2.45
	Farm level data	-0.127 ***	0.040	-3.20
	Studies using European data	0.003	0.053	0.05
Structural variables	Multiple equation model	0.009	0.026	0.34
	Double log specification	0.021	0.034	0.60
	Spatial econometrics	0.205 ***	0.042	4.88
	Lagged dependent variable used	-0.308 ***	0.043	-7.13
	Lagged independent variable used	-0.090 **	0.036	-2.49
Informational variables	Publication	-0.027	0.031	-0.85
	R-squared	0.616		

***p<0,01, **p<0,05, *p<0,10

Source: Authors' own compilation.

In regard to the *Z* variables, the results show that taking theoretically consistent land rents (returns to land) to explain land values leads to lower elasticities of capitalisation. A similar effect occurs if non-agricultural variables are included in the estimations. Significantly higher capitalisation elasticities are observed for arable land and for aggregated data. 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 significant negative influences. Elasticities in published studies are not significantly different from those found in work that was not published.

5. Discussion

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 that 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 a good's characteristics. 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 stream of earnings from this asset. Using this as a starting point, we explained some of the developments and extensions of this model in regard to the NPV of land. 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 relationship between land prices and probably the most important influence factors – land rents and government payments – it also suffers several 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 the model is lacking theoretical consistency. Second, the NPV model does not explain what determines land prices beyond expected future earnings. We have discussed that in the econometric adoption of the NPV model additional explanatory variables can be introduced as shifters, comparable to the urban pressure indicators used in Goodwin et al. (2003). 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 estimations.

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 – and 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 capitalisation rates. The results show that total government payments (not distinguishing different types) capitalise into land values with an elasticity of 0.388, with a 95% interval between 0.293 and 0.483. We are not able to find any significant difference in the capitalisation elasticity for market price support and direct payments compared to total payments. This seems reasonable (especially for market price support), given the importance of these two categories in total government payments. However, we find a significant higher capitalisation elasticity of additional 0.143 for decoupled direct payments. This is in line with theoretical considerations by Kilian et al. (2011), who argue that decoupled direct payments in the EU are strictly a subsidy on the input factor land and hence increase land rents to a larger extent than market price support or animal payments. Results indicate a significantly lower capitalisation rate (-0.184) for agri-environmental payments compared to total payments. This seems reasonable given that agri-environmental payments often decrease land rents through decreased yields or increased input costs.

Furthermore, the results show that taking theoretically consistent land rents (returns to land) to explain land values, rather than a proxy like market revenues, leads to lower elasticities (-0.184) of capitalisation in regard to government payments. Hence, taking a proxy significantly overestimates the capitalisation rate. The same is true for not including non-agricultural variables accounting, for example, for urban pressure. Neglecting them results in a 0.148 percentage point higher capitalisation rate. In addition, we find a significant influence of the land type, the data type and estimation techniques on the capitalisation rate.

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Appendix

Table A.1 Selection of articles which estimate land price coefficients

Article	Research Design	Main Results
Government support not mentioned		
Traill, 1979	Study of the farm income effect (E.C. product price changes) on land values. Average annual price of land for England and Wales, farm income data for the UK, time span 1946 – 1978.	1% increase in product prices would raise land prices by about 10% in the long run. Net farm income coeff.: 10.51, which is an equivalent to an elasticity of 1.19 at the means of all variables.
Melichar, 1979	Implements the annual growth rate of the current return into the capitalisation formula.	If the annual growth rate is greater than zero the net present value of an asset rises, even though the rate itself and the discount rate applied to future returns remain unchanged. Net farm income is not an appropriate measure to explain farmland values. Reconsidering the variables expected capital gains and current yields on alternative investments.
Castle and Hoch, 1982	National data of 1920 to 1978.	Capital value of farm real estate includes the capitalised value of a stream of expected future increases (or decreases) in rent plus capital gains (or losses) not associated with service flows in agricultural production.
Alston, 1986	Use of cash rents as a measure of income to land rather than residual income measure. Annual data for eight US states for the period 1963 to 1982 is used.	Identifies real growth of rental income to land and the interaction of inflation and tax laws of the real growth of land prices in the 70s and 80s. The sum of the estimated weights on lagged capital gains: 1.54 (which is used as a coefficient of β). Negative effect of an increase in expected inflation on real land prices, although relatively small.
Burt, 1986	Second-order rational distributed lag on net crop-share rents. Sample period 1960 – 1983.	Capitalisation rate on rent = 4%. No significant effect of the expected rate of inflation and an exponential trend on rent expectations and land prices.
Featherstone and Baker, 1988	Use of cash rent and land price data of Tippecanoe County, Indiana, from 1960 through 1985. The crop returns data are estimates of the actual returns to land for corn and soybeans.	Cash rent coeff.: 5.936 Land value is a function of historical cash rents, while cash rents are a function of historical residual returns to land.
Falk, 1991	Use of statistical techniques to study the relationship between financial asset prices and returns. Annual farmland price and rent data over 1921 to 1986.	High correlation of farmland price and rent movements, but farmland price is more volatile. Failure of the net present value model. Farmland is characterised by rational bubbles and a time-varying discount rate could be favourable. Suggestion of non-traditional (or fad) models to explain farmland prices.
Veeman et al., 1993	A dynamic model of demand for Canadian farmland is developed and applied to data for Canada and for the provinces Alberta, Saskatchewan, Manitoba and Ontario from 1961 to 1987. Total farm cash receipts are used as a proxy variable for the current economic returns from farm operations.	Direct government payments account for 8.1% of total farm cash receipts from 1971 to 1990. The abolition of direct government transfer payments to farmers would reduce total farm cash receipts by 13.1% and would lead to a drop of land prices of 4.98% in the short run and by 18.47% in the long run. Cash receipt elasticity, short-run: 0.26 – 0.47 Cash receipt elasticity, long-run: 0.92 – 1.52

Clark et al., 1993	Questions of capitalisation of farm subsidies into land values and if subsidies can simply be added to income from farm operations in explaining changes in land values. Annual, province-level observations from 1950 to 1987 on subsidies, income and land values in Saskatchewan, Canada. Subsidy data include direct and indirect payments.	Subsidies as well as farm-generated income are capitalised into land values. Income by itself cannot support the secular growth in land values, income plus subsidies may.
Hardie et al., 2001	County level farmland and residential housing values for 230 counties in the Mid-Atlantic region. Farm returns, developed land values, household incomes, population densities, location as variables for 3 cross-sections of 1982, 1987 and 1992.	Inelastic response of farmland prices to change in farm returns and more elastic response to nonfarm factors. Farm prices tend to increase systematically relative to house values as counties become more populous – diminishing elasticity of response of farmland price to house price. Mean revenue elasticity: 0.437 – 0.605 Farm expenditure elasticity: 0.2 – 0.5
Taylor and Brester, 2005	The study quantifies the impact of U.S. sugar policy on Montana's irrigated cropland prices as an examination of noncash income transfer on agricultural land prices. The land transactions data include 569 observations on sales in 15 counties between 1986 and 1999. The expected real annual price of sugar beets is used as a proxy for returns to land from sugar production.	Capitalisation of the economic rents from noncash income transfer into land price Sugar beet price elasticity: 0.16 Cash receipt elasticity: 0.10 Sugar beet price plus sugar beet producing county elasticity: 0.32 Statistically significant coefficient for population density.
Government support as a coefficient		
Klinefelter, 1973	Annual Illinois average for each variable in the time period 1951 – 1970.	Government payments coeff.: -1.6937 Estimation result against theory. Multicollinearity probably a reason. Strong positive correlation between land values and government payments.
Vantreese et al., 1989	The influence of Burley tobacco quota is the centre of investigation. Data basis are individual agricultural land transactions over a thirteen-year period from 1973 to 1985 for twenty-nine counties across Kentucky, United States. Exclusion of observations with potential bias through hobby farming and urbanisation. Regression of parcel's price on hedonic factors. Use of year dummy variables for the tobacco quota.	The quota value as a percentage of average land value per acre is calculated after the estimation of capitalised values by year. According to the authors the capitalised value of quota per acre is between 12.1% and 38.9%. The tobacco quota values fluctuated 75% between some years.
Runge and Halbach, 1990	Examination of the relative role of exports in determining expected net returns to farming over time as main objective. Observations in the grain region "Northwest Area" over the period 1949 to 1985. Direct government payments are the cash payments made to farmers complying with various provisions of farm program legislation.	Domestic demand and foreign demand as explanatory variables have a positive and significant influence on land and building values in most states as well as direct government payments. Direct government elasticity: -0.056 to 0.404 over the period 1949 to 1985 Domestic demand elasticity: 0.193 - 0.701 over the period 1949 to 1985 Foreign demand elasticity: 0.260 – 0.484 over the period 1949 to 1985

Goodwin and Ortalo-Magné, 1992	Observation of the role of policy in determining agricultural land values in 6 important wheat-producing regions of Canada (Manitoba, Saskatchewan), US (Kansas, North Dakota) and France (Centre, Picardie). Government support for agricultural producers is measured through OECD PSE. Pooled data from 1979 to 1989.	PSE elasticity: 0.38, implicating that a 1% increase in PSEs corresponds to a 0.38% increase in land prices. Expected yields and adjusted producer prices are also shown to significantly influence land values (elastic response, all elasticities between 1.02 and 1.19).
Just and Miranowski, 1993	Cross-section/time-series data by state from 1963 to 1986. Research of the effects of naïve expectations of land prices, market returns and government payments, opportunity cost of capital, inflation etc.	Government payments account for 15 to 25% of the capitalised value of land, but only for a small part of fluctuations. They do not change significantly from year-to-year, when they do, they only partially offset the change in market returns to farming. Large price swings are largely explained by inflation rates and changes in real returns on alternative uses of capital.
Barnard et al., 1997	Two different regression-based approaches to address the question of how much impact government commodity programs currently have on the value of cropland via capitalisation of direct government payments. In the dataset, 1994 to 1996, county-level averages of the annual amount of direct government payments are used.	Government payments elasticity: 0.12 – 0.69 (only those 8 states with a greater effect than 10%). Variables like population access and the presence of intensive crops have a significantly positive influence on land values.
Weersink et al., 1999	Weersink allows the discount rates of the two income sources (farm production and government subsidies) to vary in a NPV model. Annual data from 1947 to 1993 of Ontario, Canada, on farmland prices, direct government subsidies and income from farm operations.	Government payments are discounted less than are market based returns suggesting – government payments have been viewed as a more stable source of income than market-based returns. Subsidy elasticity, short-run: 0.009 Subsidy elasticity, long-run: 0.625 Production income, short-run: 0.062 Production income, long-run: 0.433
Duvivier et al., 2005	Effects of the 1992 and subsequent CAP reforms on arable farmland prices in Belgium are the centre of investigation. Use of a balanced panel of 42 Belgian districts for the period 1980 to 2001. The sum of agricultural family income to account for market sales and the amount of support by hectare and the area of the crop (cereals, rapeseed, flax and fallow) to account for government support are used (instead of realised payment per hectare). The expectation approach is constructed through a four year average.	Positive effect of the 1992 CAP on the arable farmland price in Belgium. Compensatory payment elasticity: 0.12 – 0.47 The authors state that the sensitivity of arable farmland values to compensatory payments increases during the 1993-2001 period. The expected land rent from market sales has an important effect on arable farmland prices. The intervention price cut induced by the 1992 CAP reform decreases the rate of capitalisation of the expected land rent from market sales (decreasing elasticity from 0.24 to 0.18).

Devadoss and Manchu, 2007	Use of county level cross-sectional and time-series data of the counties along the Snake River valley in Idaho, United States, covering the years from 1983 to 1997. Government payments and net farm income was obtained from the USDA and the farmland values from the Idaho State Tax commission.	Government payments: 0.0058 (Model I, not sig.) and 0.0002 (Model II, not sig.) Net farm income: 0.01 (in both models) Net farm income, wheat yield, population and credit availability have positive effects on land values. Property tax rates, interest rates and debt to asset ratio have negative effects on land values. Demographic and macroeconomic variables are more important than the government subsidies.
Weerahewa et al., 2008	Objective of determining the impact of changes in income from the market and government payments on farmland values. Use of provincial data from 1959 to 2004. Separation of this sample period into three general policy regimes (1959 – 1974, 1975 – 1990 and 1991 – 2004).	Farmland values seem to be disconnected from adjusted earnings per acre regardless of model specification. Positive influence of population density and negative influence of increases in real interest rates on land prices. Decoupling of government payments (introduction in 1991) appears to have had no negative effect on land values. Net farm income elasticity: 0.01 – 0.003 Government payment elasticity: 0.02 – 0.06
Shaik et al., 2010 (improvement of Shaik, 2005; Shaik et al., 2006 and Shaik, 2007)	Use of an extended income capitalisation model to pay attention to counter-cyclical payments. U.S. state level data for 48 states in the period 1938 to 2006.	On average 41.0-45.6% of farmland values can be identified with farm program payments and 54.4-59.0% with farm returns. Regional differences in capitalisation. Farm program payment elasticity: 0.103 – 0.875 depending on the resource region Farm program payment elasticity: 0.326 in the U.S.
Predominantly separate modelling of government support measures		
Pyykkönen, 2005	National Land Survey (NLS) land price data of arms-length transfers of arable land from 1995 to 2002. Use of location on GIS coordinates for the creation of a weight matrix in the spatial lag specification. Average yield of barley on province level as a proxy for land quality (1995 – 2000). The support variables are on municipality level; only land-based support was included.	Yield elasticity: 0.489 (2000 – 2002) - 0.547 (1995 – 1999) CAP elasticity: 0.212 (1995 – 1999) – 0.602 (2000 – 2002) LFA elasticity: 0.166 (1995 – 1999) – 0.835 (2000 – 2002) Results for environmental payments and national land-based support are not significant. CAP and LFA payments are similar and discounted at a lower rate than market income. CAP discount rates are lower in the 2000 – 2002 period compared to the 1995 – 1999 period. The author reports that ignoring spatial dependence leads to incorrect results. Influences on land prices are reported for land quality parameters, structural differences and structural change and infrastructure (other industries).
Latruffe et al., 2008	Private transactions between 1995 – 2001 used as averages per district and per year. Average crop yields at the district level to proxy market-based returns. Assumption that effect of support is similar across districts and therefore national data is used.	Strongest effect of direct payments (in this case area payments), compared to payments based on output and farm income. Higher capitalisation in pasture and gardens than in arable land. Capitalisation of government payments with a delay effect. No significant influence of population density and the average crop yield. Gov. paym. elasticity: 0.07 - 0.22 for arable land Gov. paym. elasticity: 0.10 – 0.89 for pasture Gov. paym. elasticity: 0.06 – 0.61 for gardens

Goodwin et al., 2010 (improvement of Goodwin et al., 2003 and Goodwin et al., 2005)	USDA NASS survey farm-level data of 1998 – 2005. Farmland values are estimated by farm operators. Favours expected payments (historical average values, preceding 5-years) instead of current payments – substantive differences in estimates.	Market return coeff: 3.45 (5-year avg.) Total payments coeff: 13.13 (5-year avg.) Highest capitalisation of disaster payments and LDP, then direct payments and other payments and an important role of urban pressure.
Kilian, 2010	A pooled OLS regression of actual transactions in Bavaria for odd years from 2001 to 2007 (model I) and a cross-section of 2007 (model II) on cropland sales transactions.	Direct payments: € 6.74 (model I) and € 29.77 (model II) Agri-env. payments: € -26.41 LFA payments: € 3.43 (not significant) Influence of variables describing non-agricultural demand.

Source: Authors' own compilation.

Comparative Analysis of Factor Markets for Agriculture across the Member States

245123-FP7-KBBE-2009-3

The Factor Markets project in a nutshell

Title	Comparative Analysis of Factor Markets for Agriculture across the Member States
Funding scheme	Collaborative Project (CP) / Small or medium scale focused research project
Coordinator	CEPS, Prof. Johan F.M. Swinnen
Duration	01/09/2010 – 31/08/2013 (36 months)
Short description	Well functioning factor markets are a crucial condition for the competitiveness and growth of agriculture and for rural development. At the same time, the functioning of the factor markets themselves are influenced by changes in agriculture and the rural economy, and in EU policies. Member state regulations and institutions affecting land, labour, and capital markets may cause important heterogeneity in the factor markets, which may have important effects on the functioning of the factor markets and on the interactions between factor markets and EU policies. The general objective of the FACTOR MARKETS project is to analyse the functioning of factor markets for agriculture in the EU-27, including the Candidate Countries. The FACTOR MARKETS project will compare the different markets, their institutional framework and their impact on agricultural development and structural change, as well as their impact on rural economies, for the Member States, Candidate Countries and the EU as a whole. The FACTOR MARKETS project will focus on capital, labour and land markets. The results of this study will contribute to a better understanding of the fundamental economic factors affecting EU agriculture, thus allowing better targeting of policies to improve the competitiveness of the sector.
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Partners	17 (13 countries)
EU funding	1,979,023 €
EC Scientific officer	Dr. Hans-Jörg Lutzeyer