Determinants of agricultural land values in Argentina

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Etudes et Documents n° 16

July 2014

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Directeur de la publication : Vianney Dequiedt

Directeur de la rédaction : Catherine Araujo Bonjean

Responsable d'édition : Annie Cohade

ISSN : 2114 - 7957

Abstract

In the context of the rapid development of the cultivation of genetically modified soybeans in Argentina, we conduct a hedonic analysis of agricultural land values. The main objective is to evaluate the impact of land tenure systems and agricultural practices on these values. Data on 338 parcels, located in the Pampas region, are analyzed. The tenure appears to be a particularly important variable. We find that plots rented either by physical persons or by companies are negatively valued in relation to plots owned. Results also highlight the importance, though not to a large degree, of a diversified cropping pattern compared to soybean monoculture. Soil quality, location of the plots, distance to markets, as well as to the nearest city, were also found to affect land values.

Keywords

Genetically modified soybean, hedonic prices, farmland values, Argentina, tenure

JEL Codes

O13, Q15, Q51, R3

1. Introduction

Farmland price movements attracted widespread interest in Argentina because of their explosive appreciation in the Pampas region in recent years. The driving force behind this dramatic upward trend has been the spectacular change in land use that has taken place in the last decades in response to the availability of a new technological package for soybean production. The resulting increase in net farm income has led to a strong farmland demand, whereas the supply of farmland for sale remained very limited. This pushed farmland values to unprecedented levels.

Buying land has become impossible due to the dramatic increase in prices and, therefore, the race for land induced by the highly profitable cultivation of soybeans has been dominated by acquisition of user's rights (renting and leasing) rather than by acquisition of land. Tenancy has thus increased compared to farming one's own land and accounts for nearly 60% of the land cultivated. Moreover, most land lease agreements are short-term, usually one planting season.

In the meantime, different arrangements, aimed at coordinating linkages between different actors in the value chain, have emerged. They usually include production-management contracts as well as resource-providing contracts. In most cases, the contracting parties are landowners who farm or rent out their own land, farmers-entrepreneurs who rent land for their own account or gather in companies with other producers , service companies for the main farming operations, and agro-industrial firms.

The long-term sustainability of this new system of production, usually called contract agriculture, became a matter of concern during the first decade of the 2000s. For various reasons, most landowners chose to give up control of their land to service companies or agro-industrial firms. This disconnection between land ownership and land cultivation led to land use concentration, excessive planting of soybeans, bad land management practices such as incomplete rotation patterns, and a loss of autonomy in farm management. The expansion of contract farming also supported practices that are detrimental to the long-term preservation of land resource quality, such as intensive use of pesticides and overexploitation of land (Gras and Hernández, 2009; Gras, 2009; Leguizamón, 2013; Pengue, 2005). Contract farming in Argentina thus remains a highly contested model.

Attention has recently been paid in the literature to the value of the biophysical attributes of land, suggesting that land values may vary with potential environmental contamination (Boisvert et al., 1997), soil exhaustion and degradation (Sills and Caviglia-Harris, 2009), and the cropping history of the plot (de la Fuente et al., 2006). Another strand of literature emphasizes the implications of land tenure on fertilization, adoption of conservation practices, and long-term land improvements (Abdulai et al., 2011; Myyrä et al., 2007; Soule et al., 2000). However, the extent to which different tenure modes are reflected in land values has not yet been examined. Knowing this would provide strong signals regarding land use sustainability as well as convey important information for public policies aimed at protecting land resources and providing incentives for better practices.

This paper investigates the factors that determine the values of farmlands in the Pampas region using hedonic price functions. It makes two contributions to this body of research. First, our unique data set provides detailed plot-level data on farmlands, their localization, and their value. Second, this data set allows for testing the role of tenure and agronomic practices on these values.

The structure of this paper is as follows. Section 2 presents the historical context of genetically modified (GM) soybean production in Argentina. Section 3 discusses the literature on the use of the hedonic price method applied to farmland values. Data collection and the empirical strategy are presented in Section 4. Results and their implications are discussed in Section 5 before we conclude.

2. GM soybean production in Argentina

Soybeans are one of the main agricultural products worldwide, after rice and wheat.[1] Soybeans may serve several uses, such as livestock feed, biofuel, or in textile and plastic production.

GM soybeans were introduced in Argentina in 1996. Their adoption expanded at a surprising rate, actually higher than in the United States. Currently, more than 90% of the total soybean production is genetically modified and is concentrated in the Pampas region. Argentina appears to be the second largest producer of GM crops with 21% of the world's biotech crop area. For each type of production, the share of land allocated to GM crops is 99% for soybean, 83% for maize and 94% for cotton. Argentina is the third largest exporter of soybeans after the USA and Brazil (Filomeno, 2013; Leguizamón, 2013).

The dramatic success of the so-called Argentinian "*modelo sojero,*" based on intensive, large-scale mechanized production, has been driven by four main factors (Leguizamón, 2013; Burachik, 2010). First, following the Washington Consensus during the 1990s, Argentina implemented some key economic and structural reforms which boosted the competitiveness of agriculture and created a more favorable environment for investment in the agricultural sector. Second, the introduction of soybean transgenic cultivars resistant to glyphosate has been associated with shortening rotations, resulting from the direct planting technique (no tillage), and a better disease control, which resulted in an impressive rise in yields per hectare. Third, the GM technological package provides large economic gains due to major reduction in costs (especially labor).[2] Fourth, the growth of soybean production has been sustained by a favorable evolution of prices driven by an increasing global demand for agricultural products.

The expansion of GM soybeans was accompanied by radical changes in farm organization. The most significant was the emergence of new forms of associations between various actors to finance and manage soybean production (Hernandez, 2009). The farmers-contractors, who may be an individual person or an association of farmers, such as the commonly called "sowing pools" (*pools de siembra*), remain the central actors. He (or they) assumes the management of the production and bears the risk of the activity. The landowner brings the land resources. Highly specialized service providers (*contratistas)* deal with the various farming operations (ploughing, direct planting, harvesting, etc.). Finally, investors, who come from outside of the primary sector (banks, finance companies) as well as inside (agro-industrial firms, providers of agricultural inputs) bring resources to finance the activity. These resources are sometimes

[1] In terms of value of production in 2010 (cf. Filomeno, 2013).
[2] "No more than six workers are needed to harvest a 600 hectare farm in two days" (Leguizamón, 2013).

provided in kind by agro-industrial groups in the form of GM seeds, agricultural equipment, fertilizers, and agrochemicals.

This new and very efficient management of production has supported an impressive growth of soybean production. However, it has also given strong incentives for the intensification of agricultural land use, resulting in rapid conversion of rotational cropping patterns into permanent soybean production and expansion of the agricultural frontier at the expense of natural lands.

The negative impacts of the "*modelo sojero*" are now widely documented (Carreño et al., 2012; de la Fuente et al., 2006; Gavier-Pizarro et al., 2012; Leguizamón, 2013). They include land concentration far beyond what is considered a desired structure, increase in short-term contracts for land, a net loss of employment due to lower needs and the requirement of higher skills that many rural workers do not have. Intensive agriculture also contributes to serious environmental degradation through the large use of agrochemicals, which results in soil contamination. Intense deforestation in regions such as El Monte (which is used to provide wood and long-term jobs to peasants), destruction of ecosystems, loss of species richness particularly in the sensitive bio diverse ecoregions such as the Yungas or the Great Chaco (Gavier-Pizarro et al., 2012), threaten indigenous and peasants' inhabitations, along with other important negative effects. Rising violence linked to land grabbing has also been noted.

3. Literature review

Since the early analyses of Ricardo (1821) and von Thünen (1910), three types of theoretical models have been developed to explain the value of agricultural land, namely, the Demand-Supply Model (DSM),[3] the Net Present Value Model (NPVM),[4] and the Hedonic Price Method (HPM). The HPM is continuing on from the NPVM. The HPM is widely used in environmental and natural resources economics and in real estate economics.

The HPM consists of the analysis of the price of differentiated goods based on their characteristics. Rosen (1974) formalized the HPM through his seminal article that has since become the main reference in the field. The HPM consists of revealing the implicit prices of various attributes of heterogeneous goods. The HPM implies that housing or farmland is an heterogeneous good consisting of a set of characteristics $Z = (z1 ,...,zk ,...,zK)$ sold in bulk. Properties are distinguished from each other, both through their intrinsic as well as extrinsic characteristics. The HPM calculates the implicit marginal price of these different characteristics from the overall price $P(Z)$ of the property. At equilibrium, each implicit marginal price pk is equal to the marginal willingness to pay for this characteristic and is calculated, in the case of quantitative variables, as the derivative of the aggregate price $P(Z)$ with respect to the quantity zk. The empirical calculation of different marginal implicit prices thus requires the estimation of the hedonic price function by regressing prices of properties on their various characteristics.

[3] The DSM consists of estimating a simultaneous equation model of demand and supply for agricultural parcels (cf. Devadoss and Manchu, 2007; Herdt and Cochrane, 1966; Tweeten and Martin, 1966).

[4] The NPVM approach assumes that farmland values are determined by discounted annual returns (cf. Burt, 1986; Devadoss and Manchu, 2007; and Melichar, 1979).

Turning to the HPM for agricultural lands, Palmquist (1989) and Palmquist and Danielson (1989) may be considered as the seminal papers, respectively, for rental values and for property values. One may also refer to Maddison (2000) for an application of the model to agricultural land.

While the literature on hedonic analysis of real estate properties is prolific, literature on agricultural land values is abundant in the USA but scarce in other countries. We present a literature review of the main articles dealing with farmland values in Appendix 1.

Several types of dependent variables are used in the models. The different articles focus either on farmland values (e.g. Palmquist and Danielson, 1989 ; Sklenicka et al., 2013) or rental values (e.g. Palmquist, 1989 ; Donoso and Vicente, 2001). Among the studies using farmland values, most use the price per acre or hectare. Using the latter reduces the risk of heteroscedasticity (Maddison, 2000). In the subsequent analysis, we will therefore use the price per hectare.

Depending on the country and the availability of data, data used are from actual transactions (e.g. Chicoine, 1981), survey data (e.g. Donoso and Vicente, 2001), or even professional valuation (e.g. Maddison, 2000). The number of studies on American farmlands can be explained in part by the availability of data on land transactions and the ease of access to these. In the case of developing and emerging countries, like Argentina, accessing sales data remains more difficult. There does not exist any consultable register that counts land transactions and gives indications on the characteristics of the land exchanged. Therefore, we use survey data.

Factors that are expected to influence farmland prices in the hedonic literature shall be split into two groups, intrinsic and extrinsic characteristics. The former includes structural characteristics such as surface (e.g. in Chicoine, 1981; Donoso and Vicente, 2001; Gardner and Barrows, 1985; Huang et al., 2006; Maddison, 2009, 2000; Troncoso et al., 2010, among others), soil characteristics (e.g. in Ay et al., 2012; Donoso and Vicente, 2001; Huang et al., 2006; Maddison, 2009, 2000; Miranowski and Hammes, 1984; Troncoso et al., 2010, etc.), land quality (Faux and Perry, 1999; Nivens et al., 2002; Palmquist and Danielson, 1989; Xu et al., 1993, etc.), productivity (Chicoine, 1981; Gardner and Barrows, 1985; Maddison, 2000; Wasson et al., 2013), and yield. Extrinsic characteristics include locational characteristics such as access to the nearest city (Ay et al., 2012; Maddison, 2009, 2000; Sklenicka et al., 2013), access to roads (Nivens et al., 2002; Troncoso et al., 2010), urban pressure (Herriges et al., 1992; Huang et al., 2006; Maddison, 2000; Sklenicka et al., 2013; Taylor and Brester, 2005), and climate (Maddison, 2000).

Hedonic studies for farmland values primarily rely on ordinary least square estimations (OLS)[5] (e.g. Ay et al., 2012; Chicoine, 1981; Donoso and Vicente, 2001; Gardner and Barrows, 1985; Maddison, 2009; Miranowski and Hammes, 1984; Palmquist and Danielson, 1989; Troncoso et al., 2010). In order to determine the best functional form, the Box-Cox estimation is used in some studies (Ma and Swinton, 2012; Maddison, 2000; Miranowski and Hammes, 1984; Nivens et al., 2002; Palmquist and Danielson, 1989).

[5] Some specify spatial models or spatio-temporal models when data allows for it (Huang et al., 2006; Ma and Swinton, 2012; Maddison, 2009; Nivens et al., 2002). However, we do not have coordinates of the plots.

4. Empirical analysis

4.1. Study area

The empirical analysis utilizes data collected from a sample of farms located in two provinces of the Pampas region of Argentina. Historically, agriculture in Argentina has been concentrated in this region where soils have the greatest productive potential. Pampas agriculture consists primarily of GM soybean production, followed by grain production and livestock.

The two study areas, namely Junin in the province of Buenos Aires and San Justo in the province of Santa Fé, were selected for practical reasons. They correspond to the area of two research programs[6] in which a portion of territory of 110 thousand hectares was randomly selected. Within this territory, each plot of land had been listed. References of the owner and the producer (who usually do not overlap), type of productive activity, and tenure mode were collected. This rich database allowed the selection of a simple random sample among producers only (owners who gave up agriculture were excluded from the scope of our study). Another interest of this geographical choice consisted of a network of qualified enumerators/supervisors, well-known to the producers, with whom strong ties had long been established.

Both provinces are quite representative of Pampas agriculture. However, of the selected areas, Junin is more urbanized than San Justo, as well as the closest to Buenos Aires. Junin is also known for having a higher share of agricultural area devoted to transgenic soybean, whereas livestock is much more developed in San Justo.

4.2. Data collection

Our data is taken from a random sample comprising 186 farmers owning and/or cultivating 338 plots of land. The survey was undertaken during July-August 2011.

Information on land transactions was collected during the survey. Relatively few plots of land were bought or sold in any given year. Only 13 producers had purchased land in the previous five years before the survey and only two had sold a piece of land. Farmers were also asked to assess the per-hectare value of each plot of land they cultivate. Since very few recent land transactions were captured in our survey, we use self-reported land values for our analysis.

The extent to which self-reported land values closely approximate the market value is of course a critical issue for the regression analysis. There are several convincing arguments to say that it is the case. First, we can postulate that farmers are the best informed on the various attributes of the land they cultivate (absentee landowners were excluded from the sample). Second, people interviewed did not have any incentive to misreport the value of their land. The survey was administered by qualified enumerators trained by the authors and able to control for the accuracy of farmers' answers. Third, although land market transactions were rare among surveyed farmers during the previous three years, a lot of information on land prices is conveyed through specialized internet sites. Fourth, previous literature suggests that self-

[6] The first one is a European program on the climate, named CLARIS LPB, and the second one is a project financed by the French Agency for Research (ANR), named INTERRA.

reported land values can be used as suitable instruments for market observations (Boisvert et al., 1997; Merry et al., 2008; Roka and Palmquist, 1997; Sills and Caviglia-Harris, 2009). Last but not least, the consistency of parameters estimates (cf. infra) presents evidence that perceived land values are acceptable valuation of market values.

One of the benefits of survey data that collects self-reported land values is that it produces a measure of the desirability of a particular plot of land and reveals which characteristics the land farmers value the most. Second, the use of self-reported land values allows for knowing whether farmers consider potential environmental degradation in valuing land. This point is particularly important, since one of our interests is to identify if good land management is perceived by farmers and capitalized in their land prices estimations.

The survey also collected information on the soil quality of each plot of land. Although soil quality was usually well known by producers, farmers' declarations were compared to agronomic soils maps from INTA which classified soil types in six land classes that summarize soil characteristics, class 1 being the best quality. This resulted in a high level of confidence in stated soil quality. In addition, the spatial dispersion of our sample has allowed us to capture the full variability of soil quality.

We also collected a large amount of plot-specific information on location and accessibility, on value in agricultural use as measured by percentage of the plot under soybean cultivation, and operator socio-demographic characteristics as well.

4.3. Sample characteristic

The variables used in the analysis and their expected effect on farmland values are presented in Table 1, as well as summary statistics for each variable. Average stated value per ha of land is $10,218, with a wide range from $1000 to $40000. Nearly half of the plots are of high agronomic quality and only 12% are of low quality. On average, parcels are 8 km from the nearest road and only 20% of the plots are located more than 10 km from the nearest road. However, after heavy rains, nearly two thirds of the plots are difficult to reach, reflecting the absence of asphalt road. Distance to market is, on average, rather high (88 minutes by truck), as many farmers prefer sending their production directly to the nearest port or main market (Puerto Rosario or Santa Fé from the area of San Justo, Puerto Rosario from the area of Junin), which are quite distant from the production zones. Those who choose this marketing strategy usually get better prices.

A large majority of farmers (80%) grow soybeans in various rotation schemes, including, usually, wheat and maize and sometimes sorghum and pasture. Eleven percent of farmers choose to cultivate soybeans continuously and nine percent leave the plot under permanent pasture. Crop rotation is an important management practice, the benefits of which result from many interacting factors. Previous studies have shown that, for various reasons, continuous soybean cultivation involves significant yield decrease in the long-term (Crookston et al., 1991; Kelley et al., 2003; Meese et al., 1991), has negative effects on soil water balance (Salado-Navarro and Sinclair, 2009), influences soil chemical properties, and increases disease pathogens. However, the benefits of crop rotation depend on which crops are included in the rotation, and in which sequence (Lund et al., 1993). Unfortunately, it has been impossible to obtain detailed information about the precise number of rotation sequences and schemes which have been used over years. Therefore our variable 'rotation' only indicates whether soybean has been rotated with another crop or not during the previous three years.

INSERT TABLE 1

The percentage of land under different tenure reflects the recent changes in land use in the Pampas region of Argentina, i.e. the dramatic increase in non-owner management of farms as well as collective forms of ownership and management. Only 31% of the plots surveyed are under "traditional" tenure ("tenure1"), i.e. plots owned and cultivated by the same physical person (the landowner/producer). 52% of plots are cultivated by non-owner managers: 26% are cultivated by physical persons ("tenure2") (tenant-farmers or sharecroppers) and another 26% by professional managers in enterprises formed by producers' associations ("tenure4"). 15% of plots ("tenure3") are owned by societies and are usually managed with family arrangements aimed at avoiding land subdivision through inheritance and benefit economies of scale arising from cultivating large tracts of land. "Tenure 5" gathers plots under mixed forms of tenure, i.e. partly owned, partly rented by physical persons or by societies.

The size of the plots varies significantly, ranging from 2 ha to 1200 ha, with a mean size of 148.6 ha. Land devoted to soybean represented, on average, 58.7% of the total surface of each plot in 2011.

Residential infrastructure is quite widespread, with at least one house present in more than half of the parcels. 56% of the plots are located in Junin which is a district of the province of Buenos Aires and 40% percent in San Justo, a department of the Santa Fé province. Junin is a more urbanized area than San Justo, as well as better connected to the capital city, Buenos Aires.

4.4. Econometric model and analysis

In line with the literature on hedonic analysis of farmland values (Palmquist and Danielson, 1989 ; Faux and Perry, 1999; Nivens et al., 2002; Miranowski and Hammes, 1984; Ma and Swinton, 2012; Maddison, 2000), we test a Box-Cox transformation of the dependent variable such that:

$$P_i^{(\theta)} = \alpha_0 + \sum_{k=1}^{K} \alpha_k . z_{ik} + \sum_{m=1}^{M} \beta_m . D_{im} + u_i \, , \qquad [1]$$

where i = 1,…, 338; P_i: "farmland values"; z_k: the K quantitative variables; D_m: the M qualitative variables and where:

$P_i^{(\theta)}$is the Box-Cox transformation of farmland values per hectare.

$P_i^{(\theta)} = (P_i^{(\theta)} - 1)/\theta$ if $\theta \neq 0$, $P_i^{(\theta)} = \ln(P_i)$ otherwise.

We consider the model on a set of different values of θ. The estimation procedure of the linear Box-Cox functional form indicates that the value of θ is 0.14. To simplify the calculation of marginal effects, the parameter is constrained to 0. To check whether this approximation is valid, it is necessary to do a comparison test model which calculates the value of the following test: - 2.(LMconstraint - LMnon contsraint) where the term LMconstraint (resp. LMnon constraint) corresponds to the value of the logarithm of the maximum likelihood of the constrained model (resp. of the non-constrained model). This formula can be adjusted by iterations to obtain the best possible transformation according to the criterion of maximum likelihood. It allows for estimating the model parameters with or without restrictions. When θ is close to 0, the relationship between farmland values and characteristics is logarithmic. When the parameters are close to 1, it is linear.

This test follows asymptotically a χ^2 with two degrees of freedom. In our case, the likelihood ratio test indicates that the value of θ is consistent with θ=0. Indeed we obtain LR = 5.35 (resp. 172.35 for θ=1), the value being inferior to the theoretical value 5.99 ($\chi^2_{\alpha=5\%}(2)$). The hypothesis θ=0 is accepted at the 5% threshold. The log linear form is retained for the subsequent OLS estimation of the hedonic price function.

Farmlands are heterogeneous goods. This heterogeneity can create heteroscedasticity in the residuals of the estimation of the hedonic price function. Indeed we detect heteroscedasticity in our model. Therefore, we estimate robust models[7] (cf. Table 2).

Due to the high number of characteristics available, multicollinearity may be a serious concern. Recall that multicollinearity leads to unstable coefficients and inflated standard errors. We use Variance Inflation Factors (VIFs) to detect it. VIF values do not exceed 3.16 (and mean VIFs do not exceed 1.76) in all models, which is in line with the most conservative rules of thumb.[8]

5. Results analysis

Table 2 presents alternative models that capture the determinants of land values. Following the Box-Cox transformation previously tested, the log linear form is retained, i.e. models A and B. Because these two models are nested, they are comparable using the adjusted R-squared. We will therefore interpret our results using Model B. This model explains 34% of land value variations. Marginal effects for Model B are presented in Table 3. For a continuous variable, a unit increase of any variable leads to a variation of 100*coefficient % of the parcel value. For binary variables, the impact in % is measured by $(e^{\beta} - 1)$*100.

The parcels in the province of Buenos Aires are worth more than those located in Santa Fé. This result supports the commonly held hypothesis about land prices and location. Location includes a wide range of characteristics, such as the general condition of the local economy, the distance to markets, and local public goods, which are not specific to any particular land plot but rather to all land in a particular area. Land in the province of Buenos Aires is closer to better developed cities, including the capital city, with greater commercial and residential development as well as recreational enterprises. Furthermore, land in this area benefits from better road infrastructure, better connection to markets, and has a wider possibility of conversion to nonfarm use in the future. These site characteristics are capitalized into a higher stated average price of land in the province of Buenos Aires.

[7] We use the Huber/White/sandwich estimator in order to have robust standard errors.
[8] The most conservative rule of thumb advocates that the mean of VIFs should not be considerably larger than 1 (Chatterjee and Hadi, 2006).

As expected, we find that the larger the surface plots, the lower the value per hectare is. This result is in line with, for instance, Gardner and Barrows (1985), Maddison (2000), Maddison (2009), Troncoso et al. (2010), and Yoo et al. (2013).

Good quality of land has a positive impact on its value relative to average quality. Conversely, poor quality has a negative impact. This result is consistent with our expectations. Existing studies using comparable proxies for land quality find similar results (e.g. Troncoso et al., 2010; Nivens et al., 2002; Maddison, 2000 ; Faux and Perry, 1999).

In the model, we have three accessibility variables. They are expected to play a significant role in the formation of agricultural land values; notably, the closer a plot is to the city, the higher its value (see, for instance, Ay et al., 2012; Chicoine, 1981; Sklenicka et al., 2013; Troncoso et al., 2010; Yoo et al., 2013). Indeed, we find that (i) poor access to parcels in the case of rain lowers their value and (ii) the closer a plot is to the market, the higher its value. However, distance to the nearest road is not significant, although we expected a positive impact of the proximity of the road, given the results of the literature. Indeed, Troncoso et al. (2010) find that, in Talca (Chile), the price per hectare decreases as the distance to paved roads increases. Nivens et al. (2002) in Kansas (USA) find that highway or gravel road access is positively valued compared to dirt road access. As our result is counter-intuitive, we build a binary variable, "road2," which takes the value 1 if the distance to the road is more than 10 km. This corresponds to model C (Table 2 and Table 3). In this case, we obtain the expected sign. Indeed, the plots more than 10 km from the nearest road are less valued than others, all things being equal.

As expected, plots in rotation are positively valued in relation to pasture, but not much compared to plots where soybean is continuously grown. This result is partly disappointing. Admittedly, a more diversified cropping history of the plot is better valued than soybean monoculture. However, soybean mono cropping is not transmitted into significant lower land prices, despite its negative long-term effect. In other words, the negative externalities associated with soybean monoculture are poorly valued by the farmers. This may be explained by the fact that soybean is the most profitable crop in the rotation. Because economic considerations are inevitably taken into account when they value farmland, improved cash flow and short-term increased net returns of planting soybean after soybean are strongly valued by farmers. This also suggests that crop production, whatever the land management practice, is a good indicator for the productive potential of the land. It is consistent with farmers' comments that, in the areas under consideration, the land devoted to raise cattle is unsuitable for crop production. Last but not least, our variable "rotation," roughly measured, does not capture whether good rotation practices are really being followed.

The tenure appears as a significant variable of farmland values. Indeed, we find that plots rented (including the modality of sharecropping), either by physical persons or by societies, are negatively valued relative to plots owned. Land rented by a physical person (tenure2) loses 14% of its value compared to land cultivated by the owner and nearly 19% if rented by a company (tenure4). This result is probably one of the most interesting, considering the Argentinian context of dramatic changes in agricultural production organization during the last three decades. Despite the fact that the non-owner forms of land management achieved high professional standards and productive efficiency of land, farmers still assign greater value to traditional forms of production management by landowner-cultivators. This result is consistent with previous empirical research, which supports conventional expectations that owner-operators are attentive to the long-term value of their land and thus are more likely to adopt conservation practices than renters[9] (Abdulai et al., 2011; Kabubo-Mariara, 2007; Myyrä et al., 2007; Soule et al., 2000). This careful land management is obviously valued in farmers' opinions about land values.

INSERT TABLE 2

Since different lease arrangements may also influence renters' practices, the land rented and managed by a society is worth less, in famer's opinion, than land rented and managed by a physical person. This is because among the latter we find share-renters who may have incentives to adopt conservation practices. On the contrary, the short-term duration of "pure" land lease contracts (usually one planting season), which are common when societies are involved, do not provide incentives for good agronomic practices that preserve the resource in the long run.

Finally, land leased might be characterized by unobservable quality differences compared to land owned, and thus not captured by the quality variables of the model.

INSERT TABLE 3

6. Concluding remarks

Land resources have long been a key factor in Argentina's agricultural development. Starting from a historical base with farmers cultivating the land they owned, there has been a steady trend toward the transfer of land through the operation of land markets. Because economies of scale and technical skills became very important with the new technologies involved in the production of GM soybean, many owners chose to rent out their land rather than cultivate it. As a result, contract agriculture has extensively developed in the Pampas region of Argentina. However, the phenomenon is difficult to precisely evaluate, since most land contracts are private and, most of the time, take the form of oral informal contracts. The usual estimates, confirmed in our survey data, mention that nearly 60% of agricultural land is under non-owner operator management (Manciana, 2009).

The main benefits of this new organization has been a rapid transfer of technology, improved access to inputs, dramatic growth in production as well as in exports based on improved competitiveness, and over all a spectacular increase in farm incomes. Endowed with an enormous potential for agricultural production, Argentina has become one of the most efficient producers of soybeans and other agricultural commodities such as wheat and maize.

However, since the agricultural sector will continue to be a crucial piece in Argentina's future growth, justified concerns about severe productivity problems related to land mismanagement should be addressed. There are some reasons for hope. The fact that complete rotation patterns add value to the land, although not much compared to soybean mono cropping,

[9] Conservation practices typically include measures to maintain or improve soil fertility (e.g. by crop rotation), control of soil erosion, and limitation of nutrients and pesticides applications.

indicates a certain awareness on the part of farmers of changes in land fertility and potentially decreased yields in the future resulting from cultivating only soybeans. In the same manner, farmers' perceptions about tenure and land management provide significant signals regarding the expected sustainability of intensive production on land under contract farming. Nevertheless, the decision whether to undertake long–term investments in land conservation is balanced by the short–term time horizons of production decisions by most non-owner operators. There are, thus, few chances that the issues surrounding the mismanagement of land will be solved without public intervention improving the incentives to farmers to care for the land they cultivate.

Two major policy implications come out of these results. The new organization of production has developed without any legislative framework. As a result, countless forms of contracts emerged, whether oral or written, with very different levels of formality and different contents, such as the term and the payment of the rent. Actually, many arrangements take the form of simple, short-term specification contracts and usually consist of simple verbal agreements between partners. Therefore, a first way to prevent environmental damage would be to implement a national policy that ensures better contract design, longer-term land lease contracts and contract renewal. Specifically, a legislative measure on the minimum duration of land lease contracts may increase the incentives for cultivators to carefully manage the land and ensure the long-term fertility of soils. A second option could be the establishment of a monitoring system on the state of land that would provide reliable information on the history of plot management as well as agronomic details, such as the level of nutrient depletion and soil structure degradation. Farmer's organizations as well as INTA (National Institute of Agricultural Technology) could be associated with this effort of transparency. The availability of this information to all land market participants would certainly affect land prices and thus create significant incentives for the protection of the large natural advantage Argentina has for agricultural production.

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Table 1. Summary statistics of farmland in the study area

Variable	Description	Expected sign	Mean	std	min	max
Value	Declared land value (US dollar per hectare)	Dependent variable	10 218.44	5 973.07	1 000	40 000
lnvalue	Logarithmic transformation of "value"	Dependent variable	9.07	0.60	6.91	10.60
highquality	= 1 if land is of class 1 or 2, 0 otherwise	+	0.49	0.50	0	1
medquality	= 1 if land is of class 3, 0 otherwise	+	0.38	0.48	0	1
lowquality	= 1 if land is of class 4, 5, or 6, 0 otherwise	-	0.12	0.33	0	1
Road	Distance of the plot to the nearest road (km)	-	7.59	7.35	0	50
Lnroad	Logarithmic transformation of "road"	-	1.71	0.99	-2.30	3.91
road2	= 1 if "road" > 10 km	-	0.20	0.40	0	1
Rain	= 1 if in the case of rain, access to the plot is difficult	-	0.66	0.47	0	1
rain2	= 1 if in the case of rain, access to the plot is not difficult	+	0.33	0.47	0	1
rain3	= 1 if missing data for "rain" and "rain2"		0.01	0.08	0	1
market	Transportation time by truck to the point of sale of products (mn)	-	88.88	98.16	4	480
lnmarket	Logarithmic transformation of "market"	-	3.90	1.11	1.39	6.17
rotation	= 1 if there is crop rotation	+	0.80	0.40	0	1
rotation2	= 1 if there is no crop rotation	-	0.11	0.32	0	1
rotation3	= 1 if land under pasture	-	0.08	0.28	0	1
tenure1	= 1 if the plot is owned by a physical person	+	0.31	0.46	0	1
tenure2	= 1 if the plot is rented by a physical person	-	0.26	0.44	0	1
tenure3	= 1 if the plot is owned by a society	+	0.15	0.36	0	1
tenure4	= 1 if the plot is rented by a society	-	0.26	0.44	0	1
tenure5	= 1 if the plot is under mixed forms of tenure		0.02	0.14	0	1
surface	Surface of the plot (hectares)	-	148.61	169.34	2	1 200
lnsurface	Logarithmic transformation of "surface"	-	4.50	1.03	0.69	7.09
soybean	% of the plot surface under soybean cultivation	+	58.76	39.81	0	100
lnsoybean	Logarithmic transformation of "soybean"	+	4.23	0.55	1.61	4.61
construct	= 1 if presence of buildings on the plot (house, employees' house, etc.)	+	0.56	0.50	0	1
construct2	= 1 if no building on the plot	-	0.43	0.50	0	1
construct3	= 1 if no information on the presence of building		0.01	0.11	0	1
Buenos Aires	= 1 if the plot is in Buenos Aires province	+	0.56	0.50	0	1
Santa Fé	= 1 if the plot is in Santa Fé province	-	0.44	0.50	0	1

N=338

Table 2. Regression results

VARIABLES	Model A lnvalue	Model B lnvalue	Model C lnvalue
highquality	-0.0295	0.129**	0.118**
	(0.0602)	(0.0597)	(0.0582)
lowquality	-0.264**	-0.218*	-0.213*
	(0.126)	(0.114)	(0.117)
Road	-0.000855	0.00113	
	(0.00603)	(0.00569)	
road2			-0.141*
			(0.0788)
rain	-0.236***	-0.188**	-0.156**
	(0.0777)	(0.0778)	(0.0709)
market	-0.000642**	-0.000797***	-0.000805***
	(0.000311)	(0.000283)	(0.000274)
rotation	0.535***	0.384**	0.334**
	(0.161)	(0.165)	(0.169)
rotation2	0.477***	0.362**	0.324*
	(0.173)	(0.177)	(0.180)
tenure1	-0.0434	0.0400	0.0496
	(0.0958)	(0.0910)	(0.0892)
tenure2	-0.176*	-0.151*	-0.147*
	(0.0897)	(0.0848)	(0.0828)
tenure4	-0.317***	-0.205**	-0.173**
	(0.0900)	(0.0848)	(0.0847)
tenure5	-0.286	-0.0637	-0.0336
	(0.210)	(0.205)	(0.187)
surface	-0.000443**	-0.000467***	-0.000407**
	(0.000202)	(0.000179)	(0.000169)
soybean		-0.000966	-0.000898
		(0.000799)	(0.000789)
construction		-0.0528	-0.0403
		(0.0575)	(0.0572)
Buenos Aires		0.481***	0.487***
		(0.0579)	(0.0577)
Constant	9.068***	8.838***	8.870***
	(0.194)	(0.212)	(0.216)
Observations	338	338	338
R-squared	0.242	0.369	0.376
Adj R-squared	0.214	0.340	0.347
Max VIF	2.67	3.16	3.13
Mean VIF	1.71	1.76	1.74

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3. Marginal effects for Models B and C

VARIABLES	Variation of the value per hectare due to a one unit increase (continuous variable) or for having the characteristic (dummy)		Variation for the average value per hectare	
	%		USD per hectare	
	Model B	Model C	Model B	Model C
highquality	13.77	12.52	1406.98	1279.79
lowquality	-19.59	-19.18	-2001.53	-1960.34
road2		-13.15		-1343.83
rain	-17.14	-14.44	-1751.29	-1475.95
market	-0.08	-0.07	-8.14	-8.22
rotation	46.81	39.65	4783.72	4052.05
rotation2	43.62	38.26	4457.27	3910.05
tenure2	-14.02	-13.67	-1432.14	-1396.92
tenure4	-18.54	-15.88	-1894.02	-1623.32
surface	-0.05	-0.04	-4.77	-4.15
Buenos Aires	61.77	62.74	6311.84	6411.32

Appendix 1. Examples of regression models used to estimate farmland values

Study	Area	Sample	Years covered	Dependent variable	Examples of explanatory variables
(Chicoine, 1981)	Will County (USA)	491	1970-1974	Price per acre (farmland transactions, sales data)	Distances, neighborhood, soil productivity
(Gardner and Barrows, 1985)	Southwestern Wisconsin's Crawford and Vernon counties (USA)	158	1977-1979	Price per acre	Surface, erosion, slope, land contract, productivity
(Maddison, 2000)	England and Wales	400	1994	Price per acre (actual valuation and professional valuations)	Surface, number of rooms, milk quota offered with the property, population density in the county, quality of soil, climate, localization
(Maddison, 2009)	England and Wales	601	1994-1996	Price per acre	Surface, distance to the nearest city, number of rooms, land classification
(Herriges et al., 1992)	Iowa (USA)	718	1988-1990	Whole farm rent per acre (rental survey data)	Population density, rate of population, average corn, oat, soybean prices from the previous marketing year
(Troncoso et al., 2010)	Talca (Chile)	92	2003-2006	Price per hectare	Size, soil quality, water rights, connectivity (distance to the nearest road) and localization
(Donoso and Vicente, 2001)	Pampas Region (Argentina)	86	July 1996	Rental rates (survey)	Surface, soil characteristics, etc.
(Ma and Swinton, 2012)	Southwestern Michigan (USA)	203	2003-2007	Sale price, sale price per acre, appraised value, appraised value per acre	Environmental production and consumption variables, built production, location, transaction variables
(Ay et al., 2012)	Côte d'Or, Burgundy (France)	4254	1993-2005	Price	Lot size, distance to nearest urban center, soil attributes, and topography
(Miranowski and Hammes, 1984)	Iowa (USA)	94	1978	Land price per acre	Soil characteristics, locational characteristics and regional dummies
(Huang et al., 2006)	Illinois (USA)	2 121	1979–1999	Price per acre (farmland prices are calculated as the weighted average price per acre at the county level)	Surface, soil characteristics, localization, population, density, etc.
(Sklenicka et al., 2013)	Czech Republic	286	2008	Sale price per square meter	Proximity to a settlement, municipality population, travel time to the capital city, accessibility of the parcel, soil fertility
(Wasson et al.,	Wyoming (USA)	220	1989-	Nominal price	Productivity, localization,

2013)			1995	per deeded (privately owned) acre	etc.
(Taylor and Brester, 2005)	Montana (USA)	569	1986-1999	Price per acre	Expected annual real price per ton of sugar beets, soil quality, localization, cash receipts, population density, size (size^2), year, etc.
(Nivens et al., 2002)	Kansas (USA)	8178	1993-1999	Price per acre	Road access, real interest rate, irrigation, soil characteristics and quality, location, vegetation
(Faux and Perry, 1999)	Oregon (USA)	225	1991-1995	Price per acre	Localization, land quality index, building value, etc.
(Xu et al., 1993)	Washington State (USA)	1806	1980-1987	Price per acre	Size, time, gross income per acre, proportion of total acres that is pasture, localization, quality of land, land characteristics, house characteristics, assessed value of machinery per acre
(Palmquist and Danielson, 1989)	North Carolina (USA)	252	1979-1980	Price per acre	Erosion, soil wetness, quality of soil rating, tract size, % cropland, tobacco quota, population variables, building variables, soil quality variables
(Yoo et al., 2013)	Phoenix, Arizona (USA)	151	2001-2005	Price per acre (agricultural land transactions)	Slope, surface, distance to the freeway, % of shrub in the area, % of developed cover in the area, water rights, city