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Drivers for farmland value revisited: adapting the returns discount model (RDM) to the sustainable paradigm

Bazyli Czyżewski[a], Piotr Kułyk[b] and Łukasz Kryszak[a]

[a]Department of Macroecnomics and Agricultural Economics, Poznan University of Economics and Business, Poland; [b]Department of International Economics, University of Zielona Góra, Poland

ABSTRACT
In recent studies many researchers have identified non-agricultural attributes of land that significantly contribute to its value. They claim that the increasing proportion of the value of land may now be explained by environmental amenities in rural areas. On the other hand, mainstream economics says that farmland values are determined by the discounted stream of returns (present value model). The main aim of this work was to adapt neoclassical concept of the Returns Discount Model (RDM) of Saphiro–Gordon type to the case of a land market in Poland. We introduced a modified RDM (i.e. the multilevel variance component model) to answer whether it remains applicable to the valuation of farmland in the context of sustainable agriculture. It was found that in spite of the growing role of non-productive functions of agriculture the improved RDM continues to perform well as a tool to assess changes in land prices.

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1. Introduction

Mainstream economic theory says that farmland values are determined by the discounted stream of expected returns (Burt, 1986; Capozza & Helsley, 1989; Featherstone & Baker, 1987). Meanwhile, a consensus has been achieved that farmland prices are not well explained by the present value model which is a different name for RDM (Return Discount Model) (see for example Burt 1986; Falk 1991, 1992; Falk & Lee, 1998; Featherstone & Baker 1987). Many researchers have expressed the opinion that agricultural utilities explain a diminishing part of the value of land while farming has been becoming more sustainable. The main assumptions of the sustainable paradigm are social awareness of the global ecosystem's limitation and recognition that not only market goods but also extra-market, public goods such as environmental welfare including landscape, biodiversity, safety and high quality food as well as a vitality of rural areas are of great importance for the development of agriculture (Altieri, 1995;

CONTACT Bazyli Czyżewski b.czyzewski@ue.poznan.pl Department of Macroecnomics and Agricultural Economics, Poznan University of Economics and Business, Poland

Gliessman & Rosemeyer 2010; Uphoff 2002). In the sustainable agriculture, rural areas shall become a supplier of public goods (Cooper et al., 2009; Lyon, 2009). The recognition of the need for these goods means that the technological efficiency cannot be measured only in terms of economic (market) categories, but also in terms of the degree to which production complies with environmental requirements (Malkina-Pykh & Pykh, 2003). The results of Delbecq et al. (2014) and Czyzewski et al. (2018) show that farmland values are only partially explained by agricultural returns. Those authors identified multiple non-agricultural attributes of farmland contributing to its market value, which fall into three groups: population and urban influence, recreational and natural amenities, and locational characteristics. There is strong evidence that in many areas throughout the United States, the market value of farmland has exceeded its use value in agricultural production. Wasson et al. (2013: 466–478) argue that parcel-level attributes that comprise recreational and visual values are essential to explain agricultural land value since in amenity-rich areas, for example in western Wyoming (U.S.), these values constitute as much as 60% of a parcel's value. There are also empirical findings which suggest that farm profitability will decline in the coming years in favour of the non-agricultural components of value which however do not transform into a stream of returns (Delbecq et al., 2014).

Summing up, there has been shown to be a growing divergence between market value and agricultural use value when these attributes occur. Nevertheless, there are also doubts about the 'new drivers' of land prices, due to the relatively weak explanatory power of the land value models based on amenities. In the study by Nilsson and Johansson (2013) the R2 coefficient for their model is close to 40%, while Choumert and Phélinas (2015) report R2 values of 21–35% in the hedonic approach. Although authors cited in the first paragraph formally or informally rejected the present value model as an explanation of farmland prices (Gutierrez et al., 2007), it is claimed that it could happen due to the inappropriate forms of the econometric models which did not reflected breaks in time series. Thus, the question of explaining contemporary farmland value by RDM is not unambiguous.

The main aim of this article is to adapt the classical returns discount model (RDM of Saphiro–Gordon type) to the contemporary processes in the farmland market in Poland using the data from the all 16 regions (voivodships) in the years 2003–2014 (48 quarter series).

Secondly, we formulate a research problem relating to the national level. The determinants of land prices in Poland have been significantly affected by integration with the European Union, increased international exchange, broader participation in global food chains, and processes of globalisation. In the 1990s agriculture, like the economy as a whole, underwent a transition, and to an increasing degree became subject to a system of regulation and financial support, at the same time experiencing above-average growth in agricultural production and exports, particularly to EU countries. These factors had a significant impact on the conditions in which farms operated, and indirectly also on the equilibrium in the market for agricultural land. Under the neoclassical approach, the present and expected land rents are capitalised in land prices. This market, however, exhibits significant specific features, not only because it is a market for a production factor, but also because it concerns a factor of great importance socially and environmentally. At the same time, it is a market that is subject to significant regulation. All of this has exerted an influence on farmland prices. What, then, is the formula for valuing agricultural land? Is it possible, in spite of significant regional differences, regulations, and the CAP, to indicate a pattern by means of a RDM model which is a quite universal formula for pricing capital? These questions will also be addressed in the following investigations.

The paper is organised as follows. In the next section we review different approaches to the evaluation of drivers of land prices. Then we discuss the advantages and limitations of the neoclassical approach, i.e., perpetual RDM. In the methodology section we construct a theoretical model based on the Gordon–Saphiro approach, attempting to overcome its limitations. The final section contains results, discussion and general conclusions.

2. Complexity of farmland price drivers

Numerous studies have been made of the factors affecting the value of land and the consequent shaping of prices. Different approaches have been taken with regard to both the set of price drivers considered and the research method adopted.

With regard to the set of variables explaining land values, three dominant research approaches can be distinguished (Larson, 2015): the residual approach, as found in the work of Case (2007), Davis and Heathcote (2007), and Davis (2009); spatial analyses of transactions, as in Haughwout, Orr, and Bedoll (2008) and Nichols, Oliner, and Mulhall (2013); and hedonic methods, as in Diewert (2010) and de Haan, Diewert, and Hendriks (2011).

The residual approach uses data relating to the discounted revenues and costs of investments in facilities and the residual value of land. The second method is relatively complex. In the modelling process, consideration is given both to sale prices and to quality attributes of the land sold, including not only the value of current transactions, but also locational features which affect the price. The last approach involves investigation of a hedonic function for farmland prices. An advantage of this method of estimating prices is that all transactions and services relating to land may be used to compute the model parameters. In this way, account is take of the heterogeneity of the land factor.

Based on studies carried out to date in various countries, the following factors have been found to exert an influence on farmland prices (Barnard et al., 1997; Burt, 1986; Drescher et al., 2001, Ciaian et al., 2010; Shi et al., 1997): the expected value of the future stream of net income from agricultural production, prices of agricultural raw materials, environmental values, soil quality, physical and economic availability of agricultural land in a given region, demand for land coming from urban areas, infrastructure development, regulations affecting the market for agricultural land, financial support for agriculture, the commonness and parameters of lease agreements, number of potential tenants, level of fees and taxes in rural areas, and state economic policy. As can be seen, the number of these factors is very large, and they may have either a macro-, meso- or microeconomic nature. Their effects overlap, causing difficulties in identifying endogenous relationships. This creates a very broad, holistic space for explanation of the process by which farmland prices are shaped, and this constitutes a significant limitation on the construction of value models.

Moreover, particular attention needs to be paid to the importance of sectoral policy in relation to agriculture. The significance of this factor is not unambiguous. The present EU policy on financial support to agriculture (the CAP), by limiting the intensity of farming and introducing decoupling (a paradigm change towards more sustainable agriculture), increases the variability of prices of agricultural products (Kułyk, 2016; Monge et al., 2016), and consequently also of land prices. The higher variability of land prices has an adverse effect on farmers' long-term decisions, and reduces willingness to purchase land for purposes of agricultural production. On the other hand, various government programmes capitalise into farmland values. There is strong evidence that decoupled payments have a larger impact than coupled payments linked to market conditions, according to the empirical results of Latruffe and Le Mouël (2009), Latruffe et al. (2008), Duvivier et al. (2005), Patton et al. (2008), Ciaian and Kancs (2012), and Nilsson & Johansson (2013).

Furthermore, those countries which underwent political transformation before entering the structures of the European Union exhibit a greater degree of variability than the 'old' member states. In the case of Poland, this variation is partly a remnant of the historical distribution of collective farms (PGRs), and later of the land remaining in the hands of the state Agricultural Property Agency. The markets for land in countries which have undergone transformation are characterised by a higher level of transaction costs, which constitutes a barrier to farms wishing to expand their operations (Luca & Alexandri, 2010). Nonetheless, in those countries a dynamic growth in trading in agricultural land is observed, leading to an increase in land prices. This process has led to huge disproportions between regions. In Romania, for example, the price of land is approximately €1500 per hectare in the western and central regions, but below €150 per hectare in the north-eastern region (Luca, 2011). This points to a need to investigate land prices taking into account both spatial and structural heterogeneity (Foster et al., 2016).

Another issue is the regulations applicable to the land market. The main purpose of these is usually to protect farmers against rises in land prices which would exclude local purchasers from the market. However, such regulations reduce the number of potential transaction partners. It may be asked to what extent this leads to a fall in demand for land. In conditions of 'land hunger', experienced in many regions of Poland, for example, the effect is not great. Differences in legal conditions between countries lead to differentiation in farmland prices. All OECD countries have laws that limit the possibilities of taking land out of agricultural production and using it for other purposes (Latruffe & Le Mouël, 2009). There also exist a number of tax benefits for owners of this resource. Capital gains from the sale of agricultural land may be exempted from taxation (as in the Netherlands, Ireland, Austria, Norway and France). Generally there exist regulations that favour maintenance of the agricultural use of land (reducing its mobility). In Germany, for example, capital gains from an increase in a farmer's assets are not taxed, on condition that income from the sale of agricultural assets is reinvested in the farm.

Particular importance thus attaches to the problem of alternative use of land (and hence the matter of the discount rate). The problem of the transfer of agricultural land to other uses has been the subject of numerous studies, indicating the importance of this factor in determining the level of land rent and of farmland prices (Beilin et al., 2014; Di'az et al., 2011; Francis et al., 2012; Irwin & Bockstael, 2007; Zhang et al., 2014). These studies show that even in conditions where changes in land use are subject to significant restrictions, this is a factor that has a strong impact on land prices. A change in land use generally leads to an increase in the price of the land, in spite of the associated external effects (such as loss of landscape features, reduction of biodiversity, retention of water, floods, lower carbon capture, and risk of desertification: Plantinga et al., 2002; Wang, Qiu, & Ruan, 2016).

In summary of this section, we conclude that the heterogeneous determinants of agricultural land value are so complex and multifaceted that it is difficult to identify a set of genuinely independent variables which to a satisfactory degree explain the process of creation of value. A better solution, therefore, may be to make use of neoclassical simplifying assumptions and to apply homogeneous aggregates (proxies) in the form of the expected stream of rent and the discount rate.

2.1. The neoclassical approach: advantages and limitations

The neoclassical approach makes it possible to avoid such a many-sided analysis. It is assumed that the effect of all of the potential value drivers (e.g., quality and locational attributes, structural factors relating to transformation, agricultural policy, regulation of the land market) are taken into account in expectations as to the stream of land rent, while the opportunity costs (related to the flow of land to other uses) are reflected by the discount rate. According to the assumption of marginal returns, characteristic of mainstream economics, land flows from less productive to more productive uses (Swinnen et al., 2006). In determining a value, we take account of the current value and the future revenue that can be obtained by allocating funds to agricultural land. We thus take account of a wide range of influential factors, but in the synthetic form of discounted income streams. In this context, changes in the price relationships of agricultural land reflect changes in the level of productivity of particular plots, estimated and discounted to obtain a current value. However there are the following limitations for the concept of the discount rate.

First, institutional determinants, including legal and political restrictions on the sale of land, cause transaction costs to increase, reducing the significance of the effect of expected productivity on the level of farmland prices, in favour of opportunity costs (the discount rate).

Secondly, the neoclassical approach implies acceptance of the assumption that there does not exist a dichotomy between the money market and the market for goods (Czyżewski & Majchrzak, 2018). In view of the analysis that will be presented below, attention should be given here to the importance of monetary policy in determining farmland prices. High interest rates may induce both domestic and foreign investors to purchase bonds, which reduces pressure on the real property market. In turn, inflation affects land prices, generally positively, as it reflects the risk of capital losses which can be avoided by investing in property. Political risk has similar consequences; an example is the situation in Brazil following the 2002 elections, when the danger arose of a worsening of economic results, leading to an increase in prices of agricultural land (Novelli, 2010).

Thirdly, it should be noted that a shortage of agricultural land, whether locally, nationally or globally, is not merely a consequence of physical scarcity, but is also an indication of a shortage of the products which such land could be used to produce. Shortage of food is often caused by the low elasticity of production and substitution of foodstuffs, which can be compensated for only to a limited extent by inputs of capital or labour.

Then, the neoclassical concept is frequently criticised for its excessive focus on supply factors relating to the use of the land as a production factor, and the difficulties in determining future discounted values of flows due to the uncertainty which increases as the time horizon becomes more distant. Due to economic instability many investors who are more risk-averse may in conditions of economic downturn allocate their funds to agricultural land, which is considered low-risk in times of crisis (Gaffney, 2009). There is a tendency, in times of turbulence, to move capital into safe assets such as land. This accents the non-productive function of agricultural land – as a means of storage of value.

Consideration of such liquidity-related factors means that, in line with a post-Keynesian approach, changes in land value are not determined exclusively by the present and expected changes in the value of agricultural production resulting from use of the land factor, but are influenced by a broad spectrum of other factors, which are linked to the phenomenon of speculation and the assurance of liquidity. In consequence, the analysis of prices should be extended to include other conditions than those resulting merely from the marginal return. This also means that these prices are affected to a significant degree by random factors. Undoubtedly Poland's integration with the EU and the current CAP reforms are factors stimulating speculation on the land market. This speculation brings into sharper focus the agrarian question, which concerns the continuing disparity in agricultural incomes. An example is the situation in Brazil, where ever since colonial times, speculation on the land market has been an obstacle to more integrated economic development (Telles et al., 2016).

Among the most important consequences of this phenomenon is the increase in demand for agricultural property in periods of increased economic turbulence, and a fall in demand for such assets in periods of greater national macroeconomic stability. Reydon et al. (2006), using simulations of an investment portfolio including land, savings and stock-market investments, showed that land is an investment with a rate of return comparable to that of the other assets. Studies of economic crises have confirmed that an investor with funds kept partly in land and partly in savings accounts may obtain better results in critical periods than if the funds had been invested solely in financial assets (Reydon et al., 2006).

Last but not least, we may refer to the problem of the scarcity of land and its intrinsic utility theory which is of the main interest in the paradigm of sustainable agriculture (Czyzewski & Matuszczak, 2016). In an anthropogenic environment, as a result of development processes that reduce the availability of land, its value constantly increases independently of current production-related effects. This is indirectly a result of increased economic development and growing demand for the public goods provided by land. As a result, the utility of agricultural land becomes a positive function of its scarcity, and the law of diminishing marginal utility ceases to apply to that factor (Czyzewski & Matuszczak, 2016).

To recap, we have indicated both the advantages and limitations of the neoclassical model of the value of land as a form of capital. The limitations can be expressed in three points:

1. the immobility of production factors in agriculture (the problem of determination of a discount rate), which calls into question the assumption concerning marginal returns;
2. processes of speculation and accumulation, which distort the stream of discounted income obtained from land;
3. the growing utility of land as a function of its scarcity, which also leads to an increase in its value.

In our study we attempted to modify the Gordon–Shapiro model of perpetual rent (Bringham & Gapenski, 1990; Gordon, 1962) so as to take into account the impact of the factors in the second and third points above. (The first point can be treated as an assumption).

3. Data and methods

Since the data analysed here are combined cross-sectional and time series data, the formation of land prices was investigated using panel regression taking into account of the randomness in the regression coefficients caused by space heterogeneity (hierarchical regression).

The use of panel analysis with fixed effects to study changes in land prices has been criticised, particularly when taking into account the effect of financial support, in view of the asymmetry of observations in time (changes in agricultural policy) and the different rates of development (e.g., the development of towns) in the analysed spatial units (Haughwout et al., 2008).

We tested a model with random effects estimated as an aggregated element of the random component of the model, as well as random components of the functions describing the regression coefficients (it is i.e. the multilevel variance component model).

Regarding the sources of data for analysis, information was collected concerning the rental values determined by way of auctions run by the Agricultural Property Agency in each quarter of the years 2003–2014, broken down into 16 Polish provinces (the entire population) and into two property size categories: 1.01–9.99 ha and 10.00–99.99 ha. The source of data on land prices in the regions was the data published by the Agricultural Property Agency in the reports titled *Rynek ziemi rolniczej. Stan i perspektywy* ('The agricultural land market. Status and prospects') (IERiGŻ, 2004–2015). Data on discount rates come from the OECD (2017) (quarterly country data). Information on changes in utilised agricultural area in the regions comes from the Local Data Bank of the Central Statistical Office (GUS) – https://bdl.stat.gov.pl (regional annual data).

We began with an assumption in line with the neoclassical approach, that in spite of the multiplicity of conditions affecting the agricultural land market, they are all reflected in the discounted streams of future income obtained from land. The value of land is thus decided by the sum of expected financial income, discounted to the time when the value is determined. The base model of perpetual rent is expressed as follows:

$$L = \frac{D}{R} \tag{1}$$

where:
L is the price of agricultural land;

D is the rental price;

R is the discount rate (the long-term interest rate for deposits of over one year). We choose the long-term rate for deposits since it is a common way of assessing opportunity costs for land while this kind of deposits represents an investment with the similar, low risk level assets as the agricultural land.

The function for the dependent variable (L), converted to logarithmic form and with the introduction of appropriate coefficients of elasticity (α, β), is written as follows:

$$lnL = \ln(D) - \ln(R) \tag{2}$$

$$logL_{it} = \alpha lnD_{it} - \beta lnR_{it} + b_i \tag{3}$$

We nonetheless concluded that the base form of the model was inadequate, in view of the limitations described in the preceding section. We therefore introduced two additional multipliers, representing the effect of speculative (or accumulative) motivations and the effect of the increasing scarcity of land (which increases its utility as was said in the intrinsic utility theory). The speculation multiplier is based on trends in the land market, and reflects the annual increase in prices calculated from a four-period moving average $(1 + t)$. This variable recalls the Gordon–Saphiro model (Gordon, 1962), which assumes a dividend increasing at a constant rate. In the case of agricultural land, however, it is not easy to defend the claim that land rent increases at a constant rate, since it is generally assumed that expectations in agriculture are adaptive rather than rational (we also follow this route). In each period we therefore compute the discounted value of the stream of perpetual rent, increased in each case by means of another multiplier resulting from the trend in the land market in the past four periods (12 months). Hence, if our multiplier simply increases the discounted rent in each case, and is not a constant rate of growth, then there is no good reason to subtract it from the discount rate (in the denominator) as is done in the Gordon–Saphiro model.

We also introduce an additional multiplier representing the expected rent related to the increased scarcity of agricultural land in the economic system $(1 + k)$. The increasing scarcity is expressed in terms of the decrease in the utilised agricultural area in a given region. The scarcity multiplier is thus applied to the expected rent D*(1 + k) and indicates the rate of growth in demand for each hectare resulting from the fall in the utilised agricultural area, assuming that demand for land is inelastic. This assumption is confirmed by a number of publications referring to the phenomenon of land hunger in Poland (Kowalczyk & Sobiecki, 2011; Marks-Bielska, 2010; Sikorska, 2013).

To sum up, our multipliers derive from the major limitations of the classical land value model. By the speculation multiplier we address the problem of unstable conditions in a macroeconomic environment. By the scarcity multiplier we take an attempt to address the concept of intrinsic value of agricultural land under sustainable development paradigm, which explains its utility as a positive function of scarcity. In these conditions the problem of land scarcity is of growing importance because land acts not only as a production factor but it gains also a new role – it provides multiple public goods. Furthermore, in developed countries the ongoing economic growth and urbanisation make an increasing pressure on land, contributing to its value.

As a result, our model takes the form:

$$L = \frac{D(1+k)(1+t)}{R} \tag{4}$$

Taking the logarithm of both sides of the equation, and obtaining the function for the dependent variable y:

$$lnL = \ln(D) + \ln(1+k) + \ln(1+t) - \ln(R) \tag{5}$$

$$lnL_{it} = \alpha \ln D_{it} + \beta \ln(1+k)_{it} + \delta \ln(1+t)_{it} - \gamma \ln R_{it} + b_{it} \tag{6}$$

where (for a detailed description of the variables, see below):

L is the price of agricultural land in zloty (PLN) per hectare;

D is the expected rental price (annual land rent) in PLN;

1 + k is the scarcity multiplier (see description below);

1 + t is the speculation multiplier (see description below);

R is the discount rate.

With a view to the differences in reactions and functions, plots were divided into two categories: small areas of up to 9.99 ha, and medium and large areas of 10 ha and over. This enabled a structural factor to be included in the considerations. It was also assumed that the motivations for the transactions in these two categories were different, and thus that the transaction values were determined in a different manner and require different models for their description. Moreover, previous research has pointed to the different roles of small and medium-sized entities in the system of agricultural production. In the case of the first, social functions play a dominant role, while the function of production of foodstuffs and other products is of lesser importance.

Regarding the expected effect of the variables, the signs of the coefficients are expected to be the same as in the base form of the Gordon–Saphiro model. They can be explained as follows:

3.1.1. Expected rental price (annual land rent)

This, as noted above, serves as an aggregated measure for a wide range of factors affecting the returns from a farm (which are of the nature of a perpetual rent), including qualitative attributes of the plot as well as agricultural policy and other institutional regulations. Naturally, the regression coefficient for the rental price is expected to take a positive sign.

3.1.2. Speculation multiplier (1 + t)

This serves to multiply the expected rent by a rate of growth resulting from the trend in the agricultural land market in the last four periods (quarters). The regression coefficient is expected to take a positive sign.

3.1.3. Scarcity multiplier (1 + k)

This variable serves to multiply the expected rent by a value relating to the growing scarcity and utility of agricultural land. It reflects the rate of growth in demand per hectare of utilised agricultural area, computed as:

$$1 + \mathrm{k} = \frac{\frac{d}{UAA_t}}{\frac{d}{UAA_{t-1}}} \tag{7}$$

where UAA denotes the utilised agricultural area, and d the demand for land.

The growth in demand per hectare determined in this way relates exclusively to changes in available UAA in a given region. The regression coefficient is expected to take a positive sign.

3.1.4. Discount rate R

This reflects the opportunity cost for income obtained from the land. By assumption, it ought to show the rate of return from assets with a similar level of risk to that of land.

As we use a multilevel panel model including random coefficients, the estimated equation is as follows:

$$lnL_{ijk} = \beta_{ojk} + \beta_{1k} ln(D)_{jk} + \beta_{2k} ln(1 + k)_{jk} + \beta_{3k} ln(1 + t)_{jk} + \beta_4 ln(R)_{jk} \tag{8}$$

$$\beta_{0jk} = \beta_0 + v_{0k} + u_{ijk}$$

$$\beta_{1k} = \beta_1 + v_{1k}$$

$$\beta_{2k} = \beta_2 + v_{2k}$$

$$\beta_{3k} = \beta_3 + v_{3k}$$

$$\begin{bmatrix} v_{0k} \\ v_{1k} \\ v_{2k} \\ v_{3k} \end{bmatrix} \sim N(0, \Omega_v) : \quad \Omega_v = \begin{bmatrix} \sigma^2_{v0} & - & - & - \\ \sigma_{v01} & \sigma^2_{v1} & - & - \\ \sigma_{v02} & \sigma_{v12} & \sigma^2_{v2} & - \\ \sigma_{v03} & \sigma_{v13} & \sigma_{v23} & \sigma^2_{v3} \end{bmatrix}$$

$$u_{ijk} \sim N\left(0, \sigma^2_{u0}\right)$$

where i is an ordinal, j is time (quarter), k is the region (voivodeship), v and u are random terms, σ^2_{v0} is the between variance, σ^2_{u0} is the within variance (residual random term), the σ_v are covariances, and Ω_v is the matrix of variances and covariances.

The multilevel (hierarchic) approach allows us to take account of both the random free term and the nesting of random regression coefficients, due to the arbitrary number of horizontal variables. As in the classical panel model with random effects, there are two levels, time and cross-section, denoted in our model by the subscripts j and k, respectively. The difference is the possible occurrence of random regressors β1, β2, β3 due to the grouping variable: region. This means that the regression functions of particular variables may have differing slopes in different regions. In the classical panel model the slope is assumed to be constant, a highly simplifying assumption. In the analysed population it is quite probable that the regression slopes of the variables D, $1+t$ and $1+k$ will vary (the problem does not apply to R, since the discount rate is the same throughout the country). The randomness of the regressors may result from differences in natural conditions, soil quality classes and levels of economic development between regions. The random regression coefficients make it possible to compute covariance and correlations between coefficients and the covariance of coefficients and the free term. Therefore a model in this form enables the description of endogenous relationships.

A random effects coefficient regression model is an effective method for solving problems of 'space heterogeneity', as is acknowledged in the literature (Gruchociak, 2012; Zieliński & Radkiewicz 2010; Sagan, 2007; Twisk, 2006). The decision on whether the addition of random regressors to the model is statistically significant is taken on the basis of a likelihood ratio test (LRT). We performed this test in each case by computing the difference between the '–2 log likelihood' values for the model with and without a given random regression coefficient. The same procedure we employed to assess whether the introduction of our multipliers improves the model fit at all. At the next step we evaluated the significance of the computed regression coefficients using Wald's test, i.e., by dividing the obtained coefficient by its standard error and squaring the result. The resulting statistic has a chi-square distribution with one degree of freedom. In the logarithmic model the marginal effects are interpreted as the percentage changes in Y in response to a change in X by one percent.

We next computed the intraclass correlation coefficient (ICC), the equivalent of 'rho' in the classical panel model. This coefficient shows what part of the unexplained variation in land prices can be attributed to individual effects of regions (Twist, 2006: 32–33). The fit of the model was evaluated on the basis of the coefficient of determination.

4. Results and discussion

We shall begin by commenting on the descriptive statistics (cf. Table 1). The mean prices of agricultural land in Poland and the mean rental values in the years 2003, 2004, 2006 and 2013 indicate a rapid rate of transformation in the land market, which was of a fairly universal nature (relatively speaking, the standard deviations are not high). The price of land per hectare rose more than five-fold, and the rental value more than seven-fold. Comparing the periods 2003–2007 and 2008–2014 it can be seen that the scarcity multiplier (reflecting the rate of decrease in available UAA, which was on average 1% greater each year in 2008–2014) gained in significance, while the significance of the speculation multiplier decreased.

A detailed comparison of the estimated models is given in Table 2. The model for small plots is as follows:

$$lnL_{ijk} = \beta_{0jk} + 0.29871(0.01956)lnD_{small\ \ plots_{jk}} + \beta_{2k}ln(1+k)_{jk} + 0.25445(0.08616)ln(1+t)_{jk} - 0.84087(0.07856)lnR_{jk}$$

$$\beta_{0jk} = 5.21798(0.22526) + v_{0k} + u_{ijk}$$

$$\beta_{2k} = 1.99198(1.18774) + v_{2k}$$

between variance:

$$\begin{bmatrix} v_{ok} \\ v_{2k} \end{bmatrix} \sim N(0,\Omega_v) : \Omega_v = \begin{bmatrix} 0.03175(0.01287) & - \\ 0.00063(0.22636) & 18.86535(7,94431) \end{bmatrix} \quad (9)$$

$u_{ijk} \sim N\left(0, \sigma^2_{u0}\right)$ $\sigma^2_{u0} = 0.14768(0.00853)$ within variance

$$-2{*}loglikelihood = 650.56217\ \ (631\ \ of\ \ 768\ \ cases\ \ in\ \ use)$$

pseudo-R^2 = 0.64750

Table 1. Descriptive statistics of the variables used in modelling.

statistic	Land prices Pln*	Rental Values P ln*: Medium and large plots	Rental Values P ln*: Small plots	Interest Rate	Scarcity Multiplier	Speculation Multiplier
2003					2003–2007	
Mean	4171.92	123.85	87.56	0.058	1.003	1.216
St. deviation	1659.68	73.20	58.63	0.006	0.018	0.067
2004					2008–2014	
Mean	4912.38	236.92	130.47	0.069	1.018	1.104
St. deviation	1679.89	182.28	88.67	0.004	0.014	0.030
2006						
Mean	7573.84	201.96	186.67	0.052		
St. deviation	1881.12	115.62	106.96	0.003		
2013						
Mean	21516.48	873.63	714.48	0.041		
St. deviation	7454.62	509.01	467.93	0.003		

*The average US dollar–zloty exchange rate in 2003–2014 was 1 USD = 3.14 PLN (IMF).
Source: own calculations.

Table 2. Comparison of RDMs for different plot sizes.

Var.[1]	Model for small plots 1.01–9.99 ha	S.E.	Corr.	p-value	Model for medium and large plots 10.00–99.99	S.E.	Corr.
Dependent var.	Ln land price per ha				Ln land price per ha		
Fixed part							
cons	5.21798	0.22526	–	0.00000	4.84632	0.28990	–
$LnD_{small\ farms}$	0.29871	0.01956	–	0.00000	–	–	–
$LnD_{medium\&large}$	–	–	–	–	0.30308	0.03414	–
$Ln(1+k)$	1.99198	1.18774	–	0.09352	0.98282	0.46591	–
$Ln(1+t)$	0.25445	0.07618	–	0.00084	0.26614	0.08616	–
ln R	−0.84087	0.07856	–	0.00000	−0.92261	0.08662	–
Random part							
Level region:							
between variance	0.03175	0.01287	–	–	0.38129	0.20109	1.00000
$Ln(1+k)$/cons covariance	0.00063	0.22636	0.00081	–	–	–	–
$Ln(1+k)$ variance	18.86535	7.94431	–	–	–	–	–
$LnD_{medium\&large}$ /cons covariance	–	–	–	–	−0.06622	0.03511	−0.96688
$LnD_{medium\&large}$ variance	–	–	–	–	0.01230	0.00630	–
Level time:	–	–	–	–	–	–	–
within variance	0.14768	0.00853	–	–	0.16005	0.00986	–
No. obs.	631	–	–	–	558	–	–
rho (excluding random variance of coeff.)[2]	0.044179				0.8501971		
−2*loglikelihood:	650.56217	–	–	–	609.57715	–	–
pseudo-R^2	0.64750				0.61801		

[1]descriptions of variables as in (equations 6 and 7).
[2]rho = square of 'between'/(sum of squares of 'within' and 'between').
Source: own computations using MLwiN 2.36 (Centre for Multilevel Modelling, University of Bristol).

Standard errors are given in brackets; other symbols have the same meanings as in equations (6 and 8).

In model 9) all variables are statistically significant (p-value below 0.05), and the signs are in accordance with expectations. The model explains more than 64% of the variation in prices. This is a very high value relative to the typical explanatory power of the hedonic models described in the literature. In the estimation procedure (described in the previous section) the best fit was found for the model with a random regression coefficient for the scarcity multiplier (the addition of other random regressors was statistically insignificant). The matrix of covariances does not provide any new information, however, because the covariance of the regression value β_{2k} and the free term carries too great a standard error (0.23). On the other hand, the rho coefficient (cf. Table 2) indicates that individual effects of regions are responsible for only 4.4% of the residual variation not explained by the model.

Interpreting the marginal effects, we may note that the effect of the scarcity factor is relatively the strongest in the case of properties with small areas. A 1% increase in the scarcity multiplier causes an increase in land prices by 1.99%. In other words, a 1% faster rate of decrease in available UAA causes land prices to rise by approximately 1.99%. Secondly, we may note the inversely proportional effect of the discount rate. A 1% increase in the interest rate on long-term deposits causes *(ceteris paribus)* a fall in land prices by 0.84%. The significances of the rental value and of speculation effects are relatively weak in this case. In the case of the rental value, which serves as an approximation to the use values of agricultural land, this was to be expected, since holdings with small areas have relatively low productive importance. The marginal effects of these factors were 0.30% and 0.25%, respectively. The relatively large significance of the supply of small-area UAA in explaining prices in this category shows that the importance of non-production-related attributes is increasing. In the case of small plots, some confirmation is obtained for the view that the source of land rent is the intrinsic utility of the land and its new functions, which the market appears to discount in its expectations. It can be seen, however, that even in this case the neoclassical RDM is applicable. An interesting observation is that a large role is played by macroeconomic determinants, in the form of interest rates reflecting the opportunity cost of capital.

The model for medium and large plots is as follows:

$$lnL_{ijk} = \beta_{0jk} + \beta_{1k} lnD_{medium\&large\ \ plots_{jk}} + 0.98282(0.46591) ln(1+k)_{jk} + 0.26614(0.08616) ln(1+t)_{jk} - 0.92261(0.08662) lnR_{jk}$$

$$\beta_{0jk} = 4.84632(0.28990) + v_{0k} + u_{ijk}$$

$$\beta_{1k} = 0.30308(0.03414) + v_{1k}$$

between variance:

$$\begin{bmatrix} v_{ok} \\ v_{1k} \end{bmatrix} \sim N(0, \Omega_v) : \Omega_v = \begin{bmatrix} 0.38129(0.201209) & - \\ -0.06622(0.03511) & 0.01230(0.00630) \end{bmatrix} \tag{10}$$

$u_{ijk} \sim N\left(0, \sigma^2_{u0}\right)$ $\sigma^2_{\mathrm{u0}} = 0.16005(0.00986)$ within variance

$$-2{*}loglikelihood = 609.57715 \ \ (558 \ \ of \ \ 768 \ \ cases \ \ in \ \ use)$$

pseudo-$R^2 = 0.61801$

Standard errors are given in brackets; other symbols have the same meanings as in equations (6 and 8).

In model 10) all variables are again statistically significant (p-value below 0.05, in one case below 0.1; cf. Table 2), and the signs accord with expectations. The model explains approximately 62% of the variation in land prices. In the estimation procedure (described in the previous section) the best fit was found for the model with a random regression coefficient for the 'rental price' variable (the addition of other random regressors was statistically insignificant). Interestingly, the value of rho in this case indicates that individual effects of regions account for as much as 85% of the residual variation not explained by the variables in the model (cf. Table 1). This means that individual regional determinants have a much greater impact on land prices in the case of large plots than with small plots.

Interpreting the marginal effects, we may note that in this case the effects of the scarcity factor (land hunger) and of interest rates (the discount rate) are relatively the strongest. This indicates that the parties to these transactions have stronger market links than in the case of small plots, which is in line with expectations. However, the impact of the scarcity factor is less than half as strong as in model 9). The marginal effects of speculation and rental value proved to be stronger. Note should also be taken of the free terms of the two models (9 and 10). In the absence of dummy variables, these can be interpreted as the intrinsic value or utility of land, namely the value of the resource free of any facilities or productive activity. Interestingly, this is higher in the case of small plots, which gives further support to the previously cited claim concerning the intrinsic utility of land in the new paradigm. In the case of this model, interesting conclusions can also be drawn from analysis of the matrix of covariances. This shows that the regression coefficient for the 'rental price' variable is negatively correlated (endogenously) with the free term (correlation coefficient −0.97; cf. Table 1) and that this is a statistically significant dependence. There are two ways of interpreting this: the greater the effect of rental value, the smaller the intrinsic value of the land; or the stronger the individual effects of regions (due to differences in natural attributes, for example) the weaker the effect of the rental value on land prices.

5. Conclusion

Our data and results indicate the rapid growth in land prices which becomes a significant barrier for farmers willing to increase the scale of their farming activities. The Common Agricultural Policy reinforces the pressure on land prices due to the decoupled (direct) payments but also CAP 'green programmes' (Czyzewski et al., 2018). This is why we may expect further increase in land prices. Therefore, at the national level, the government should enact regulations for the land market which would make speculation more difficult and at the same time facilitate land purchase for farmers but also for people eager to settle a local business activity in rural areas (e.g., agritourism) or buying land for own residential purposes.

The fruitful line for further research might be to test our model in the countries with a different agrarian structure or a different population density. One may assume that in the latter case a role of the scarcity multiplier will be even higher.

The analysis has shown that the market for agricultural land in Poland underwent significant changes during the period under consideration. Large differences between regions were identified, although the main tendencies were similar in terms of both the direction and the scale of the transformation. By the same token, it can be stated both that the causes of internal differentiation were persistent, and that factors of a universal nature had uniform effects in the different regions. However, different models of land prices were obtained when transactions involving different plot sizes were considered.

The study has demonstrated that proposed adaptation of the neoclassical RDM explains relatively well the prices of agricultural land in Poland, in spite of the significant variation during the period analysed in macroeconomic conditions, speculation on the land market, multifaceted integration with EU structures, new functions of agricultural land, the evolution of the CAP towards sustainable farming, and far-reaching regulation of the agricultural land market in Poland. This is a surprising result, particularly since the number of transactions on the market being considered was limited. By taking account of additional factors reflecting the questions of increasing scarcity and speculation, it is found to be possible to apply the classical capital approach even in conditions where the development paradigm for agriculture is changing. It is worth noting that the RDM is certainly not obsolete, even in terms of the sustainable development path. Moreover, there is still much truth in the statement of M. Blaug that 'modern economics has abandoned the notion that there is any need for a special theory of ground rent. In long-run stationary equilibrium, the total product is resolvable into wages and interest as payments to labour and capital – there is no third factor of production … ' (Blaug, 1997: 82).

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