Impacts of Agricultural Policy Reform on Land Prices:

A quantitative analysis of the literature

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Abstract
Agricultural policy support to farmers is being reconsidered in most industrialized countries. The adverse incentive structure of price support is generally considered to be inadequate. Income support schemes may therefore be preferable in view of externalities of agricultural production such as the development and maintenance of nature. A plethora of studies comprises estimates of the impact of a sustained future benefit stream (among other things through continued price and income support) on land prices. The empirical results of these studies vary considerably. We apply meta-analytical methods to identify the factors explaining this variation in capitalization of future benefits in agricultural land prices. The resultant information is of crucial importance given the current change from price support to income support in agricultural policymaking. The results of the meta-analysis show that there is considerable variation due to the way in which income is taken into account, and the way in which expectations of future benefits are operationalized. There is also evidence that a change from a mixed price and income support scheme to a system of income support will result in substantially lower capitalization in land values.

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1. Introduction

The capitalization of agricultural income, price support, and government payments into agricultural land and other asset values has received quite some attention in the economic literature. The single most specific feature of the production factor land is the fact that it is the input with the least elastic supply. According to standard economic theory, this implies that its value rises as a result of price increases, such as for instance, caused by agricultural price support. Several policy questions are at stake when considering the extent to which agricultural income is capitalized into land values. One of the main objectives of agricultural policy is to stabilize and support the income of farmers and the rural community. However, if agricultural policy results in an increase of land prices, part of the agricultural support might flow out of the agricultural sector if farmers are not owner operators but tenant farmers. In fact, farmers who have to rent land might even be worse off, because increasing land values do imply increasing land rents and hence higher costs for tenant farmers. Another policy issue is the role of land prices in land use decision-making. Inflated agricultural land values increase farmers' capital costs, implying that high production values (attained through the use of intensive production methods) are needed in order to earn back these costs. A price reduction for land, possibly resulting from a change in agricultural policy, may induce a trend towards less intensive production patterns. This intensity reduction may also have positive effects on environmental quality in rural areas, and induce alternative, more environmentally friendly, land-uses such as recreation.

In the literature a plethora of studies comprises estimates of the impact of agricultural income, changes in agricultural price support and government payments on land prices. The empirical results of these studies vary considerably, depending on, for instance, geographical location, time period covered, explanatory design, and the use of econometric techniques. In our review of 17 studies, published between 1966 and 2001, we find 232 elasticities ranging from –.34 to +1.79 with an average elasticity of +.33. This seems to indicate that there is a positive, although inelastic, relation between income and income-enhancing policy measures and private land use values. The range of values observed in the literature is, however, considerable. In order to identify the underlying factors causing the variation in the impact of different sources of income on agricultural land prices as reported in the literature, we apply meta-analytical methods. Meta-analysis is an established statistical technique in medicine and the sciences, usually applied in the context of (semi-) controlled experiments.

In particular we will look for the influence of substantive differences, such as differences among various sources of income (including policy-related price and income support), differences over geographical space or among different crops. We will, however, also control for differences in time coverage, crucial aspects of the research design, data characteristics, and estimation techniques. The meta-analysis should enable us to shed light on the potential success of the switch from price support to income support measures currently contemplated in many industrialized countries.

The organization of the remainder of this paper is as follows. Section 2 reviews the literature on the capitalization of agricultural income regulations on land values, and identifies the main issues that are being discussed in the literature. Section 3 introduces meta-analysis, and discusses the pros and cons of such an analysis. In Section 4, we present the main characteristics of the meta-database. Section 5 contains the results of the meta-regression. Finally, Section 6 summarizes the main results and presents conclusions.

2. The state of the art in the agricultural land price literature

In the agricultural economic literature an extensive body of work on the determinants of farmland rents and values exists.[1] Shi et al. (1997) divide the literature on agricultural land price determination into two broad categories. The first category of studies uses income from agricultural production as the major determinant for land rent and prices. The theoretical framework underlying most of the studies of this category is the asset pricing or capitalization model implying that the value of an asset is equal to the discounted value of all future expected earnings. The asset-pricing model emerged from finance and real estate theory, but it is also related to the net present value model used in natural resource economics (Randall and Castle 1985). The main reason for the increasing interest in the determinants of agricultural land prices, especially in the US, was the explosive increase in farmland prices in the 1970s followed by an equally rapid decrease in the 1980s. As the main explanations for this cyclic pattern in farmland prices economists have suggested, changes in agricultural returns (e.g., Alston 1986; Burt 1986; Phipps 1984), inflation and real interest rates (e.g., Feldstein 1980; Gertel 1990; Just and Miranowski 1993), capital gains (e.g., Castle and Hoch

1982; Melichar 1979), and debt acquisition (e.g., Shalit and Schmitz 1982; Reinsel and Reinsel 1979).

The second category of studies mainly uses non-farm factors to explain the variation in agricultural land prices. These studies are based on the hedonic pricing model, and frequently use variables such as the distance to urban centers or highways, population density, the attractiveness for recreational activities, and/or land and soil characteristics. The focus of these studies ranges from the valuation of urbanization and urban fringes (e.g., Chicoine 1981; Clonts 1970; Dunford 1985; Hushak 1975; Shi et al. 1997; Shonkwhiler and Reynolds 1986; Steward and Libby 1998), to soil and site characteristics (e.g., Elad et al. 1994; Miranowski and Hammes 1984; Xu et al. 1993), and erosion control and soil conservation (e.g., Ervin and Mill 1985; King and Sinden 1988; Palmquist and Danielson 1989).

The above shows that there is considerable consensus about theoretical and modeling aspects of land price determination. Studies are either based on the theoretical notion of asset pricing, or they take a rather ad hoc revealed preference approach as their basis. However, as pointed out by Robison and Koenig (1992), the most striking aspect of the asset pricing and the hedonic pricing literature is the lacking consensus with respect to the data that adequately represent the rent, and the way in which expectations should be modeled. The basic capitalization model is formulated by:

$$LV_t = \int_0^\infty E_t R_{t+k} e^{-kr} dk \quad (1)$$

where LV_t is the equilibrium land value at time t, R_{t+k} the real residual returns to land, or land rent, at time $t+k$, E_t the expectation on returns to land conditional on the information available at time t, and r the continuous real discount rate (Featherstone and Baker 1987). The ways in which expectations and land rent are built into a model are thus of crucial importance for the resulting estimates. A popular approximation of the land rent, which is used in many studies, is net farm income. Net farm income is generally defined as the residual income from agriculture after deducting costs for capital, land, and hired labor.[2] Melichar (1979) points out, however, that net farm income may be inappropriate for measuring returns to land, and that "pure" returns to land should be used instead.

More recent studies often use net rents or residual returns to land or assets as an approximation for the rent. Unfortunately, net rent data are almost exclusively available in the US. Studies dealing with areas outside the US are unequivocally forced to use other agricultural income indicators to operationalize the rent concept. For instance, Canadian studies often employ cash rent, farm income or gross farm income (Gunjal et al. 1996). Another group of studies resorts to the agricultural production value or market revenue, defined as physical yield times the average price.[3]

In addition to the use of above approximations of land rent, some studies explicitly focus on determining the land price elasticity of direct government aid. Direct government payments are typically income support measures, for instance related to the farmer's participation in projects. The distinction between the two types of studies (i.e., those based on rent approximations and those focusing on government payments) enables us to determine the influence of a mixed system of price and income support, which is incorporated in the rent, and "pure" income support. This is again related to the contemplated change in perspective of agricultural policy.

Theoretically, the value of land is actually determined by *expectations* of the future returns to land. In a situation of agricultural price support and direct government payments aimed at stabilizing and protecting agricultural income, farmers are assumed to have optimistic expectations about future returns, which subsequently results in inflated land prices. If farmers are confronted with new information, they may have to adjust their expectations of future returns. Agricultural policy reforms with respect to market liberalization, which imply uncertainty about future prices and income from the farmer's point of view, may induce more pessimistic expectations about future returns. The elasticity of land prices regarding expected farm revenues is therefore crucial for agricultural land price determination (Featherstone and Baker 1988; Runge and Halbach 1990, citing Hicks). This is, however, another important source for variation among studies in this literature. Among the divergent ways in which the expectation aspect of farm revenues is accounted for, include taking the weighted average of income over a number of previous years (e.g., Gunjal et al. 1996; Gertel 1990), the use of a so-called Fisher lag (e.g., Traill 1979; Weisensel et al. 1988), and the inclusion of an income variable lagged one or more years (e.g., Burt 1986; Featherstone and Baker 1988).[4]

Apart from the apparent differences in the type of income indicator taken into account and the way in which expectations are modeled, there are potentially many more sources of structural variation among studies. Variations with respect to study characteristics include differences in the location of the area of study, the way in which and the extent to which agricultural characteristics of the area are taken into account, and divergence in the time periods considered. Another important source of variation is related to the nature of the data being used. The use of time series data is very popular in agricultural land price studies. There are, however, also studies that use cross section data or a time series of cross section data. These differences can obviously impact the estimation results. The level of aggregation has been hypothesized to have an effect on the magnitude of the estimates as well. Burt (1986) points out that difficulties, such as heterogeneity of land quality, the influence of non-agricultural values, and inaccurate estimates of rents and land values, are aggravated by using highly aggregate data. The estimated elasticities derived from aggregate data may be biased downwards.

Other aspects responsible for variation among studies are related to the specification of the model and the estimation technique used. The specification and the nature of explanatory variables in addition to agricultural returns, the functional form of the regression, and the properties of the estimator used in the estimation may have an influence on the estimation results.

Table 1 presents an annotated overview of the studies that we use in the meta-analysis. Apart from the abovementioned differences in the specification of the income variable, and the way in which expectations are accounted for, Table 1 shows that there is considerable variation in terms of revenues considered (ranging from government payments to total revenues from domestic or foreign markets), crops, spatio-temporal dimensions, model specification (functional form, definition of explanatory variables, estimator), type of data (time series, cross section, or panel data), and the number of observations. This makes it particularly difficult to draw straightforward conclusions from a narrative review of the land pricing literature, and calls for a multivariate analysis of the empirical results of different studies. In the next section we show that meta-analysis provides such a perspective.

3. Meta-analysis

A literature review, by means of which we usually typify and summarize the literature, is usually implicitly based on vote-counting (Light and Smith 1971). Vote-counting essentially boils down to counting the number of significantly positive, significantly negative, and insignificant results, or in this case, for instance, the number of elastic and inelastic results. These results are subsequently simply tallied, and the category with the plurality of cases is usually taken to represent the true characteristics of the underlying population. This procedure is, however, basically flawed because for each estimate there is a probability that the wrong conclusion is drawn (i.e., the so-called Type-II error), and these mistakes do not cancel out when the number of studies considered increases. Consequently, we tend to draw the wrong conclusion more often as the number of studies increases (Hedges and Olkin 1985).

Meta-analysis constitutes a technique developed in the context of the (social) sciences based on an experimental methodology, mainly medicine, psychology, marketing, and education. It refers to the statistical analysis of statistical summary indicators of studies performed previously, usually labeled "effect sizes." Typically, effect size indicators are defined as standardized mean differences, probabilities, or correlations. In economics (standardized) regression coefficients and elasticities have often been used (Van den Bergh et al. 1997).

In the context of meta-analysis, a series of statistical techniques has been developed, covered in sufficient detail in, for instance, Hedges and Olkin (1985), and Cooper and Hedges (1994). In various subdisciplines of economics, meta-analysis is now gaining ground, most notably in environmental economics and particularly in the field of environmental valuation. Meta-analyses on urban pollution valuation studies are carried out by, for instance, Schwartz (1994), Smith (1989), Smith and Huang (1993, 1995), and Van den Bergh et al. (1997), on recreational benefits by, e.g., Smith and Kaoru (1990), Smith and Osborne (1996), Sturtevant et al. (1995), and Walsh et al. (1989), and on groundwater and wetland valuation by, e.g., Boyle et al. (1994), Brouwer et al. (1997), and Woodward and Wui (2001). In agricultural economics, meta-analyses are performed by Alston et al. (1998) investigating the returns to agricultural R&D, Espey and Thilmany (2000) focusing on wages elasticities of farm labor demand, Marra and Schurle (1994) studying the effect of farm size on measures of wheat yield risk, Nijkamp and Pepping (1998) exploring differences in pesticide price elasticities, and Phillips (1994) who looks at farmer education and farmer efficiency. The general conclusion that can de drawn from the meta-analyses in the agricultural economic literature is that variations of study results can primarily be ascribed to the underlying agricultural conditions (such as, types of agricultural production, structure of the agricultural sector), and the regional setting. Methodological and operational differences are, however, not without consequences either.

Taking into account sign and significance alone — as in the popular vote-counting — is obviously insufficient to determine whether the results of different studies agree. Differences in magnitude of the estimated effects convey important information as well. Moreover, the results of an empirical study may provide a reasonable estimate of the sampling uncertainty of results, but non-sampling issues such as research design, model specification and estimation techniques, are usually relatively constant within a study (Hedges 1997). Meta-analysis, in which non-sampling characteristics can be taken into account as moderator variables, constitutes an attractive and rigorous approach to synthesizing research results. Most meta-analyses in economics are based on the so-called meta-regression technique. Concisely, a meta-regression is based on some least square estimator of the following relation (Stanley and Jarrell 1989):

$$y = f(p, x, r, t, l) + \varepsilon \qquad (2)$$

where y is a specific effect measure observed in a series of studies, p the specific underlying cause, x moderator variables affecting the cause-effect relationship, r, t and l moderator variables representing differences among research designs, time-periods considered, and locations covered by the initial studies, and ε a random disturbance term.

Apart from the well-known criticism that meta-analysis is invalidated by trying to compare "apples and oranges," there are three evident methodological pitfalls (see also Glass et al. 1981). First, sample selection bias, for instance due to selective sampling on the basis of theoretical framework, date of publication, publication as such, research design, etc. Second, dependence between the observations included in the sample, due to multiple sampling from the same study, dependencies over space and/or time, studies with the same author, etc. Third, heterogeneity among sample observations, which may show up in varying parameters (or heteroscedasticity in a regression context), due to different sample sizes of the initial studies, quality differences among studies, differences in research designs, etc.

The issue of sample selection bias does not receive substantial attention in the economics literature, except for publication bias (Card and Krueger 1995; Ashenfelter et al. 1999). Smith and

Huang (1995) use a logit model to determine the likelihood of sample selection bias by means of including the inverse Mills ratio, which is related to the estimated probability of including a study in the meta-sample on the basis of year of publication, published or unpublished, etc. A careful sample selection process is therefore obviously of paramount importance (see below).

Although most studies in economics use multiple estimates sampled from the same study, the resulting correlation between the estimated effect sizes is usually comfortably ignored. This approach can be justified since ignoring the dependence among estimates sampled from the same study does not affect the unbiasedness and consistency of ordinary least squares estimators. However, it does lead to inefficient parameter estimators. Hedges and Olkin (1985, pp. 220-222) point out that the efficiency gain is probably rather small, and the techniques for handling correlated estimates (such as generalized least squares) may be rather cumbersome to apply (see also Gleser and Olkin 1994).

The methodological caveat of heterogeneity is an inherent problem in meta-analysis, because heteroscedasticity always exists due to the differing number of observations on which the underlying studies, and hence the effect sizes and their standard deviation, are based. Some of the apparent heterogeneity can be incorporated in the specification of the design matrix, as mentioned above. Unobserved heterogeneity can be remedied through a fixed or random effects estimator. Heteroscedasticity can be remedied through the use of weighting procedures (weighted least squares) or White-adjusted variances.[5] In some studies the number of observations on which the effect size is based is included among the explanatory variables, and it usually contributes substantially to the fit of a meta-regression. It should be noted, however, that this “remedy” is not very informative, because it merely replicates the statistical “fact” that the variance of estimated effect sizes is inversely proportional to the number of observations.

4. Description of the meta-dataset

A crucial factor determining the validity of the meta-analysis is the adequacy of the literature retrieval process. We sampled the studies by means of searches in the databases EconLit and Agris, by screening references in available articles, and by looking through the online working paper databases of several agricultural economic departments and institutes. Some of the keywords used, are:

“farm” and “agricultural” in combination with “land prices,” “land values,” “land markets,” “land policy,” and “policy.” From the bulk of literature that resulted from this sampling procedure we restricted the meta-sample to studies containing a quantitative assessment of agricultural land prices or land values that include a measure of agricultural income, rent, or government payments among the explanatory variables.

The interpretation of the estimated coefficients in the resulting set of studies is fairly complicated. A considerable number of studies estimate absolute changes in land prices, which means that the coefficients have to be interpreted in the light of the respective currencies, actual land price, and quality. A comparison of those estimates would have little meaning (Weisensel et al. 1988). A second complication limiting the degree of comparability pertains to differences in the unit of measurement of the agricultural income variable. The major part of the studies uses per acre or hectare units. However, a number of studies, in particular those dealing with a European country, use other units of measurements such as agricultural income per worker or total national income from agriculture. Because the estimated coefficients are not dimension-free, a straightforward comparison of these estimates is precluded as well. In order to obtain a sufficiently high level of comparability, we ultimately sampled only those studies that report an elasticity of the effect of agricultural income on land prices (or alternatively, the elasticity can be computed based on the information provided) and in which a per acre or hectare unit of measurement is used. This sampling framework may obviously be a source of selection bias, but in the context of this paper we will not consider this issue in detail (see also Section 3).

In total we retrieved 17 studies that met the requirements for inclusion in the meta-sample (see also Table 1). The number of observations for the meta-sample, obtained from the different studies, varies considerably. There are three studies from which we sampled only one observation, but from Runge and Halbach (1990) we derived 72 observations. The total of 232 observations are price elasticities of land with respect to agricultural revenues. They are presented in Figure 1, ordered according to magnitude. The elasticities have been obtained in a straightforward manner. For example, Runge and Halbach (1990) estimate separate effects of domestic market returns, foreign market returns, and direct government payments on land values in a model pertaining to eight different states in the US and three different time periods. Hence, we sampled 3 observations from each model for different types of returns, for eight different states and three different time periods, resulting in 72 meta-observations. A similar sampling framework is applied with respect to all studies, also those containing a multiple lag structure. For example, Gertel (1990) and Burt (1986) include agricultural income with and without a temporal lag, which implies that we sampled two meta-observations for the different specifications. Although this procedure results in dependence among the meta-observations, the one-to-one correspondence to the specification of the design matrix may help to mitigate the disturbing influence of the dependence problem.[6]

Figure 1 shows the total sample containing 232 elasticities, ordered by magnitude, with a minimum of –.34, a maximum of +1.79, a mean value of +.33 that is significantly different from zero ($p < .01$), and a standard deviation of +.34. The elasticities have either been taken directly from the study if the specification is doublelog, or they have been calculated using the estimated parameter at the sample mean value.[7] It is obvious from Figure 1 that the vast majority of the estimated elasticities imply a positive and inelastic relation between land values and agricultural revenues.

Figure 2 shows a funnel plot of the estimated elasticities against (the log of) sample size. Because most elasticities are positive the shape of the plot resembles a triangle rather than a funnel, which is not uncommon for strictly positive or negative indicators. The distribution of the elasticities corresponds to the expectation that the variation of the estimated values for lower sample sizes is considerably larger than for higher sample sizes, although the largest variation is observed for analyses based on 50-100 observations, rather than in the 10-50 range.

In Figure 3 the elasticities are grouped according to the differing definitions of agricultural revenues. It shows that elasticities based on government payments as the source of revenues are fairly similar to those of market returns. Net income and return to land are somewhat different because they by and large result in elasticities smaller than .5. Elastic revenue values are obtained for all types of revenues, except for government payments.

5. Meta-regression analysis

In the meta-analysis we use a multivariate regression framework building the design matrix according to the aforementioned dimensions of structural variation between the underlying studies. We use the following categories of variables:

- theoretical and methodological issues,
- agricultural production characteristics,
- spatio-temporal differences, and
- specification and estimation characteristics.

The acronyms of the explanatory variables within these categories and a short description are listed in Table 2.

5.1 Theoretical and methodological issues

The first important dimension refers to the theoretical framework. Most studies are based on the asset pricing theory, but for those employing a hedonic model we have included a dummy variable labeled HEDONIC.

The second dimension refers to the different ways in which agricultural revenues are taken into account. We have grouped the studies in four different categories. The first group, labeled MARKETREV, contains the studies using the broadest definition of income, market revenue defined as physical yield times the price of the crops. Runge and Halbach (1990) further distinguish market revenue according to its domestic (MARKETDOM) or foreign origin (MARKETFOR). It is of crucial importance to note that in this operationalization of agricultural revenues only price support is taken into account. The second group comprises the next level of income, which covers different definitions of net agricultural income (indicated by NETINCOME). It may be assumed that this group of studies takes into account both price support and direct government payments. The third group, defined here as the lowest level of aggregation regarding agricultural income, contains those studies that are explicitly based on returns to land as the income variable (RETURNLAND). The fourth group includes the studies incorporating direct government payments, such as payments for land diversions, commodity storage, deficiency payments, crop insurance, and various other conservation and stabilization programs (GOVPAYMENTS).[8]

An important methodological difference pertains to the way in which expectations are incorporated, or alternatively, the form of lag structure chosen to describe the information on which farmers built their expectations. Various possibilities exist in this respect. A number of studies assume myopic expectations, which implies that they use agricultural returns from the current time period. Other studies include a one-year lag, or a combination of no lag and a one-year lag. There is only one study that uses a two-years lag (Burt 1986). These studies, employing some sort of lag specification, are labeled LAGRENT. Two studies (Weisensel et al. 1988; Traill 1979) use a Fisher lag over five and three years, respectively. Although the time span of the Fisher lag differs, we included them in one category (FISHAVER). Also included in this category are two observations from Gertel (1990) using agricultural income defined as the average of five preceding years. Veeman et al. (1993) and Cavailhes and Degoud (1995) employ the expectation operator λ into their models, which has been labeled (LAMBDALAG).

5.2 Agricultural production characteristics

Four different types of agricultural production are taken into account. First, there are general grain producing areas (GRAIN). Second, there are observations referring in particular to corn and soybeans (CORNSOY). The third group is characterized by wheat production (omitted category), and the last group comprises all those observations for which the type of agricultural production is not explicitly specified (NOTSPEC).

5.3 Spatio-temporal differences

The 232 observations are concerned with three geographical areas, which are the US (11 studies), CANADA (3 studies), and EUROPE (2 studies, one in the UK and one in France). The level of spatial aggregation is threefold. The first category (NATIONAL) includes all observations based on national data, which means that data are aggregated over the whole area of the US, Canada, France or the UK. The second category contains observations based on (multiple) state- or province-level data (STATAPROV). The lowest level of aggregation is given by the third category, data on county and district level (COUNTY).

The time dimension may be an important factor as well, in particular given the rather erratic price fluctuations, mainly in the US during the 1970s and 80s. The variable FIRSTYEAR refers to the first year to which the elasticity is an estimate. The time span, representing the time period (in years) for which the elasticity is relevant, is labeled TIMESPAN.[9]

5.4 Specification and estimation characteristics

The studies are also subdivided according to the type of data used, following the standard classification of time series (TIMESERIES), cross section (CROSSSECTION), and pooled (POOLED) data. The bulk of the studies employ time series data (11 studies). Two studies use cross section data. The remaining four studies employ pooled data: either time series data for different areas with a dummy variable referring to the areas, or cross section data for different years with a dummy for the respective years.

In terms of the specification of the model the inclusion of lagged land prices in the model may be an important issue. According to theory, lagged land prices are supposed to incorporate expectations of farmers in the past. It can be assumed that the estimated elasticity may be biased downwards if a model includes lagged land prices (PRICELAG). It may also be relevant to see whether a time trend has been included (TIMETREND). In terms of the definition of the elasticities a distinction should be made between short and long run elasticities (LONGRUN).

Finally, in the estimation the functional form may exert an influence. We therefore included a dummy variable distinguishing a loglinear specification from a standard linear model (DOUBLELOG). In addition, we indicate whether the model is a single equation model, or a system of equations (SYSEQUA). In terms of estimators we make a distinction between OLS and more complicated estimators, such as maximum likelihood, two stage least squares, and autoregressive estimators.

5.5 Results of the meta-regressions

Table 3 presents the results of the meta-regressions. In the initial regression we specify a simple linear model based on the abovementioned variables. Subsequently, we use a backward stepwise specification strategy, in which first the least significant variable is removed, the model is re-estimated and the variable corresponding to the least significant estimate is removed, etc., until all variables are significant at the 10% level or lower. This procedure is followed using the OLS estimator (Columns 1 and 2), and using the White-adjusted variance estimator (Columns 3 and 4), because the White test indicates heteroscedasticity.

Various interesting results can be derived from Table 3. It turns out that virtually none of the "control variables" (accounting for differences in research design, and spatio-temporal dynamics) are significantly different from zero. The theoretical and methodological differences on the contrary are both significantly from zero and very robust. In the extended specifications (Columns 1 and 3) the elasticities for corn and soybeans are (significantly) greater than wheat, whereas elasticities in studies that do not specify a specific crop are significantly lower than those for wheat.[10] The studies with the doublelog functional form show a significantly smaller elasticity. This may, however, at least partly, also be due to the fact that the elasticities derived from doublelog specifications generally cover a larger time-period than those based on the linear specifications. The latter are oftentimes concerned with shorter time periods, and some of those that we derived from sample information provided in the original study are even concerned with one specific year. In accordance to theoretical expectations, long-run elasticities are significantly greater than short-run elasticities, and elasticities derived from specifications containing the lagged dependent variable are significantly smaller.

The most interesting results relate to the theoretical and methodological issues that we discussed above. First, there are no significant differences between the elasticities derived on the basis of the asset pricing theory and the substantially more ad hoc based specifications following a hedonic pricing model. Second, although the appropriateness of using returns to land vs net-income constitutes a major issue in the literature, there are no differences in magnitude between the empirically generated elasticities for these two types of revenue variables. Third, the highest land price elasticities are obtained in relation to net income. Elasticities of market returns are substantially lower, and in the "full" models the elasticities for government payment are the lowest. These results are remarkably robust, as can be seen from the "trimmed down" specifications. However, the latter results show that elasticities for foreign market returns are somewhat lower than those for net income, but both the land price elasticities for government payments and total market return are very similar as well as the lowest as compared to net income. In terms of the redesign of agricultural policy this seems to imply that a change from price and income support systems — representing the current situation — to a system that increasingly makes use of income support as a main policy instrument will result in lower capitalization of future revenues. Although such a system does not have an elasticity that is substantially different from a system of price support (as can be seen from the similar estimate for market return, in which only price subsidies are accounted for) it is likely to have less adverse effects. In addition it may result in a less intensive agricultural production, and hence less environmental pressure.

Finally, the methodological issue of modeling expectations has a substantial influence on the results, in particular when the expectation aspect is modeled by means of a Fisher lag over a medium-sized period (3-5 years).

6. Conclusions

In most industrialized countries agricultural policy support to farmers is being reconsidered. Adverse incentive effects of price support schemes are increasingly viewed with skepticism and positive side effects are attributed to a system based on income support. The latter are justified through externalities of agriculture on land and nature development, and rural prosperity.

An important topic, extensively analyzed and discussed in the agricultural economic literature, is the issue of capitalization of future income revenues (and hence price and income support as well) in the values of agricultural land. There is a substantial literature in which the price elasticity of land with respect to future revenues is empirically assessed. Two important theoretical and methodological aspects of this literature concern the way in which the concept "revenues" or "income" should be understood, and the way in which future expectations can be captured.

This paper focuses on a quantitative assessment of this literature. In particular, we statistically investigate 17 studies with 232 elasticities, that have been based on different theoretical models (hedonic pricing vs asset pricing), use different income variables (ranging from government payments to market return), operationalize future expectations in slightly different ways, have a different research design, and use different types of data. There are several main conclusions to be drawn from this meta-analysis.

First, several differences between the studies, in particular those related to spatio-temporal variation, different types of data, and differences in research design, do not seem to have an important effect on the magnitude of the estimated elasticities. Second, there are also no major differences between the elasticity estimates derived by means of a hedonic pricing model as compared to the asset-pricing model. Third, the ways in which the concept of "future expectations" is operationalized as well as the way in which "revenues" or "income" is specified are of major importance. In relation to the latter differences it can be concluded that the land price elasticity is highest with regard to net income, in which both price and income subsidies are taken into account. Studies that explicitly focus on the elasticity in relation to government payments (i.e., income support) or market revenues (including only price support) show significantly lower estimated elasticities. This can be taken as initial and preliminary evidence that a change from the currently mixed system of supports to a system that is more heavily dependent on income support will result in a lower capitalization in land values. Subsequently, this may have positive externalities in terms of nature development and lower environmental burdens, due to a less intensive production structure.

The results reported in this paper are still preliminary, because there are several issues that should be considered in considerable more detail. Among those topics for further future research are the potential implications of sample selection bias and lacking independence among the meta-sample observations. It is also of considerable importance to further investigate the exact income definitions of the underlying studies, and the potential impact of different categorizations of agricultural revenues for the results of the meta-analysis.

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Notes

[1] The terms “land value” and “land price” are used interchangeably in this paper.

[2] The precise definition of net farm income differs between countries and has undergone changes over time. For an overview of agricultural income indicators see, e.g., Hill (1996).

[3] Differences in the definition of agricultural income indicators used in the studies that make up the meta-analysis are described in detail in Section 4.

[4] Futher details are again provided in Section 4.

[5] Boyle et al. (2000) use weighted least squares deriving standard errors by means of the Huber-White consistent covariance estimator (see also Smith and Osborne 1996).

[6] One can of course maintain that multiple sampling from the same study violates the requirement of non-autocorrelation among the observations because the estimates are derived from the same data. As mentioned in Section 3 this dependence problem is generally considered not to have a substantial impact on the results of a meta-analysis.

[7] Most studies use a doublelog specification (see Table 1). In several studies the elasticity is calculated using the estimated coefficient and the value of the respective variables at the sample mean, either for the whole time period (Traill 1979; Hardie et al. 2001; Tweeten and Martin 1966) or for selected years only (Weersink et al. 1999). Pope (1985) and Featherstone and Baker (1987) provide sufficient data to calculate elasticities, even though they are not reported in the study. Because Featherstone and Baker (1987) provide the complete data set, point elasticities for every single year could be calculated, in addition to the elasticity for the entire time period.

[8] It should be noted that there is some arbitrariness in the definition of these groups, and that the classification of studies was rather cumbersome due to lacking accurate definitions of the income indicator and the precise sources of income included.

[9] For studies using a doublelog specification the time span of the elasticity coincides with the time span of the underlying data used for the estimation. This is not necessarily the case for studies that calculate elasticities *ex post* using the estimated parameters and sample mean values (e.g., Weersink et al. 1999; Featherstone and Baker 1987).

[10] In these cases an extended area is usually covered, with a mix of various different crops.

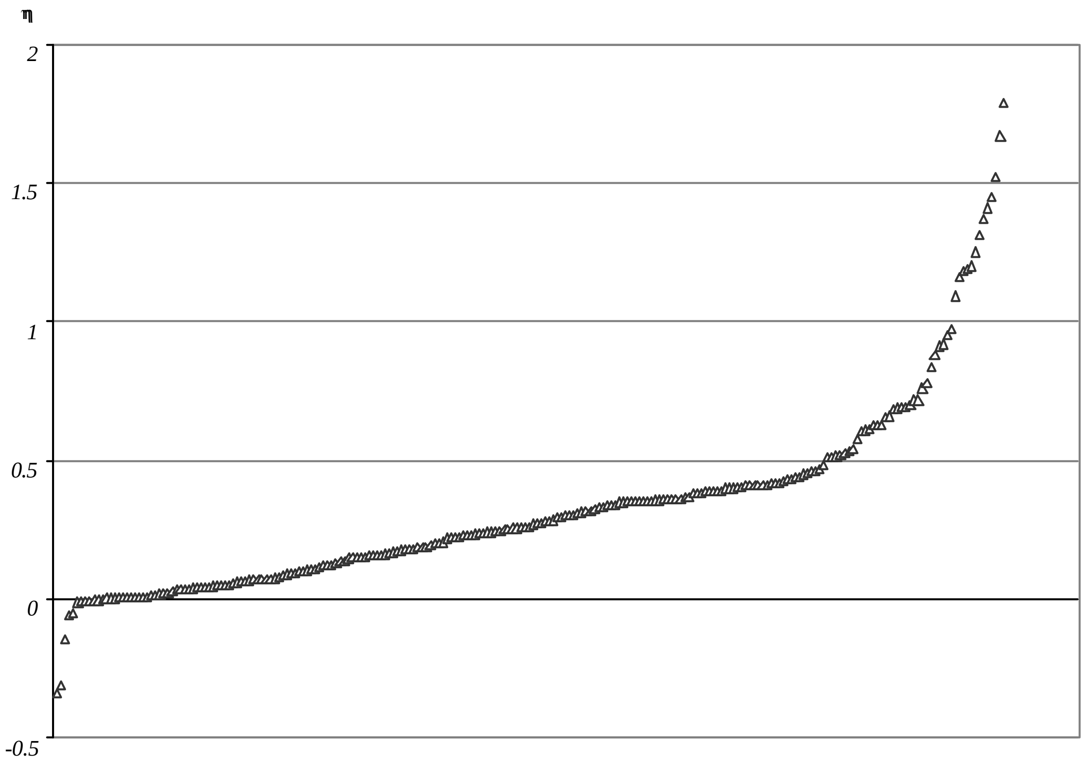

Figure 1: The distribution of estimated land value elasticities (η) ordered by magnitude.

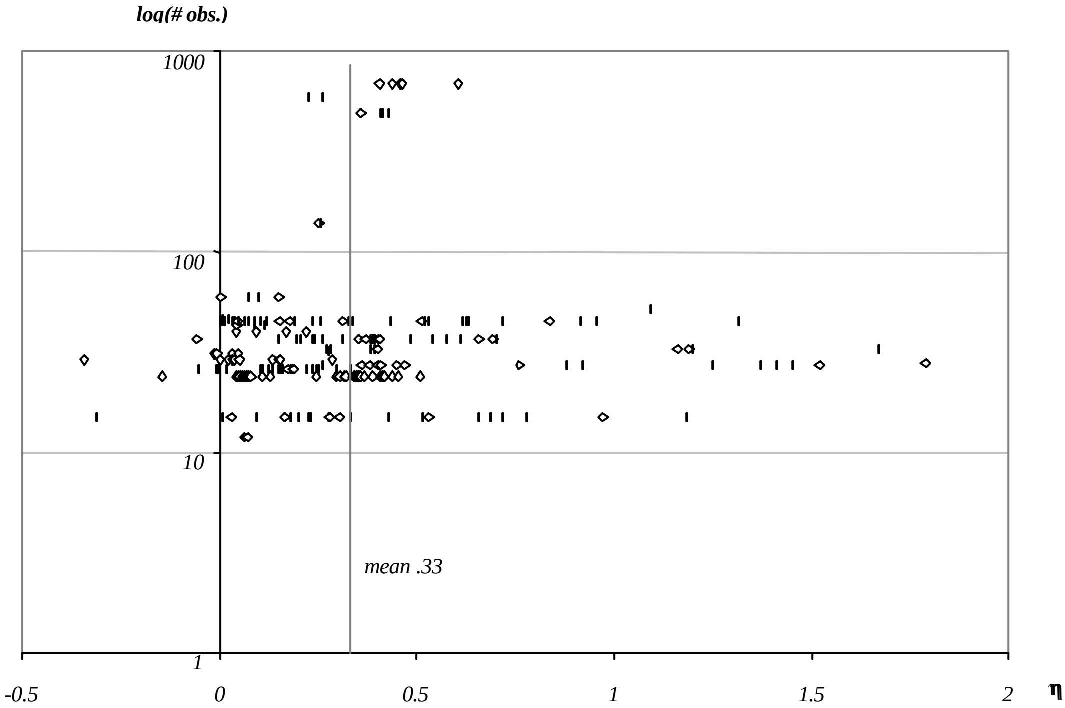

Figure 2: Funnel plot of the estimated elasticities against (the log of) sample size.

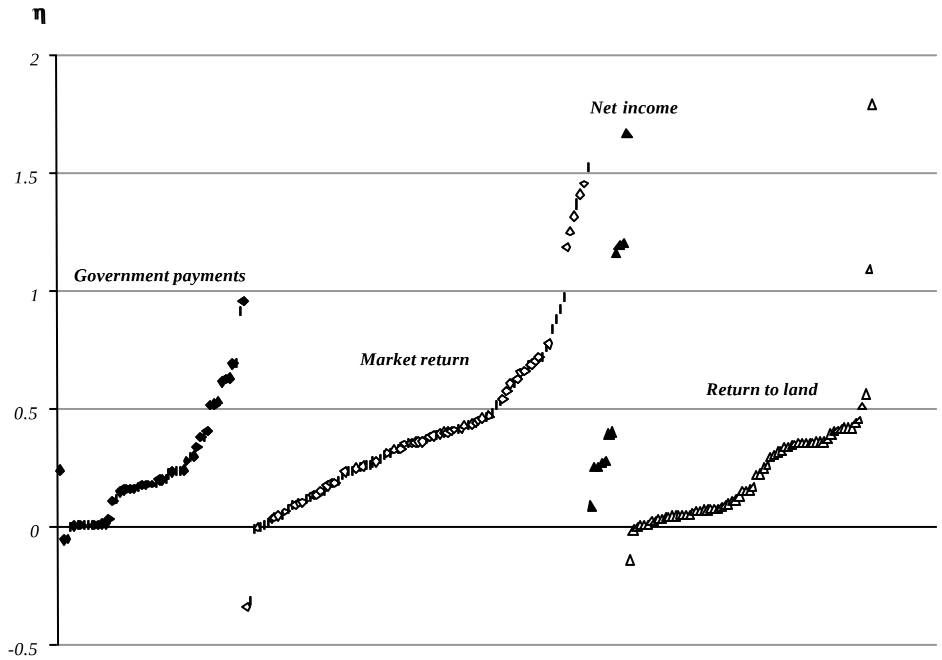

Figure 3: The distribution of estimated land value elasticities (η) ordered by magnitude according to income category used.

Table 1: Studies Included in the Meta-Analysis and their main Characteristics

Study	**# of η**	*country*	*years studied*	**η_{min}**	**η_{max}**	**aver. η**	*income indicator*	*lag structure*	*crops*	*type of data*	*functional form*[1]	*estimator*	*# of obs*
Runge&Halbach (1990)	72	US	1949-85	-0.313	1.184	0.305	MR,GP	none	not spec	time series	double-log	OLS	15-37[2]
Weersink et al. (1999)	40	CA	1949-93	0.002	1.313	0.297	MR,GP	lagrent	grain	time series	others	SYSEQUA	45
Bernard et al. (1997)	8	US	1994-96	0.12	0.69	0.265	GP	none	not spec	pooled	double-log	OLS	na
Veeman et al. *(1993)*	15	CA	1961-87	0.26	1.52	0.845	NFI	lagrent	various	time series	double-log	NONOLS	27
Pope (1985)	2	US	1981	0.224	0.262	0.243	RL	none	not spec	cross sect	others	OLS	592
Gertel (1990)	22	US	1942-87	-0.013	1.789	0.196	RL	various	various	various	double-log	various	28-60[2]
Traill (1979)	2	UK	1946-78	1.16	1.19	1.175	NFI	fishaver	not spec	time series	others	NONOLS	33
Hardie et al. (2001)	5	US	1982-92	0.405	0.605	0.474	MR	none	not spec	pooled	others	SYSEQUA	690
Featherstone&Baker (1988)	27	US	1960-85	0.295	0.51	0.374	RL	lagrent	corn&soy	time series	others	SYSEQUA	24
Goodwin&Ortalo-Magne (1992)	1	US,CA,FR	1979-89	0.38	0.38	0.38	GP	none	wheat	pooled	double-log	NONOLS	33
Cavailhes&Degoud (1995)	6	FR	1961-93	0.27	1.67	0.702	NFI	various	not spec	time series	double-log	OLS	33
Weisensel *et al.*(1988)	4	CA	1950-85	-0.342	0.284	0.088	MR	fishaver	wheat	time series	double-log	NONOLS	29-32[2]
Folland&Hough (1991)	6	US	1978	0.355	0.427	0.387	MR	none	not spec	cross sect	double-log	various	494
Van Vuuren (1968)	2	US	1952-65	0.253	0.254	0.256	NFI	none	not spec	pooled	double-log	SYSEQUA	140
Shalit&Schmitz (1982)	3	US	1950-78	0.034	0.051	0.041	RL	lagrent	not spec	times series	double-log	SYSEQUA	329
Tweeten&Martin (1966)	1	US	1923-63	0.086	0.086	0.086	NFI	lagrent	not spec	time series	others	OLS	41
Burt (1986)	16	US	1960-83	-0.144	0.56	0.1	RL	various	wheat	time series	double-log	NONOLS	12-24[2]
TOTAL	**232**			**-0.342**	**1.789**	**0.334**							

[1]indicates the way in which the elasticity is calculated, double-log means that elasticity is directly estimated, others means that elasticity is calculated based on absolute changes and means of relevant variables; [2]different models in the respective papers are based on varying number of observations
(CA: Canada; FR: France; MR: market revenue; GP: government payments; NFI: net farm income; RL: returns to land; NONOLS: more complicated estimators, such as maximum likelihood, GMM, Cochrane Orcutt, GLS; SYSEQUA: system of equation; not spec: not specified; na: not available)

Table 2: List of Explanatory Variables

VARIABLE	LABEL	# of observations
GEOGRAPHICAL SETTING, AGRICULTURAL CHARACTERISTICS		
USA	Study is set in USA	165
CANADA	Study is set in Canada	60
EUROPE	Study is set in Europe (UK and France)	9
TOTAL		**234**[1]
GRAIN	Grain producing area	140
CORNSOY	Corn and soybeans	37
WHEAT	Wheat production	11
NOTSPEC	Not specified	44
TOTAL		**232**
DATA: TYPE, LEVEL of AGGREATION		
TIMESERIES	Time series data	192
CROSSSECTION	Cross section data	10
POOLED	Pooled data	30
TOTAL		**232**
NATIONAL	National data (whole USA, Canada, etc.)	21
STATAPROV	Data on (multi-)state or provincial level	163
COUNTY	Data on county and district level	48
TOTAL		**232**
Characteristics of the ELASTICITY		
EFFECTLP	EFFECTSIZE: elasticity of income wrt land prices	**232**
DOUBLELOG	Elasticity obtained by logarithmic values in estimation	149
GOVPAYMENTS	Government payments	53
MARKETREV	Market revenue	35
MARKETDOM	Market revenue from domestic market	24
MARKETFOR	Market revenue from foreign market	24
RETURNLAND	Returns to land	70
NETINCOME	Net farm income	26
TOTAL		**232**
LONGRUN	Long run elasticities	28
LAGRENT	Rent one, two year(s) lagged	90
LAMBDALAG	Expectation operator Lambda included as lag	20
FISHAVER	Fisher lag and average of previous years	8
TOTAL		**232**
FIRSTYEAR	Starting year of elasticity	
TIMESPAN	Tme span of elasticity	
CHARACTERISTICS of the MODEL		
PRICELAG	Lagged land price (different years) included as expl. var.	68
TIMETREND	Time trend included as explanatory variable	43
HEDONIC	Hedonic study	20
OLS	Estimated by OLS	106
NONOLS	Correcting for unregularities of the error term	49
SYSEQUA	Estimated by a system of equations	77
TOTAL		**232**

[1]one study contains overlapping categories (Goodwin&Ortalo-Magne)

Table 3: Estimation Results

Variable	(1)	(2)	(3)	(4)
Constant	-5.314	0.598***	-5.314	0.598***
	(-1.288)	(12.193)	(-1.058)	(11.152)
USA	0.170		0.170	
	(-0.875)		(0.540)	
CANADA	-0.116		-0.116	
	(-0.866)		(-0.772)	
CORNSOY	0.127		0.127**	
	(1.188)		(2.037)	
GRAIN	-0.078		-0.078	
	(-0.503)		(-0.487)	
NOTSPEC	-0.460**		-0.460**	
	(-1.951)		(-2.390)	
TIMESERIES	-0.010		-0.010	
	(-0.049)		(-0.55)	
POOLED	-0.044		-0.044	
	(-0.349)		(-0.370)	
STATAPROV	-0.338		-0.338	
	(-1.260)		(-1.342)	
COUNTY	-0.221		-0.221	
	(-1.017)		(-1.088)	
DOUBLELOG	-0.233***	-0.129***	-0.233**	-0.129***
	(-2.765)	(-3.091)	(-2.038)	(-3.666)
GOVPAYMENTS	-0.569***	-0.347***	-0.569**	-0.347***
	(-3.061)	(-7.232)	(-2.282)	(-6.273)
MARKETDOM	-0.403**		-0.403	
	(-2.116)		(-1.549)	
MARKETFOR	-0.472**	-0.151**	-0.472*	-0.151**
	(-2.480)	(-2.440)	(-1.842)	(-2.273)
MARKETREV	-0.503***	-0.379***	-0.503**	-0.379***
	(-2.790)	(-6.800)	(-2.151)	(-5.553)
RETURNLAND	-0.368**		-0.368	
	(-2.121)		(-1.614)	
LONGRUN	0.521***	0.408***	0.521***	0.408***
	(8.432)	(6.834)	(6.858)	(5.62)
LAGRENT	0.016		0.016	
	(0.226)		(0.327)	
LAMBDALAG	-0.119		-0.119	
	(-0.119)		(-0.350)	
FISHAVER	0.451***	0.553***	0.451	0.553
	(2.785)	(5.891)	(1.549)	(4.135)
FIRSTYEAR	0.003		0.003	
	(1.593)		(1.295)	
TIMESPAN	0.003		0.003	
	(1.251)		(1.270)	
PRICELAG	-0.462***	-0.333***	-0.462***	-0.333
	(-4.337)	(-7.262)	(-2.938)	
TIMETREND	-0.009		-0.009	
	(-0.062)		(-0.047)	
HEDONIC	0.288		0.288	
	(1.279)		(1.221)	
NONOLS	0.093		0.093	
	(1.287)		(1.545)	
SYSEQUA	-0.141		-0.141	
	(-1.287)		(-1.268)	
Adjusted R-squared	0.566	0.458	0.566	0.442
F-statistic	12.588***	27.093***	12.588***	27.094***
White-test	43.571**	31.733***	--	--
n	232	232	232	232

(t-value in parenthesis; ***: 1% significance level, **: 5% significance level, *:10% significance level)