

MACROECONOMIC DETERMINANTS OF INVESTMENT IN AGRICULTURE IN POLAND – DEMATEL METHOD

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Abstract: Investments in agriculture have a direct impact on the sector as well as on the economy in general. These effects are determined by many internal (microeconomic) and external (macroeconomic) factors. In the literature there are many studies on the influence of microeconomic factors on decisions regarding investments in agriculture holdings. Few authors, however, have dealt with macroeconomic conditionality for such decisions. The paper presents the possibility to apply the DEcision MAKing Trial and Evaluation Laboratory (DEMATEL) method in examining the causal links between macroeconomic factors and investment in rural areas. Basing on the three independent experts' opinions referring to the analyzed relationships, we reveal direct and indirect links between the investigated variables.

Keywords: agriculture, investment, macroeconomic factors, causal relations, DEMATEL

INTRODUCTION

The challenge facing modern agriculture is to balance sustainable development with its increased effectiveness [Jain 2012]. Responding to this challenge, that requires considerable restructuring and investments in agriculture, may encourage the growth of businesses operating in this economic sector [Józwiak 2010]. Despite the fact that the share of agriculture in elementary macroeconomic categories is decreasing in relative terms, the sector, being one of the parts of food production and agribusiness, is of fundamental importance for the whole economy as it ensures the national food security [Babuchowska and Marks-Bielska 2015], [Kowalski 2009, 2010].

The range and character of agricultural investments give direction to the development trends in this sector and largely determine its economic situation, the changes in agricultural production and the transformations of economic units within the sector. Similarly to investing in other parts of the economy, agricultural investments trigger multiplier effects that enhance production in the economy in general. Therefore, the impact of investments in agriculture goes beyond the limits of the sector as such.

Rich literature discussing investments in Polish agriculture confirms their inherent importance to the growth of agricultural businesses. Their effects are mostly visible in production. They ensure technological advancement of farms, which, in turn, determines their economic situation [Kocira 2008; Zając 2012], they facilitate the development and modernisation of farms [Sobczyński 2011; Wójcicki and Rudeńska 2015], enhance their productivity, competitiveness and market power [Kisiel and Babuchowska 2013; Dziwulski 2013]. Along with savings and external transfers, the investments give a ground for the changes in technical relationships and in the productivity of agricultural production [Bezet-Jastrzębska and Rembisz 2015]. Moreover, the investments in agriculture bring effects outside the production as they improve animal welfare, environmental protection as well as food and work safety [Wasąg 2009; Grzelak 2015].

Similarly to the economy in general, the conditions for investments in agriculture are varied. They can be of internal character or result from the external situation [Gołębiowska 2010]. This means that investments are determined by a number of factors on the part of farmers (internal, endogenous, microeconomic) [Poczta and Siemiński 2009] and by factors that occur independently from them (external, exogenous, macroeconomic).

According to the literature, there are the following external determinant factors of agricultural investments:

- natural environment in which a given farm is operating and where its production is located [Zając 2012];
- the volume of disposable income, the supply of subsidised loans, commercial interest rates and the accessibility of EU funding [Sulewski 2005];
- market conditions (e.g. demand for new agricultural products, price stability on the produce market, stability and flexibility of the produce market institutions, prospects of the produce market), technological conditions (e.g. productivity and the quality of effects of new technological solutions) and financial conditions (e.g. credit restrictions or the financial market policies and institutions) [Kataria, Curtiss and Balmann 2012];
- macroeconomic variables, market conditions and financial standing of farms [Bórawski 2014];
- stages of the economic cycle, legal regulations concerning business activity, competitiveness and economy globalisation [Filipiak 2014];

- factors related with the macroeconomic and political situation, demographic pressure, institutional solutions and legal regulations [Kusz, Gędek, Ruda and Zajac 2014];
- factors related with the demand for a given produce, expected and current prices (of produce), supply conditionality (costs to incur, the availability and cost of production factors), present and projected economic trends, systemic solutions (financial, economic and institutional), economic policies (agricultural, fiscal and monetary in particular), inflation and interest rates that determine capital costs, the level of economic openness, legal regulations, insurance and consulting organisations and institutions, and, finally, the requirements concerning environmental protection and animal welfare [Thijssen 1996, Kusz 2012, Kusz and Gędek, Kata 2015];
- a pro-investment impulse provided by the Common Agricultural Policy funds whose importance has been growing since the Poland's pre-accession period [Domańska and Felczak 2014, Czubak 2015], and which offer investment support from public funds [Kusz and Gędek 2015].

Some of the above listed external factors are the ones that are specific for agriculture, but the majority are the general macroeconomic determinants of investment [Miłaszewicz 2007, p. 64-79].

The investment decisions made by farmers are a resultant of both exogenous and endogenous factors. The present article discusses the latter as its purpose is to present the use of the DEcision MAKing Trial and Evaluation Laboratory (DEMATEL) method to investigate the cause-and-effect relationship between agricultural investments and their macroeconomic determinant factors. The proposed algorithm of a multi-criteria assessment and ordering of the interplay among the examined variables helps to define the structure and hierarchy of the factors that are built according to the independent experts' opinions.

MATERIAL AND METHODS

The multi-criterial method referred to as DEMATEL (DEcision MAKing Trial and Evaluation Laboratory) was proposed by Gabus and Fontela [1972] in the 1970s with a view to detect the causal relationships between the global and regional economic and social problems. As such it can be used for determining the relevance of factors determining investments in agriculture. It is a method consisting of several steps, the first of which is the selection of factors to be analyzed [Wawrzynek 2014].

The factors used in the DEMATEL-based analysis were selected on the basis of theoretical deliberations in the previous part of this paper. The above mentioned factors not only determine the internal determinants of agricultural investments, but they are interrelated as well. Out of numerous external determinants described in the literature (W1) the authors chose 13 potential variables: W2 – the possibility to

change the use of land, W 3 – domestic economic situation (in general and in agricultural industry), W4 – the price of land; W5 – inflation, W 6 – unemployment rate, W7 – legal regulations (referring to trading in agricultural land, environment protection, etc.), W8 – monetary concessions (e.g. credit facilities for farmers), W9 – fiscal concessions (e.g. tax credits, tax exemptions, paying tax in instalments or fuel subsidies), W10 – EU subsidies, W11 – profitability of agricultural production, W12 – available markets, W13 – support institutions, W14 – land supply. The use of the DEMATEL method allows their mutual influence and a cause-and-effect relationship between the variables and agricultural investments to be shown.

Another step in the DEMATEL method is the evaluation of the examined factors. The experts' opinions on the relations between these factors are collected. In the subsequent step, on the basis of the experts' opinions a graph illustrating these cause and effect relationships serves as a starting point for calculations. The arrows in the graph show the relations between factors or events, simultaneously indicating the direction of impact. There is a variety of scales to define power this relations. In this paper the following scale is applied [Kobryń 2014]:

1. Non-influence.
2. Low influence.
3. High influence.
4. Very high influence.

On the basis of this graph a matrix of direct impact B is produced. It is a square matrix where all the entries on the main diagonal always equal zero. They denote the influence of a given factor on itself. The other entries are derived from the graph. The element with an index where i is the influence received and j the influence given represents the power of this influence. The direct influence matrix is normalised [Ginda and Maślak 2012]:

$$B' = \frac{1}{\lambda} B, \quad (1)$$

then [Ginda and Maślak 2012]:

$$\lambda = \max \left\{ \max_j \sum_{i=1}^n b_{i,j}; \max_i \sum_{j=1}^n b_{i,j} \right\}. \quad (2)$$

where $b_{i,j}$ is an element of the direct influence matrix and n is its size.

The influence matrix B' describes only the direct influence. However, the relationships between the factors can be of indirect nature as well. The matrix B' does not contain information about such influence. This information is delivered by the total influence matrix T that is a sum of the matrix B' and the indirect influence matrix \hat{B} [Kobryń 2014]:

$$T = B' + \hat{B}. \quad (3)$$

The indirect influence matrix \hat{B} is produced by summing up direct influence sub-matrices B' raised to i -th power, where $i = 1, 2, 3, \dots$ [Ginda and Maślak 2012]:

$$\hat{B} = B'^2 + B'^3 + \dots = \sum_{i=2}^{\infty} B'^i. \quad (4)$$

Substituting \hat{B} to Formula (3):

$$T = B' + B'^2 + B'^3 + \dots = \sum_{i=1}^{\infty} B'^i, \quad (5)$$

which equals (Ginda and Maślak 2012):

$$T = B'(I - B')^{-1}, \quad (6)$$

where I is an identity matrix.

The indirect influence can be derived from the Formula [Kobryń 2014]:

$$\hat{B} = B'^2(I - B')^{-1}. \quad (7)$$

When the collective analysis of all influences is necessary, for each of the factors we calculate the significance indices [Kobryń 2014]:

$$t_i^+ = \sum_{j=1}^n t_{i,j} + \sum_{j=1}^n t_{j,i}, \quad (8)$$

and the influence indices (Kobryń 2014):

$$t_i^- = \sum_{j=1}^n t_{i,j} - \sum_{j=1}^n t_{j,i}. \quad (9)$$

The significance index describes the general participation of the object in a network of influence. The higher the index, the stronger a given factor influences the remaining factors and/or the stronger the remaining factors influence this factor. The influence index shows if the influence given by a factor is stronger than the influence it receives.

RESULTS

For the purpose of the study into the influence of macroeconomic factors on investments, three experts in various fields of economic science, such as management, finances and economics, were asked to share their opinions. The respondents' opinions on the influence power of individual factors were expressed on the scale from 0 to 3. For each expert a sub-matrix of direct influence between macroeconomic factors was produced (Table 1).

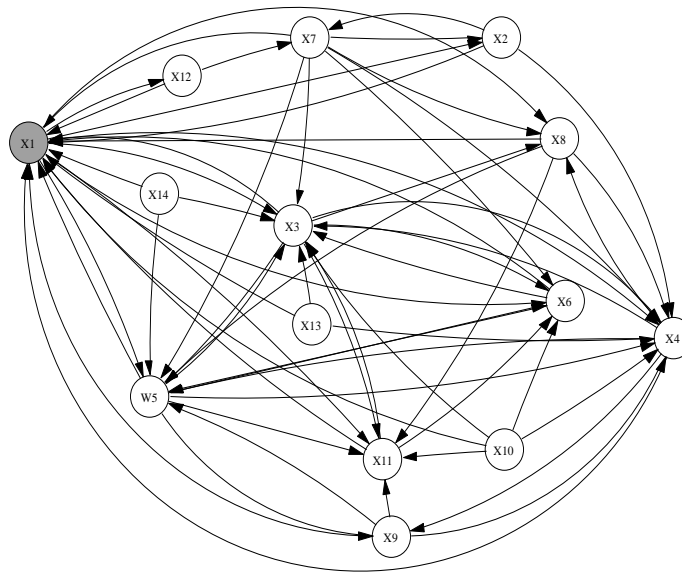
First, a partial matrix of the direct impact of the analysed factors was made for each expert. Then, the median defining the impact power was calculated on the basis of the matrix values. In the next step, the matrix of direct impact was constructed whose representation is a cause-and-effect diagram (Figure 1).

Table 1. Sub-matrix of direct influence

Variables	W ₁	W ₂	W ₃	W ₄	W ₅	W ₆	W ₇	W ₈	W ₉	W ₁₀	W ₁₁	W ₁₂	W ₁₃	W ₁₄
W ₁	0	2	3	2	1	3	0	1	0	0	2	1	0	0
W ₂	2	0	0	3	0	0	3	0	0	0	0	0	0	0
W ₃	3	0	0	2	2	2	0	1	0	0	2	0	0	0
W ₄	2	0	1	0	3	0	0	2	1	0	0	0	0	0
W ₅	2	0	2	3	0	2	0	0	2	0	2	0	0	0
W ₆	2	0	3	0	2	0	1	0	0	0	0	0	0	0
W ₇	3	3	2	3	1	1	0	2	0	0	0	0	0	0
W ₈	3	0	0	2	1	0	0	1	0	0	1	0	0	0
W ₉	2	0	0	1	2	0	0	0	0	0	1	0	0	0
W ₁₀	2	0	2	2	0	1	0	0	0	0	2	0	0	0
W ₁₁	3	0	2	0	0	1	0	0	0	0	0	0	0	0
W ₁₂	3	0	0	0	0	0	1	0	0	0	0	0	0	0
W ₁₃	1	0	1	1	0	0	0	0	0	0	0	0	0	0
W ₁₄	3	0	1	0	1	0	0	0	0	0	0	0	0	0

Source: own analysis

Figure 1. Cause-and-effect diagram of analysed factors' impact on investments



Source: own analysis

Having normalised the matrix of direct impact and the constructed on that basis the matrix of indirect impact, a normalised matrix of the total impact of the analysed factors was made (Table 2).

Table 2. The normalized total influence matrix

Variables	W ₁	W ₂	W ₃	W ₄	W ₅	W ₆	W ₇	W ₈	W ₉	W ₁₀	W ₁₁	W ₁₂	W ₁₃	W ₁₄
W ₁	0.05	0.07	0.13	0.09	0.06	0.12	0.01	0.05	0.01	0	0.08	0.03	0	0
W ₂	0.09	0.02	0.02	0.12	0.02	0.02	0.10	0.02	0.01	0	0.01	0	0	0
W ₃	0.13	0.01	0.04	0.09	0.09	0.09	0	0.05	0.01	0	0.08	0	0	0
W ₄	0.09	0.01	0.05	0.03	0.11	0.02	0	0.07	0.04	0	0.02	0	0	0
W ₅	0.10	0.01	0.09	0.12	0.03	0.09	0	0.01	0.07	0	0.08	0	0	0
W ₆	0.09	0.01	0.12	0.03	0.08	0.02	0.03	0.01	0.01	0	0.02	0	0	0
W ₇	0.14	0.11	0.09	0.14	0.06	0.06	0.01	0.08	0.01	0	0.02	0	0	0
W ₈	0.12	0.01	0.02	0.08	0.05	0.02	0	0.04	0.01	0	0.05	0	0	0
W ₉	0.08	0.01	0.02	0.05	0.07	0.02	0	0.01	0.01	0	0.04	0	0	0
W ₁₀	0.09	0.01	0.09	0.08	0.02	0.05	0	0.01	0	0	0.08	0	0	0
W ₁₁	0.11	0.01	0.08	0.02	0.01	0.05	0	0.01	0	0	0.01	0	0	0
W ₁₂	0.11	0.01	0.02	0.01	0.01	0.01	0.03	0.01	0	0	0.01	0	0	0
W ₁₃	0.04	0	0.04	0.04	0.01	0.01	0	0.01	0	0	0.01	0	0	0
W ₁₄	0.11	0.01	0.05	0.02	0.04	0.02	0	0.01	0	0	0.01	0	0	0

Source: own analysis

Basing on the matrix of total impact a conclusion can be drawn that the agricultural investments (W₁) are mostly affected by legal regulations (concerning trading in agricultural land, environmental protection, etc.) (W₇), domestic economic situation (in general and in agricultural industry) (W₃) and monetary concessions (e.g. credit facilities for farmers) (W₈). The majority of the analysed factors have a relatively strong impact on agricultural investments (W₁) with the exception of support institutions (W₁₃). Agricultural investments (W₁) strongly affect unemployment rates (W₆). Similarly, legal regulations (referring to trading in agricultural land, environment protection, etc.) (W₇) have a considerable influence on the price of land (W₄). Moreover, unemployment rates (W₆) significantly influence domestic economic situation (in general and in agricultural industry) (W₃), while inflation (W₅) and the possibility to change the use of land (W₂) have a strong effect on the price of land (W₄).

The aforementioned calculations have revealed a weak indirect impact of available markets (W₁₂) and land supply (W₁₄) on agricultural investments (W₁) despite the fact that the experts indicated a strong relationship among these variables. A similar discrepancy occurs in reference to the impact of legal regulations (concerning trading in agricultural land, environmental protection, etc.) (W₇), the possibility to change the use of land (W₂) and the price of land (W₄) on inflation (W₅), as well as to the relationship between the possibility to change the use of land (W₂) and legal regulations (W₇). The experts considered these impacts weak. The study, however, showed a strong indirect relationship between legal regulations (W₇) and agricultural investments (W₁) and land prices (W₄). The

matrix of indirect impact also reveals that there is a strong indirect impact of inflation (W5) on agricultural investments (W1).

Basing on the total influence matrix a matrix of significance indices T^+ and influence indices T^- of the analysed variables are determined (Table 3).

Table 3. Significance indices T^+ and influence indices T^-

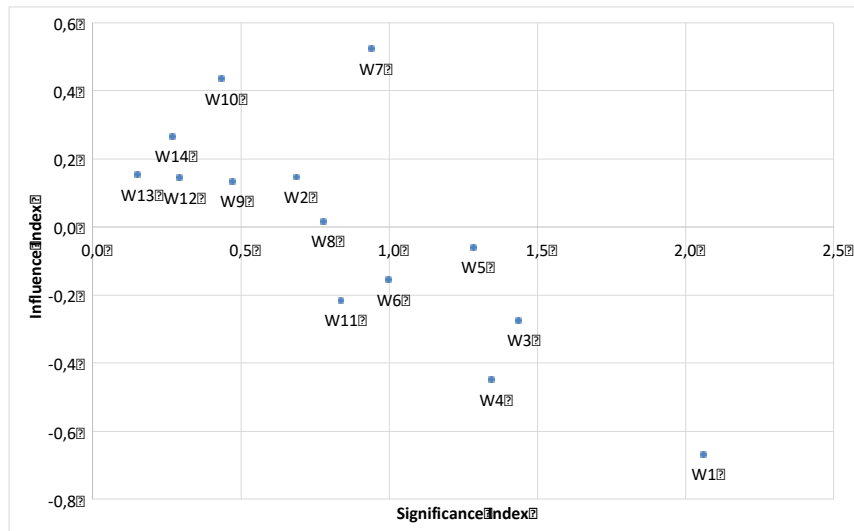
Factors	T^+	T^-
W ₁	2.06	-0.67
W ₂	0.69	0.15
W ₃	1.44	-0.27
W ₄	1.35	-0.45
W ₅	1.28	-0.06
W ₆	1.00	-0.15
W ₇	0.94	0.52
W ₈	0.78	0.02
W ₉	0.47	0.13
W ₁₀	0.44	0.44
W ₁₁	0.84	-0.21
W ₁₂	0.30	0.14
W ₁₃	0.15	0.15
W ₁₄	0.27	0.27

Source: own analysis

The above results give ground for the conclusion that there is a strong interrelation between the investments in agriculture and other factors. The value T_1^- equal -0.67 implies that mainly the analysed factors have an impact on the agricultural investments. High values of T_i^- for legal regulations (concerning trading in agricultural land, environmental protection, etc.) (W7) and EU subsidies (W10) mean that these two factors have stronger influence on the remaining variables than the remaining variables have on them. Moreover, high values of T_i^+ for agricultural investments (W1), domestic economic situation (in general and in agricultural industry) (W3), the price of land (W4) and inflation (W5) indicate strong relationships between these factors and the remaining ones.

The above findings are confirmed by the map of the total impact (Figure 2) among the analysed factors. A conclusion can be made that the position of W1 in the lower part of the diagram (a negative value of the impact indicator at -0.67) means that the impact of the remaining factors on the agricultural investments is much stronger than the reverse relationship. Because the value of the importance indicator is high (2.06), the interaction between W1 and the remaining determinants of agricultural investments is very strong.

Figure 2. Map of impact of analysed variables – final analysis results



Source: own analysis

CONCLUSION

In theoretical considerations about the economy it is possible to eliminate certain phenomena (factors) and relationships by adopting the rule of *ceteris paribus*. In the real economic world none of the phenomena occur in isolation and it is their specific feature that they influence one another in a cause-and-effect relationship. This complexity of the economic reality hinders the observation of individual phenomena, their investigation and analysis as well as impedes their modification by means of economic policies. The obstruction to the analysis can be overcome if we have adequate tools at our disposal. One of them is DEMATEL - an uncomplicated method based on simple mathematical transformations which is an effective tool for identifying the cause-and-effect relationships among selected main factors of direct and indirect impact within a certain process or phenomenon.

The results of applying this method in the analysis of the impact of exogenous factors on agricultural investments confirm the research value of the DEMATEL method for economics. The fact that it has been based on the opinions of experts from different areas of economics makes it possible to include factors that are evaluated from different points of view. Based on the relevance of the cause-and-effect relationships among any number of factors, the findings obtained by means of the DEMATEL method can be used in decision-making processes in the analysed economic sector, when creating economic policies influencing these decisions as well as in other areas of theoretical and applied economics.

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