TOWARDS SUSTAINABLE AGRI-FOOD SYSTEMS:
BALANCING BETWEEN MARKETS AND SOCIETY

Drivers for land value revisited: is the returns discount model (RDM) obsolete in sustainable agriculture?

Bazyli Czyżewski[1], Piotr Kułyk[2] and Łukasz Kryszak[3]

[1] Poznań University of Economics and Business, email: bazyli.czyzewski@ue.poznan.pl

[2] University of Zielona Góra, Poland, email: p.kulyk@wez.uz.zgora.pl

[3] Poznań University of Economics and Business, email: Lukasz.Kryszak@ue.poznan.pl

Contribution presented at the XV EAAE Congress, "Towards Sustainable Agri-food Systems: Balancing Between Markets and Society"

August 29th – September 1st, 2017

Parma, Italy

Drivers for land value revisited: is the returns discount model (RDM) obsolete in sustainable agriculture?[1]

Abstract

Although mainstream economics says that farmland values are determined by the discounted stream of returns, many researchers have identified non-agricultural attributes of land that significantly contribute to its value. It is claimed that in sustainable agriculture, an increasing proportion of the value of land is explained by amenities. It is necessary to consider whether the neoclassical RDM remains applicable to the valuation of farmland. The main aim of this work was to test RDM of Saphiro–Gordon type for farmland prices in Poland. It was found that in spite of changes to the CAP, the RDM continues to perform well.

Keywords: **[farmland price, RDM model, sustainable agriculture, land rent]**

1 Introduction

Mainstream economic theory says that farmland values are determined by the discounted stream of expected returns (Burt, 1986; Featherstone and Baker, 1987; Capozza and Helsley, 1989). However, many researchers have expressed the opinion that agricultural utilities explain a diminishing part of the value of land. The results of Delbecq et al. (2014) 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 evidence that in many areas throughout the United States, the market value of farmland has exceeded its use value in agricultural production (Barnard, 2000; Flanders, White and Escalante, 2004). Wasson et al. (2013) argue that parcel-level attributes that comprise recreational and visual values are essential to explain agricultural land value. According to those authors, amenity premiums play a large role, especially in amenity-rich areas, for example in western Wyoming (US), where amenity values constitute 5% to 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 return component of values (Delbecq et al., 2014). Summing up, multiple studies have identified 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 has been shown to be a growing divergence between market value and agricultural use value when these attributes occur.

Nevertheless, the present authors have 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 R^2 coefficient for their model is between 41% and 51%, while Choumert and Phelinass (2015) report R^2 values of 21–35% in the hedonic approach. The main aim of this article is to test the classical returns discount model (RDM of Saphiro–Gordon type**)** for farmland prices in the all 16 provinces (voivodeships) in Poland in the years 2003–2014 (48 quarter series) to verify whether it has indeed lost its explanatory power. There is also the more general research question of how much the "use value" for land has diminished as European agriculture has shifted to the sustainable development path since the 1990s.

[1] The article was written by the project funded by the National Science Centre in Poland allocated on the basis of the decision: OPUS 6 UMO-2013/11/B/HS4/00572.

2 Modern vs classical approaches

With regard to the set of variables explaining land values, three modern 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 Diewert, de Haan 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; Shi et al., 1997; Ciaian et al., 2010): 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 produce (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), and Ciaian and Kancs (2012). According to Nilsson and Johansson (2013) the decoupled payments translate into higher land values. Similar findings had been made in previous studies (Clark et al., 1993; Weersink et al., 1999). However, further findings of Karlsson and Nilsson (2013) suggest that the single farm payment has no influence on farm prices when measured at local and regional levels. Since the results concerning policy incidence on land value are ambiguous, there is a need for continuing research in this area.

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 and 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).

The classical approach makes it possible to avoid a such complicated and many-sided analysis. It is assumed that the effect of all of the factors such as 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 alternative costs (related to the flow of land to other uses) are reflected by the discount rate.

The neoclassical concept is however frequently criticised for its excessive focus on supply factors relating to the use of the land 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. In line with post-Keynesian concepts, 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 phenomena of speculation and value storage.

In view of the gradual reduction in the amount of land in agricultural use, we may also refer to the problem of the intrinsic utility of land. 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. A new theory of land rent states that the source of that rent in sustainable agriculture is the higher expected productivity of capital in agriculture than in related sectors. This productivity is not subject to compensation, in view of the immobility of land and labour in agriculture and the absence of mechanisms for valuation of the public goods produced in agriculture. Nonetheless, this surplus productivity is discounted by the market in land prices.

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 (Gordon, 1962; Bringham and Gapenski, 1990) 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 Methodology

Since the data analysed here are combined cross-sectional and time series data, the formation of land prices was investigated using panel regression taking 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 account of the effect of financial support, in view of the asymmetry of observations in time (changes in agricultural policy) and the different rates of development in the analysed spatial units (Haughwout et al., 2008).

We therefore 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 (using MLwiN 2.36 software from the Centre for Multilevel Modelling, University of

Bristol). In the random effect model the individual effects differ in space, and are not assigned to objects (each region may generate a different individual effect in each period). As a result we do not treat individual effects as parameters and do not estimate their values, but we interpret them as individual random components.

As regards 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 "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. These constitute a value which, in the overall mass of transactions, also takes account of other factors affecting transaction costs on the agricultural land market. The value of land is thus decided by the sum of expected financial income, discounted to the time when the value is determined. It is assumed that, in spite of the regulations in effect and the impact of a wide set of factors on farmland prices in Poland, the market mechanism has shaped the conditions in accordance with this fundamental assumption. The base model of perpetual rent is expressed as follows:

$$L = \frac{D}{R} \quad 1)$$

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).

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:

$$lnL = \ln(D) - \ln(R) \quad 2)$$
$$lnL_{it} = \alpha lnD_{it} - \beta lnR_{it} + b_i \quad 3)$$

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). 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). Moreover this rate cannot be constant, in view of the changes in availability of the land factor in the stocks of the Agricultural Property Agency, changes in macroeconomic conditions (slowing of economic growth and gradual lowering of inflation in Poland) and the gradual increase in the level of subsidies to agriculture in the course of Poland's integration with the EU. 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 and Sobiecki, 2011; Marks-Bielska, 2010; Sikorska, 2013). As a result, our model takes the form:

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

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

$$lnL = \ln(D) + \ln(1+k) + \ln(1+t) - \ln(R) \quad 5)$$

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

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;
1+t is the speculation multiplier;
R is the discount rate.

With a view to the differences in reactions and functions, plots were divided into two categories: small areas of 1 ha up to 9.99 ha, and medium/large areas of 10 ha up to 99.99 ha. This is a specific classification used by the Agricultural Property Agency in Poland covering a majority of transactions of a land from the state resource. The Agency has also distinguished plots above 100 ha however these time series lack to many data to be considered. Although prices in those auctions run by the Agricultural Property Agency are usually a bit lower that in the between-neighbours turnover, they make a reference point for the agricultural land market tendencies in Poland. 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.

As regards 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:

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.

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.

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:

$$1+k = \frac{\frac{d}{UAA_t}}{\frac{d}{UAA_{t-1}}} \quad 7)$$

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.

Discount rate R

This reflects the alternative 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 hierarchical panel model including random coefficients, the estimated equation is as follows:

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

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

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

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

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

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

$$u_{ijk} \sim N(0, \sigma_{u0}^2)$$

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

The hierarchic approach allows us to take account of both the random free term and the nesting of random regression coefficients. 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 provinces. 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 (Radkiewicz and Zieliński, 2010; Sagan, 2007; Gruchociak, 2012; Twisk, 2006). The model is estimated using the maximum likelihood (ML) method, implemented in the software used by the authors (MLwiN) as IGLS (Iterative Generalised Least Squares). In this approach, the fit of the model can also be evaluated from a relative standpoint by comparing the statistic "–2 log likelihood" for successive model versions (and also by computing the coefficient of determination based on the residual variance not explained by the model).

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. This difference has a chi-square distribution with a number of degrees of freedom corresponding to the difference between the numbers of estimated parameters in the two models (Twisk, 2006). The procedure is repeated for each regression coefficient. In the same way one can check whether it is appropriate to use a panel model – the LRT is used to evaluate whether there is justification for a random free term.

At the next step we evaluated the significance of the computed regression coefficients using Wald's test, that is, 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). The fit of the model was evaluated on the basis of the coefficient of determination.

As regards the robustness of standard errors, the maximum likelihood method is more robust than the classical least squares method with respect to deviations from the assumptions of classical linear regression. Nonetheless, the continuous result variable ought to have a normal distribution. In our case this assumption generally holds, although according to certain tests the distribution of the explained variable deviates slightly from normal. The multicollinearity of the variables was evaluated on the basis of Variance Inflation Factors (VIFs). None of the variables exceed VIF=2, which is in line with the most radical rules of thumb (Chatterjee and Hadi, 2006).

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 fivefold, and the rental value more than sevenfold. 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:

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

$u_{ijk} \sim N(0,\sigma_{u0}^2)\ \sigma_{u0}^2 = 0.14768(0.00853)$ *within variance*

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

$R^2 = 0.64750$

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

Table 1. Descriptive statistics

statistic:	LAND PRICES PLN*	RENTAL VALUES PLN*		INTEREST RATE	SCARCITY MULTIPLIER	SPECULATION MULTIPLIER
		Medium and large plots	Small plots			
2003					2003–2007	
Mean *St. deviation*	4171.92 1659.68	123.85 73.20	87.56 58.63	0.058 0.006	1.003 0.018	1.216 0.067
2004					2008–2014	
Mean *St. deviation*	4912.38 1679.89	236.92 182.28	130.47 88.67	0.069 0.004	1.018 0.014	1.104 0.030
2006						
Mean *St. deviation*	7573.84 1881.12	201.96 115.62	186.67 106.96	0.052 0.003		
2013						
Mean *St. deviation*	21516.48 7454.62	873.63 509.01	714.48 467.93	0.041 0.003		

*The average euro–zloty exchange rate in 2003–2014 was 1 EUR = 4.1 PLN (Eurostat)
Source: own computations using MLwiN 2.36 (Centre for Multilevel Modelling, University of Bristol)

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 alternative 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:

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

$$u_{ijk} \sim N(0, \sigma_{u0}^2)\ \sigma_{u0}^2 = 0.16005(0.00986)\ within\ variance$$

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

$R^2 = 0.61801$

Standard errors are given in brackets; other symbols have the same meanings as in equations 6) and 7).

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.

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	-	-
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)

5 Conclusions

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 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. To answer the question posed in the title of this article, the RDM is certainly not obsolete. 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).

6 References

Barnard, C.H. (2000). Urbanization affects a large share of farmland. *Rural Conditions and Trends,* 10(2): 57–63.

Barnard, C.H., Whittaker, G., Westenbarger, D., Ahearn, M. (1997). Evidence of capitalization of direct government payments into U.S. cropland values. *American Journal of Agricultural Economics,* 79(5): 1642–1650.

Blaug, M. (1997). *Economic Theory in Retrospect*. Cambridge: Cambridge University Press.

Bringham, E.F., Gapenski, L.C. (1990). *Intermediate Financial Management*. Hinsdale: Dryden Press.

Burt, O.R. (1986). Econometric modeling of the capitalization formula for farmland prices. *American Journal of Agricultural Economics,* 68(1): 10–26.

Capozza, D.R., Helsley, R.W. (1989). The fundamentals of land prices and urban growth. *Journal of Urban Economics*, 26(3): 295–306.

Case, K.E. (2007). The value of land in the United States: 1975–2005. *Land Policies and Their Outcomes*: 127–147.

Chatterjee, S., Hadi, A.S. (2006). *Regression Analysis by Example*. Hoboken: Wiley-Interscience.

Choumert, J., Phélinas, P. (2015). Determinants of agricultural land values in Argentina. *Ecological Economics*, 110: 134–140.

Ciaian, P., D’artis K., Swinnen, J. (2010). *EU Land Markets and Common Agricultural Policy*. Brussels: CEPS.

Ciaian, P., Kancs, D.A. (2012). The capitalization of area payments into farmland rents: Micro evidence from the new EU member states. *Canadian Journal of Agricultural Economics*, 60(4): 517–540.

Clark, J.S., Klein, K.K., Thompson, S.J. (1993). Are subsidies capitalized into land values? Some time series evidence from Saskatchewan. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, 41(2): 155–168.

Davis, M.A. (2009). The price and quantity of land by legal form of organization in the United States. *Regional Science and Urban Economics*, 39(3): 350–359.

Davis, M.A., Heathcote, J. (2007). The price and quantity of residential land in the United States. *Journal of Monetary Economics*, 54(8): 2595–2620.

de Haan, J., Diewert, E., Hendriks, R. (2011). Hedonic Regressions and the Decomposition of a House Price Index into Land and Structure Components. *Department of Economics Discussion Paper*, 11-01: 1-31.

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

Diewert, W.E. (2010). *Alternative approaches to measuring house price inflation. Technical report,* Discussion Paper 10-10. Department of Economics. Vancouver: The University of British Columbia.

Duvivier, R., Gaspart, F., de Frahan, B.H. (2005). *A Panel Data Analysis of the Determinants of Farmland Price: An Application to the Effects of the 1992 Cap Reform in Belgium*.

Featherstone, A.M., Baker, T.G. (1987). An examination of farm sector real asset dynamics: 1910–85. *American Journal of Agricultural Economics*, 69(3): 532–546.

Flanders, A., White, F.C., Escalante, C. L. (2004). Equilibrium of Land Values from Agricultural and General Economic Factors for Cropland and Pasture Capitalization in Georgia. *Journal of Agribusiness*, 22(1): 49–60.

Foster W., Anríqueza G., Melo O., Yupanqui, D., Ortega J. (2016). Geographic disparities in rural land appreciation in a transforming economy: Chile, 1980 to 2007. *Land Use Policy*, 57: 655–668.

Gordon, M.J. (1962). *The Investment, Financing and Valuation of the Corporation*. Homewood: Irwin.

Gruchociak, H. (2012). Możliwości zastosowania modelowania dwupoziomowego w badaniach ekonomicznych. *Przegląd Statystyczny*, 59(4): 409–433.

Haughwout, A., Orr, J., Bedoll, D. (2008). The price of land in the New York metropolitan area. *Federal Reserve Bank of New York: Current Issues in Economics and Finance*, 14(3): 1–7.

IERIGŻ (2004–2015). *Rynek ziemi rolniczej. Stan I perspektywy.* Warsaw: IERiGŻ.

Karlsson, J., Nilsson, P. (2013). Capitalisation of Single Farm Payment on Farm Price: An Analysis of Swedish Farm Prices Using Farm-level Data. *European Review of Agricultural Economics*, 40(4): 1–22.

Kowalczyk, S., Sobiecki, R. (2011). Europejski model rolnictwa–uwarunkowania ewolucji. *Roczniki Nauk Rolniczych*, 98(3): 9–20.

Larson, W. (2015). *New Estimates of Value of Land of the United States* (No. 0120). Washington: Bureau of Economic Analysis.

Latruffe, L., Doucha, T., Le Mouël, C., Medonos, T., Voltr, V. (2008). Capitalisation of the government support in agricultural land prices in the Czech Republic. *Agricultural Economics-Czech*, 54(10): 451–460.

Latruffe, L., Le Mouël, C. (2009). Capitalization of government support in agricultural land prices: What do we know?. *Journal of Economic Surveys*, 23(4): 659–691.

Luca, L. (2011) An estimation of agricultural land price in Romania after the accession to the EU. *Agricultural Management/Lucrari Stiintifice Seria I, Management*, 13(1): 59–66.

Luca, L., Alexandri, C. (2010). Constraints and restrictions of land market in Romania. *Agricultural Management/Lucrari Stiintifice Seria I, Management Agricol*, 12(1): 1–8.

Marks-Bielska, R. (2010). *Rynek ziemi rolniczej w Polsce: uwarunkowania i tendencje rozwoju*. Olsztyn: Wydawnictwo Uniwersytetu Warmińsko-Mazurskiego.

Monge, J.J., Parker, W.J., Richardson, J.W. (2016). Integrating forest ecosystem services into the farming landscape: A stochastic economic assessment. *Journal of Environmental Management*, 174: 87–99.

Nichols, J.B., Oliner, S.D., Mulhall, M.R. (2013). Swings in commercial and residential land prices in the United States. *Journal of Urban Economics*, 73(1): 57–76.

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

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

OECD (2017), Long-term interest rates (indicator). doi: 10.1787/662d712c-en (accessed 11 January 2017).

Patton, M., Kostov, P., McErlean, S., Moss, J. (2008). Assessing the influence of direct payments on the rental value of agricultural land. *Food Policy*, 33(5): 397–405.

Sagan, A. (2007). Wielopoziomowe modele strukturalne w analizie postępowania konsumentów–porównanie modeli pomiarowych. *Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie*, (756):

Shi, Y.J., Phipps, T.T., Colyer, D. (1997). Agricultural land values under urbanizing influences. *Land Economics*, 73(1), 90–100.

Sikorska, A. (2013). Obrot ziemia a przemiany agrarne w indywidualnym rolnictwie. *Zagadnienia ekonomiki rolnej*, 1(334): 8–21.

Twisk, J. W. (2006). *Applied multilevel analysis: a practical guide for medical researchers*. Cambridge University Press.

Wasson, J.R., McLeod, D.M., Bastian, C.T., Rashford, B.S. (2013). The effects of environmental amenities on agricultural land values. *Land Economics*, 89(3): 466–478.

Weersink, A., Clark, S., Turvey, C.G., Sarker, R. (1999). The effect of agricultural policy on farmland values. *Land Economics*, 75(3): 425–439.

Zieliński, M.W., Radkiewicz, P. (2010). Hierarchiczne modele liniowe. Co nam dają i kiedy warto je stosować. *Psychologia Społeczna*, 2–3(14): 217–233.