What can we say about land prices?

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Abstract

Stakeholders in agricultural land markets can have a legitimate interest in the impact of policy changes on land prices. Agricultural economists may be asked to answer questions regarding the potential impacts of suggested policy changes on land price, ex ante. This paper addresses the question of what agricultural economists can answer, given enquiries into such matters. Based on a comparison of methodologies used the paper concludes, that even though methods in the field are advanced they tend to focus on either a cash flow dimension or a quality dimension of land price, while the questions that stakeholders need answered require both.

Keywords: Hedonic models, Discounted cash flow models, Business cycle models

JEL Code: Q11, Q14, Q15

1. Introduction

Farmers, land owners, policymakers and others stakeholders in agricultural land markets can have a legitimate interest in the impact of policy changes on farm land prices. As agricultural economists we may be asked to answer questions regarding the potential impacts on land price of suggested policy changes, ex ante.

This discussion article will address the question of what agricultural economists may be able to answer, given enquiries into such matters, based on a comparison of methodologies used in analysis of farm land prices.

The motivation for the article comes from the authors' first hand experiences while doing government consultancy work on policy impact on land prices, where we gradually became aware of a gap between the questions that stakeholders really were asking and the questions that the current methods can answer.

Basically we argue that stakeholders in relations to land price are interested in the effects of future events on land prices i.e. future policy changes. E.g. policymakers tend to be interested in

the effect of policy proposals on land prices; farmers and other long-term investors tend to be interested in the land price 1-5-10, and 20 years down the road; bankers are interested in the value of their collateral, etc. While land market studies may be able to decompose land price into the value of different attributes, and even assess the impact of specific policies at specific times, their ability to predict i.e. capitalization elasticities and implied transfer efficiencies of proposed policy changes may be limited.

Regrettably this article offers no new solutions; the modest contribution of this article is the identification of a research gap and an effort to raise awareness about the limitations of the current methods applied to questions regarding land price, as well as a few suggestions for further lines of research.

2. Comparison of current methods

2.1 land price models

Literature on land price can roughly be grouped in three categories; literature based on hedonic models (Rosen, 1974), sometimes combined with difference-in-difference type policy analysis or other quasi-experimental designs (Kuminoff et al., 2010); discounted cash flow models (Just and Miranowski, 1993) and business cycle / credit driven land price models (Rajan and Ramcharan, 2015, Weber and Key, 2015, Weber and Key, 2014).

Looking at the different types of land price models there is a striking difference in the typical set of explanatory variables, at first glance. After a closer look you may realize that some of the differences are in fact different reflections of the same underlying factors. E.g. soil type in a hedonic land price model may be reflective of a difference in the level of cash flow from operation or land rent, in a discounted cash flow model; distance to urban centre in the a hedonic model may be reflective of expected future sales price of land in a discounted cash flow model (Just and Miranowski, 1993), etc.

Emphasis in the different types of models are, however, very different, e.g. discounted cash flow models may have very detailed accounts of the effects of taxes, both with regard to income taxes and deferrable capital gains taxes. These kinds of effects are seldom found in hedonic models. On the other hand hedonic models may identify amenities (Borchers et al., 2014) that could reflect opportunity cash flows or non-pecuniary gains from holding land, which may not be fully reflected in discounted cash flow models.

A frequent type of research question in land market studies is related to the question of the level of capitalization of government support to agriculture (Ricardo, 1817, Weersink et al., 1999, Goodwin et al., 2003)

While the hedonic and discounted cash flow models are grounded in different theoretical explanations[1], the econometric adoption in empirical analysis converge when shift variables, e.g. reflecting spatial shifts in expectations, are included in the models (Feichtinger and Salhofer, 2013).

This section compares the different methods, first we compare hedonic models and discounted cash flow models and second we compare discounted cash flow models with business cycle models. The comparisons will take the form of light literature reviews focussing on the key explanatory variables in the literature applying the different methods.

2.2 Hedonic models vs. discounted cash flow models

2.2.1 Hedonic models

The hedonic methodology is applied to pricing of characteristics of differentiated consumer products or as in the case of farm land differentiated factors of production (Palmquist, 1989). The method is commonly attributed to Court (1939) with an automobile application where price of cars was estimated based on a number of attributes.

Interestingly the hedonic methodology can also be traced back to an even earlier, but non-influential, land price application. According to Colwell and Dilmore (1999) the use of hedonic models on agricultural land prices goes all the way back to G. C. Haas´ 1922 monograph based on his master's thesis.

The theoretical basis for the hedonic model was provided by Rosen (1974) and have been a highly cited reference in applications of the methodology ever since. Relatively early work on land price, including the interactions of urban and farm land in the urban fringe, was provides by Chicoine (1981)[2], a recent example of this focus is in Delbecq et al. (2014).

Hedonic models commonly include agricultural influences on land price through productivity variables such as parcel size, soil productivity indices or soil type classification and permanent improvement such as drainage and/or irrigation. Non-agricultural influences are included by

[1] Consumer utility theory for hedonic models and profit maximisation for discounted cash flow models
[2] Who, by the way also recognised Haas' early 1922 work.

variables such as distance to large cities, population density etc., to take urban development potential, non-agricultural land use etc. into account (Huang et al., 2006).

Hedonic models of land prices can methodologically speaking be divided in at least three groups; spatial econometric models, time series models and spatiotemporal models taking both the effects of time and space into account. (Yang et al., 2019). Adoption of spatial econometric methods took off around 2000 improving the control for spatial heterogeneity and spatial autocorrelation (Anselin, 2001).

Yang et al. (2019) recently provided an interesting application of spatiotemporal model to study spatial and temporal diffusion of land prices and find that while land prices linked by long-run equilibria, this does not mean that land prices converge (to a constant difference after controlling for quality), because there are also short-run price transmissions at play.

2.2.2 Structure of transaction data

The structure of the agricultural real estate market and the data available for researchers and analysts may differ in important ways. The basic details about this structure are generally under reported in the literature.

In some countries such as Germany it is customary to have transaction data on the plot/parcel level (Yang et al., 2019) with specified land price for each plot of land and an individual price for the plot(s) with buildings and residence. E.g. Feichtinger and Salhofer (2016) report an average transacted plot size of 1.7 ha.[3]

In other countries such as Sweden and Denmark it is customary to have transaction data on the farm level, that is, one price for the entire property (Karlsson and Nilsson, 2014, Nilsson and Johansson, 2013).

If parcels of land are sold in individual, independent transactions the plot level data is no problem, however, if plot level transactions are in fact part of larger real-estate transactions involving multiple plots of land and, residential buildings as well as agricultural buildings, the individual plot level data may be biased, and the data for the entire transaction should, if possible, be bundled in the hedonic analysis.

[3] 1.7 ha in 2001 and 1.8 in 2007 (Feichtinger and Salhofer, 2016).

The reason that bundling is relevant is that the plot level observations cannot be considered independent market observations, if in fact the market price is determined for the whole farm, and this price subsequently is divided onto the different elements of the farm.

An analogy in the real estate data used in hedonic models of the housing market is that if there is a market for living rooms you can estimate the price per square meter living room space based on the price for living rooms. However, if living rooms always are sold as part of houses, then you should estimate the value per square meter of living room space based on the price of houses, even if you have information on the stated prices for living rooms.

However, obtaining the necessary data to controlling for the value of buildings in case of whole farm data may be difficult, especially for highly specific animal housing facilities, but on the other hand these facilities may be an important source of spatial and serial variation, if they are not observed. The sales price of animal housing can be argued to be more sensitive to current terms of trade in the particular type of production, than land in crop production. One reason is simply that land has a longer, maybe infinite, production span, in contrast to animal housing and other installations which are worn down or become technologically obsolete.

Obviously the research question addressed may justify simplifications in control variable such as buildings and structures, but lack of detail in control variables may bias the basic estimations and limit the scope of analysis.

2.2.3 Discounted cash flow models

Theoretically, discounted cash flow models[4] determine the maximum price a farmer is willing to pay for specific plot of land at a specific time (Feichtinger and Salhofer, 2013). According to Feichtinger and Salhofer (2016) this approach therefore only depicts the demand side of the market. Contrary to this statement we argue that discounted cash flow models not only determines the maximum willingness to pay for land, but also the minimum willingness to accept offers on land already owned by the individual land owner. In this sense the discounted cash flow models depict both the demand side and the supply side of the land market.

One reason that current land owners may both be unwilling to sell and buy land, at a given price at a given time, is the taxation of capital gains on farmland. A capital gains tax may result in a lock-in-effect decreasing supply of land at a given price, and result in a negative capitalisation

[4] Or Net Present Value models

effect decreasing demand for land at a given price (Plaxico and Kletke, 1979, Dai et al., 2008, Hennessy, 1999, Pietola et al., 2011).

Other possible reasons related to discounted cash flows may be; a) non-constant marginal cost of capital i.e. that the discount rate may change with increase in land market exposure, for example due to increasing credit risk premiums, b) portfolio considerations, c) spatial diseconomies of scale, i.e. additional land will usually be further away from the centre of operations than current landholdings. Many other factors are likely to affect willingness to buy or sell land, for example high age and/or financial hardship seems likely to increase propensity to sell.

Just and Miranowski (1993) develop a theoretic discounted cash flow model to a very refined state (Ay and Latruffe, 2013) including inflation, different forms of taxes, credit market imperfections, transaction cost and risk aversion. However, their model of land price today is in a very basic sense a function of the expected cash flow from operations tomorrow plus the expected land price tomorrow, appropriately discounted to a present value.

It is usual to extended this line of reasoning to a perpetuity where the mathematics simplify and the price of land becomes a function of the expected land rent, the growth rate of the land rent and the discount rate (Feichtinger and Salhofer, 2013).

Unfortunately this simplification also shifts focus away from a key aspect of land pricing, the expected land price in the near future. Private land owners cannot hold land in perpetuity, and therefore must form expectations about land prices during their investment horizon.

The fact that discounted cash flow models are based on (unobservable) expectations, result in serious problems with the empirical implementation of the model. As Goodwin et al. (2003) explain in detail empirical implementations of discounted cash flow models of land prices suffer from error-in-variables problems. What is observed at any given time is the current state of explanatory factors and the market realised price (in time and space). However theory states that it is the expectations regarding the future - not current - state of the explanatory variables that drive land values.

This leads to another subtle distinction. Land value and land price is not necessarily the same thing. Land value is equivalent of the maximum of minimum willingness to accept for current owners and maximum willingness to pay for prospective buyers. Land price is the market realisation of instances where the maximum willingness to pay is above the minimum willingness

to accept, but as the market can take a form close to bilateral bargaining it is likely that land price neither perfectly reflects maximum willingness to pay nor minimum willingness to accept.

In fact land market turnover in the open market, where market prices are studied, is very low. This makes it worthwhile to pause and think about the extent to which land prices are reflective of land value.

Feichtinger and Salhofer (2016) report that approximately 0,2 % of total Bavarian agricultural land was sold in the open market in 2007 and that this is relatively stable over the years. This means that if a plot of land is sold on the open market, you should on average not expect to see this land on the open market the next 500 years! Feichtinger and Salhofer (2016) conclude that the share of agricultural land sold each year is relatively low. We would go a bit further and say that it is extremely low in Bavaria. In Denmark the comparable turnover level in the open market is around 3 % (equivalent of holding times of 33 years) which is probably relatively high compared to agricultural land turnover in other Western European countries, but still relatively low compared with other asset classes. The overall turnover of agricultural land (including family transactions) is around 5 % a year in Denmark[5]. This is equivalent of an average holding time of 20 years.

Even if empirical estimations of discounted cash flow models could reflect the expectations imbedded in the market price, which is unlikely (Goodwin et al., 2003), this would only say something about the expectations of the active participants in the land market. It does not necessarily say anything about the expectations regarding land value for the owners of the +95 % of the land which is not sold (except maybe in the cases where current land owners that are also active buyers in the market).

Figure 1 illustrates this point by graphing four possible aggregate demand and aggregate supply curves resulting in an equilibrium price and quantity reflective of the turnover level in Denmark (3 %). This graph is obviously an abstraction, as real markets are not fully integrated and the equilibrium price should be seen as a quality adjusted price.

[5] Based on own calculations on data from Statistics Denmark for the period 2000 – 2010 – after the financial crisis in 2008 there has been a downward trend in annual turnover (Pedersen, 2016).

Supply, Supply I, Supply II, Supply III, reflect different possibilities of the aggregate minimum willingness to accept of current landowners. Demand, Demand I, Demand II, Demand III, reflect different possibilities of the aggregate maximum willingness to pay for possible buyers of land.

The point is that we are dealing with very thin markets and we should be careful about claiming that price is reflective of the expected present value of future cash flows for all farm land. This can be underlined with a variation of figure 1 (not printed) reflecting the 0.2 % turnover in Bavaria (Feichtinger and Salhofer, 2016).

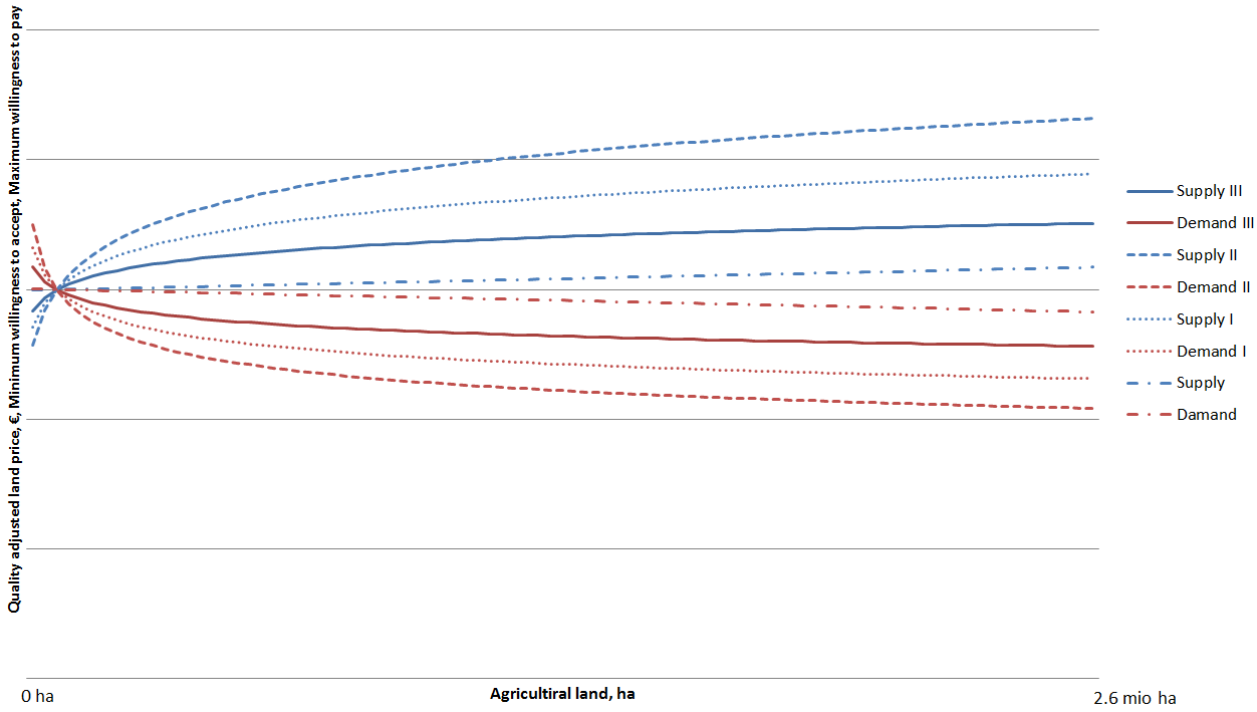

Figure 1: Illustration of possible aggregate demand and supply functions in the Danish land market

If all agents had uniform expectations and economic conditions, in the presence of transaction costs, we should expect zero turnover in the open land market. Observing low turnover, the question arises whether this is due to transaction costs, heterogeneity in expectations or heterogeneity in economic conditions (e.g. capital gains lock-in-effects, etc.), other factors or combinations of the above.

Surprisingly, with all the work on agricultural land markets, the focus is almost exclusively on land price and very little focus is on the quantity side of the market, while policy barriers to efficient allocation of land could have equally important welfare implications as pricing issues.

For example it is conceivable that a capital gains tax increase can have both a capitalizations effect that reduces demand at a given price and a lock in effect that reduces supply at a given price resulting in a leftward shift in the equilibrium quantity possibly without change in equilibrium price (Dai et al., 2008).

2.2.4 Comparison of hedonic and discounted cash flow models

On the surface hedonic and discounted cash flow models have very different sets of explanatory variables; however there may be quite strong proxy relationships between the explanatory variables of the two models.

Figure 2 below illustrate a non-exhaustive list of usual explanatory variables in both hedonic and discounted cash flow models of agricultural land prices, with indication of possible proxy relations between the explanatory variables in the two types of models.

As mentioned earlier hedonic models usually either focuses on the entire farm or only on farm land. When data is obtained on the farm level the rental value of residential buildings and the return to farm buildings in a discounted cash flow can be proxies for a size, type and quality of buildings in a hedonic model or vice versa.

Plot size, farm size, soil type and information on installations such as irrigation and drainage in the hedonic model can be proxies for classical land rent in discounted cash flows and to some extent to government payments and property tax.

Buildings may appreciate or depreciate, but in the long run they usually depreciate as they get technologically obsolete. Land on the other hand tends to appreciate (at least in nominal terms) over time. Gradual appreciation or depreciation are not directly observed cash flows, but are important variables in the discounted cash flow models as they represent the expected value of the asset ´tomorrow´ in models like Just and Miranowski (1993).

Urban pressure indicators such as distance to urban centres are usual in hedonic models, but are also seen in discounted cash flow models as a proxy for differences in the unobserved expected future price of land. Note that, expected land rent is unobserved as well, but an arguably better proxy is available, with observation of the current land rent.

Discounted cash flow models can be very refined (in the theoretical core) with regard to variables in the denominator of the models. Hedonic models on the other hand very seldom have much

more refinement than control variables for time, such as year dummies. More refined hedonic type models, with controls for unobserved spatiotemporal variance, mitigate the possible unobserved / omitted variable bias, but are still silent about the details concerning proxies for the variables in the denominator of the discounted cash flow model.

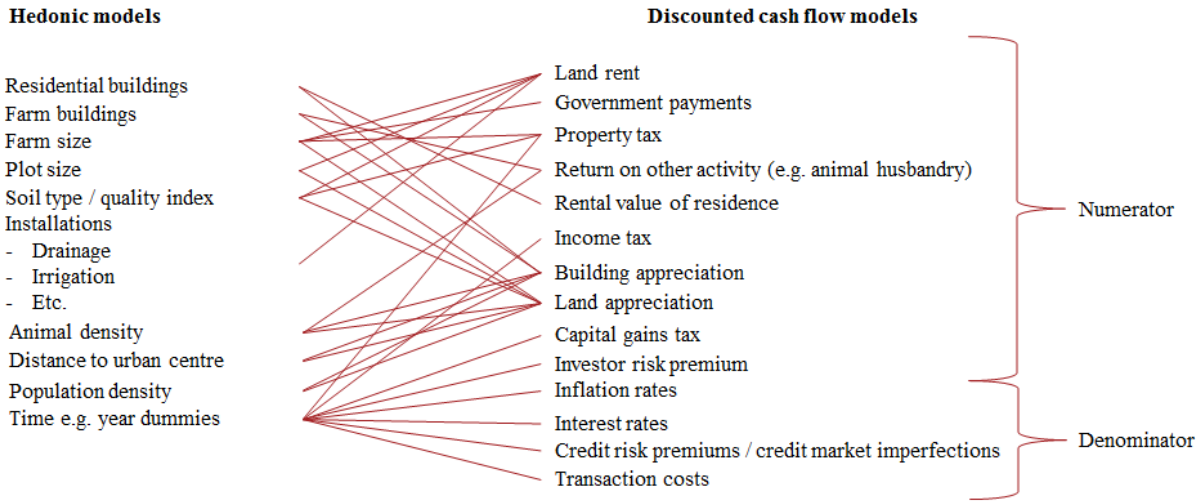

Figure 2: Illustrative non-exhaustive list of explanatory variables in hedonic and discounted cash flow models of agricultural land prices, with indication of proxy relations between the explanatory variables in the two types of models. Note that hedonic models have relatively low level of detail related to the variables that go into the denominator in discounted cash flow models.

Feichtinger and Salhofer (2013) present a list of six broad categories of variables in land price models presented in table 1 below. The two right columns are our own amendments to the list indicating the usual focus of the different models.

Table 1: Categories of variables in land price models

Category	Hedonic models	DCF models
Agricultural returns – Monetary variables		X
Agricultural returns – Non-monetary variables	X	
Government payments	(X)	X
Variables describing the market	X	
Macroeconomic factors		X
Urban pressure indicators	X	(X)
Source: Feichtinger and Salhofer (2013)	Own amendment	

Feichtinger and Salhofer (2013) go on to show how the hedonic and the discounted cash flow models converge in their empirical estimation. The expectations variables in the core of the theoretical frame of the discounted cash flow models are unobserved (Goodwin et al., 2003). In

the econometric adoption of discounted cash flow models this is overcome by the use of observables related to cash flows, as indicated in table 1, however, proxies for differences in expectations (shift variables) are also used, such as urban pressure indicators. Hedonic models may also apply variables based on monetary returns converging towards discounted cash flow models e.g. Borchers et al. (2014).

It seems that most current method applications provide answers that are very detailed with regard to either the quality dimension or the time dimension, but not both. A few exceptions exists e.g. (Yang et al., 2019).

On top of the fundamental errors-in-variables problem of unobserved expectations (Goodwin et al., 2003), we argue that there is another serious problem of dimensionality related to the types of questions that (we argue) stakeholder really want to have answered.

Given that the agricultural land markets are thin, the level of detail in the models that can be estimated is low compared to the needs for refined models (Just and Miranowski, 1993, Ay and Latruffe, 2013), especially if spatial aspects of diverse expectational trends are to be reflected.

Naturally it is of some interest, what impact future policies might have on land prices if conditions where comparable to historic empirically investigated case. But it is also rather naïve to expected that 'not exactly the same' policy change under 'not exactly the same' conditions would have an impact that is 'exactly' related to the policy impact in empirically investigated reference case.

2.2 Business cycle models vs. discounted cash flow and hedonic models

Where discounted cash flow models may reflect the value of holding land, wealth and credit drive business cycle studies may add demand and supply dynamics to explanations of land market trends such as price and allocation of ownership.

In two recent studies Weber and Key examine U.S. land markets under periods of high and low land appreciation. In the first study they focus on the wealth gain from land appreciation and how it affects agricultural activity (acreage under cultivation) and land ownership (land owned) for individuals. They find that wealth gains from land appreciation have little effect of acreage while a larger ex ante ownership share led to an increase in the growth of land owned (Weber and Key, 2014). The reasoning here is, that wealth from land appreciation lead current landowners to buy even more land, while farmers basing their operations on rented land are less likely to buy land.

In their second study they focus on the link between borrowing and land appreciation and find that wealth gains from land appreciation lead young farmers to increase real-estate-secured borrowing and land acquisition suggesting that collateral based lending may contribute to land price changes, see also Shalit and Schmitz (1982) for more on collateral based lending.

Rajan and Ramcharan (2015) study land markets in the U.S. in the 1920s with a boom and bust cycle of land appreciation during WWI and depreciation during the 1920s. They find that land price appreciation driven by commodity price increases during the war was amplified by credit availability, but also that area with high credit availability ex ante suffered greater depreciations and lower credit availability in the decades after the bust.

These studies show effects of wealth and credit that empirical discounted cash flow and hedonic models usually doesn't take into account.

In the 1960's some studies on land prices was done based on simultaneous equation models estimating supply and demand functions (Herdt and Cochrane, 1966, Tweeten and Martin, 1966), compared to single equation models their forecasting ability was however rather disappointing (Pope et al., 1979). Model specification problems may be at the roots the failure of these models (Burt, 1986), but the bulk of following research have applied single equations framework. It is unknown whether the problems with the simultaneous equations models could have been resolved, but the shift in research focus to single equation models have also resulted in a narrow scope of land market research emphasising price, at the expense of a broader focus on both quantity (economy wide allocative efficiency of land) and price.

Feichtinger and Salhofer (2016) apply an advanced demand and supply methodology, allowing supply side variables to re-enter land price models. They convincingly report an increase in the capitalization elasticity from somewhere between 0.07 to 0.09 in 2001, to somewhere between 0.2 and 0.28 in 2007. This is a clear increase in the degree of capitalization of government support payments into agricultural land prices between 2001 and 2007.

However, Feichtinger and Salhofer (2016) go on to attribute this increase to the 2003 Fischler Reform changes in the CAP. While there is good theoretical explanations for Fischler Reform to have such an impact, Feichtinger and Salhofer (2016) fail to control for, or merely recognise, other possible reasons that the capitalization elasticity could increase. Basically the problem is

that everybody is treated and there is therefore no control group, but possibly omitted variables e.g. chance in discount rate[6].

Under some circumstances it is possible to apply a difference in difference setup for policy analysis, however more often than not there are no control groups and the difference in difference approach or other quasi experimental designs cannot be applied. When this is the case and other possibilities for identification of the treatment are not possible, the conclusions should not be strong. Maybe the capitalization elasticity changed because expectations about inflation, interest rates or the future of the CAP, changed, and not (only) because payments was decoupled.

This example underlines a general problem with land price studies. As Rajan and Ramcharan put it each [policy case] 'is sui generis, driven by differences in a broad range of hard-to-control-for factors' (Rajan and Ramcharan, 2015, p. 1439). This makes causal inferences very hard.

3. What we can say about land prices – and what we have to say about our models

Although the literature in the three categories is advanced in many ways, we find the ability to give satisfying ex ante answers to questions regarding possible impact of policy or other changes on land prices rather limited, and uncertain.

To some degree land price models may suffer from the principle of the drunkard's search (Kaplan, 1964), where the answers the models are giving are driven by the available data (searching under the lamppost[7]). From a pragmatic viewpoint this is not a big problem as long as the conclusions are made cognizant of that fact. It may however influence the type of conclusions that can be made and the type of questions that can be answered.

For more than 200 years agricultural economists have been aware that agricultural support maybe capitalized into land prices to some degree (Ricardo, 1817). We question whether we ever really will come any further? Except for special case of natural experiments we are unlikely to identify the capitalization effect, because we cannot control for confounding factors. When we in rare cases are able to identify capitalizations effects, we cannot generalize these results to other policies under different conditions.

[6] The long term German government bond interest rate fell from 4.80 in 2001 to 4.22 in 2007(EUROSTAT).

[7] As the well-known story goes; a policeman sees a drunken man searching for something under a streetlight and asks what the drunk has lost. He says he lost his keys and they both look under the streetlight together. After a few minutes the policeman asks if he is sure he lost them here, and the drunk replies, no, and that he lost them in the park. The policeman asks why he is searching here, and the drunken man replies, this is where the light is.

The empirical answers current methods are able to provide are not predictive of future land prices except for cases with identical - but unobserved – conditions. If conditions are unobservable, how can we know whether or not they are identical with prior conditions?

Better integration of the different kinds of models related to land prices may increase the level of detail in answers and the level of confidence in parameter estimates. However, dealing with very illiquid assets resulting in relatively few observations compared to the theoretically plausible explanatory factors the level of accuracy in these models will probably always be modes. Communicating realistic limitations of the research to stakeholder is therefore also found to be important.

In this article we argue that ex ante analysis of the land price effect of policy changes may seldom be more than educated guesses, as information about expectations of market participants are unobtainable.

Drawing general conclusions from empirical studies is difficult if not impossible. Based on prior empirical evidence we may be able to make ex ante statements that similar policies have had capitalization effects significantly different from zero, this does however not enable us to make ex ante statements about the magnitude of capitalization for new policy initiatives which policymakers may be interested in. This does not put us in a much better position than we were 200 years ago after the reasoning of Ricardo (1817).

While we do not believe that these problems will ever be fully resolved, we do believe that the current methods are providing interesting results and that further improvements are worthwhile. We have noted some suggestions for further lines of research:

The current reasoning behind discounted cash flow models is almost entirely demand orientated (Ay and Latruffe, 2013, Feichtinger and Salhofer, 2013). In our view this is without any good reason, we claim that land price reflect minimum willingness to accept (supply side) just as well as the price reflects maximum willingness to pay (demand side). Furthermore, given the low level of turnover in the land markets, and the available knowledge on current owners and operators from the broader agricultural economics field, we propose that there is more information available on the supply side that on the demand side of the market. Think of the area above and to the right of the equilibrium in figure 1, where minimum willingness to accept is not satisfied vs. the area above and to left of the equilibrium, where the maximum willingness to pay is satisfied.

Burt (1986) is critical about the relevance of supply functions, claiming that a classical supply function for land does not exist [as it cannot be reproduced]. While it is true that land generally cannot be produced, the far right end of the supply curve is not very interesting given the thin land market. You should not think of the supply curve of land as a production related cost curve, but as a minimum willingness to accept curve, which can be related to discounted cash flows. The curvature of the supply curve close to equilibrium is more relevant than the end point.

The exclusive focus on price with single equation models limits the scope of land market research. Broader approaches revealing both quantity and price with a renewed focus on supply side factors seems promising. Feichtinger and Salhofer (2016) provide a good example that supply side elements can be incorporated in refined current methods.

Given the general trend of aging farm population research on supply side demographics (age of current owners) could be an interesting new explanatory variable to explore. While demand side demographic proxies for urban pressure is commonplace in many studies of land price (Devadoss and Manchu, 2007), supply side demographics such as (local) age distribution of land owners (possibly obtainable from cadastre data) have not been applied as far as we know. The level of financial distress or wealth situation of current owners following (Weber and Key, 2014, Weber and Key, 2015) could also be interesting to explore in a European setting.

Regarding capitalization of policies the diverging results on the effect of government payments both in the land market and in the land rental market (Kilian et al., 2012, Michalek et al., 2014), could benefit from a broader focus on what, in the innovation literature, is called the regimes of appropriability (Teece, 1986). Ciaian et al. (2014) and Kilian et al. (2012) recognise payment entitlements as a crucial factor for capitalization of subsidies in land prices. This is an example of complementary assets where capitalization of the policy rent will tend be appropriated by the owners of the assets with least competitive pressure. If there are fewer entitlements than eligible hectares of land, the policy rent will most likely be appropriated by the owners of the entitlements. If these are tradable the rent could be capitalized in the price of the entitlements. Opposite, if there are more entitlement then land, the capitalization will tend to be on the land price. However other assets could also be complementary to policy rent appropriation, i.e. tradable milk quotas in the historical CAP. Ciaian and Swinnen (2009) show how credit market imperfections may affect capitalization of policy rents, the level of perfection in the credit market

could however in itself be a result of policies and be capitalized in complementary assets such as land.

Summing up we find that none of the current methods applied in land market studies tell the truth, the whole truth and nothing but the truth. Most applications of the methods are serious pieces of work and we have enormous respect for the work done in refining the respective methods, but while the respective methods generally report the truth and nothing but the truth, they seldom report the whole truth.

References

Anselin, L. 2001. Spatial econometrics. *In:* BALTAGI, B. H. (ed.) *A companion to theoretical econometrics.* Blackwell Publishing Ltd.

Ay, J.-S. & Latruffe, L. 2013. The empirical content of the present value model: A survey of the instrumental uses of farmland prices. *Factor Markets Working Paper,* No. 53**,** Centre for European Policy Studies, Brussels, Belgium.

Borchers, A., Ifft, J. & Kuethe, T. 2014. Linking the price of agricultural land to use values and aminities. *American Journal of Agricultural Economics,* Vol. 96 No. 5**,** pp. 1307-1320.

Burt, O. R. 1986. Econometric modeling of the capitalization formula for farmland prices *American Journal of Agricultural Economics,* Vol. 68 No. 1**,** pp. 10-26.

Chicoine, D. L. 1981. Farmland values at the urban fringe - an analysis of sale prices. *Land Economics,* 57 3**,** 353-362.

Ciaian, P., Kancs, D. & Swinnen, J. 2014. The impact of the 2013 reform of the common agricultural policy on land capitalization in the european union. *Applied Economic Perspectives and Policy,* 36 4**,** 643-673.

Ciaian, P. & Swinnen, J. F. M. 2009. Credit market imperfections and the distribution of policy rents. *American Journal of Agricultural Economics,* 91 4**,** 1124-1139.

Colwell, P. F. & Dilmore, G. 1999. Who was first? An examination of an early hedonic study. *Land Economics,* 75 4**,** 620-626.

Court, A. T. 1939. Hedonic price indexes with automotive examples. *The dynamics of automobile demand.* New York: General Motors.

Dai, Z. L., Maydew, E., Shackelford, D. A. & Zhang, H. H. 2008. Capital gains taxes and asset prices: Capitalization or lock-in? *Journal of Finance,* 63 2**,** 709-742.

Delbecq, B. A., Kuethe, T. H. & Borchers, A. M. 2014. Identifying the extent of the urban fringe and its impact on agricultural land values. *Land Economics,* 90 4**,** 587-600.

Devadoss, S. & Manchu, V. 2007. A comprehensive analysis of farmland value determination: A county-level analysis. *Applied Economics,* 39 18**,** 2323-2330.

Feichtinger, P. & Salhofer, K. 2013. What do we know about the influence of agricultural support on agricultural land prices? *German Journal of Agricultural Economics,* 62 2**,** 71-85.

Feichtinger, P. & Salhofer, K. 2016. The fischler reform of the common agricultural policy and agricultural land prices. *Land Economics,* Vol. 92 No. 3**,** pp. 411-432.

Goodwin, B. K., Mishra, A. K. & Ortalo-Magné, F. N. 2003. What's wrong with our models

of agricultural land values? *American Journal of Agricultural Economics,* Vol. 85 No. 3**,** pp. 744-752.

Hennessy, D. A. 1999. The taxpayer relief act, estate planning, and resource mobility in us agriculture. *American Journal of Agricultural Economics,* 81 3**,** 534-543.

Herdt, R. W. & Cochrane, W. W. 1966. Farmland prices and technological changes. *Journal of Farm Economics,* No. 2**,** pp. 265-276.

Huang, H. X., Miller, G. Y., Sherrick, B. J. & Gomez, M. I. 2006. Factors influencing illinois farmland values. *American Journal of Agricultural Economics,* 88 2**,** 458-470.

Just, R. E. & Miranowski, J. A. 1993. Understanding farmland price changes. *American Journal of Agricultural Economics,* Vol. 75 No. 1**,** pp. 156-168.

Kaplan, A. 1964. *The conduct of inquiry, methodology for behavioral science,* Scranton, Chandler Publishing Company.

Karlsson, J. & Nilsson, P. 2014. Capitalisation of single farm payment on farm price: An analysis of swedish farm prices using farm-level data. *European Review of Agricultural Economics,* 41 2**,** 279-300.

Kilian, S., Anton, J., Salhofer, K. & Roder, N. 2012. Impacts of 2003 cap reform on land rental prices and capitalization. *Land Use Policy,* 29 4**,** 789-797.

Kuminoff, N. V., Parmeter, C. F. & Pope, J. C. 2010. Which hedonic models can we trust to recover the marginal willingness to pay for environmental amenities? *Journal of Environmental Economics and Management,* 60 3**,** 145-160.

Michalek, J., Ciaian, P. & Kancs, D. 2014. Capitalization of the single payment scheme into land value: Generalized propensity score evidence from the european union. *Land Economics,* 90 2**,** 260-289.

Nilsson, P. & Johansson, S. 2013. Location determinants of agricultural land prices. *Jahrbuch für Regionalwissenschaft,* 33 1**,** 1-21.

Palmquist, R. B. 1989. Land as a differentiated factor of production - a hedonic model and its implications for welfare measurement. *Land Economics,* 65 1**,** 23-28.

Pedersen, M. F. 2016. Ejer- og generationsskifte i dansk landbrug: Drivere og barrierer for ejer- og generationsskifter. *IFRO Udredning.* Department of Food and Resource Economics, University of Copenhagen.

Pietola, K., Myyra, S. & Pouta, E. 2011. The effects of changes in capital gains taxes on land sales: Empirical evidence from finland. *Land Economics,* 87 4**,** 582-594.

Plaxico, J. S. & Kletke, D. D. 1979. Value of unrealized farm land capital gains. *American Journal of Agricultural Economics,* 61 2**,** 327-330.

Pope, R. D., Kramer, R. A., Green, R. D. & Gardner, B. D. 1979. An evaluation of econometric models of u.S. Farmland prices. *Western Journal of Agricultural Economics,* No. 4**,** pp. 107-118.

Rajan, R. & Ramcharan, R. 2015. The anatomy of a credit crisis: The boom and bust in farm land prices in the united states in the 1920s. *American Economic Review* Vol.105 No. 4**,** pp 1439-1477.

Ricardo, D. 1817. *On the principles of pollitical economy* London, John Murray.

Rosen, S. 1974. Hedonic prices and implicit markets: Product differentiation in pure competition. *The Journal of Political Economy,* Vol. 82 No. 1**,** pp. 34-55.

Shalit, H. & Schmitz, A. 1982. Farmland accumulation and prices. *American Journal of Agricultural Economics,* 64 4**,** 710-719.

Teece, D. J. 1986. Profiting from technological innovation - implications for integration, collaboration, licensing and public-policy. *Research Policy,* 15 6**,** 285-305.

Tweeten, L. G. & Martin, J. E. 1966. A methodology for predicting u.S. Farm real estate price variation. *Journal of Farm Economics,* Vol. 48 No. 2**,** pp. 378-393.

Weber, J. G. & Key, N. 2014. Do wealth gains from land appreciation cause farmers to expand acreage or buy land? *American Journal of Agricultural Economics,* 96 5**,** 1334-1348.

Weber, J. G. & Key, N. 2015. Leveraging wealth from farmland appreciation: Borrowing, land ownership, and farm expansion. *Land Economics,* 91 2**,** 344-361.

Weersink, A., Clark, S., Turvey, C. & Sarker, R. 1999. The effect of agricultural policy on farmland values. *Land Economics,* Vol. 75 No. 3**,** pp. 425-439.

Yang, X., Odening, M. & Ritter, M. 2019. The spatial and temporal diffusion of agricultural land prices. *Land Economics,* 95 1**,** 108-123.