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The Value of Farmland and Its Determinants—The Current State of the Art

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Abstract: This article aims to perform a literature review on the topic of farmland valuation, covering the determinants of farmland value and the models that are used to price land. To do so, recent literature on the topic was combined with classical and well-known papers. All the factors considered in these papers to explain farmland prices and/or to model them were retrieved, presented, and compared. Then, the main models proposed in the literature are presented and their suitability and goals are explained. This study can help academics as it gives an overview of the current state of the art, summarizes the main factors proposed by researchers to explain farmland prices, and sheds light on new lines of research. Besides that, it is also relevant for policymakers because farmland valuation and its use have implications on society and on urban planning, which is a hot topic under discussion.

Keywords: farmland valuation; urban pressure; farmland price determinants; hedonic valuation models; econometric models

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1. Introduction

The existence of arable land has been galvanizing the development of mankind for generations. It is no coincidence that throughout time, major cities were formed in prosperous and fertile land, following the well-known Von Thünen model [1]. Indeed, in Ref. [2] it is argued that for a long time the main sources of wealth in the western world were property and agriculture. Presently, the agricultural land market is key for the sustainable development of rural areas [3]. In Ref. [4], it was observed that the agro-industry was hurt by COVID-19 because agricultural producers took losses due to their strong dependency on imported phytopharmaceutical products and equipment. Moreover, mankind's production of food and model of consumption needs areas available for agriculture and livestock and nationwide policies to manage agricultural soils [5]. In that study, it is also mentioned that it is important that human activity of hunting in wildlife areas and the wildlife commerce are controlled and have proper areas for their practice. Thus, it is also necessary to have public policies to manage soils.

Farmland is the livelihood of many people across the globe, such as agricultural and livestock producers, developers, and investors. These, and in due course, government officials, would all benefit from understanding what triggers farmland price volatility and knowing the factors that influence farmland prices [6]. Farmland accounts for 85% of the asset base of the USA's farm sector; consequently, any changes in farmland values have enormous implications for the financial health of this sector, in the biggest economy in the world [7]. Therefore, it becomes crucial in the modern world to appraise farmland accurately.

Traditional economic theory states that farmland values are determined by the discounted stream of future rents. So, in rural areas where agricultural land is only used for

agricultural production, land prices are not influenced by the demand for its use in urban activities [6]. However, if there is the possibility of future development driven by urban necessities, then one needs to account for the expected return related to those changes in the current land value. Those necessities do not only include urban sprawl and expansion (e.g., [6]), but also the purchase of land for portfolio diversification (see [8]) and the push by urbanizations for developments capable of creating food and energy (see [9]). The market value of properties in areas where land-use changes are likely to occur intrinsically has an element of hope value [10]. Besides that, the amenity value of farmland is relevant. Not only are there natural amenities that influence the value of farmland, but also a land parcel itself may constitute a natural amenity for the surrounding properties. Furthermore, there is not enough liquidity in the real estate market to keep its players updated, and information asymmetry enhances the differences between the property's value and its sale price [11]. This fact threatens the concept of fair value. Hence, traditional economic theory is only able to partially value farmland, because agricultural land values are driven by a complex set of factors [12].

Although agriculture plays a big role in economic development and sustainability, agricultural producers are less keen to remain in the sector because of its increasingly challenging environment [13]. The continuity of the sector depends on the funding of their projects, preferably by using agricultural land as collateral [13]. Thus, farmland valuation becomes essential for all the people involved in the process: not only the farmers, but also financiers, investors, and ultimately consumers.

Farm real estate is a significant source of value in the farming sector and in the typical investment portfolios of families that live off agriculture [14]. Also, changes in the values of farm real estate have significant implications on the sector's health and the households' well-being because nearly a quarter of agricultural lands in the USA are subject to urban influences and consequently to the changes in the demand of residential markets [14]. Furthermore, real estate is often used in investment portfolios because it lowers risk while offering returns. In a study for New Zealand, it is confirmed that the risk-return trade-off of portfolios of financial assets can be improved if farm real estate is included in them since the diversification benefits are robust under high and low inflationary periods [8]. Moreover, farm real estate is a consistent part of risk efficient portfolios, as the risk reduction benefits of diversifying with farm real estate outweigh the risk enhancement benefits. The results show that farm real estate is more of a risk-reducer rather than a return-enhancer in a globally diversified portfolio [8]. However, there are some factors brought in by other researchers that are contrary to this view. For example, in a mixed-asset portfolio, the autocorrelation in the returns of agricultural land increases risk in the long run, which results in a lower diversification effect when compared to other traditional investment assets [15]. For the authors, given farmland's illiquidity, indivisibility, and high transaction costs, investors could select it for a longer retention period, but it is precisely during that period that autocorrelation and risk become significant.

Despite its relevance, in a study for Portugal, it is stated that the valuation of farmland is not popular among professionals and it is difficult to justify its different prices [16]. Since individuals rely heavily on experts to make decisions in the real estate market [11] and farmland valuation is difficult, the pathway for information asymmetry is formed. The lack of information, together with the differences in the search for land and bargaining costs in agricultural land impact price dispersion [17]. In the same study, it is claimed that information asymmetry causes an uneven playing field because when it is present institutional sellers can sell with markups whereas other sellers incur losses. Besides that, the authors also state that local farmers and buyers have an edge in the level of information they have on a property and take advantage of it, obtaining lower prices and search costs. So, it is suggested that other sellers could eventually halve their costs due to the lack of information if they were more professional and that tenant-buyers can benefit from informational advantages during the harvest season [17]. The significance of the characteristics of buyers and sellers in information asymmetry is also examined in [18],

who determined that social and economic factors impact information asymmetry because realtors avoid making deals with clients who resort to credit, live far from the property, or look for cheap assets. Moreover, blindly trusting expert opinions to track the farm real estate conditions induces measurement errors labeled appraisal smoothing, which may negatively impact investment decisions and policy in agriculture [19].

Furthermore, at the time of the study in [20], the valuation of farmland was regaining interest because of tax adjustments, the purchase of land for public building and social purposes, and because it is necessary when the owners wish to claim EU grants. This last factor becomes even more pertinent today, as the EU's financial stimulus in reaction to the COVID-19 pandemic and subsequent crisis is the biggest ever in Europe [21]. Additionally, the growing demand for land for urban use impacts society as a whole. An example of that is the region of Flanders, where the remaining open spaces are being pressured by urbanization to deliver food and biomass, but not always with success for the society [9]. The societal impacts also include health. Residents of more compact urban counties show better health indicators because the urban environment encourages health-related good behaviors, while urban sprawl is often associated with obesity, hypertension, diabetes, and the low number of minutes walked [22]. Control in generalized urban sprawl is necessary, as it lacks accessibility and open spaces, and conveys exaggerated public spending and loss of resource lands [23]. However, there are ways to preserve farmland in the face of urbanization, according to [24]. In his article, the author provides a representative example of Oregon's policies, where there are exclusive farm use zones, boundaries for urban and exurban sprawl, and tax incentives for farmers to keep their activity. In a more recent article ([9]), it is mentioned that the optimal land use depends on the location and socio-economic context of the land and denotes the difference in regions with high and low population densities: in the former, cultural values are becoming more important for post-production rural development, while for the latter an exclusively production-oriented philosophy is preferred. For the authors, this is one of the aspects that shifts the preference toward more unconventional land-use alternatives, which integrate agro-ecological production with nature development. These shifts in the preference for land use and the aforementioned tax incentives are relevant for farmland valuation since policy changes impact land price because the prospects for that land are changed [25].

There is a gap in the literature on farmland valuation, according to [26]. The authors suggest that the current state of the art lacks sufficient detail on farm management and agronomic conditions, and the heterogeneity in behavioral constraints, and suggest incorporating learning and collective structures, and modeling complex adaptive systems. The literature, according to the authors, also needs articles that work on farm interaction and incorporate spatial dimensions: interactions should be modeled directly and established on empirical data, and researchers must use statistically sound methods to initialize the population, including its positioning in space. Moreover, land valuation can be inaccurate because of factors of a methodological, technical, and legal nature.

2. Materials and Methods

Considering the relevance of the topic, the aim of this literature review is to present the current state of the art on the topic of the value of farmland and its determinants. To do so, a literature review was conducted based on more than 50 research items, which are cited in this article. Following the lines of the present introduction, in Section 2, we delve into the factors presented in the literature that are utilized to explain the value of farmland, which are in line with the factors that researchers use in models they construct to value farmland. These factors will start by being exhibited, alongside the authors that mention them or use them in their valuation models. Then, the researchers' conclusions about those factors will be compared. This section is also meant to name the models used in farmland valuation and to see their limitations. Then, Section 3 is dedicated to the results and discussion. Here, the main results of the methodologies presented in Section 2 are presented and compared

and some implications are discussed. Last but not least, in Section 4, the main conclusions on the topic of farmland valuation will be drawn.

It is known that valuing land can be a difficult task because many variables may influence farmland value. As previously mentioned, the value of land in rural areas goes beyond its discounted stream of agricultural rents or net returns. The literature on the topic of farmland valuation puts forward many factors which impact the value of farmland. While some researchers mention their effect, others build models to evaluate it. It is also possible to, for instance, measure the amenity benefits of farmland (e.g., [27]) and study the transfer of development rights (e.g., [28]).

However, in Table 1, our goal is to present the factors mentioned in the covered literature that are utilized to explain the value of the land. Therefore, no distinction is made between the methodology of the studies, as it is intended to go through the main factors in the literature first.

Table 1. Factors that impact farmland value and supporting literature.

Variables	Sources
A—Seller/Owner characteristics	[3,17,29–32].
B—Buyer characteristics	[17,30,31,33].
C—Location (including the characteristics of the neighborhood—industrial, commercial, agricultural, . . .)	[2,3,12,16,17,29,30,32–37].
D—Distance	[3,12,16,20,28,30,33,37–41].
E—Travel time	[12,33,35,42].
F—Farm income	[12,31,33,38,42–46]
G—Cultivated crops	[3,6,7,20,28,29,33,45].
H—Good access	[3,6,16,17,20,28,30,34–36,39,41,47].
I—Macroeconomic conditions	[7,32,38,42–44,48].
L—Land characteristics	
L1—Water rights	[7,16,30,34,36,45,47,49–51].
L2—Soil productivity	[2,3,6,17,20,28–30,33–37,41,45,50,52].
L3—Climate	[2,17,20,29,32,39,43,49].
L4—Tree cover	[12].
O—Other	Percentage of non-farm employment in manufacturing [6]; Percentages of people below the poverty line, agriculture in the state's GDP, and non-agricultural workers in the state [47]; Hunting licenses per square mile [12]; Debt to asset ratio and consumer distress [43]; Per capita income in each county [2,42]; Tenant farmer legislation [33].
R—Environment	[2,3,29,45].
S—Size	[6,12,16,17,28,33,34,37,41,45,49,50].
T—Date or time	[28,42].
U—Population	[2,6,12,33,38,45,47].
U'—Population growth	[6,42,49].
V—Property characteristics	
V1—Fence	[16,20].

Table 1. *Cont.*

Variables	Sources
V2—Infrastructure	[16,20,33,49].
V3—Geometry of the plot	[3,20,39,41].
V4—Unevenness of the plot	[3,20,39,50,52].
V5—Immediate and future development potential	[3,12,28,33,35,40,44,50].
W—Loss of farmland to sprawl	[6].
X—Government/Other subsidies	[17,29,32,38,43,44,53].
Y—Farm yields or production	[6,20,29,36,42,44,47,48].

Source: Own elaboration.

As for Table 1, it should be noticed that macroeconomic conditions include mentions of interest rates, annual returns on investment in the S&P 500 index as a proxy of the economy, and commodity price volatility. According to [43], the farmland option values per acre are positively related to inflation, commodity price volatility, weather, S&P500 annual return, and GDP; and are negatively related to the home price index and consumer distress index. On the other hand, although there is a consensus on the impact of inflation on the value of farmland, it was found to be irrelevant in the study [44]. Besides that, there are superscripts in the sources that correspond to [47] because this paper analyzes the Indian territory on two different levels: (1) corresponds to the study conducted for the district and village levels, and (2) to the all-India level. The authors discovered that the most important factors that influenced land prices on a village level were population density, road density, distance to the nearest town, percentage of people living below the poverty line, crop yield, non-agriculture share in the state's GDP, and workers in the non-agricultural sector as a ratio of agricultural workers. On a district level, the demand for more land from urban areas plays a big role in farmland prices, as industrialization and tourism drive the expansion of cities [47]. Interest rates are another macroeconomic factor that should be considered to explain real estate, and in particular, farmland prices [48]. Low interest rates allow investors to finance themselves at a cheaper price. Therefore, there is more demand and prices increase. On the other hand, with high interest rates, money becomes more expensive to borrow and demand decreases. Moreover, the increase in marked-to-market mortgages may increase the supply in the real estate market. So, in such a scenario, prices are expected to decrease.

An example of a paper that includes both the seller's and the buyer's characteristics is [17], as it was aforementioned. This subject is also tackled by [30], where the author states that farmland is exchanged at a lower price when both market participants are individuals (ceteris paribus) because when one of the parties is a corporation, due to its liquidity, the transaction occurs closer to the time of conversion to urban use. The authors of [31] introduce the characteristics of buyers and sellers in the model's equilibrium, in which the increase in a farmer's bid given a marginal increase in one of the characteristics must be equal to the increase in the market of the parcel's rent with a marginal improvement in that characteristic, or the farmer would profit by using land with different characteristics. Another condition is added in equilibrium: the farmer's total bid must equal the parcel's rental price. Since different farmers have different skills, the bid function is not equal to the hedonic price and locational preferences emerge [31].

Observing Table 1, it is important to note the characteristic called "T—date or time". The sale date was included, for example, in Ref. [28], as additional data that could impact selling prices. However, the authors do not mention any direct relation between it and selling prices. Furthermore, the discount stream of agricultural rents, which according to traditional economic theory determines farmland values, is mostly dependent on interest rates and/or inflation, so the impact of the transaction date on farmland prices is expected to be captured by other macroeconomic factors.

The location also impacts farmland value in different ways depending on its price range [29]. It is explained in Ref. [29] that at a higher price range of farmland, natural amenity heavily impacts the value because it is more "luxury" than "necessity". Attributes such as water area as a proportion of the total county area and high-value crop farms are also "luxury". At lower quantiles, land retirement programs positively impact farmland values [29].

The factor named distance generally comprises the inclusion of the distance to the nearest town, city, or metropolitan area in the study. However, in Ref. [12], the distance to services and recreational areas is also included. Curiously, the authors find that proximity to urban areas on land values is not statistically significant, as measured by the driving time to small and large town centers. Therefore, population interaction and development pressure can be more useful in explaining agricultural land values than simply the distance to an urban area [12]. This disagrees with the findings in [33], who conclude that farmland prices decrease steeply with distance when they are close to the city and then gently further away using an econometric approach. The authors were even able to study the gradient at which agricultural markets respond to distance from the city. The distance to technological centers and sales markets is also included in a study that uses fuzzy logic theory [3]. Furthermore, a peculiar finding in Ref. [42] is also included in the category of distance. The authors conduct a study where they include not only the distance to the nearest metropolitan area but also the second nearest metropolitan area, in the New York region. As expected, an increase in the distance to the closest metropolitan area is correlated with a decrease in land value, but land values increase when the distance to the second nearest metropolitan area increases, as is also the case for travel times [42].

Whether land has good access or not also impacts its value, according to the literature. For example, in Ref. [30] it is argued that the effect of distance to the nearest town on land price may be reduced in part by the location of parcels relative to the boundaries of incorporated towns, as closeness to such areas increases farmland prices by 40%. The author presented an example that considers the parcels located on non-township roads and with good access to motorways are also more expensive.

Logically, the value of farmland in the urban fringe is impacted by immediate and future development potential. The urban fringe is defined in Ref. [30] as the areas that border central cities and that consist of the surrounding close-in suburbs and non-contiguous nearby towns, extending into the adjacent, open countryside. However, apart from distance, location, and travel times, other characteristics measure immediate and future development potential, which is the reason why there is also a category named after that factor. For example, the per-acre premium related to entitlements: one-home-site entitlement increases the value of an agricultural parcel by 130,000$ [28]. The expectation of future development can go beyond the distance to the closest city or metropolitan area, and that expectation influences the farmland price [40,50].

The main task when valuating land is to identify the variables, which affect its value [20]. So far, some variables which are present and common in the literature are identified alongside their sources. Having checked those variables, some studies build models to value land. The following subsections are intended to ascertain the models that are utilized in the literature and their applicability, performance, and shortcomings.

2.1. Hedonic Valuation Models

The hedonic methodology can be traced back to 1939 and became widely used in the 1960s, according to [31]. The author also states that the hedonic methodology received a theoretical model that consolidates the empirical techniques in 1974. Economists started using the hedonic price method to value farmland amenities in the late 1990s [54]. Hedonic pricing can be used to estimate the values of individual farmland characteristics [6] and allows for a more explicit model of the complex set of attributes that form the basis for farmland valuation [12]. Therefore, hedonic valuation models are widely used in the literature, due to the fact that they are well-established and easily applied.

An example of such a model is the one developed in Ref. [16] for farmland valuation in Portugal. The hedonic valuation model shows that there are factors that impact the farmland's value, besides the factors which include the quality of the soil and other characteristics that generate a certain cash flow for that land [16]. The authors explicitly included those factors, such as proximity to highly populated areas, population density, and possible land use, in the hedonic pricing model, and they could explain why asking square meter prices change so much, for all the studied land sizes (up to 100.000 square meters).

In Ref. [6], farmland values are also modeled as a hedonic function of factors that include the location (proximity to metropolitan areas), physical land characteristics, and the potential of converting farmland to alternative uses. The authors included dummy variables to measure the influence of urban access on farmland prices for sales in non-metropolitan areas and the natural logarithm of the land's price per square meter as the target.

In Ref. [12], the authors decided to take a slightly different approach to the hedonic price model. Since the authors intended to model both the agricultural and non-agricultural determinants of farmland values, they think of the portion of farmland's market value not attributed to agricultural use as a "residual" value. This regression shows the degree to which non-agricultural factors explain the portion of land values not attributed to agricultural returns [12]. To account for spatial dependence and spatial autocorrelation, the authors use spatial fixed effects and spatial error clustering. Another study [34] used the same methodology, achieving results in agreement with the aforementioned study; the hedonic price model is also utilized to estimate the impact on the price of Chilean farmland of the following variables: size, soil quality, water rights, connectivity (distance to the nearest paved road) and location.

The hedonic price model is also used in [30] to ascertain the natural and man-made factors that impact farmland prices in an urban fringe market. This model is adequate because it identifies the specific characteristics of different parcels, accommodating the heterogeneous qualities of land [30].

Although hedonic price models generally include a simple linear regression in their methodology, a different approach is carried out in Ref. [31]. In the article, the author starts with a hedonic price model for land rents and mentions that it does not need to be linear. Then, the bid function (payment the farmer is willing to pay for the use of a parcel) is derived and it depends on the characteristics of the parcel, the prices of outputs and other inputs, the desired profit level, and the farmer's production skills. The authors then proceed to derive conditions for equilibrium: the increase in a farmer's bid given a marginal increase in one of the characteristics must be equal to the increase in the market of the parcel's rent with a marginal improvement in that characteristic, and the farmer's total bid must equal the parcel's rental price. Since different farmers have different skills, the bid function is not equal to the hedonic price and locational preferences emerge [31].

2.2. Econometric Models

Econometric models, on the other hand, have been widely used in this subject, namely regarding the incidence of USA agricultural subsidies on farmland rental rates, according to [46]. In their study, the authors apply a general spatial model that combines a spatial lag and a spatial error model and justify that it is necessary to obtain consistent results. An econometric model is also built in [42], now for the price of farmland, using the average per-acre net return from agricultural land, the population change in the two nearest metropolitan areas, the travel times to those areas, and the per-capita income of the county. Essentially, what the authors were able to grasp was the impact of urban pressure on farmland values. An interesting approach to ascertain the urban influence on farmland prices is also undertaken in [33]. The utilized methodology is also an econometric model, which was revealed to be suitable for this task.

In a study for Midwest [48], the authors use an econometric approach and state that farmland has grown in value due to low interest rates, an increase in the demand for grains

and lower stocks. These authors conclude that there is some speculation, especially for high and medium-quality land, which is in agreement with the warnings made in [33].

2.3. Other Alternative Models

So far, the literature on farmland valuation using hedonic pricing models and econometric models has been addressed. However, other valid and adequate models should also be presented. For instance, multiple correspondence analysis (MCA) is widely used in social sciences, and the authors of [20] state that it is an adequate method for farmland valuation in Spain due to the possibility of multicollinearity and redundant information. Using this method, followed by a linear model with the variables that resulted from MCA, the authors managed to build a simple model with R-square values greater than 0.92.

A semi-parametric quantile regression was used in [29], which according to the authors has advantages over the conventional ordinary least squares method. Namely, it provides a more complete picture of the conditional distributions of a dependent variable given a set of regressors, it is more robust to outliers, it can be more efficient when the error is non-normal, and heteroskedasticity can be conveniently analyzed by estimating quantile regressions. This method allowed the authors to group explanatory variables into "luxury" or "necessity" factors and to verify spatial differences in farmland values.

A Samuelson-McKean model is proposed in [10], which is an option pricing model, to determine the hope value of farmland. In this article, the authors prove its efficacy in the valuation of land plots with development potential. The application of an option pricing model is also seen in [43], a study that uses a real options approach for the farmland market of Illinois.

Furthermore, the authors of [3] propose the application of fuzzy logic theory to valuate agricultural lands. This method is cheap, efficient, and transparent throughout the entire valuation procedure; thus it is useful in a limited market with an insufficient number of sales transactions or in underdeveloped regions.

In Ref. [54], a literature review work on amenity values generated by farmland, the authors indicate that contingent valuation studies were widely used in the 1980s to estimate willingness to pay to protect farmland. In Ref. [27], the authors estimated the amenity value of horse farmland in Kentucky using the contingent valuation and the hedonic pricing model methods. A different approach is taken in [38], using a so-called gravity model, based on the idea from Marketing research that the attraction of retail between two cities is proportional to their populations and inversely proportional to the square of the distance between both cities. The authors successfully grasp the urban impact on land prices of farmland located in the rural-urban fringe, as their model explains more than 95% of the variations in farmland prices. A classic and simple methodology is proposed by the authors of [6], who state that according to economic theory, farmland values are based on the expected economic returns. Thus, net present value models are usually used to evaluate farmland values. In these models, the net present value of farmland represents the sum of all future income streams from farming, accounting for the difference between the value of money today and at some future date [6]. The authors of [6] also note that farmland values are based on expected returns, not necessarily historical revenues. These observations are backed by another study [42], which states that in a competitive land market, the price for land equals the present discounted value of the stream of future rent.

3. Results and Discussion

3.1. Results of the Methodologies

In this subsection, we list the main conclusions and results of farmland valuation using the aforementioned methodologies.

Something that is a result of many studies is the impact of urban necessities on farmland value. For instance, using a hedonic valuation model, the authors of [12] state that development potential and population interaction are significant determinants of market value, as a 1% increase in the land area subject to immediate development potential has a

0.43% increase in cropland values and a 0.74% increase in pastureland values. Moreover, future development potential shows similar premiums [12]. In fact, with a similar methodology, in Ref. [34] it is seen that the most important attribute is the location of farmland and the second most important attribute is the quality of the land, and that both have a double-digit percent impact on the price of farmland. The importance of the location of farmland reflects the market's preference for places where non-farm profits can be obtained from a future real estate development, while the remaining variables are of little impact, according to the authors. The distance to paved roads and the parcel's size slightly decrease the value of land, while the impact of water rights on farmland prices is only marginally positive [34]. However, according to a previous study [35], farmland values tend to be higher near urban areas for more reasons, apart from susceptibility to development pressures. Those reasons, according to the authors, include the soil's productivity, as many urban centers initially grew among particularly fertile soils, greater access to markets and ports and therefore lower transportation costs, and recreational opportunities and lifestyle amenities offered at the urban fringe to the nearby population. As a consequence, farmland values are higher in urban-influenced areas with a premium at the median of approximately USD 2000 per acre [35]. A hedonic valuation model [30] also allows concluding that neighboring waters impact farmland prices negatively because they increase the risk of floods or present unacceptable levels of water quality, and the uses of neighboring land significantly impact urban fringe farmland prices. The insertion of land in an industrial/commercial zone increases its value by 28% over agriculturally zoned land [30].

Econometric approaches validate the previous methodology's conclusions on the impact of urban pressure on farmland value. For instance, in a study for New York [42], the authors found that since land development is perceived as imminent due to higher rates of population change, land values increase. An increase of 1000 people in the rate of population change in the nearest metropolitan area increases the land value by USD 97 per acre; similarly, the corresponding number for the second-nearest metropolitan area is USD 101 per acre [42]. The conclusions in Ref. [42] are backed by another study where an econometric model is used [33]. According to the authors, in peri-urban areas, since farmland is expected to be converted to urban uses which are translated into potential capital gains from such development, farmland prices decrease with distance to cities. More specifically, in Ref. [33] it is found that farmland prices are only determined by agricultural factors far from urban influence, approximately 35–40 km away from the closest city. It is also stated that for land for residential use, the land price decrease per kilometer is −12.8% at the urban pole boundary, −3.3% at 20 km from the boundary, and almost flat at 35 km. Land rents were also studied by the authors, who concluded that the main determinant of land rent is the trade-off between commuting costs and land rent and that its impact is bigger than that of development expectations because once there is residential use, we are dealing with actual conversion instead of expectations. The limitation of urban sprawl caused by the ideas and policies of urban planners is the main driver of the farmland prices bubble, according to [33]. Thus, cities must be dense and surrounding rural areas must be preserved, and consequently, expectations of demand for new residential land will disappear [33]. Rental prices are also an object of study in Ref. [46], where it is seen that farmland rental prices are mainly influenced by the rental prices in the parcel's neighborhood and by regional livestock density, which are heavily influenced by agricultural policies.

Moreover, an option pricing method in Ref. [43] led to the conclusion that rising farmland values are primarily dependent on agricultural commodity prices and interest rates and that the farmland market value is also influenced by uncertainty about future growth and capital gains. Furthermore, the farmland option values per acre are positively related to the inflation rate, commodity price volatility, weather, S&P500 annual return, and GDP; and are negatively related to the home price index and consumer distress index [43].

A combination of hedonic pricing models and contingent valuation in Ref. [27] allowed concluding that Kentucky's residents feel that horse farms are a positive amenity, because

of their cultural heritage, prettiness, and their service as an impediment to gentrification. Farmland itself generates positive externalities, and that is shown in both methods [27].

Like the authors of [33], who took on an econometric approach, the authors of [38] found that expectation adds more value to farmland than actual present returns, with a gravity model: a one-dollar increase of the net real returns to land from farming adds USD 0.74 to the value of farmland, while the expectation of a one-dollar growth in real capital gains increases farmland value by USD 1.27.

3.2. Comparison of the Methodologies

Hedonic pricing methods are arguably the most straightforward models to conceive and implement. In most standard cases, the researcher collects in the literature a set of impactful characteristics in farmland valuation and builds a simple regression model.

An example of a successful application of such a model is found in [6]. The model was significant at the 0.001 level, with an R-square value equal to 0.46, condition indices below 30, and no variable had two or more variance proportion values greater than 0.5 [6]. Therefore, multicollinearity was assumed not to be a problem and the methodology was appropriate, according to the authors. Hedonic pricing methods also allow for the usage of supplementary statistical treatment of the data. As was mentioned before, an example of that is found in Ref. [12], where the authors use cluster analysis to account for spatial autocorrelation.

A good alternative when there is a possibility of multicollinearity and redundant information is multiple correspondence analysis [20]. As seen in the previous section, in Ref. [29] a semi-parametric quantile regression is used, which is useful when the error is non-normal and to analyze any potential case of heteroskedasticity.

Spatial econometrics is a very robust way of seeing the impact of proximity to urban centers, for example. This variable is no ordinary example; across all the studies reviewed that include it, its impact was always measured to be positive. Since spatial econometrics is capable of grasping the spatial correlations and including them in the model, it is a strong and classical candidate to measure the impact of these factors, in particular.

3.3. Discussion

As for the determinants of farmland value, there is an agreement in some of the determinants, although the literature covered in this article often disagrees about the effects of some factors on farmland value.

Soil productivity is an example of a factor in which there is agreement about its positive impact on the farmland's value (see, for example, [6,29,41]). However, there is some disagreement about to which extent it is significant. On one hand, the types of soil and their diversity is the most important characteristic when valuing farmland, according to the authors of [41], and soil productivity's double-digit percent impact on farmland price is outlined in [34]. On the other hand, the authors of [30] observed that the soil productivity index is not statistically relevant because farmland transactions are mainly for speculative and urban purposes. Therefore, it is concluded that when valuing farmland, it is important to keep in mind its future use. The productivity of the soil is important if the land is used for agricultural purposes; on the contrary, if there is a potential for urban development, the impact of soil productivity on the farmland's value will be diluted.

Urban development pressure and potential are also driving factors of farmland prices, according to the literature. In this article, it was shown that, given a land parcel, researchers propose different measures of urban influence on it [20]; in Ref. [47], for example, the authors utilize the distance to the nearest urban center and observe its significant and positive impact on land prices. Distance to the urban fringe is also investigated by the authors of [33], who put a timespan for the conversion of farmland to urban use of roughly 30–50 years for parcels 5–40 km away from the urban fringe, in a non-linear form. An urban influence index that relates the size of the nearest urban pole and the distance to it was proposed by the authors of [38], who found out that a one-unit increase in the

numerical value of that index will increase per acre real land value by $132.60. However, the authors of [12] warn that measuring population interaction can be more effective in explaining land prices than simply the distance to an urban area, and the authors of [54] state that there is no evidence to attest to the impact of distance on farmland amenity values. Furthermore, the proximity of farmland to urban centers affects both the development component of farmland values and agricultural rents, because places with better access to population centers have a larger share of high-value crops, which is consistent with the von Thünen formulation [55]. Moreover, when there are policies that prevent the conversion of farmland from agricultural to urban uses, farmland prices are not influenced by distance to the city [33]. This evidence indicates that each land plot must be attentively considered and looked into along with the existing legislation. Thus, researchers must be cautious when using distance when trying to measure the urban influence in a plot, as there can potentially exist multicollinearity issues, as the aforementioned observation in Ref. [55] points out.

The literature review conducted in this work shows the difficulty in developing a method for valuing and determining the factors that impact farmland value that can stand across time and different regions. Another example of such a factor is water rights or water irrigation. It is stated in a study [50] that the prices of irrigated lands, regardless of their productive orientation, are approximately twice the prices of dry lands. The authors of [29] have a different view, stating that the water area as a proportion of the total county area positively impacts farmland value because it is viewed as a "luxury" factor. On the other hand, it is observed in [30] that neighboring waters impact farmland prices negatively because they increase the risk of floods or present unacceptable levels of water quality. This example illustrates the necessity of integrating a factor with a variety of others that influence it. It is expected that irrigated lands are more valuable if they are located in an area where the climate is usually propitious to draughts, for example, so the climate should be taken into account.

Due to some characteristics of the farmland market, such as high transaction costs and low turnover, they have characteristics of inefficient markets [43]. That explains why plattage value (the value of breaking one larger parcel into several smaller parcels) exists in the market because of subdivision costs, the liquidity of the buyers, and the lack of market information held by the sellers [30]. The real estate market is not efficient and information asymmetry is a particular problem that buyers must face, as it is crucial to find both the positive and the negative aspects of a property [56]. If information asymmetries are correlated with hedonic characteristics, not acknowledging their implications can lead to inefficient estimation and biased coefficients for the hedonic function [17]. For example, heterogeneity is extremely common in Spanish orography, as geographically close districts do not share their main land features [20], which reveals how spatial autocorrelation might not always be as strong as expected. For buyers and sellers, this means that knowing the prices of properties sold in geographically close areas may not be a reliable source of information about the fair value of a given plot.

Therefore, appropriate and fair farmland valuation serves individuals and society as a whole. The urban fringe is a delicate problem because the remaining space must be used innovatively [9]. Moreover, with the urban development sprawl, conflict regarding land use in rural communities has grown [6]. The grassland ecosystems are in danger due to the expansion of their conversion to row crops, driven by commodity price increases, technological improvements, and agricultural policy [57]. Today, land use is a central concern in evaluating agri-environmental policies and the role of the government in agriculture is a major source of uncertainty affecting agricultural production and farmland markets [43]. This often leads to contradictory views by urban planners and policymakers. The process of the demand for the expansion of urban land increases the interest in single-family detached homes, which also require land for household support services (e.g., schools and shopping centers) [28]. Private investments must be channeled transparently and with a long-run vision for the implementation of sustainable urban land development,

according to [58]. The author also reinforces the idea that the government must be involved to support this objective and achieve economic sustainability, providing funds to socially and environmentally sustainable realms.

4. Conclusions

The objective of this work was to highlight the importance of farmland valuation, break down the determinants of farmland prices and valuation, and describe some of the models and methodology used in the literature to value farmland.

Furthermore, this work is relevant for policymakers. At this point, it is important to remember that there is more to the value of farmland than simply the value of the land itself. From a social point of view, farmland is crucial to the people who live off it and to the industries that depend on it. Public policymakers and stakeholders must weigh both potential uses and returns: urban development and rural use. Therefore, in a certain region, it becomes essential for policymakers to know the value of farmland if it is exclusively used for urban development and if it is used to create jobs and value via farming. The topic of farmland valuation and the relationship between urban and rural poles must be studied together by academia and decision-makers because of the reasons stated above. As for academia, this topic of research is still open because this study must often be conducted on a micro-level for there to be an agreement about the determinants of farmland prices. Any future lines of work can use this article to ascertain which land features to use, as well as to see the models covered and their suitability to the work that is intended to be carried out. It is our belief that this article can be a good starting point for such studies due to the extensive amount of articles reviewed, the explanatory factors presented (which are extracted from those articles), and the introduction to several valuation models and their suitability for the desired research direction.

Starting from this literature review, in future work we intend to develop a multiple linear regression model through which we can test the dependent variables that impact the value of farmland. That model will allow the verification, in practical terms, of the value of the different agricultural properties, which, by comparing to the market prices, will allow inferring if the price is below or above the model's reference value.

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