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INFORMATION ASYMMETRY AND MASS APPRAISAL[1]

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Abstract: In the article, we propose a new method of valuation based on market value coefficients which we have called the Szczecin algorithm of mass appraisal (SAMWN). This algorithm takes into account the idea that it is possible to measure the effects of both immeasurable and measurable variables which have not been directly included in the valuation. It is therefore a proposal to solve the problem of asymmetry of information in the mass appraisal. The article discusses the procedure of estimating the property value in the process of mass appraisal, in which the attribute related to location and fashion is not included a priori.

Keywords: asymmetry of information, mass appraisal, real estate appraisal algorithms

JEL classification: C10, C51

INTRODUCTION

According to the Real Estate Management Act (Real Estate Management Act 1997), in the process of real estate valuation the following values can be estimated: market, replacement, cadastral and other. The market value is defined as the most likely price that could be obtained for the property at the date of valuation under certain conditions: both parties to the transaction are to be independent of

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each other, determined to enter into the transaction, not acting under constraint and having the same knowledge about the property in question. An additional condition is the passage of appropriate time, which allows for appropriate exposure of the real estate on the market. The market value can only be determined for properties that are or can be traded [Źróbek and Bełej 2000]. Replacement value has been determined as the estimated amount consisting of the cost of land acquisition (its market value) and the cost of production of property components, taking into account the degree of wear and tear, assuming that production costs were incurred at the date of valuation [Hopfer Ed. 1999]. Contrary to the market value, the replacement value applies to properties which are not or cannot be traded (due to the type of property, current use or purpose). The cadastral value is determined during the universal property taxation. Despite the fact that in Poland the methodology for determining this value has been specified, in practice the cadastral value has not yet been estimated. It may even be said that it has not even been defined, as the Act indicates only its purpose (universal taxation).

In practice, real estate valuations can take place in two completely different legal and organisational situations:

1. individual appraisal,
2. mass appraisal.

The cadastral value determination (in practice even for thousands of diverse properties) will require a second approach. Individual appraisal is the case when the object of valuation is a single property or a relatively small group of properties. Valuated properties will differ due to their individual attributes: location, land development, type of market (segment and sub-segment), purpose and scope of valuation, the dates when the property state was inspected and when prices on a local property market were recorded, etc. Individual appraisals are the most frequently performed procedures with the use of the applicable valuation rules provided by law and a number of professional norms, which in Poland include professional standards, basic and specialist appraisal standards and interpretative notes.

Mass appraisal is the case when [e.g. Hozer Ed. 2002; Telega Ed. 2002; Kuryj 2007]:

1. the subject of valuation is a large number of properties of one type,
2. valuation is to be carried out by means of a uniform, objective approach resulting in consistent results,
3. all properties subject to valuation are valued 'at the same time', i.e. the state of the property and the level of prices are recorded on the same day.

From the organisational point of view, the mass appraisal takes place in two stages:

1. collecting all the necessary information and data concerning all the valued properties and the respective market,
2. calculating the value of all properties subject to appraisal with the use of an appropriate (single) algorithm.

The postulate of the necessity to apply one algorithm in the process of mass appraisal means that individual approach to the appraised property is not possible. The list of specific attributes that should be covered by the valuation is defined in advance, either by the valuer (or a valuation team), or even regulated by law.

Pursuant to Article 161(1) of the Real Estate Management Act, the universal taxation is aimed at determining the cadastral value of a property. Cadastral values, as defined in Article 162, paragraph 2 of the Act, are used:

- for determining the taxable base for real estate tax,
- when determining the value of real estate owned by the State Treasury or a relevant local government unit,
- when executing official procedures for the purpose of which it is necessary to specify the individual value of a property.

Depending on the type of land and its components, the specific attributes are defined in the Ordinance on universal real estate taxation of 29 October 2001.

Article 8 of the said Ordinance provides that the specific attributes of land built on or intended to be developed, as well as land intended for purposes other than agricultural and forestry, shall include:

1. location,
2. the function designated in the local land use plan,
3. level of equipment with technical infrastructure facilities,
4. the state of development,
5. plot ratio,
6. the soil class, if it has been defined in the real estate cadastre.

The specific attributes of agricultural and forestry land include:

1. location,
2. type of land in use,
3. level of equipment with technical infrastructure facilities for agricultural or forestry production,
4. soil class.

The specific attributes of buildings include:

1. location,
2. type of building,
3. equipment with in-building installations,
4. technical data within the meaning of the provisions on cadastre,
5. wear and tear.

The specific attributes of a unit include:

1. position within a building,
2. type of unit,
3. equipment with in-building installations,
4. wear and tear.

Apparently, in the case of determining the cadastral value, the catalogue of property specific attributes to be explicitly included in the valuation is a closed catalogue, although the legislator has stipulated otherwise. The above results from the provision stating that the aforesaid specific attributes of land, buildings and their units may also include other attributes, if they are typical of a given taxation zone. The term „specific" does not solve the problem of the „individual" attributes of a property. At the final stage of determining the cadastral value, maps and tactile tables are constructed, which unambiguously define the attributes that should be explicitly included in the valuation. Therefore, it is not possible to include in the valuation other information (e.g. soil and water conditions) relevant for the value of land designated for development. Soil and water conditions often make investment impossible or make it significantly more expensive. So, we are dealing with an asymmetry of information. For example, almost all investments in the Szczecin seaport require piling prior to any construction works. Water and ground conditions can therefore have a significant impact on the value of many properties. This asymmetry of information in property valuation is the reason why the individual value of the property, determined by means of algorithm-based methods, cannot be compared in any way with the value of a property estimated individually, e.g. by the method of paired comparison. They are two different economic categories.

Decision making processes in the economy should assume the logical and rational nature of decision-makers (managers), and the decisions taken should best serve the interests of the organisation. hen facing a situation that requires a decision, the manager should therefore:

- obtain complete and perfect information,
- eliminate any doubts,
- evaluate everything rationally and logically, and finally make a decision that serves the best interests of the organisation (in the case of the cadastral tax it is the state or a local government).

In the context of mass appraisals, it is pre-supposed that we have incomplete information. Such assumption, however, seems reasonable and logical because limited information reduces the costs of the (mass) appraisal itself. The estimated result of particular real estate valuations will usually differ from the actual market value of properties, but from the point of view of the central or local government policy, it will be neutral, because it is highly probable that the number of overvaluations will be balanced by the number of undervaluations, and the final effect (here: the fiscal one) will be similar [Hozer, Kokot, Kuźmiński 2002].

The asymmetry of information in mass appraisal may cause a plenty of other problems, the most important of which is the conflict between the parties.

Herbert A. Simon was one of the first to note that decisions are not always made according to the principles of rationality and logic [Simon 1983]. In practice, when in the decision-making situation managers:

- use incomplete and imperfect information,

- are limited in their rationality (e.g. because they can acquire and process information),
- tend to be satisfied with the first acceptable solution, and finally make decisions that may or may not serve the interests of the organisation. The quality of their decisions clearly depends on the available information.

Thus, in practice, we are dealing with incomplete and unreliable information, as well as with decision-making in the conditions of conflict between the parties involved. The conflict of the parties in the case of mass appraisal may consist in e.g. the taxpayer's feeling an unfair fiscal burden (cadastral tax is an ad valorem tax, i.e. the higher the value of a property, the higher the amount of tax). The inability to build a building or a structure (e.g. due to unfavourable water and ground conditions) will result in the investor's disapproval of tax amount, if the mass appraisal process has not included in calculations this particular defect of the property in question. This will in all probability result in an appeal by the taxpayer against the decision to charge the mandatory duty. At first glance, the problem seems to be rather minor, but in practice it may paralyse the whole process of a asessing the tax rates, thus causing immense losses for the organisation (the state, a local government). If we assume that the cadastral value is not the same as the market value of a property (as it has already been highlighted by real estate valuation methodologists), almost every administrative decision in this respect may be challenged or appealed by taxpayers. In 2018 in Warsaw, during an international conference „European Valuation Standards and Statistical Valuation Methods - are they legal?" held by the European Group of Valuers' Associations (TEGoVA) and the Polish Federation of Valuers' Associations, Ewa Kucharska-Stasiak (professor at the University of Łódź, PFVA) observed that the subject of discussion should be neither the technical feasibility of using statistical methods in valuation nor the concern to enhance demand for valuers' services, but the answer to two questions: does the property value determined with statistical methods correctly represent the concept of market value and is the result of the estimation carried out by statistical methods understandable for the client. The answers to both questions were negative.

The algorithm-based methods of property valuation, the results of which do not allow for determining the market value of a property, should be applied only in specific cases. In all other situations when it is necessary to use market value, traditional methods of individual valuation should be used. When the legislators supplement the Act with the definition of a different type of property value, i.e. the cadastral value, the valuers will be able to apply mass appraisal methods.

A good field to apply mass appraisal are valuations for the purpose of revaluing real estate portfolio, e.g. by banks or investment funds. No direct contact between bank and borrower, fund and investor takes place here, and discrepancies in values for individual properties are of little importance for the entire portfolio. Another application of mass appraisal is to estimate the economic effects of adopting or

changing local spatial development plans. The tools and methods of mathematical and statistical modelling are very useful in the real estate market analysis, i.e. at the stage of preliminary property valuation performed in an individualised manner.

LITERATURE REVIEW

In the literature the issue of mass appraisal is often discussed. What is considered are groups of methods rather than individual approaches. Attempts at systematisation can be found e.g. in: [Kauko, d'Amato (Ed.) 2008; Doszyń 2011; Kuźmiński 2004; Hozer 2001; Kokot 2004; Kuryj 2007; Pawlukowicz 2001; Prystupa 2000; Telega et al. 2002]. Most commonly used division distinguishes three groups of methods based on:

1. econometric models of multiple regression and their derivatives,
2. neural networks,
3. Automated Valuation Models (AVM).

Attempts to apply econometric regression models have so far been the most frequently explored, but the results of modelling have not always been satisfactory [Gdakowicz, Putek-Szeląg 2018; Wyatt 1996]. That was mainly due to:

1. unmeasurability of explanatory variables,
2. collinearity of explanatory variables.

Reservations also concerned the occurrence of catalysis and coincidence of attributes, as well as poor fit of models, which strongly limited their practical use, [e.g. Sztaudynger 2003; Dacko 2000; Dacko 2001; Źróbek 2000; Lipieta 2000]. Another reason for the lack of applicability of the models were heterogeneous data. Some of the models used in the simulation also produced negative results [Czaja 1998]. The valuations obtained with the use of neural networks often gave satisfactory results [Lis 2001; Wiśniewski 1998], however, the correlations between variables were not clear.

The automated pricing models (AVMs) have been used in the United States since the early 1980s and in Europe since the 1990s. However, it was not until the 21st century that satisfactory results were achieved with automatic valuation models [Waller 1999] that were initially used to determine the value of individual properties. There are many examples of successful AVM implementations. The paper [Francke 2008] presents a hierarchical time series model of house valuation, called the hierarchical trend model. In the Netherlands, this model has been successfully applied to the valuation of about one million houses for property tax purposes. Property values obtained by means of AVMs find use for other legal purposes, such as water and agricultural taxes or income taxes collected by the Dutch central government.

The paper [Figurska 2017] documents the functioning of over twenty commercial solutions applied in the USA, Australia, Canada, Germany, Great Britain, Switzerland, the Netherlands and Sweden. In many other countries, AVMs are at

different stages of development. Success in the implementation of algorithms, however, largely depends on the quality of the data that can be obtained. According to the American standard on AVM [Standard on Automated Valuation Models – AVMs Approved 2003; revised approved 2018]:

1. Transactional data should be sufficient to produce reasonable valuation models. The number of sales should be at least five times (fifteen times is desirable) the number of independent variables explaining the price volatility.
2. Sales transactions should be valid transactions that reflect the market value of a property under valuation.
3. Data should be consistent across the whole population of the properties to be valued.
4. The data on the attributes of properties should be as accurate as possible for use in the model and its application to the property population.
5. Sales data and property attributes should be representative of the underlying population or the subset of properties that may be subject to valuation using the AVM.

METHODOLOGY

The proposal to solve the problem of information asymmetry, as well as of incomplete and unreliable information in the mass appraisal, is a theory based on econometric analysis of relationships and the study of the effect of unmeasurable variables

In the econometric analysis, when using a model to examine the relationships:

$$X_{1t} = f(X_{2t}, X_{3t}, \ldots, X_{kt}, U_t),$$

we can measure, e.g.:

1. the states of variables X_{it},
2. the changes in the states, i.e. $\Delta X_{it} = X_{it} - X_{it-1}$,
3. the effects of variables X_{2t}, X_{3t}, …, X_{kt} na X_{1t} (structural parameters),
4. the outcome of the effects of variables X_{it} , i.e. $X_{1t}(X_{it})$; $i = 2, 3, \ldots, k$.

It appears that even when it is not possible to examine the processes listed in points 1 to 3, we still can examine the effects of non-measurable explanatory variables (attributes) on the explanatory variable [Hozer 2003].

When analysing the real estate market, it becomes clear that the attribute strongly influencing the value of a property is its location. A residential property located in an attractive, fashionable neighbourhood will be valued higher than a similar property[2] located in an unattractive area, far from the city centre. Location is

[2] Similar property means that it is a property with attributes on a similar level, of similar size, finishing standard, technical condition, etc.

a qualitative feature. Experts try to quantify this attribute by describing it as desirable, average or undesirable. But even such a definition of an attribute is very subjective - the state of the location determined for a given property depends on the personal emotion of a person describing the property. So, it is hard examine the effect of a qualitative variable (location) on the value of a property. In the first stage of the study, variables that significantly affect the value of a property were specified. From the collection of variables, these attributes should be selected that have the strongest effect on the value of a property and at the same time there is the possibility to collect them (e.g. size, transport accessibility, neighbourhood, development, utilities, water and ground conditions). It is often impossible to meet both of these conditions, because the question arises how to measure, for example, fashion which undoubtedly affects the value of a property? In the Szczecin land property mass appraisal algorithm (SAMWN) presented below, both deliberate human activity and non-measurable factors are taken into account in the form of market value coefficients (*WWR*) that eliminate the effect of information assymetry:

$$\widehat{W}_{ji} = WWR_j \cdot pow_i \cdot W_{baz} \cdot \prod_{k=1}^{K}(1 + A_k), \tag{1}$$

where:

$\widehat{W}_{ji}$ – market (or cadastral) value of the *i*–th property in the *j*–th elementary area,
WWR_j – market value coefficient in the *j*–th elementary area $(j = 1, 2, \dots, J)$,
J – number of elementary areas,
pow_i – size of the *i*–th property,
W_{baz} – price of 1 m^2 of the cheapest land in the valuated area,
A_k – effect of the *k*–th attribute $(k = 1, 2, \dots, K)$,
K – number of attributes.

Coefficients WWR_j are computed for individual elementary areas[3] as an arithmetical mean of WWR_i (formula 2) computed for individual properties-representatives from each of the elementary areas. These, in turn, are the quotient of the market value of the property (formula 3) determined by the property valuer[4] (in the process of individual valuation) and the hypothetical value of the property determined on the basis of formula 4.

$$WWR_j = \frac{\sum_{i=1}^{l} WWR_i}{l}, \tag{2}$$

[3] Elementary area is defined as an area in which a certain number of valued properties are located that are characterised by the same effect of the location attribute on their value.

[4] Property valuers who estimated the value of the property in question included the location in the collection of attributes describing the property.

$$WWR_i = \frac{WR_{ri}}{\widehat{W}_{hi}}, \tag{3}$$

$$\widehat{W}_{hi} = pow_i \cdot W_{baz} \cdot \prod_{k=1}^{K}(1 + A_k), \tag{4}$$

where:
WWR_i –ratio of the market value to the hypothetical value of the *i*-th property,
l – number of properties in the *j*-th elementary area,
WR_{ri} –market value of the *i*-th property, as determined by a property valuer,
$\widehat{W}_{hi}$ – hypothetical value of the property calculated on the basis of the model.

In the proposed SAMWN formula (formula 1) the problem is to determine the A_k coefficients measuring the effects of particular attributes (features) on the value of the property. Since the attributes are presented on a qualitative scale, two methods are employed to determine the effects of particular characteristics on the value of real estate: Spearman coefficients (R_{xy}) and standardised β_k coefficients. Beta coefficients are calculated according to the following formula β_k. Beta coefficients are calculated according to the following formula:

$$\hat{\beta}_k = \frac{S_{A_k}}{S_{WR_r}} \cdot \frac{(WR_{ri} - \overline{WR}_r)}{(A_k - \bar{A}_k)}, \tag{5}$$

where:
$\hat{\beta}_k$ – standardised beta coefficients of the *k*-th attribute,
S_{WR_r} – standard deviation of the value of 1 m^2 of land determined by a property valuer,
$\overline{WR}_r$ – average value of 1 m^2 of land calculated on the basis of values determined by a property valuer,
S_{A_k} – standard deviation of the effect of the *k*-th attribute,
$\bar{A}_k$ – average value of the effect of the *k*-th attribute.

Calibration of the attributes of land properties is carried out on the basis of a mathematical formula (correction coefficients ($1+A_k$) are determined according to the method of distance from extreme values) [Lis 2003]:

$$\begin{aligned} 1 + A_k = \left(1 - \frac{1}{2}\rho\right) + \left[\left(1 + \frac{1}{2}\rho\right) - \left(1 - \frac{1}{2}\rho\right)\right] \cdot \frac{l_{kp}}{k_p - 1} = \\ \left(1 - \frac{1}{2}\rho\right) + \rho\frac{l_{kp}}{k_p - 1}, \end{aligned} \tag{6}$$

where:
l_{kp} – the *p*-th category of the *k*–th attribute,
ρ – standardised coefficients of the *k*-th attribute, depending on the method adopted: Spearman coefficient R_{xy} or beta coefficient $\hat{\beta}_k$.

In order to be able to explain the value of the property in 100%, the values of the relevant Spearman coefficients and standardised beta coefficients are adjusted so that the sum of their absolute values is equal to 1.

In the next step of the study, the results of property estimation obtained through individual valuers' valuations are juxtaposed with the results of property value estimation made with SAMWN using:

1. adjusted Spearman coefficients,
2. beta coefficients.

The results obtained are compared using a relative valuation error. The relative error is calculated using the following formula:

$$\partial = \frac{\left|W_{ji} - WR_{ri}\right|}{W_{ji}} \cdot 100\%. \tag{7}$$

Additionally, the following variation measures are calculated

$$Se = \sqrt{\frac{\left(WR_{ri} - WR_{ji}\right)^2}{n}}, \tag{8}$$

$$Vs = \frac{Se}{\overline{WR_{r\iota}}} \cdot 100\%, \tag{9}$$

where:
Se – standard deviation of the value of 1 m^2 land,
Vs – variation coefficient of the value of 1 m^2 of land.

EMPIRICAL EXAMPLE

The study used data on 567 plots of land in Szczecin designated for housing purposes, which were the subject of individual valuation in 2005. The plots were located in 5 elementary areas (Table 1).

Table 1. Quantity of individual elementary areas covered by the study

Elementary area	Quantity
3	187
4	37
5	178
6	62
7	103
Total	567

Source: own study

Plots were described with the following collection of attributes:
y – value of 1 m^2 (in PLN) – a dependent variable;
x_1 – physical traits: 0 – undesirable, 1 – average, 2 – desirable;
x_2 – development: 0 – no, 1 – yes;

x_3 – utilities: 0 – no, 1 – partial, 2 – full;
x_4 – neighbourhood: 0 – undesirable, 1 – desirable;
x_5 – accessibility: 0 – poor, 1 – average, 2 – good;
x_6 – location: 0 – undesirable, 1 – average, 2 – desirable;
x_7 – size: 0 – large, 1 – medium, 2 – small,
x_8 – water and ground conditions: 0 – bad, 1 – undesirable, 2 – average, 3 – desirable.

Since the main purpose of the article is to present the method of calculating the effect of information asymmetry, when calculating the impact of unmeasurable variables or of measurable variables not included in the appraisal procedure on the property value, the location attribute was omitted in subsequent calculations. The value of this attribute was determined on the basis of a property valuer's opinion and it also contained an opinion on the popularity, or fashion, of the area in question. Spearman correlation coefficients and coefficients $\hat{\beta}_k$ between the value of 1 m^2 of a land property in Szczecin and individual attributes are shown in Table 2.

Table 2. Spearman correlation and $\hat{\beta}_k$ coefficients between value of 1 m^2 and individual attributes of land properties in Szczecin in 2005

Coefficients	x_1	x_2	x_3	x_4	x_5	x_7	x_8
R_{xy}	-0.063	**0.282**	**0.343**	-0.074	**0.175**	-0.081	**0.187**
Adjusted R_{yx}		**0.286**	**0.347**		**0.177**		**0.190**
$\hat{\beta}_k$	0.039	**0.106**	**0.158**	-0.049	**0.092**	**-0.155**	**0.389**
Adjusted $\hat{\beta}_k$		**0.118**	**0.176**		**0.102**	**-0.172**	**0.433**

x_1 – physical traits, x_2 – development, x_3 – utilities, x_4 – neighbourhood, x_5 – accessibility, x_7 – size, x_8 – water and ground conditions.
Relevant coefficients at significance level of 0.05 are in bold.

Source: own study

When determining the impact of attributes using the adjusted Spearman coefficients, the following variables proved to be insignificant: physical traits, neighbourhood and size. When using the standardised beta coefficient, the following attributes also proved to be insignificant: physical traits and neighbourhood. The value of the property was most strongly influenced by utilities (according to the Spearman coefficient). In the case of beta coefficients, the highest correlation was observed between the value of the property and water and ground conditions. All coefficients were characterized by low values. The lines in which the corrected Spearman and beta coefficients are presented were calculated by adjusting the significant values of the coefficients of individual attributes, so that their sum was equal to 1. Only the attributes significantly affecting the value of the property were taken into account.

Table 3 shows the calculation of the effect of each attribute state on the property value.

Table 3. Calculation of values of land property attributes

Attribute	Attribute alternative	Adjusted R_{xy}	$1+A_k$	A_k %	Adjusted $\hat{\beta}_k$	$1+A_k$	A_k %
Development	0	0.286	0.8571	-14.29	0.118	0.9410	-5.9
	1		1.1429	14.29		1.0000	0
Utilities	0	0.347	0.8265	-17.35	0.176	0.9121	-8.79
	1		1.0000	0		1.0000	0
	2		1.1735	17.35		1.0879	8.79
Accessibility	0	0.177	0.9114	-8.86	0.102	0.9492	-5.08
	1		1.0000	0		1.0000	0
	2		1.0886	8.86		1.0508	5.08
Size	0	-	-	-	-0.172	1.0860	8.6
	1		-	-		1.0000	0
	2		-	-		0.9140	-8.6
Water and ground conditions	0	0.190	0.9051	-9.49	0.433	0.7837	-21.63
	1		0.9684	-3.16		0.9279	-7.21
	2		1.0316	3.16		1.0721	7.21
	3		1.0949	9.49		1.2163	21.63

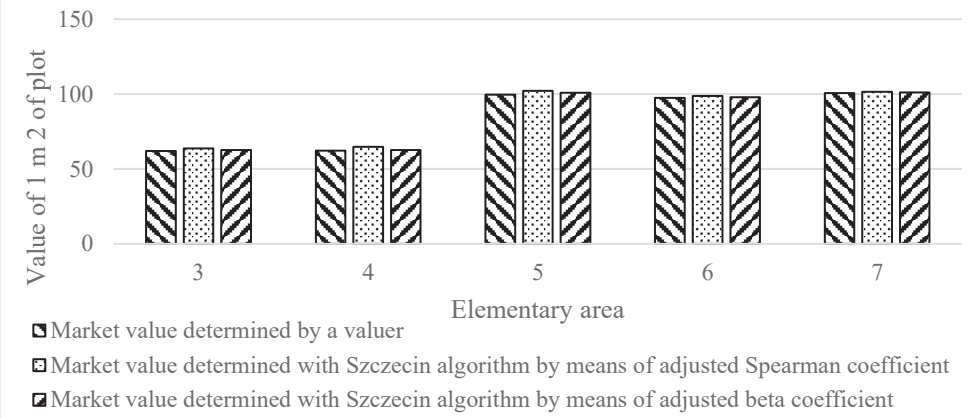
Source: own calculations

The power of the attributes' effect on the value of a property varies depending on the applied coefficient. When we use the adjusted Spearman coefficient, it is the utilities that have the strongest effect on the value of 1 m^2 of land. Plots equipped with all the required utilities are on average 34.7% more expensive than non-equipped plots. The next most important feature is development. The weakest effect on the value of the property is exerted by water and ground conditions and accessibility.

On the other hand, when applying the adjusted coefficient $\hat{\beta}_k$ the most significant variable was water and ground conditions. A plot of land with favourable water and ground conditions was on average 43.3% more expensive than a plot with poor water and ground conditions. The remaining attributes influencing the value of the plot are: utilities, development and accessibility. In the case of the second method (beta coefficients), the size also proved to be an vital attribute influencing the dependent variable, however, what is questionable is the sign of the correlation - the smaller the plot, the lower the value of 1 m^2 (1 m^2 of a small plot was 17.2% lower than 1 m^2 of a large plot). In economic practice we observe a positive rather than negative correlation on the real estate market - the smaller the plot, the higher the value (price) of 1 m^2 [Foryś, Gdakowicz 2004]. The

negative sign of the coefficient may indicate that in the analysed sample small plots of land belonged to natural persons (and the value of the plot was lower), while the sellers of large plots were institutionalised entities, and the value of these properties was higher.

Figure 1. Summary of the average value of 1 m^2 of land estimated by property valuers and calculated using SAMWN with the application of adjusted Spearman coefficients and standardised beta coefficient in individual elementary areas



Source: own calculations

The average value of 1 m^2 of land estimated both by property valuers and using Szczecin mass appraisal algorithm (with the use of both approaches) stood at a comparable level, in each of the elementary areas. According to property valuers, popular and attractive plots (i.e. worth more) were located in elementary areas marked with numbers 5, 6 and 7 - the value of 1 m^2 of the plot was about PLN 100. The application of the Szczecin algorithm of mass appraisal of real estate confirmed the results obtained through individual valuations - plots located in areas 5, 6 and 7 were valued higher than plots located in areas 3 and 4. The application of the SAMWN calculation algorithm and the estimation of WWR_j values for particular elementary areas made it possible to include in calculation the effect of the plot location (fashion) although that variable was not one of the *a priori* attributes.

Table 4 presents values of market value coefficients (WWR_j) estimated for particular elementary areas by means of SAMWN. The results obtained using the algorithm (in both variants: using the adjusted Spearman and beta coefficients) are compared with the values estimated by property valuers. The consecutive columns present measures of agreement between the obtained results, such as the residual deviation, coefficient of variation and relative valuation error.

Table 4. Coefficients of market values for particular elementary areas and measures of agreement between SAMWN results and valuers' valuations

Elementary area	Adjusted R_{xy}				Adjusted $\hat{\beta}_k$			
	WWR_j	Se	Vs	∂	WWR_j	Se	Vs	∂
3	0.978	8.377	13.50	13.03	0.983	4.643	7.48	6.05
4	0.987	10.525	16.89	16.96	0.973	3.507	5.63	4.54
5	1.546	13.736	13.79	13.13	1.575	9.226	9.26	6.73
6	1.537	9.641	9.91	7.73	1.431	5.978	6.15	4.33
7	1.449	7.663	7.61	6.12	1.546	5.432	5.40	4.45

Source: own calculations

Notably, the obtained results are similar to those acquired by means of other approaches with regard to all the elementary areas under consideration. On the other hand, the lower both relative and absolute variations in *WWR* estimation justifies the choice of a measure based on the adjusted $\hat{\beta}_k$.

For instance, the coefficient of the market value in the 5. elementary area (for the Spearman coefficients) is 1.546, which means that the value of land in this area as calculated with the use of the SAMWN was on average 54.6% higher than the value of land located in a less attractive elementary area. On the other hand, the coefficient of market value in the 5. elementary area at 1.575 means that the value of land in this area calculated with the SAMWN using the $\hat{\beta}_k$ coefficient was on average 57.5% more expensive than the value of land located in the less fashionable elementary area. When the SAMWN (the adjusted Spearman coefficient) was applied, the value of a plot of land in the 3. elementary area differed on average from the value estimated by the property valuer by +/- PLN 8.38 per 1 m^2, which constituted 13.5% of the average value of land determined by the valuer. However, when applying the adjusted $\hat{\beta}_k$ coefficient for the same elementary area, the value of 1 m^2 of land valued by the valuer differed on average by +/- PLN 4.64 per 1 m^2, which represented 7.48% of the average value of land determined by the valuer.

In all elementary areas the results were characterised by lower values of stochastic structure parameters

CONCLUSION

The problem of asymmetry of information in real estate valuation and the way how the impact of non-measurable variables on the explained variable and the impact of variables omitted in the valuation procedure are approached is particularly close to people professionally dealing with the real estate market analysis, especially to those operating in the fields where hundreds, or even thousands of properties are subject to valuation. Many attributes that influence the value and price of real estate are non-measurable, for example: fashion, attractiveness or popularity. Many properties have their individual, sparse attributes or the ones that are indigenous to

a specific area. The paper proposes a procedure of estimating the value of real estate in a mass appraisal, in which one of the above instances takes place. The attribute related to location and fashion is not included *a priori*.

The juxtaposition of the value of real estate estimated with the use of SAMWN and obtained on the basis of individual valuers' appraisals gave similar results. The construction of the algorithm allows - through estimating the WWR_j - to take into account the effect of non-measurable attributes on the value of the property. In the proposed two methods of determining the influence of attributes on the property value, better results were obtained when adjusted beta coefficients were applied.

The proposed procedure for estimating the property value takes on particular importance in the context of mass appraisal of real estate and the method of statistical market analysis. In both cases, the legislator has not defined a detailed procedure, leaving a large margin of discretion to property valuers. The presented research may be an important voice in the debate on the use of econometric and statistical methods in the process of real estate valuation.

Real estate valuation is a process subject to legal regulations. A property valuer is obliged to choose an appropriate approach, method and technique of valuation depending on the purpose of valuation. Within each method and technique, procedures have been agreed to ensure a uniform manner of valuation, taking into consideration the attributes strongly influencing the value of a property. The least regulated method is the statistical analysis of the market. Since algorithms that can be used in this method often require a large set of observations (algorithms are often statistical-econometric tools), they can be applied in the mass appraisal. The application of *WWR*s improves the quality of valuations when information available is incomplete (asymmetry of information between the parties).

The paper proposes a procedure that is conducive to solving the problem, as well as it shows how to include in the process of property valuation the valuation the imperfections in the knowledge about attributes influencing its value, and not known to one party of the procedure. For this purpose we used Szczecin's algorithm of mass property valuation (SAMWN), thus proposing two ways to determine the impact of attributes on the value of real estate: Spearman coefficient and beta factors. The results were compared with the results obtained in the process of individual property valuation performed by property valuers.

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APPLICATION OF THE LINEAR ORDERING METHODS TO ANALYSIS OF THE AGRICULTURAL MARKET IN POLAND

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Abstract: The agricultural market is an integral component of the entire market, and its aim is the production of food and essential raw materials. The subject of research was the analysis of the agricultural market in Poland. For this purpose, several rankings for each year were developed using selected methods of linear ordering. To choose the best one ranking, the method of rankings comparison was applied. This allowed to present changes that took place during analyzed years in Poland.

Keywords: agricultural market, methods of linear ordering, ranking, synthetic variables

JEL classification: C44, C61

INTRODUCTION

The agricultural market, in a broad sense, is all exchange relations between producers, sellers and buyers. It is an integral part of the entire market, and its economic situation is highly dependent on the overall condition of the economy.

The agricultural market, like other markets, is governed by identical economic laws [Chabiera et al. 1988]. One of the many factors affecting the volume of production and the price level is the weather. In the low season, there is a noticeable increase in prices, especially in the vegetable and fruit market. Also

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during the season, prices may be high due to adverse weather conditions (drought, frost, floods). The prices of products on which this market depends, e.g. prices of feed or fertilizers, also play an important role. Due to the short-lived products of this market, it is required to create the right infrastructure for storage to extend their freshness. It is important to provide the right means of transport as well as to adjust the transport time. Otherwise, additional costs are generated.

Agriculture in Poland is very fragmented because there are many small farms. Over half (in 2016 - 53.9%, in 2010 - 54.1%) has an area of up to 5 ha, which means that these farms use traditional methods that do not require high fertilization and consumption of plant protection products, as well as feed industrial in animal feed. The percentage of large-scale farms over 50 ha increases from year to year, the largest of which is in the WP Province. According to the data from the National Agricultural Census conducted in 2010, more than 50% of Polish farms mainly produce to meet their own needs. As a result, they reduce food expenses and family maintenance costs.

The subject of the research was an attempt to analyze the regional diversity of agricultural development in Poland in terms of selected characteristics in the period from 2006 to 2016. To this end, the linear ordering method of a set of objects based on a synthetic variable was used to describe the studied phenomenon. A synthetic measure allowed to organize individual provinces by the level of agricultural market development. The condition of Polish agriculture is a frequent topic of reflection among many authors [Binderman 2005a,b, 2006a,b, 2007, 2008, 2009, 2013; Kukuła 2014; Majchrzak, Wysocki 2007; Ossowska, Janiszewska 2013; Kisielińska 2016].

In the article for the name of the province replaced by following codes: DŚ-Lower Silesia Province, KP-Kujawy-Pomerania Province, LB-Lublin Province, LS-Lubusz Province, ŁD-Łódź Province, MP-Małopolska Province, MZ-Mazovia Province, OP-Opole Province, PK-Podkarpacie Province, PL-Podlasie Province, PM-Pomerania Province, ŚL-Silesia Province, ŚK-Świętokrzyskie Province, WM-Warmia-Masuria Province, WP-Wielkopolska Province, ZP- West Pomerania Province.

EMPIRICAL DATA

The analysis was conducted on the basis of data from the Statistical Yearbooks of Agriculture issued by the Central Statistical Office of Poland (CSO) for 2006, 2009, 2013 and 2016. The applied methods of linear ordering were selected based on the following literature items: [Hellwig 1968; Nowak 1977, Strahl 1978; Hwang, Yoon 1981; Kukuła 1986, 2000, 2012]. The study assumes that each diagnostic variable brings the same amount of information to evaluate the objects tested [Kukuła, Luty 2015]. Diagnostic variables adopted for analysis are as follows:

X_1 - income of budgets of local government units due to agricultural tax [PLN million],
X_2 - share of certified organic farms in total utilized agricultural area [%],
X_3 - consumption of mineral or chemical fertilizers calculated on the pure component and per 1 ha of agricultural land [kg],
X_4 - purchase value of agricultural products per 1 ha of arable land (current prices) [PLN],
X_5 - persons employed in agriculture per 1 ha of agricultural land [os],
X_6 - share of arable land in the administrative area of the province [%].
All variables were classified into the stimulant set. The values of numerical characteristics of diagnostic variables are presented in Table 1.

Table 1. Selected characteristics of adopted diagnostic variables

	X_1	X_2	X_3	X_4	X_5	X_6
	2006					
Mean	50.58	0.51	121.31	1825.63	13.11	50.07
Median	46.6	0.33	114.55	1750	12	50.02
Minimum	19.3	0.04	61.3	798	4	35.86
Maximum	90.1	1.19	182.3	3269	26.2	61.10
Standard deviation	19.94	0.40	31.16	598.69	6.65	7.78
Skewness	0.64	0.60	0.33	0.69	0.56	-0.29
	2009					
Mean	77.41	1.47	117.38	2174.19	12.92	50.42
Median	72.75	1.20	120.25	2294	11.5	49.82
Minimum	35.1	0.25	55.4	900	4.1	36.24
Maximum	121.6	4.76	186.8	3738	26.2	63.18
Standard deviation	25.63	1.12	36.48	648.90	6.61	8.79
Skewness	0.25	1.64	0.24	0.36	0.61	-0.14
	2013					
Mean	104.06	3.62	135.53	3663.19	17.74	45.37
Median	96	2.64	135.2	3608	11.75	44.46
Minimum	48	0.49	68.2	1508	5.2	29.16
Maximum	155.9	11.77	223.5	6103	48.5	58.61
Standard deviation	34.60	3.02	41.16	1154.13	12.75	9.89
Skewness	0.11	1.57	0.24	0.16	1.40	-0.18
	2016					
Mean	94.59	3.12	127.56	3644.63	17.83	45.03
Median	84.11	1.96	127.45	3614.5	11.7	43.75
Minimum	40.71	0.46	70.2	1591	5.2	28.59
Maximum	154.17	9.56	203.2	6367	48.4	57.35
Standard deviation	34.71	2.83	35.67	1217.03	12.71	9.87
Skewness	0.35	1.46	0.41	0.47	1.37	-0.22

Source: own elaboration

METHODS

The linear ordering is based on the creation of a ranking of compared objects, i.e. this is based on juxtaposition of the objects from the best one to the worst one in the analyzed research context (Kaczmarczyk 2018). Variables to be ordered should be measured on an interval scale. When they are measured on a range or quotient scale, they need to be normalized).

Four linear ordering procedures were selected to determine the synthetic variable (Table 2). Lebles in Table 2: Q_i - synthetic variable value, Z_{ij} - normalized value of the j-th variable for the i-th object.

Table 2. Selected methods of linear ordering

Method	Formula
Hellwig	$Q_i = 1 - \frac{d_i^+}{d_0}$, $d_i^+ = \sqrt{\sum_{j=1}^{m}(z_{ij} - z_j^+)^2}$, $z_j^+ := \max_i \{ z_{ij} \}$, $d_0 = \bar{d} + 2S_d$, $d = [d_1^+ \quad d_2^+ \quad \ldots \quad d_n^+]$
TOPSIS	$Q_i = \frac{d_i^-}{d_i^- + d_i^+}$, $d_i^+ = \sqrt{\sum_{j=1}^{m}(z_{ij} - z_j^+)^2}$, $d_i^- = \sqrt{\sum_{j=1}^{m}(z_{ij} - z_j^-)^2}$, $z_j^+ := \max_i \{ z_{ij} \}$, $z_j^- := \min_i \{ z_{ij} \}$
Median ordering	$Q_i = 1 - \frac{d_i^+}{d_0}$, $d_i^+ = med_j \left\| z_{ij} - z_j^+ \right\|$, $z_j^+ := \max_i \{ z_{ij} \}$, $d_0 = med_i(d) + 2{,}5 mad(d)$, $mad(d) = med_i \left\| d_i - med_i(d) \right\|$, $d = [d_1^+ \quad d_2^+ \quad \ldots \quad d_n^+]$
Non-pattern	$Q_i = \frac{1}{m}\sum_{j=1}^{m} z_{ij}$	m - number of diagnostic variables

Source: own study based on [Kukuła, Luty 2015]

Each procedure requires diagnostic variables to be normalized. The main purpose of normalization is to reduce the examined features to a similar order of magnitude. It consists in the unification of their measuring units, as well as constructing a constant range of variability. Table 3 presents the most commonly used standardization formulas.

If multiple rankings have been created using different sorting methods, select the one that is most similar to the others. For this purpose, one can use the method of comparing rankings proposed by Karol Kukuła [Kukuła 1986]. To determine the ranking that is most similar to the others, select the one for which this measure is the largest. Comparison of selected rankings allows you to evaluate changes in the object that occur at a given time. This method is the basis for the preparation and

interpretation of the ranking of the examined objects [Kukuła, Luty 2015] and is determined as follows:

$$\bar{u}_p = \frac{1}{v-1} \sum_{\substack{q=1 \\ q \neq p}}^{v} m_{pq}, \text{ p, q =1, 2, …, v,} \quad (1)$$

where:
v – number of rankings;

$$m_{pq} = 1 - \frac{2 \sum_{i=1}^{n} |c_{ip} - c_{iq}|}{n^2 - z}; \quad (2)$$

such that:
c_{ip} – position of the i-th object in the ranking with the number p;
c_{iq} – position of the i-th object in the ranking with the number q;

$$z = \begin{cases} 0, & n \in P \\ 1, & n \notin P \end{cases}$$, where P – set of even natural numbers.

Labels to the Table 3: x_{ij} - value of the *j-th* variable, z_{ij} - normalized value of the *j-th* variable for the *i-th* object; $\bar{x}_j, S_j$ is the arithmetic mean and standard deviation of the *j-th* variable, respectively; θ_{0j} - value of the *j-th* coordinate of Weber's median for the feature system; $\tilde{mad}(X_j) = \underset{i}{med} \left| x_{ij} - \theta_{0j} \right|$.

Table 3. Selected normalization formula

Method	Normalizing formula
standardization	$z_{ij} = \frac{x_{ij} - \bar{x}_j}{S_j}, \quad S_j \neq 0$
unitarization	$z_{ij} = \frac{x_{ij} - \min\limits_i x_{ij}}{\max\limits_i x_{ij} - \min\limits_i x_{ij}}, \quad \max\limits_i x_{ij} \neq \min\limits_i x_{ij}$
ratio transformation	$z_{ij} = \frac{x_{ij}}{\bar{x}_j}$
Strahl transformation	$z_{ij} = \frac{x_{ij}}{\max\limits_i x_{ij}}, \quad \max\limits_i x_{ij} \neq 0$
positional standardization	$z_{ij} = \frac{x_{ij} - \theta_{0j}}{1{,}4826 \tilde{mad}(X_j)}, \quad \tilde{mad}(X_j) \neq 0$

Source: own elaboration on the basis of [Perkal 1953; Wesołowski 1975; Kukuła 2000; Strahl 1978; Lira et al. 2002]

RESEARCH RESULTS

The following methods of linear ordering were used for multivariate analysis:

- Method non-based on the pattern of development using unitarization (R1);
- Method non-based on the pattern of development using Strahl transformation (R2);

- Method non-based on the pattern of development using ratio transformation (R3);
- Hellwig method using standarization (R4);
- TOPSIS method using ratio transformation (R5);
- Median ordering using standardization (R6);
- Non-based on the pattern of development using standardization (R7).

In each of the surveyed years, the positions of the voivodehips occupied in individual rankings may differ. In order to select the ranking which will be the most similar to all others, a method proposed by Karol Kukuła and Lidia Luty (2015) was used.

$$M_{2006} = [m_{pq}]_{p,q=1,2,\ldots,7} = \begin{bmatrix} 1 & 0.875 & 0.703 & 0.844 & 0.594 & 0.781 & 0.938 \\ & 1 & 0.828 & 0.766 & 0.719 & 0.781 & 0.828 \\ & & 1 & 0.609 & 0.891 & 0.625 & 0.672 \\ & & & 1 & 0.500 & 0.813 & 0.859 \\ & & & & 1 & 0.516 & 0.563 \\ & & & & & 1 & 0.781 \\ & & & & & & 1 \end{bmatrix}$$

$$M_{2009} = [m_{pq}]_{p,q=1,2,\ldots,7} = \begin{bmatrix} 1 & 0.922 & 0.656 & 0.766 & 0.406 & 0.672 & 0.969 \\ & 1 & 0.719 & 0.781 & 0.469 & 0.719 & 0.938 \\ & & 1 & 0.625 & 0.750 & 0.703 & 0.672 \\ & & & 1 & 0.422 & 0.703 & 0.797 \\ & & & & 1 & 0.531 & 0.422 \\ & & & & & 1 & 0.672 \\ & & & & & & 1 \end{bmatrix}$$

$$M_{2013} = [m_{pq}]_{p,q=1,2,\ldots,7} = \begin{bmatrix} 1 & 0.813 & 0.484 & 0.859 & 0.281 & 0.703 & 0.953 \\ & 1 & 0.641 & 0.766 & 0.422 & 0.594 & 0.828 \\ & & 1 & 0.500 & 0.766 & 0.359 & 0.516 \\ & & & 1 & 0.281 & 0.719 & 0.859 \\ & & & & 1 & 0.266 & 0.313 \\ & & & & & 1 & 0.719 \\ & & & & & & 1 \end{bmatrix}$$

$$M_{2016} = [m_{pq}]_{p,q=1,2,\ldots,7} = \begin{bmatrix} 1 & 0.344 & 0.547 & 0.828 & 0.328 & 0.703 & 0.938 \\ & 1 & 0.531 & 0.266 & 0.578 & 0.266 & 0.313 \\ & & 1 & 0.453 & 0.750 & 0.547 & 0.500 \\ & & & 1 & 0.266 & 0.766 & 0.891 \\ & & & & 1 & 0.375 & 0.313 \\ & & & & & 1 & 0.719 \\ & & & & & & 1 \end{bmatrix}$$

Based on the data presented, it can be concluded that the pair of rankings R7 and R1 have the highest e m_{pq} value n individual years. To choose the best ranking, it should be compared the values of the $\bar{u}_p$ measure. The values for each surveyed year are presented in Table 4.

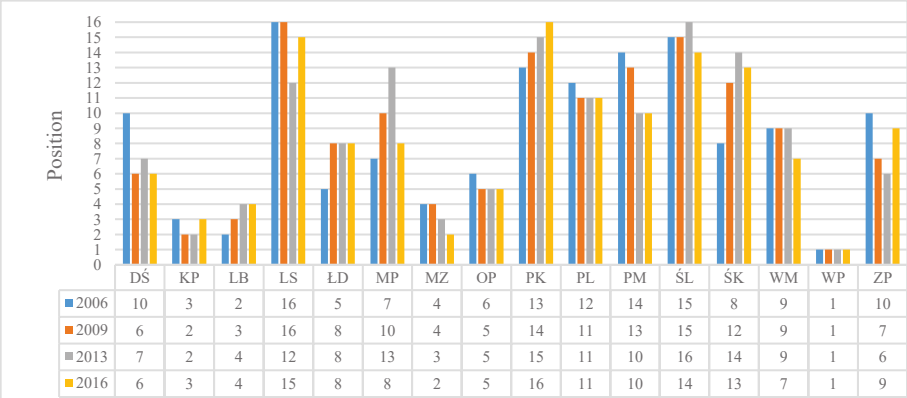
Table 4. Measures of similarity of the rankings selected for survey in the years 2006, 2009, 2013, 2016

	$\bar{u}_p$ for given ranking						
	R1	R2	R3	R4	R5	R6	R7
2006	0.789	0.799	0.721	0.732	0.630	0.716	0.773
2009	0.732	0.758	0.688	0.682	0.500	0.667	0.745
2013	0.682	0.677	0.544	0.664	0.388	0.560	0.698
2016	0.615	0.383	0.555	0.578	0.435	0.563	0.612

Source: own elaboration

After sorting the rankings by decreasing measure$\bar{u}_p$, it is noticeable that their positions are slightly different. The least similar to the others is R5 created by the TOPSIS method, which in 2006, 2009, 2013 was in last place and in 2016 in sixth. The seventh place in 2016 was taken by the R2 ranking, which in 2006 and 2009 came first and in 2013 third. Since R1 and R7 were the most similar in the M matrix in the studied years, their positions should be considered by measure $\bar{u}_p$. In 2006, R1 came in second, with R7 in third. In 2009, R7 was in second place and R1 in third. In 2013, R7 took first place, while R1 came second, but in 2016 their positions reversed and R7 was in second place, and R1 in first place. It should be noted that the rankings obtained differ significantly from each other, most of the similarity measures are roughly 0.7, but there are also values below 0.4 (for R2 in 2016 and for R5 in 2013). To compare all the analyzed years with each other, one method of ranking should be chosen. Based on the available data, the R7 ranking was selected.

Figure 1. Positions of provinces obtained by the R7 method in the analyzed years



	DŚ	KP	LB	LS	ŁD	MP	MZ	OP	PK	PL	PM	ŚL	ŚK	WM	WP	ZP
2006	10	3	2	16	5	7	4	6	13	12	14	15	8	9	1	10
2009	6	2	3	16	8	10	4	5	14	11	13	15	12	9	1	7
2013	7	2	4	12	8	13	3	5	15	11	10	16	14	9	1	6
2016	6	3	4	15	8	8	2	5	16	11	10	14	13	7	1	9

Source: own elaboration

The WP Province occupies the first position in all the surveyed years, so it is the leader on the agricultural market among other provinces. In this area, only the share of arable land in its administrative area decreases slightly, and the values of other variables used in the study are systematically increasing. Positive changes are

also taking place in MZ Province, because in 2006 and 2009 it was in fourth place mainly due to the small number of organic farms, the number of which began to increase in subsequent years, which is why its position began to grow, and in 2013 it took the third, and in 2016 the second place. The provinces with high agricultural potential also include KP Province, which took second or third place in the analyzed period.

Positive changes in agriculture can be seen in the OP Province, which in 2006 was in sixth place, and in the following years it is invariably in the fifth position. Its low position was caused by the lowest area of organic farms in relation to the total area of arable land among all provinces, but in subsequent years their area increased, as did the values of other variables. WM Province was in ninth place for the years 2006, 2009 and 2013, while its position in 2016 increased by 2 and is now 7th, which shows that changes in this area favorable for agriculture occur due to, among others an increase in the share of the area of organic farms and an increase in the purchase value of agricultural products. The group of provinces in which fruitful agricultural market development processes take place also includes the PL Province, which occupies the twelfth place in 2006, and in the eleventh in the following years, which shows, for example, an increase in local government budget income from agricultural taxes, as well as an increase in the share of certified farms ecological, and PM Province, where there was a significant increase from the fourteenth in 2006, through the thirteenth in 2009, tenth in 2013 and 2016.

A significant deterioration in the agricultural market, as compared to other provinces, occurred in ŁD Province and PK Province. In 2006, ŁD Province took the fifth position, while in subsequent years it was consistently in eighth place. This was caused by a decrease of 8.3 percentage points in the share of arable land in its administrative area, comparing the years 2006 and 2016. A much larger decrease in the value of this variable occurred in the PK Province, whose position fell in each analyzed year. In 2006 it was on the thirteenth place, in 2009 on the fourteenth, in 2013 on the fifteenth, and in 2016 it reached the sixteenth. Adverse changes in agriculture occurred in the MP Province, which from the seventh position in 2006 fell to the tenth in 2009, and then to the thirteenth in 2013.

Comparing Polish provinces, it can be noticed that in some of them there are very fast changes, which increase their position in the ranking. In others - the values of the studied variables are close to each other during these years, so they can remain in a similar position, but most often they drop by a significant number of places.

CONCLUSION

Agriculture is one of the basic sectors of the economy, which main task is to provide food, as well as the necessary raw materials (e.g. vegetable and animal fiber). It includes animal husbandry and plant production. Other types of industry are associated with it, which produce means of production for it (artificial fertilizers, agricultural machinery). The agricultural market began to develop more dynamically with Poland's accession to the European Union. Thanks to the subsidies received, the Polish village is no longer associated with the lack of adequate infrastructure. In terms of the number of people working in agriculture, Poland is one of the leading countries among the Member States. Changes in the structure of farm areas are also visible. The number of large and medium-sized farms significantly affects the country's share in the international agricultural market. The number of medium-sized farms in Poland has not changed much, while since 2006 the number of small farms below 5 ha has decreased by 58%, while the number of farms with an area over 50 ha has increased by 54%.

Thanks to Poland's accession to the European Union, a one-time non-returnable subsidy system was introduced for young farmers who started running their own farms. In addition, EU training is also conducted. In addition, Poland has obtained the possibility of exporting, as well as participation in the international market.

As a result of the research carried out in 2016, provinces: WP, MZ and KP were in the top positions. LB, OP, DŚ, WM, ŁD and ZP provinces were classified below the third place. In positions lower than nine are provinces: PM, PL, MP, ŚK, ŚL, LB and PK.

Comparing the changes that have occurred since 2006, an increase in all diagnostic variables used for the study is visible. In some provinces, this increase is not as great as in others, so they occupy the final positions. Analyzing the share of ecological farms in total utilized agricultural area, the regularity is visible that a high percentage of these farms is located in provinces that occupy final positions in the overall ranking. The same is true for the number of people working in agriculture. In provinces such as ŚK or PK provinces, the number of people working in agriculture is one of the highest in Poland, which does not translate into the position of these provinces in the ranking.

The agricultural market in Poland is constantly developing. Numerous government and EU programs are emerging that support farmers in their activities. Agricultural machinery facilitating work is constructed using technological progress, thanks to which running a farm is no longer associated with very heavy physical effort. Poland's accession to the European Union also meant that products of Polish origin, mainly regional, are valued by consumers of other European countries, thanks to which the share of exports of agri-food products increases and Poland's importance in the international arena increases.

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UNEMPLOYMENT HYSTERESIS IN TURKEY: EVIDENCE FROM NONLINEAR UNIT ROOT TESTS WITH FOURIER FUNCTION[1]

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Abstract: The purpose of the article is to give brief information about the development process of time series analysis and to test the validity of the unemployment hysteresis in Turkey for female and male graduates for the years from 1988 to 2013. For this purpose, Kapetanios et al. [2003], Sollis [2009] and Kruse [2011] nonlinear unit root tests are applied based on the smooth transition autoregressive (STAR) model. Besides, nonlinear unit root tests proposed by Christopoulos et al. [2010] and Guris [2018] are employed to model the structural breaks through Fourier approach and to model the nonlinearity through a STAR model.

Keywords: nonlinear unit root tests, Fourier approach, STAR model, unemployment hysteresis

JEL classification: E24, C22, C12

INTRODUCTION

Analysing the effects of the shocks on macroeconomic variables has been the main problem for both researchers and policy developers. It is because having a permanent or temporary effect on the variables has crucial importance in terms of

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policies to be implemented. In the literature, unit root test procedures have been utilized to see the effects of the shocks on macroeconomic variables. Unit root test procedures have been developed first in linear time series analysis by Fuller [1976], Dickey and Fuller [1979, 1981], and Nelson and Plosser [1982]. Following those tests, many other tests such as Phillips and Perron [1988], Kwiatkowski et al. [1992], Elliot et al. [1996], Ng-Perron [2001] constitute the basis of unit root literature. However, Perron [1989] points out that test results will be the non-rejection of the null hypothesis and biased when the existing structural breaks are ignored in the unit root tests. Subsequent to the contribution of Perron [1989], unit root tests with single and double breaks, such as Zivot and Andrews [1992], Perron and Vogelsang [1992], Lumsdaine and Papell [1997], Clemente et al. [1998], Lee and Strazicich [2003], Carrion-i Silvestre and Sanso [2007], Narayan and Popp [2010], Lee and Strazicich [2013], have been proposed in the literature. Nevertheless, nonlinear time series analysis has been remarkable attention as a result of the acceleration of technological and scientific progression to overcome the encountered problems in linear time series analysis.

In this study, we apply Kapetanios et al. [2003] (also known as KSS test), Sollis [2009] and Kruse [2011] nonlinear unit root tests based on the smooth transition autoregressive methodology after testing the linearity of the series with Harvey and Leybourne [2007] and Harvey et al. [2008]. On the other hand, Becker [2006] highlights that there is no possibility to know the form of breaks in reality. Thus new approaches have been suggested to literature in the light of the Becker [2006]'s paper. In recent years, the Fourier approach has been mostly used in modelling structural breaks in unit root tests. Christopoulos and Leon-Ledesma [2010] have proposed a new test procedure that models the structural breaks through the Fourier approach and models the nonlinearity through the smooth transition autoregressive (STAR) model. Guris [2018] has developed a new test based upon the test proposed by Christopoulos and Leon-Ledesma [2010]. In the new test, Guris [2018] considers the Kruse [2011] test to model the nonlinear adjustment and considers the Fourier approach to model the structural breaks. In this test, it is found that the power of the test is greater than Kruse [2011] and KSS [2003] tests, especially for the small sample.

The objectives of the study are first to evaluate the mentioned nonlinear unit root tests and, in the application part, as a second objective, to test the effects of the transitory shocks on unemployment rates of female and male graduates in Turkey in 1988-2013. Unemployment which leads to economic and social problems in a country is one of the main problems in Turkey along with the other major problems such as poverty and income inequality. The effect of the transitory shocks on unemployment is examined via Natural Unemployment Rate (NAIRU) and Unemployment Hysteresis Hypothesis. If transitory shocks in the economy have not permanent effect on the unemployment rate, Unemployment Hysteresis Hypothesis developed by Blanchard and Summers [1986] will not be valid. Identifying the impact of the transitory shocks on unemployment is a critical issue

to develop the policies to finding solutions for this problem. Our contribution here is that, as far as we know, this study is the first study which applies different nonlinear unit root tests along with the new test proposed by Guris [2018] to test the unemployment hysteresis hypothesis for female and male graduates in Turkey.

The rest of the study is organized as follows: The method is examined in the second section. Empirical data are defined in the third section. Results are given in the fourth section and finally, the summary of the study is presented in the fifth section.

METHOD

In the nonlinear time series analysis, unit root tests have been attracted attention in recent years. In the literature, there is seen that linear time series analysis is mostly used by many researchers due to the ease of application and interpretation. However, new methods have begun to emerge simultaneously with the technological and scientific developments to overcome the following problems. The encountered problems in the linear unit root tests can be listed as follows:

- A priori knowledge is needed for the date, number, and functional form of breaks.
- Dummy variables are employed to account for breaks which assumed to be instantaneous.
- If the data show a nonlinear aspect, linear unit root tests will face a power problem. Furthermore, unit root test results will be the non-rejection of the null hypothesis and biased with that problem.

At that point, nonlinear time series models have been started to develop and many unit root tests have been proposed into the literature. In the traditional linear unit root tests, structural breaks are modelled by dummy variables in which instantaneous changes are assumed. However, structural breaks can occur in a smooth structure at a time of period. Hence STAR models introduced by Chan and Tong [1986] are developed by Terasvirta [1994]. In this second approach considered the existence of the nonlinear dynamics, the transition between regimes is formed through a transition function which models the nonlinear adjustment thanks to the exponential smooth transition autoregressive (ESTAR) process or logistic smooth transition autoregressive (LSTAR) process [Terasvirta 1994]. The first nonlinear unit root test proposed by KSS [2003] is considered as a nonlinear version of the Augmented Dickey-Fuller (ADF) test. The purpose of the test is to put forth a testing procedure to specify the presence of nonstationary against a nonlinear ESTAR process, which is globally stationary.

The KSS test procedure considered the ESTAR model can be shown as follows:

$$\Delta y_t = \phi y_{t-1}.\left[1 - e^{-\theta(y_{t-1}-C)^2}\right] + \varepsilon_t, \quad (1)$$

where $\varepsilon_t \sim iid(0, \sigma^2)$. In Equation 1, c is assumed to be zero and the following equation is created.

$$\Delta y_t = \phi y_{t-1}.\left[1 - e^{-\theta(y_{t-1})^2}\right] + \varepsilon_t. \quad (2)$$

In Equation 2, the unit root null hypothesis, $H_0: \theta = 0$, is tested against nonlinear ESTAR process, $H_1: \theta > 0$. However, Equation 3 based on the Taylor series approximation is suggested since testing the null hypothesis directly is not feasible in Equation 2 [Kapetanios et al. 2003].

$$\Delta y_t = \delta y_{t-1}^3 + \sum p_j \Delta y_{t-j} + \varepsilon_t. \quad (3)$$

In Equation 3, the null hypothesis supposed to be rewritten as $H_0: \delta = 0$ and the alternative hypothesis can be rewritten as $H_1: \delta > 0$.

In the Kapetanios et al. [2003]'s paper, critical values of the t-statistics are given for three cases referred to the model with the raw data, the de-meaned data and the de-trended data. Following the KSS test, Sollis [2009] has proposed a new unit root test to test the unit root null hypothesis from the extended version of the KSS test. Symmetric or asymmetric stationary ESTAR nonlinearity is defined under the alternative hypothesis from this extended test, unlike the KSS test. The extended ESTAR process is as follows:

$$\Delta y_t = \phi_1 y_{t-1}^3 + \phi_2 y_{t-1}^4 + \sum_{i=1}^{k} k_i \Delta y_{t-i} + \eta_i. \quad (4)$$

In Equation 4, in the case of the rejection of the unit root hypothesis, $H_0: \phi_1 = \phi_2 = 0$, the symmetric hypothesis, $H_0: \phi_2 = 0$, will be tested against the asymmetric alternative hypothesis, $H_1: \phi_2 \neq 0$.

F-test statistics and critical values for the zero mean, non-zero mean and deterministic trend cases are specified in the Sollis [2009]'s paper to test the hypothesis.

Kruse [2011] has proposed a new test to test the unit root hypothesis, $H_0: \phi_1 = \phi_2 = 0$, against a globally stationary ESTAR process, $H_1: \phi_1 < 0,\ \phi_2 \neq 0$. The following model is considered as a development version of the KSS test.

$$\Delta y_t = \phi_1 y_{t-1}^3 + \phi_2 y_{t-1}^2 + \sum_{i=1}^{k} \rho_i \Delta y_{t-i} + u_t. \quad (5)$$

Kruse [2011] implements the methods of Abadir and Distaso [2007] to derive a modified Wald test. However, in the nonlinear unit root tests, there is considered that the form of the breaks is known although there is not possible to know the form of breaks, break date and numbers in reality [Becker et al. 2004, 2006]. In this respect, the Fourier approach is one of the approaches to answer the question of how the structural breaks should be modelled. Advantages of the Fourier approach can be listed as follows:

- The ability to accurately capture unknown structural fractures since the usage of the dummy is not adequate to capture the breaks.
- Suitable for unknown structural break dates.

- Suitable for unknown number of breaks.

Fourier approach can be described as follows:

$$y_t = \delta_0 + \delta_1 \sin\left(\frac{2\pi kt}{T}\right) + \delta_2 \cos\left(\frac{2\pi kt}{T}\right) + v_t, \quad (6)$$

k – optimal frequency,

t – trend,

T – sample size.

Christopoulos and Leon-Ledesma [2010] have proposed a new unit root test procedure by combining the Fourier approach and nonlinearity. In the first stage, Fourier form is applied to capture the structural breaks and in the second stage, KSS test is applied for the nonlinearity. Besides, in this study, we use the Fourier Kruse test proposed by Guris [2018]. In this new test, nonlinearity is modelled by the ESTAR model as proposed in the Kruse [2011] test (Equation 5) and structural breaks are modelled by Fourier function (Equation 6).

EMPIRICAL DATA

The data we used in the study is obtained by Turkish Statistical Institute (TUIK) for the period 1988-2013[2]. The unemployment data are divided into two groups as female and male graduates. Unemployed can be defined as people who are without work within the reference period but seeking employment for the last 3 months and who are available to work in 2 weeks[3]. Unemployment rate refers to the ratio of the unemployed population into the labour force.

Descriptive statistics presented in Table 1 can be summarized as follows:

- The mean of the unemployment rate of female graduates is 12.7% while the mean of the unemployment rate is 7.1% for male graduates.
- The median of the unemployment rate of female graduates is 12.6% although the median of the unemployment rate of male graduates is 7.0%.
- The maximum unemployment rate of female graduates is 17.6% while the maximum rate of male graduates is 9.8%.
- The minimum unemployment rate of female graduates is 8.1% while the rate is 5.3% for male graduates.
- The standard deviation is 2.8% for female graduates while the standard deviation is 1.3% for male graduates.

[2] The period is chosen depending on the availability of the dataset.

[3] The definition was revised in 2014 by TUIK as people who are seeking employment for the last 2 months instead of 3 months but the data we employ here is for the years before 2014.

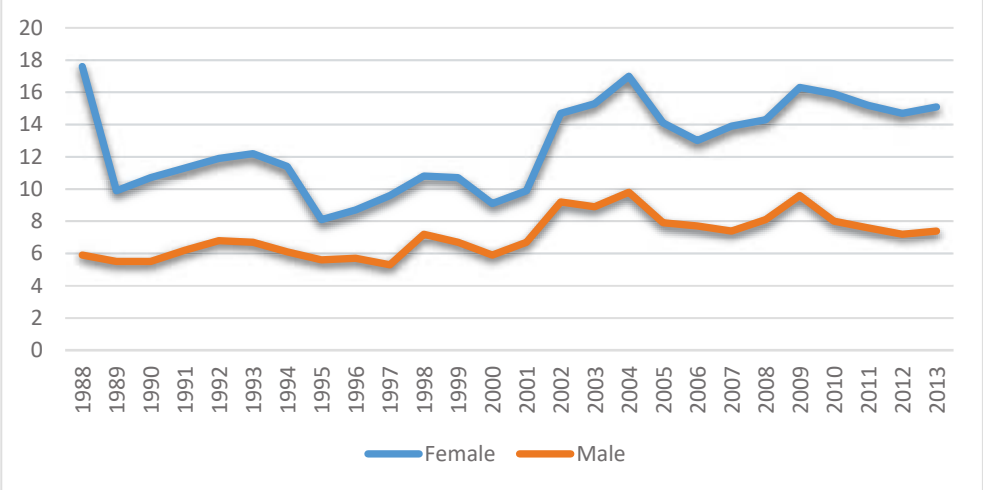
Table 1. Descriptive statistics of unemployment rates of female and male graduates

Variables	Mean	Median	Maximum	Minimum	Std. Dev.
Female	12.7	12.6	17.6	8.1	2.8
Male	7.1	7.0	9.8	5.3	1.3

Source: own calculations

Unemployment rates for female and male graduates are represented in Figure 1 with the blue- and orange-colored line, respectively. According to Figure 1, the highest unemployment rate for female is seen in 1988 with 17.6% while the highest rate for male is seen in 2004 with 9.8%. The second highest rate is obtained in 2004 for female with 17.0% and in 2010 for male with 9.6%. The lowest unemployment rate for female graduates is observed in 1995 with 8.1% while the lowest rate for male graduates is observed in 1997 with 5.3%.

Figure 1. Unemployment rates of female and male graduates (%)



Source: own preparation

RESULTS

In the first step of the analysis, we run the Harvey et al. [2008] and Harvey and Leybourne [2007] tests to test the linearity of the series. In Table 2, we see the results of the tests. According to Harvey et al. [2008] test results, the null hypothesis of linearity is rejected for female at the level of 1% and the male at the level of 5%. Harvey and Leybourne [2007] test results display that the linearity is rejected for both series at the level of 5%.

Table 2. Linearity test results

	Harvey et al. (2008)	Harvey and Leybourne (2007)		
Variables		%1	%5	%10
Female	16.25	10.62	10.47	10.39
Male	6.42	12.91	12.77	12.68

Note: The critical value for Harvey et al. (2008) test is 9.21 at the level of 1%; 5.99 at the level of 5%; 4.60 at the level of 10%. The critical value for Harvey and Leybourne (2007) test is 13.27 at the level of 1%; 9.48 at the level of 5%; 7.77 at the level of 10%.

Source: own calculations

In Table 3, we reject the unit root null hypothesis at the 1% level of significance for female and the 5% level of significance for male. The rejection of the null hypothesis reports that series are stationary which means hysteresis hypothesis is not valid for female and male graduates.

Table 3. KSS [2003] unit root test results

Variables	Lags	Akaike Criterion	KSS Test Stat	Tau Critical Values	
Female	0	3.971	-4.023***	%1	-3.48
Male	0	2.545	-2.951**	%5	-2.93
				%10	-2.66

Note: The signs of ***,** and * refer that the unit root hypothesis is rejected at the level of 1%, 5% and 10%, respectively. Minimum Akaike criterion is chosen during the estimation process in the model automatically.

Source: own calculations

In Table 4, we reject the null hypothesis at the 10% level of significance only for male graduates. For female, the non-rejection of the null hypothesis means that the hysteresis hypothesis is valid according to Sollis [2009] test results.

Table 4. Sollis [2009] unit root test results

	Lags	Akaike Criterion	Sollis Test Stat	Critical Values	
Female	1	3.765	2.991	%1	6.89
Male	0	2.616	4.328*	%5	4.88
				%10	4.00

Note: The signs of ***,** and * refer that the unit root hypothesis is rejected at the level of 1%, 5% and 10%, respectively. Minimum Akaike criterion is chosen during the estimation process in the model automatically.

Source: own calculations

As shown in Table 5, null hypothesis of the unit root is rejected at the 1% level of significance for female and at 10% significance for male. The rejection of

the unit root refers that series are stationary and thus, hysteresis hypothesis is not valid for both female and male graduates.

Table 5. Kruse [2011] unit root test results

	Lags	Kruse Test Stat	Critical Values	
Female	0	19.313***	%1	13.75
Male	0	9.549*	%5	10.17
			%10	8.60

Note: The signs of ***,** and * refer that the unit root hypothesis is rejected at the level of 1%, 5% and 10%, respectively.

Source: own calculations

Christopoulos and Leon-Ledesma [2010] test results in Table 6 show that the null hypothesis of unit root is rejected at the 5% level of significance only for female. However, the null hypothesis of unit root is not rejected for male which means that the hysteresis hypothesis is valid for male.

Table 6. Christopoulos and Leon-Ledesma [2010] unit root test results

	Lags	Test Stat	Critical Values k=1	
Female	0	-3.943**	%1	-4.14
Male	0	-2.908	%5	-3.59
			%10	-3.26

Note: The signs of ***,** and * refer that the unit root hypothesis is rejected at the level of 1%, 5% and 10%, respectively.

Source: own calculations

In Table 7, Güriş [2018] test results indicate that the null hypothesis of unit root is rejected at the 5% level of significance for both female and male graduates. Hysteresis hypothesis is not valid considering the test results given in Table 7.

Table 7. Güriş [2018] unit root test results

	Lags	Test Stat	Critical Values k=1	
Female	1	19.094**	%1	20.32
Male	1	17.364**	%5	14.72
			%10	12.32

Note: The signs of ***,** and * refer that the unit root hypothesis is rejected at the level of 1%, 5% and 10%, respectively.

Source: own calculations

KSS [2003], Kruse [2011], Christopoulos and Leon-Ledesma [2010] and Güriş [2018] test results report that the unit root hypothesis is not valid for female graduates for the period of 1988-2013. In addition, the null hypothesis is rejected for male graduates as a result of the KSS [2003], Sollis [2009], Kruse [2011] and Güriş [2018] tests.

SUMMARY

In the nonlinear time series analysis, unit root tests have been popular to identify the effects of the shocks on macroeconomic variables which show a nonlinear property. In this study, we applied three different unit root tests, KSS [2003], Sollis [2009] and Kruse [2011] based on the STAR model. However, as a result of the acceleration of technological or/and scientific development, new approaches are needed to resolve the problems we face in our analyses. The Fourier approach is seen as one of the alternative ways by scientists since it gives powerful results compared to traditional unit root tests. In other words, in the traditional unit root tests, the real problem occurs when we try to identify the time, number and form of the break since in reality, it is not possible to identify them. For this reason, we employed two different nonlinear unit root tests with Fourier approach, Christopoulos and Leon-Ledesma [2010] and Güriş [2018], in order to improve the reliability of the results.

In the application part, nonlinear unit root tests utilized to test the hysteresis hypothesis for female and male graduates in Turkey. The data for unemployment rates of female and male graduates conducted by TUIK are used for that purpose. The data remark that the highest gap in unemployment rates of female and male graduates is seen in 1988 while the lowest gap is observed in 1995 when the unemployment rate of female graduates is very close to the unemployment rate of male. Applied tests, KSS [2003], Sollis [2009], Kruse [2011], Christopoulos and Leon-Ledesma [2010] and Güriş [2018], report that unemployment hysteresis hypothesis is not valid for female and male graduates. It means that the shocks in the economy have a temporary effect on unemployment rates. Besides, it is expected that unemployment rates will be back to its mean in the long run after showing an increasing trend. For future work, it is important to work with extended data taken different education categories into account. Additionally, it is also important to include different countries into the study to make a comparison.

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THE USE OF AN ARTIFICIAL NEURAL NETWORK IN THE PROCESS OF CHOOSING THE PROJECT SUPPLY CHAIN BY THE PRINCIPAL CONTRACTOR

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Abstract: The project supply chain is characterized by many risks that expose the participating companies to bankruptcy, including primarily the principal contractor. For this reason, it is desirable to have a tool that will allow us to assess whether it is worth participating in such a chain without the risk of bankruptcy. The study showed that it can be an artificial neural network, whose support consists in indicating in which project supply chain the principal contractor should participate. In addition, it was shown which factors should be taken into account by them.

Keywords: risk, project, neural network, simulations, bankruptcy, supply chain

JEL classification: C45, G32

INTRODUCTION

The project supply chain is an issue which in Polish and foreign literature is characterized mainly in terms of logistics, without taking into account the risk and uncertainty. In addition, it is identified mainly with the construction industry [Sobotka, Wałach 2011], which can create such definition problems as well as problems with identifying factors that expose the entire project supply chain to risk. It is worth mentioning here that for the first time the concept of supply chain

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construction for the implementation of a construction project was relatively thoroughly characterized, only in the mid-90s [O'Brien 1998]. Although various aspects of the project supply chain have been already characterized, yet the fact that participation in it may expose the principal contractor, who is the most important element of such a chain, to the risk of bankruptcy, has not been taken into account. Such a study also causes problems because the number of projects implemented in such chains by enterprises is usually small, so there is a lack of historical data. Therefore, it should be assumed in the analyzes that knowledge about them is small, and the number of chains constituting the research base should also not be large.

Considering the above and wanting to fill the cognitive gap, it was decided to try to use an artificial neural network to support the functioning of the principal contractor, who may have a problem with identifying factors affecting the efficiency of the project supply chain, which means that he cannot assess in which chain he should participate, and which he should reject (at least because of the exposure to bankruptcy). All this is the main purpose of the publication, while the secondary goal is to determine such factors and express them in a numerical form for the use of an artificial neural network. The article uses a set of hypothetical data, using artificial neural networks and literature studies.

GENERAL PRESENTATION OF THE PROJECT SUPPLY CHAIN

There are few papers in Polish and foreign literature that precisely characterize the project supply chain, taking into account its most important features. After conducting literature research, it was found that the best definition was presented in 2007 and it describes the project supply chain as "(...) the global network used to deliver a project from raw materials to the final project customer through an engineered flow of information and physical distribution. The project supply chain thus involves the principal contractor who is in charge of the management of the project, the clients and their own clients, the suppliers and their own suppliers and subcontractors, the subcontractor and their own subcontractors [Parrod et. al. 2007]. Although the literature describing the presented matter is poor, however narrowing the considerations to the construction industry, it can be assumed that there are four most important areas concerning the management of such a supply chain [Vrijhoef, Koskela 2000]. However, emphasis should be placed on activities carried out on the construction site in order to minimize the costs and duration of the project. This can be done with the help of the correct relationship between the principal contractor and suppliers. One of the areas of management is related to integrated management and improvement of the entire supply chain as well as improvement of activities carried out at the construction site. All in all, such a chain is inseparably connected with the risk, the largest part of which the value cannot be precisely determined, is borne by the principal contractor. The latest research already includes the analysis of the risk of this

chain, but most researchers examine it based on a demand assessment, or take into account its uncertain environment [Lian, Ke 2018]. However, there is a lack of research related to supporting the risk management process that would include assistance in the assessment of specific project supply chains. The problem, however, is that each of them is unique, so it's difficult to determine its most important features in detail. For this reason, five value drivers described in the literature were selected, which are strategic factors that significantly increase the value of such a chain and provide its competitive advantage [Venkataraman, Pinto 2008], and which can help build a tool supporting the assessment of this chain. These factors are:

- Customer - it is emphasized that the final recipient of the project resulting from the functioning of the chain is the most important value driver, here the project's value is determined;
- Cost - costs are also an important value driver of the chain, because there is a need to minimize and control them, because cost strategies may cause the need to make changes in the chain itself;
- Flexibility - is defined as the ability to respond quickly to changes in customer preferences, or to changes in the scope of the entire project. For example, it can be seen as giving the customer the freedom to make significant changes to the ongoing project;
- Time - this driver together with costs and quality represents the three most important constraints for projects, so if the project is completed on time or ahead of schedule, then the value of the project supply chain management can be expected to increase;
- Quality - there are many definitions of quality, however, in relation to the project, it can be defined in such a way that it means a situation in which the product of the project meets or even exceeds the expectations of customers. To sum up, quality as the last value driver is designed to ensure a certain level of functionality of the project result, its delivery at a reasonable price and at a given time, thus meeting customer's expectations.

Taking into account the features of the project supply chain and its value drivers mentioned in the work, an attempt was made to build an artificial neural network, which can be an important element supporting the principal contractor within such a chain.

ARTIFICIAL NEURAL NETWORK IN THE CONTEXT OF DETERMINING THE SELECTION OF THE PROJECT SUPPLY CHAIN

The paper attempts to configure an artificial neural network in order to serve as a tool supporting the determination of the selection of a specific project supply chain. It is created by a large number of neurons [Tadeusiewicz 1993] processing information, they can also be called a binary element [Arbib 2003]. They are

connected into one network with specific weights, modified during the learning process, which is divided into three types: supervised learning with the teacher (the set of learning pairs includes the input vector and the correct answer vector, i.e. the correct answer for given vectors from the input space is known [Ghosh-Dastidar, Adeli 2009], unsupervised learning (it does not allow the possession of information that would describe the correctness of the answer that would result from the operation of the network, reinforcement learning (it does not assume the existence of a teacher, but only a criticism, assessing the correctness of the tendency to answer.

The use of artificial neural networks in the context of choosing a given supply chain can be treated as a method based on a computer pattern recognition. This network generates correct answers based on input data, even for data that was not provided in the learning process, so it can generalize the knowledge acquired during learning to generate the correct answers. When analyzing specific project supply chains, the objects are those chains. This solution, however, requires assigning specific features to the chain objects so that artificial neural networks recognize specific types of chains when learning, which will be the basis for their proper classification. The article proposes the use of artificial neural networks that require the designation of features of project supply chains. Therefore, 8 universal features based on the listed value drivers have been proposed, which are training data for artificial neural networks. The set thus proposed may allow two classes of decisions to be generated. The first would include the project supply chain in which the principal contractor should not participate (based on the expert's suggestion, the value of the standard in this case is "0"), and the second - in which he can participate (the value of the standard is "1"). Adoption of such a division is made on the basis of expert suggestions, and the above two decisions result from the separation of chains in terms of assessing their attractiveness and the possibility of exposing the principal contractor to bankruptcy. The most important assumptions about the empirical study are as follows:

- A single supply chain is a tested object, and its attractiveness is examined from the perspective of the value of the twelve proposed features (in the form of expert suggestions), so the value of the standard is "0" or "1". This will allow learning of an artificial neural network to assess hypothetical project supply chains;
- The study has used a "supervised" learning, the learning process involved analyzing 12 hypothetical cases of project supply chains, while after teaching the network, an experiment was carried out for an additional 6 potential chains, with possible values of features that can be assessed ambiguously by the principal contractor. The number of cases has been deliberately limited because the principal contractor cannot use historical data when analyzing the project supply chain, and each case should be treated as unique;

- The experiments were related to the assumption of the number of inputs equal to 8 and the changing multiple of the learning process, while the number of neurons in the hidden layer - ranged in the range of 2 – 9;
- The finally adopted network architecture consisted of a hidden layer covering 6 neurons, as well as an output layer, while the function of the transition in the hidden layer was sigmoid function (TANSIG), and in the output layer - linear (PURELIN);
- The multiple learning process of the network was 40 and it was taught by the Back Propagation method according to the L-M algorithm (Levenberg-Marquardt);
- The ultimate goal of network learning was to obtain the smallest value of the sum of squares of the difference between the output signal and the value of the standard proposed by the expert.

The proposed and possibly considered a universal set of 8 features was characterized in tabular form (Table 1.) Additionally, it was explained which indicator was used to calculate the value of the feature, taking into account the reference to the assessment of the project supply chain.

Table 1. The feature set developed for the assessment of project supply chain

Feature name	Indicator/Feature	The Essence in relation to value driver
Duration of the project supply chain	T (in years)	The feature relates directly to the value driver - time. However, it cannot be assumed that, along with a longer chain, it is very risky as it might turn profitable.
The probabilities (p_i) of obtaining specific revenues from the project at the end of a of a given period, which result from the occurrence of four assumed scenarios, were multiplied by the assumed revenues (g_i)	$p_1 \times g_1$ (monetary value)	The feature refers to the value driver - client, because at the end of the project, he can generate different revenues with certain probabilities, depending on the client's financial situation. The specified revenues were multiplied by the probabilities assigned to them, because such a set allowed to teach the network more effectively than in the case of providing single values.
	$p_2 \times g_2$ (monetary value)	
	$p_3 \times g_3$ (monetary value)	
	$p_4 \times g_4$ (monetary value)	
Foster-Hart measure of risk	$R(g)$ (monetary value)	The measure applies to value driver - cost, because as the costs increase, the principal contractor may be increasingly exposed to the risk of bankruptcy, which is why this value should be compared with the level of the principal contractor's assets. If the contractor's assets are too low in relation to the $R(g)$ value, then the project should be rejected.

Feature name	Indicator/Feature	The Essence in relation to value driver
Flexibility	F (numerical value)	The feature directly relates to flexibility, which is one of the value driver. It was assumed that if the flexibility is the smallest, then the value of the feature is "1", and when it is the highest - "10". The higher it is, the more risky the project becomes.
Quality	Q (numerical value)	The feature also refers to quality, which is the last value driver. It was assumed that if the quality required by the customer is the lowest, then the value of the feature is "1", and when it is the highest - "10". The higher it is, the more cost-intensive the project becomes.

Source: own study

The set of features presented is intended to generally reflect the situation of a given project supply chain. All feature values were built based on expert suggestions, because each project is unique and the company is not able to characterize projects based on historical data. It should be added that the Foster-Hart risk measure, which was used, was each time calculated on the basis of specific probability and income values using a commonly known formula presented in 2009 [Foster, Hart 2009]. An example period with actual data is presented in Table 2.

Table 2. Sample hypothetical data for eight features

Indicator	Value
T (in years)	4
$p_1 \times g_1$ (monetary value)	-56.25
$p_2 \times g_2$ (monetary value)	-31.5
$p_3 \times g_3$ (monetary value)	42.75
$p_4 \times g_4$ (monetary value)	67.5
$R(g)$ (monetary value)	919.49
F (numerical value)	3
Q (numerical value)	2
Z (value of the pattern)	1

Source: own calculations

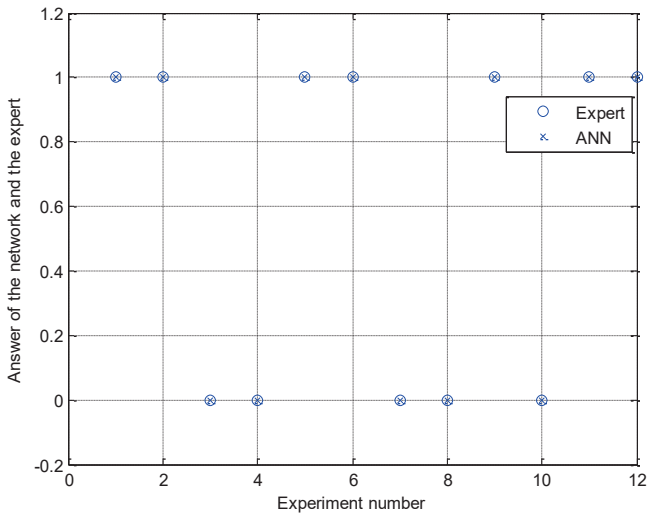
It is easy to see that the expert must be able to accurately classify chains, because they are always unique, and the number of completed projects in the

enterprise may be small. This issue is the most problematic, which is why artificial neural networks seem to be an indispensable tool that is able to support the principal contractor.

APPLICATION OF ARTIFICIAL NEURON NETWORKS FOR THE PURPOSE OF DEFINING BY THE PRINCIPAL CONTRACTOR THE DECISION ON THE PARTICIPATION IN THE PROJECT SUPPLY CHAIN

The simulation tests carried out at work in MATLAB programming environment were designed to obtain simulation results in line with the expert's suggestions. In the initial phase of the study, the neural network obtained unsatisfactory results due to the determination of incorrect weights, so the learning process was changed, assuming that the result of each learning is the beginning of the next. The number of such repetitions was chosen experimentally until the network generated satisfactory results. The result of the study was an effective network learning, which is reflected in Figure 1, in which the OX axis means the number of the project supply chains examined, while the OY axis - the value of decisions. It is easy to see that the standard values are always "0" or "1". In contrast, the network results were marked in the form "X" and the suggestions of the expert were marked in the form "O".

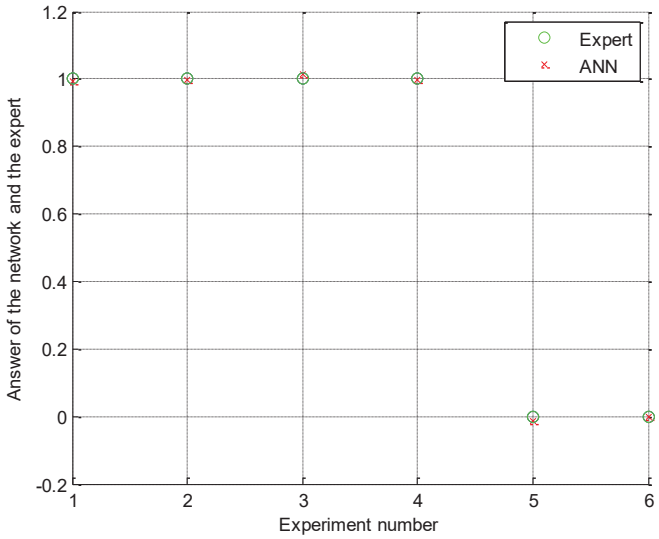
Figure 1. Example of network response for multiple learning on theoretical values in a training set for twelve project supply chains



Source: own preparation based on the MATLAB program results

Figure 1 presents the results of simulation tests, which visually can be considered as very satisfactory, because in all cases the positions of "O" and "X" are almost identical. The network taught in this way allowed for an effective use to assess the hypothetical six project supply chains that constituted the testing set. The usability of the already configured network has also been confirmed by obtaining satisfactory results, which was also illustrated by the location of "O" and "X" in Figure 2.

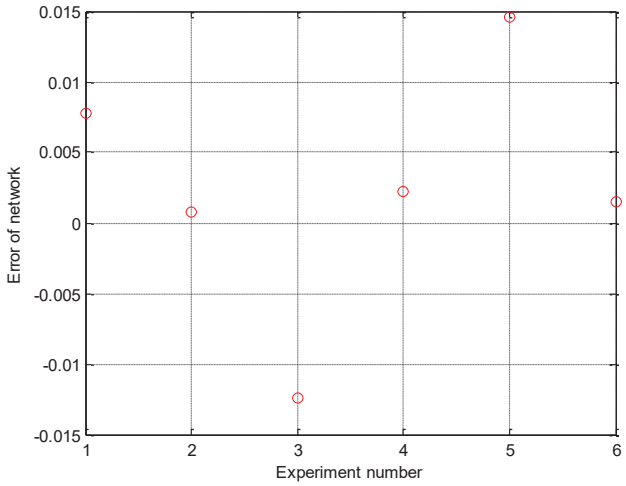
Figure 2. The results of network learning on theoretical values in a test set consisting of six hypothetical project supply chains



Source: own preparation based on the MATLAB program results

The utility of the network and the quality of the results obtained for the test set were also assessed by calculating the difference between the standard value and the value generated by the network for six hypothetical cases. Individual differences are presented graphically (Figure 3) to reflect the fact that they are relatively small.

Figure 3. Values of differences between expert and network values in the test set for hypothetical project supply chains



Source: own preparation based on the MATLAB program results

The final result of the simulation study was to obtain a network configuration that would allow the assessment of various project supply chains, which by their characteristics may expose the principal contractor to bankruptcy. It is also important that he can compare his property value with the value analyzed by the network in order to avoid the risk of bankruptcy. This aspect was not found in the Polish and foreign literature.

SUMMARY

The research was carried out to solve the research problem posed, because poor literature devoted to the project supply chain does not present how to solve it. When analyzing this chain, the first thing to consider is the fact that each one is unique. Secondly, historical data cannot be analyzed, which makes it difficult to draw conclusions about its functioning. Thirdly, in the literature on the subject, the most important value drivers regarding the project supply chain have been characterized too generally, which makes it difficult for the principal contractor to conduct analyzes. Therefore, to solve the research problem, a universal set of 8 features was proposed, referring to the value driver presented in the literature, on the basis of which the artificial neural network could be subjected to the learning process by analyzing 12 project supply chains. The learning process was the most effective when the network consisted of two layers: a hidden (consisting of 6 neurons) and an output layer (1 neuron), while the function of the transition in the hidden layer was "TANSIG", and in the output layer - "PURELINE". It was

assumed that the values of possible revenues generated by the chain were multiplied by the probabilities of achieving them and the learning multiple was 40.

In summary, satisfactory research results were obtained because the artificial neural network obtained results in line with the expert's suggestions, based on the hypothetical data of the teaching set. This way, the network also generated correct results for the test set, which is why it can be considered as an expert advisory system, supporting decision making for the principal contractor, wishing to participate in the project supply chain. The number of cases analyzed has been intentionally reduced, because each of them is unique and in business practice the enterprise may not have experience of project implementation. In addition, it seems reasonable that the proposed set of 8 features is so universal that the presented network configuration along with this data set can be useful for assessing any chain. Considering the above, it can be a comprehensive expert system supporting the risk management by the principal contractor who wants to implement a large project without any bankruptcy risk.

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ON TRADING ON THE STOCK MARKET WITH THE SHORTAGE OF THE LIQUIDITY

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Abstract: In the article the model of the market with the transaction costs is considered with the market participant who intends to sell the shares of the stock with the presence of the liquidity shortage. The shortage in the liquidity can manfest itself in the occurrence of the market impact which can siginficantly decrease the profit from the stock trade. If the trading velocity is above some level, the market impact can occure and increase the cost of the trade. However the transaction cost can be present even in case of a small transaction on the stock market. The problem of maximization of the expected amount of money obtained from the sale of the stock shares is solved for the case of strategies with the constant trade speed and the particular range of the stock price drift. The example of numerical computations with the use the formulas from the paper, is included.

Keywords: stock price drift, transaction cost, liquidity shortage, market impact, trading speed

JEL classification: C6, G11

INTRODUCTION

The level of liquidity is an important characteristic of the stock market. The liquidity shortage can manifest itself by the occurrence of the market impact which is change in the stock price, induced by trading. The market impact (also called the price impact), if occurs, is unfavorable to the initiator of the trade – the price grows when the market participant is an initiator of the stock purchase and drops if the trade initiator is selling the stock shares. Thus, the price impact can be seen as the source of transaction costs. The problem of the precise assessment of the

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transaction cost of the planned trade execution is important theoretically and practically.

Studying the market impact has become popular in quantitative finance [Tóth et al. 2011]. Price impact can be an important factor influencing the result of the investment on the stock market. The empirical study of the market impact is described, for example, in [Zarinelli et al. 2014]. It seems that the price impact assessment software can be an important tool for the financial investors [Gatheral 2010]. Another important factor affecting the profitability of the transaction is the bid-ask spread. The bid-ask spread can be defined as the difference between the highest bid and the lowest ask stock prices on the market. Occurring the positive difference between the highest bid price of the stock and the lowest ask stock price causes the transaction cost even for very slow trade execution. In the model considered in the paper the level of transaction costs depends on the speed of the execution of the trade. The dependence of transaction costs on the velocity of the trade of the trade speed was considered, for example, in [Almgren et al. 2005] and [Kociński 2018]. In the article, if the trade speed does not exceed some level then, the transaction cost ratio is constant but starting from this speed level, if the trade speed increases, then the ratio of the trade cost also increases. Thus reducing the velocity of the trade can reduce the transaction cost induced by the price impact. However, an important factor influencing the profitability of the investment on the stock market is the stock price drift. The drift may be the effect of the aggregate activity of the stock market participants which is a reaction on the information about the perspectives of profits resulting from the stock trading. For example, the positive value of the drift may be caused be the information that stock dividend paid by the company that emitted the stock shares will be higher than expected by the participants of the stock market. The negative value of the drift may be, for example, generated by the announcement that the stock dividend will be lower than it was forecasted by the stock investors. The optimization of the trade execution was considered, for example, in [Almgren, Chriss 2000].

The aim of the article is to determine the sale strategy which maximizes the expected amount of money obtained from selling the stock shares in the described in the article market model with the constraint of constant trade velocity.

THE MODEL OF THE STOCK PRICE AND SELLING

Let S_t denote the price of the stock at time t. Assume that the expected stock price $E(S_t)$ at time t is given as follows:

$$E(S_t) = S_0(1 + \mu t) \text{ for } t \in [0, T], \tag{1}$$

where μ denotes the stock price drift. It is assumed that $\mu < 0$.

Consider the market participant who has Y shares of the stock and wants to maximize the amount of money received from the sale of the stock in the interval $(0,T)$. It is assumed that the speed of the given trade is constant. It seems that on the market where the attained trading velocity can significantly differ from the trade speed planned by the stock seller, the assumption of the constant speed of the trade can be moderate with respect to the influence on the stock sale. The strategy with constant speed is characterized by the moment of the start of the sale t_0, the moment of the end of the sale t_1 and the number of the stock shares sold X. The values of t_0 and t_1 are in the interval $(0,T)$. Consider the trading strategy χ characterized by the triple (t_0,t_1,X) where $t_1 < t_2$. Notice that the trade speed of the strategy χ equals $\frac{X}{t_2-t_1}$. It is assumed that

$$1-\gamma+\mu t-\beta\frac{X}{t_2-t_1}>0 \tag{2}$$

and the expected trade price at time $t\in(t_1,t_2)$ is given as follows:

$$E(S_t)=\begin{cases} S_0(1-\alpha+\mu t) \text{ for } \dfrac{X}{t_2-t_1}\le v \\ S_0\left(1-\gamma+\mu t-\beta\dfrac{X}{t_2-t_1}\right) \text{for} \dfrac{X}{t_2-t_1}>v \end{cases}, \tag{3}$$

where α,β,γ are the nonnegative constants.

According to (3), if the trade speed doesn't exceed the level v, the trade cost is proportional to the stock price S_0 with the constant of proportionality equal to α. Moreover, by (3) it follows that if the velocity of trade is greater than v, then the cost of trading is the sum of the part proportional to the stock price S_0 with the proportionality constant equal to γ, and the part proportional to the speed of the trade with the constant of proportionality equal to β.

The meaning of the inequality (2) is clear in view of (3): if (2) holds then the negative and zero values of the expected trade price are excluded. The existing of the parameter α in the model implies that transaction cost can be paid even if the market impact effect is not affecting the stock price.

The constraint (2) is imposed in order the expected trade price of execution of the strategy χ to be positive for each trading moment from the interval (t_1,t_2).

It assumed that:

$$1-\alpha+\mu T>0 \tag{4}$$

and

$$1-\alpha = 1-\gamma-\beta v\,. \tag{5}$$

The inequality (4) implies that there exists a trading velocity such that it is possible to have a positive expected trade price for each trading moment from the interval $[0,T]$. The inequality (5) is for the expected trade price to be a continuous function of the trade speed for a fixed trading moment.

TIHE STOCK SALE OPTIMIZATION

Let $EA(\chi)$ symbolize the expected amount of money obtained by executing the strategy χ. The following formula holds:

$$EA(\chi) = \frac{X}{t_1 - t_0}\int_{t_0}^{t_1} E(S_t)dt\,. \tag{6}$$

Denote the selling strategy that maximizes $EA(\chi)$ by χ^*. By (3), (6) and by the fact that he drift is negative it follows that for the selling strategy χ, which maximizes $EA(\chi)$, the sale starts from the moment 0, which means that $t_0 = 0$. Consequently, by (3) and (6) the strategy χ^* is obtained by values of t_1 and X such that $EA(\chi)$ is maximized.

Let the function φ of two variables t_1 and X be defined as follows:

$$\varphi(t_1, X) = \begin{cases} S_0\left((1-\alpha)X + \dfrac{\mu t}{2}X\right) \text{for} \dfrac{X}{t_1} \le v \\ S_0\left((1-\gamma)X + \dfrac{\mu t}{2}X - \dfrac{\beta}{t_1}X^2\right) \text{for} \dfrac{X}{t_1} > v \end{cases}. \tag{7}$$

The strategy χ^* is obtained by determining the values of t_1 and X maximizing the function φ with the constraints:

$$0 \le t_1 \le T\,, \tag{8}$$

$$0 \le X \le Y\,, \tag{9}$$

$$1-\gamma+\mu t_1 - \beta\frac{X}{t_1} > 0\,. \tag{10}$$

However, for the pair (t_1, X) maximizing the function φ with the constraints (8) and (9) the constraint (10) is also satisfied. Therefore, the problem of determining the selling strategy χ^* is solved by finding the values t_1 and X maximizing the

function φ with the constraints (8) and (9). Denote by t^*_1 and X^* the moment of the end of the sale for the strategy χ^* and the number of the stock shares sold for the strategy χ^*, respectively.

Let τ denote the function of X such that $\tau(X)$ is the value of t_1 which maximizes the function φ with the constraint (8) and X as the parameter. Moreover, let η denote the function of X defined as follows:

$$\eta(X) = \varphi(\tau(X), X). \tag{11}$$

The problem of finding X^* is solved by finding the maximum of the function $\eta(X)$ with the constraint (9) and the value of t^*_1 equals $\tau(X^*)$.

In order to determine the strategy χ^*, three cases will be considered.

1. $\beta \geq \frac{1}{2v}\left(1-\gamma+\frac{\mu T}{2}\right)$

Then,

$$X^* = \min(vT, Y), \tag{12}$$

$$t^* = \frac{X^*}{v}. \tag{13}$$

2. $\beta \leq \frac{1}{2v}\left(1-\gamma+\frac{\mu T}{2}\right)$ and $-\mu T \leq \frac{2}{3}(1-\gamma)$.

Then,

$$X^* = \min\left(\frac{T}{2\beta}\left(1-\gamma+\frac{\mu T}{2}\right), Y\right), \tag{14}$$

$$t^* = \begin{cases} T \text{ for } X^* > Tv \\ \dfrac{X^*}{v} \text{ for } X^* \leq Tv \end{cases}. \tag{15}$$

3. $\beta \leq -\frac{\mu T}{2v}$ and $-\mu T \geq \frac{2}{3}(1-\gamma)$.

Then,

$$X^* = \min\left(-\frac{2}{\mu\beta}\left(\frac{1-\gamma}{3}\right)^2, Y\right), \tag{16}$$

$$t^* = \begin{cases} \sqrt{-\dfrac{2\beta X^*}{\mu}} \text{ for } X^* > -\dfrac{2\beta v^2}{\mu} \\ \dfrac{X^*}{v} \text{ for } X^* \le -\dfrac{2\beta v^2}{\mu} \end{cases}. \tag{17}$$

NUMERICAL EXAMPLE

In this section the following values of the parameters T, S_0, Y γ and v are used in computations: for $T = 0.125$, $S_0 = 1$, $Y = 0.5$, $\gamma = 0.05$, and $v = 0.1$. The number of the stock shares Y is expressed as the fraction of the average traded volume of the stock in the interval $(0,1)$. Thus, the market participant has 0,5 of the average traded number of the stock shares in the interval $(0,1)$. The considered values of the model parameters in this example are within of the reasonable choices to the exemplary calculations.
In Table 1 there are computed the values of X^* for 180 pairs of (β, μ).

Table 1. The number of the stock shares to sell for the strategy maximizing the expected amount of money from selling the stock of the market participant

β \ μ	-5.00	-4.50	-4.00	-3.50	-3.00	-2.50	-2.00	-1.50	-1.00
0.01	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
0.02	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
0.03	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
0.04	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
0.05	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
0.06	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
0.07	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
0.08	0.498	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
0.09	0.443	0.464	0.486	0.500	0.500	0.500	0.500	0.500	0.500
0.10	0.398	0.418	0.438	0.457	0.477	0.496	0.500	0.500	0.500
0.11	0.362	0.380	0.398	0.415	0.433	0.451	0.469	0.487	0.500
0.12	0.332	0.348	0.365	0.381	0.397	0.413	0.430	0.446	0.462
0.13	0.306	0.322	0.337	0.352	0.367	0.382	0.397	0.412	0.427
0.14	0.285	0.299	0.313	0.326	0.340	0.354	0.368	0.382	0.396

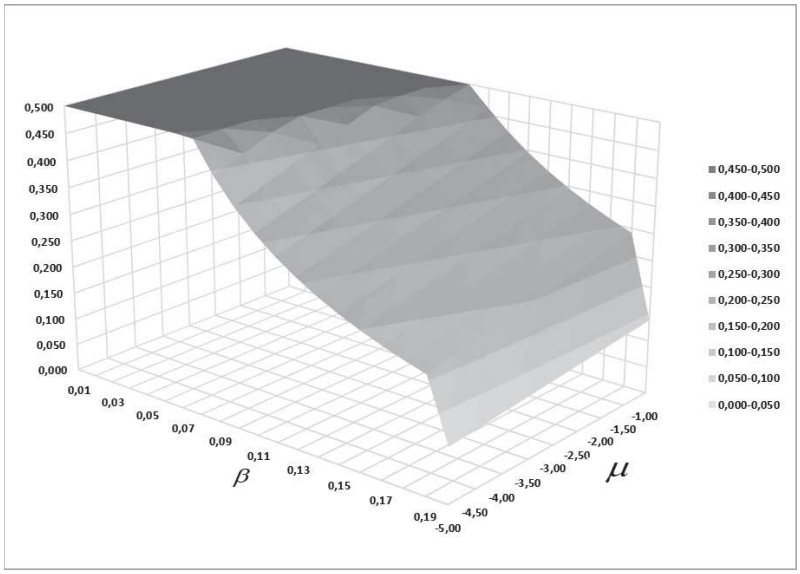
Table 1. (continued)

β \ μ	-5.00	-4.50	-4.00	-3.50	-3.00	-2.50	-2.00	-1.50	-1.00
0.15	0.266	0.279	0.292	0.305	0.318	0.331	0.344	0.357	0.370
0.16	0.249	0.261	0.273	0.286	0.298	0.310	0.322	0.334	0.347
0.17	0.234	0.246	0.257	0.269	0.280	0.292	0.303	0.315	0.326
0.18	0.221	0.232	0.243	0.254	0.265	0.276	0.286	0.297	0.308
0.19	0.210	0.220	0.230	0.241	0.251	0.261	0.271	0.282	0.292
0.20	0.100	0.104	0.109	0.114	0.119	0.124	0.129	0.134	0.139

Source: own computation

In Figure 1 it is shown how the value of X^* depends on the parameters β and μ.

Figure 1. The values of X^* depending on β and μ



Source: Table 1 and own preparation

Table 2 contains the results of computing the values of the expected amount of money obtained by executing the strategy χ^* for 180 pairs of (β, μ).

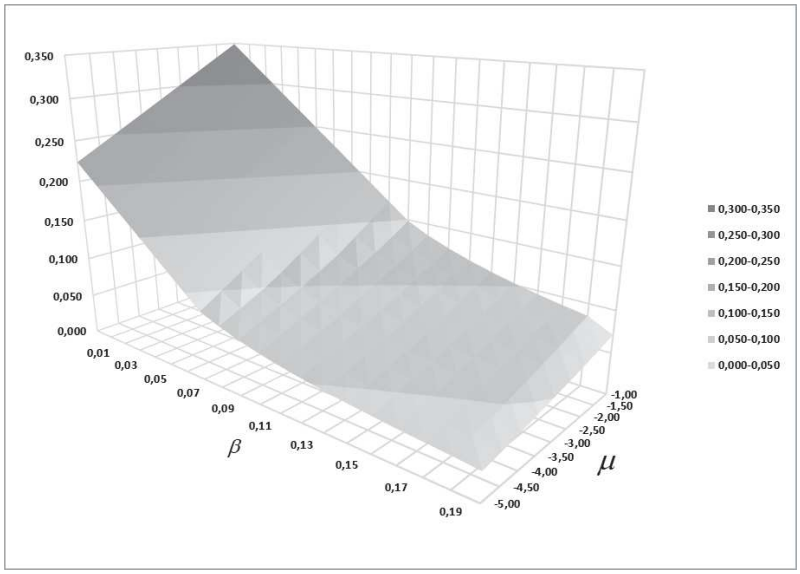
Table 2. The expected amount of money from executing the strategy χ^* by the market participant

β \ μ	-5.00	-4.50	-4.00	-3.50	-3.00	-2.50	-2.00	-1.50	-1.00
0.01	0.224	0.239	0.255	0.271	0.286	0.302	0.318	0.333	0.349
0.02	0.204	0.219	0.235	0.251	0.266	0.282	0.298	0.313	0.329
0.03	0.184	0.199	0.215	0.231	0.246	0.262	0.278	0.293	0.309
0.04	0.164	0.179	0.195	0.211	0.226	0.242	0.258	0.273	0.289
0.05	0.144	0.159	0.175	0.191	0.206	0.222	0.238	0.253	0.269
0.06	0.124	0.139	0.155	0.171	0.186	0.202	0.218	0.233	0.249
0.07	0.104	0.119	0.135	0.151	0.166	0.182	0.198	0.213	0.229
0.08	0.084	0.099	0.115	0.131	0.146	0.162	0.178	0.193	0.209
0.09	0.075	0.086	0.097	0.111	0.126	0.142	0.158	0.173	0.189
0.10	0.067	0.077	0.088	0.099	0.110	0.122	0.138	0.153	0.169
0.11	0.061	0.070	0.080	0.090	0.100	0.111	0.123	0.135	0.149
0.12	0.056	0.064	0.073	0.082	0.092	0.102	0.113	0.124	0.136
0.13	0.052	0.059	0.067	0.076	0.085	0.094	0.104	0.114	0.125
0.14	0.048	0.055	0.063	0.070	0.079	0.087	0.097	0.106	0.116
0.15	0.045	0.051	0.058	0.066	0.073	0.082	0.090	0.099	0.109
0.16	0.042	0.048	0.055	0.062	0.069	0.077	0.085	0.093	0.102
0.17	0.040	0.045	0.051	0.058	0.065	0.072	0.080	0.088	0.096
0.18	0.037	0.043	0.049	0.055	0.061	0.068	0.075	0.083	0.091
0.19	0.035	0.041	0.046	0.052	0.058	0.064	0.071	0.078	0.086
0.20	0.033	0.037	0.041	0.046	0.050	0.055	0.060	0.066	0.072

Source: own computation

In Figure 2 it is shown how the value of $EA(\chi^*)$ depends on the parameters β and μ.

Figure 2. The values of the expected amount of money from executing the strategy χ^* depending on β and μ



Source: Table 2 and own preparation

From the considered numerical computations it can be seen that the market impact and the negative drift in the price of the stock may negatively influence the financial profit of selling the shares of the stock.

SUMMARY

In the article the model of the market with the market impact, transaction costs and the drift in the stock price is considered. In a framework of this model, the stock sale strategy which maximizes the expected amount of money obtained from selling the market participant's shares of the stock with the constraint of constant trading velocity is determined. From the numerical computations included in the article it can be concluded that the market impact and the drift in the price of the stock may significantly affect the financial profit of investing in the stock market.

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ANALYSIS OF NOVEL FEATURE SELECTION CRITERION BASED ON INTERACTIONS OF HIGHER ORDER IN CASE OF PRODUCTION PLANT DATA[1]

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Abstract: Feature selection plays vital role in the processing pipeline of today's data science applications and is a crucial step of the overall modeling process. Due to multitude of possibilities for extracting large and highly structured data in various fields, this is a serious issue in the area of machine learning without any optimal solution proposed so far. In recent years, methods based on concepts derived from information theory attracted particular attention, introducing eventually general framework to follow. The criterion developed by author et al., namely IIFS (Interaction Information Feature Selection), extended state-of-the-art methods by adopting interactions of higher order, both 3-way and 4-way. In this article, careful selection of data from industrial site was made in order to benchmark such approach with others. Results clearly show that including side effects in IIFS can reorder output set of features significantly and improve overall estimate of error for the selected classifier.

Keywords: feature selection, Interaction Information Feature Selection, interactions of higher order, filter methods, information theory

JEL classification: C13, C14, C38, C44, C52

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INTRODUCTION

Nowadays, there exist multiple cases when applying feature selection to data is of critical importance – to name a few: computer vision [Zhang et al. 2018], genomic analysis [Xing et al. 2001] and natural language processing. In the context of machine learning this is an essential problem, which should be addressed at the very beginning in order to improve interpretation of a given model. Another advantage of using dimensionality reduction is a superior ability to estimate quantitatively hidden relations in data between inputs and the output. In real-life applications simplified models are often better than others, in particular they predict unseen data with lower prediction errors. Furthermore, models with decreased complexity usually take shorter time to optimize and deploy.
One of promising approaches for dealing with feature selection is set of methods based on mutual information. In particular, it is highly desirable to use such tools when there may exist complex, possibly nonlinear, dependencies in data. Due to the fact that every information-theoretic criterion belongs to a group of independent filters, no assumption of specific predictive model is made within the feature selection process. Mutual information methods have already showed successful application to classification and regression tasks.
The goal of this study is twofold – to present up-to-date overall framework for feature selection problem from the point of view of information theory and to benchmark recent achievement in the field, i.e., IIFS criterion, against one of typical business cases. In this article the proposed structure is as follows. Section „Related work" describes similar findings and introduces most common criteria based on information theory, i.e., CIFE, JMI, MIFS and MRMR. Next section „Selected data" shows the sensor data acquired from the wine factory which presents the reader a practical example of the problem. In section „Empirical study" we conduct a series of experiments including benchmark of methods for feature selection. Finally, obtained comparative outcomes are depicted in a later section „Results of research method" with closing remarks in section „Summary".

RELATED WORK

In this article we consider sequential forward feature selection methods as iterative processes. Let F be a full set of available features and S an empty output set. In each step one can compute the score for every candidate according to chosen criterion. The winning feature is usually found as one with the highest score. Afterwards, best candidate is subtracted from F and added to S. Due to this fact, such methods follow greedy approach,seeking for (sub)optimal solution in reasonable amount of time. To the best of authors' knowledge, there is minimal research devoted to heuristics proposal decreasing amount of computational burden in information-theoretic criteria.

CIFE (Conditional Infomax Feature Extraction) [Lin, Tang 2006] is using following metrics

$$J_{CIFE}(X_k) = MI(X_k, Y) + \sum_{j \in S}\left[MI\left(X_j, X_k|Y\right) - MI\left(X_j, X_k\right)\right]. \quad (1)$$

Here and in later criteria, X_k denotes candidate feature, which currently belongs to F and Y target variable. First term is responsible for evaluation of main effect: mutual information between analyzed feature and given output. Second compound term considers how much information would be added after selection of certain candidate with respect to previously chosen features, when condition on target is introduced.

JMI (Joint Mutual Information) [Yang, Moody 1999] is criterion expressed as

$$J_{JMI}(X_k) = |S|MI(X_k, Y) + \sum_{j \in S}\left[MI\left(X_j, X_k|Y\right) - MI\left(X_j, X_k\right)\right]. \quad (2)$$

Note that CIFE and JMI differ slightly only in the first term. Authors argued that for providing variability of main effect during appropriate selection process a multiplication factor is needed. Therefore, |S| represents cardinality of set in this case, which gives basic intuition of lowering second compound term influence in favor of the main effect in further algorithm iterations.

MIFS (Mutual Information Feature Selection) [Battiti 1994] has form of

$$J_{MIFS}(X_k) = MI(X_k, Y) - \sum_{j \in S} MI\left(X_j, X_k\right). \quad (3)$$

This is one of the simplest, yet very popular method, which does not incorporate complex dependencies on target variable (cf. equation 1). Author assumed that for current selection of best feature there is important need to reduce relevancy term expressed as $MI(X_k,Y)$ by redundancy term over already selected features. It can be seen as a penalization of main effect when introducing new candidate does not improve overall information gain due to dependencies with earlier chosen features.

MRMR (Minimum-Redundancy Maximum-Relevance) [Peng et al. 2005] is presented as

$$J_{MRMR}(X_k) = MI(X_k, Y) - \frac{1}{|S|}\sum_{j \in S} MI\left(X_j, X_k\right). \quad (4)$$

Here, main modification related to redundancy term was proposed. When the selection process proceeds further it is more difficult to find relevant features, thus, setting scaling factor to reciprocal of |S| increases influence of main effect. Observe that in equation 3 we had also factor equal to 1.

IIFS (Interaction Information Feature Selection) [Pawluk et al. 2019], the major contribution in recent research of feature selection, states such task in following way

$$J_{IIFS}(X_k) = MI(X_k, Y) + \sum_{j \in S} II\left(X_j, X_k, Y\right) + \sum_{i,j \in S: i<j} II\left(X_i, X_j, X_k, Y\right). \quad (5)$$

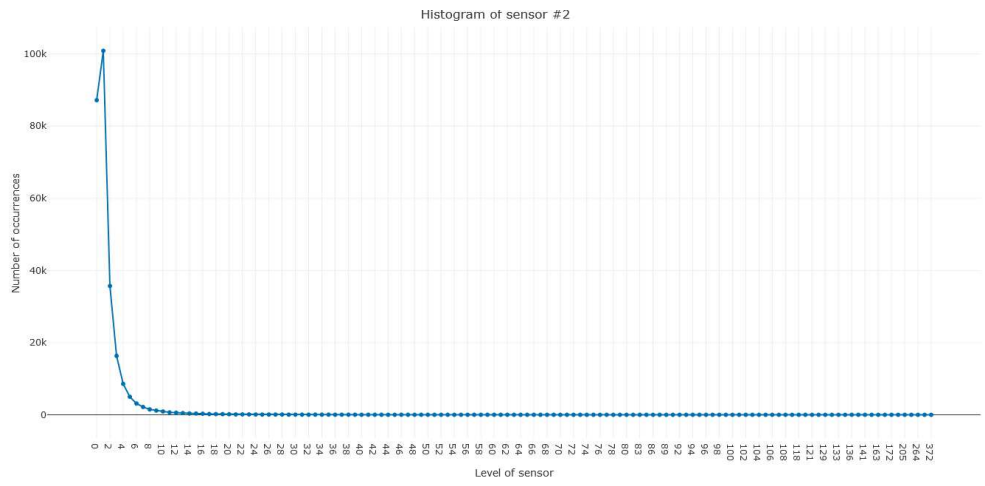
We introduced novel concept in term of feature selection – m-way interaction information of order m>3 [cf. Jakulin, Bratko 2004]. Remaining part of criterion is after basic transformations equivalent to equation 1.

Our goal was to explore higher order interaction term, which would take account of feature pairs in S, X_k and Y, whether it improves approximation of final score. Experiments showed that IIFS criterion obtained competitive results with traditional methods (CIFE, JMI, MIFS, MRMR) and can be successfully used in real-world scenarios. We believe that interaction term of high order might exist in complex dataset, such that IIFS criterion can address this case at the cost of increased amount of complexity. For the purpose of clarification, simple positive 3-dimensional interaction is XOR problem, when Y does not depend on X_1 and X_2, marginally, but jointly on the cartesian product of $X_3=(X_1 \times X_2)$. In this situation if we assume X_1 and X_2 are binary output variables and $Y=XOR(X_1, X_2)$ is binary output variable, then mutual information terms are as follows: $MI(X_1,Y)=0$, $MI(X_2,Y)=0$ and interaction information: $II(X_3, Y)=\log(2)>0$.

SELECTED DATA

For purpose of later experiment, data from the wine factory were acquired. During the process of alcohol production the sensors located in various points recorded concentration of components, sending independently information in a uniform format. We assumed that obtained input variables had the meaning of specified levels (categorical type) and denoted individual substances. Additionally, the target was set to binary variable (0/1 – bad/good wine quality according to sommelier's grade). We received approximately 150-200 thousands of observations with 14 unknown features registered. One remark related to all distributions of sensors was their common charactistics. In Figure 1 we depict histogram of selected sensor, which is skewed right.

Figure 1. Distribution of sensor #2



Source: own elaboration

EMPIRICAL STUDY

We conducted experiment in following configuration [cf. Brown et al. 2012]. At the beginning, inputs were discretized according to equal-frequency binning with 2 bins before process of feature selection. Evaluation of methods for dimensionality reduction was made using 20% hold-out set: data were divided into two subsets, each having 80% and 20% of observations, respectively. Afterwards, we employed criteria described in previous section using former sample. The size of such set was suitable for case of feature selection, because of common approach for information-theoretic techniques. These algorithms at the lowest level compute measure of entropy, which relies strongly on frequency counts if plugin estimator is chosen. In detection of most informative subset of sensors the number of inputs up to 13 was considered, i.e., we ran processing scenario with selection of 13 output features for each considered criterion. Subsequently, latter sample was utilized to assess performance of selected classification model for currently obtained set of output features having cardinality from 1 to 13. Firstly, we used simple kNN classifier with 3 neighbors, due to the fact that such method does not make any assumption on data without depending on particular criterion. Furthermore, this model is based on similarity function of euclidean distance. According to kNN classifier, we have increased chance of improvement for model evaluation when input dataset consists in only relevant features without redundant ones. Following this approach, value of used metrics can be competitive to other models metrics (including cases when models are complex units), showing that kNN is simple, yet fast and effective alternative to them (we recall ockham's razor as widely adopted way of thinking). Secondly, all subsets of features were applied to 10-fold cross-validation scheme in order to estimate classifier's error in more robust way. Finally, estimation of model's error was done based on metrics capable of dealing with imbalanced data, i.e., Balanced Error Rate (BER) [Tharwat 2018]

$$BER = 1 - 0.5 \cdot (specificity + sensitivity). \tag{6}$$

Here, specificity and sensitivity are true negative rate (proportion of all negatives that are correctly predicted as such) and true positive rate (similarly, proportion of all positives that are correctly predicted as such), respectively, and have forms of

$$specificity = \frac{TN}{N} = \frac{TN}{TN+FP}, \tag{7}$$

$$sensitivity = \frac{TP}{P} = \frac{TP}{TP+FN}. \tag{8}$$

Table 1 explains above measures in more detail and presents confusion matrix.

Table 1. Example of confusion matrix

	True positive condition	True negative condition
Predicted positive condition	TP = true positive	FP = false positive
Predicted negative condition	FN = false negative	TN = true negative

Source: own elaboration

RESULTS OF RESEARCH METHOD

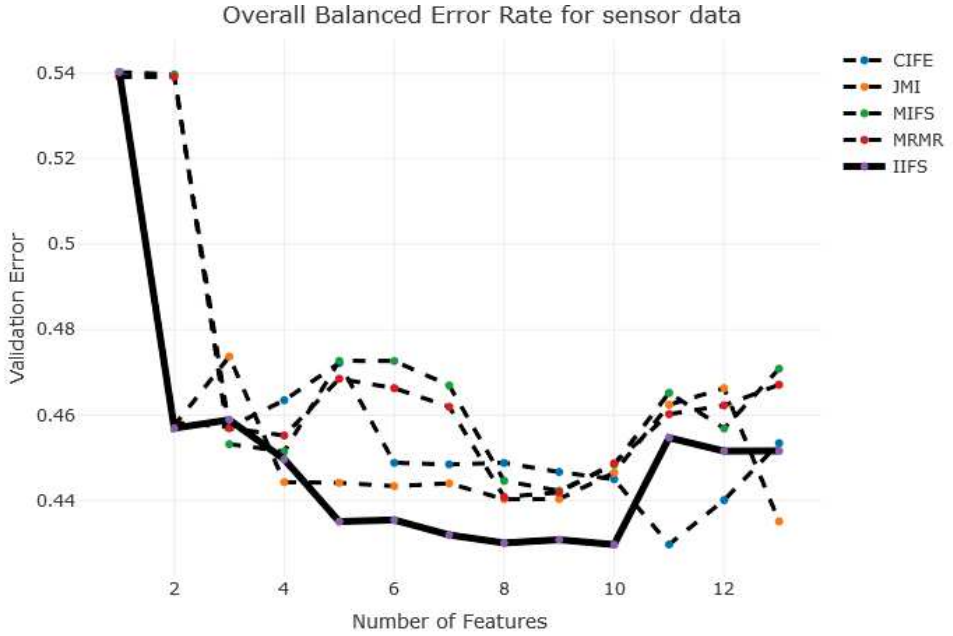
Final results of study are depicted in Table 2 and plotted in Figure 2, respectively.

Table 2. Values of errors for CIFE, JMI, MIFS, MRMR and IIFS

Criterion	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13
CIFE	0.540	0.458	0.457	0.463	0.472	0.449	0.448	0.449	0.447	0.445	0.430	0.440	0.453
JMI	0.539	0.458	0.474	0.444	0.444	0.443	0.444	0.440	0.440	0.447	0.462	0.466	0.435
MIFS	0.540	0.540	0.453	0.452	0.473	0.473	0.470	0.445	0.442	0.448	0.465	0.457	0.471
MRMR	0.539	0.539	0.457	0.455	0.469	0.466	0.462	0.441	0.442	0.449	0.460	0.462	0.467
IIFS	0.540	0.457	0.459	0.450	0.435	0.435	0.432	0.430	0.431	0.430	0.455	0.452	0.452

Source: own elaboration

Figure 2. Plots of errors for CIFE, JMI, MIFS, MRMR and IIFS



Source: own elaboration

In Table 2 we summarized errors' estimates for analyzed feature selection criteria and marked region of interest for IIFS, whose values are superior to other methods. Note that, Balanced Error Rate seems to be lowest not only in a range from 5 to 10, inclusively, but also beyond such range. When number of features is smaller than 5 all techniques work in similar way and IIFS does not fail at all. For case of numbers of inputs greater than 10, only CIFE presents better results, but the reduction of features is slight here and selection of these subsets is not reasonable.

In Figure 2 we depicted plot for analyzed feature selection criteria to show methods' behavior in visual way. It can be stated that the most encouraging trend is of IIFS ownership and all other methods cannot overcome its quality.
Summing up, there is a significant improvement of IIFS compared to remaining criteria for subsets having number of features from 5 to 10. This follows the basic assumption of strong need to address interactions existence of higher order in data, therefore, proposed criterion takes full advantage of own approach and includes them in decisive process. Consequently, overall performance is clearly better when using IIFS than other competitors. In such case, BER increases and traditional criteria cannot be used efficiently.

SUMMARY

Summing up, the analysis of real data showed undoubtedly that IIFS criterion works very well in case of complex data, which exhibits interdependent nature. However, tradeoff between complexity and accuracy needs to be examined, because calculation of high-order interactions involves considerable resources. On the other hand, if there are no specific requirements, it is recommended to follow IIFS approach when feature selection is of particular interest. This way, one can obtain better overall results in model development, allowing to be more successive in business scenarios.

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COST ESTIMATION USING ECONOMETRIC MODEL FOR RESTAURANT BUSINESS

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Abstract: Study is aimed to develop an econometric model to estimate the cost of the restaurant business in Erbil city of Kurdistan. Restaurant food is costly in Erbil city as a common opinion of consumers. Restaurants are also struggling to make the business sustainable. A basic assumption considered to evaluate all cost factors and to establish an equation to get the clarity of cost estimation and check it with sales of the business. So the research questions formulated as what are different cost factors involve with the restaurant business, which cost is the most important to consider having the significant impact on the business, and what can be the standard econometric model to incorporate cost factors? A sample of 215 restaurants has been taken as the representative of industry. Variables and data get feed in the SPSS software for the analysis. Five dimensions of cost structure from cost namely Prime Cost, Works Cost, Cost of Production, Cost of Sales and Sales has been taken in study. Conclusion of the research based on the data analysis shoes that Prime Cost is the least important, Works Cost has the negative trend shows that there is increase in Sales will have the huge fall in Works Cost, increasing Sales has the small increase in Cost of Production, Cost of Sales is under question. Finally an econometric equation model is presented assuming the standardized equation for this specific case.

Keywords: restraurant, food, econometric, cost, sales

JEL classification: C10, L21

INTRODUCTION

Cost is one of the most important factor for establishing a sustainable business. During the entire life cycle of the business, it must get cared in terms of

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cost to keep it financially viable. The current research is the exploration of different cost variables involved with the restaurant business and the cost estimation is getting performed in this industry by the mid-range of players stated by the research of Singh and Azad [2019]. Food is among the most important basic needs of human being. When we consider Kurdistan, people are influenced with different culture all around the world and mostly from Turkish a very rich food culture. Though it is not limited only to Turkey, having all Asian food from India, Pakistan and China. Arabic and Kurdish people are very fond of eating in restaurants and they are very frequent visitor to different restaurants in the city as well out of the city [Singh 2018]. During the exploration of literature on the successful restaurant business models many concepts came to the picture, which created the inquest to analyze and understand the need for the development of model for the cost estimation. Restaurant is a very cost intensive business and needs to care for hygiene and quality in a very particular manner to keep the food healthy and consumers satisfied [Singh 2017]. Food or the menu of offerings is not only the criteria decides the success of a restaurant rather it is composed of many factors leading to satisfaction of the consumer and makes the feel to visit again a and again to that specific restaurant.

All the satisfaction factors must meet the consumer desires in satisfying expectations, if it does not reach the level then will turn as a failure where the customer will visit once then will never take a look on turn and will have a negative word of mouth by Singh and Hamadamin [2019]. Restaurant business sustainability is depends on many factors like attitude of employees and service providers, communities they belong and lifestyles the carry. Though the food is the core of the business and a major responsibility goes to the chef responsible for kitchen. A small change in process or effort will lead to a big difference. Production plays another critical role in the whole process of the cost and profitability to keep the business viable [Singh, Sahin 2017]. Production sheets must get used as to keep the record of quantity of food produced and quantity of raw materials consumed. The specific way cooks prepare the food and following up the specifications also effects the cost of food and operation. Following the specifications and being aligned with the guidelines can take it to the higher level of success. Management involvement is also very important to make the business successful, it is important to know the back of the office execution that incurs huge cost. Another important issue is the control on staff, wastage and right distribution of all resources. Staffs are assets in the restaurant business but it can turn to a higher cost if not tackled properly and systematically, an organized, transparent and visible management has a better control over cost in the business.

For a successful restaurant business managers should keep themselves keen to cost issues lead by food quality, cleanliness and sanitation. A promised service is depending upon the capacity of the service provider and the commitment towards services that makes any service reliable. Restaurants characterizes themselves as the reliable, fair prices, timely food delivery and maintain the quality [Sahin, Singh

2017]. Another a better way for managers to keep the eye on operations by checking the costs on a routine basis, mostly the food and beverages which leads to wastage, and the labor costs that is one of the performance indicators of the industry. There are different approaches to calculate the food cost which can be daily or hourly basis but should have a careful monitoring mechanism. Food and beverages cost generally is calculated as the cost of food sold divided by food sales within specific time frame. Highest cost in this industry is the labor cost which gets calculated by dividing the total labor cost by the total of food and beverages ales.

LITERATURE REVIEW

The study on Morocco cereal consumption has shown the price elasticity and expenditure elasticity as the base of consumption [Essaten, Mekki & Serghini 2018]. Though the study gives the deeper insight on the expenditure which is the strongest determinant of viability of the project said by Mohinta, Singh and Mishra [2017]. The outcome of the study has the discussion on the theory advocating that the food goods are having inelastic demand. The study by Essaten, Mekki & Serghini [2018] says that the market is highly price sensitive and may be a reason for this is the consumer understanding and changing regulatory issues on consumables. Another study in Nigeria having the concentration on the development of long term relationship between the agricultural credit support and food security [Osabohien, Godwin 2018]. The cost in agriculture sector is very high, being much of the hidden cost and not being visible in the picture, understanding gets much critical by Sahin and Singh [2018]. There are only two types of credits available here commercial banks credit to farmers and the agricultural guarantee scheme, which are not enough to have the complete understanding and the elaboration for the cost structure. Study by Osabohien and Godwin [2018] shows very clearly that there is a huge cost of being failed in the lack of skills and understanding of the right process [Singh, Sahin 2019].

Many research existing have the cost variable exclusive strategic variable responsible for the viability of the firm. The economic models development can have fruitful outcome capturing the fact of the need of cost calculations [Dube et al. 2002]. Such models will have more realistic picture and can provide the competitive edge for a firm. Economic models benefit organizations in expanding and establishing new dimensions for business expansion. Econometric modeling can document the effects and causes of variables especially in the area of market predictions. A study by Erdem and Keane [1996] has developed a model for the consumer choice effecting pricing strategy which can lead to the cost of the firm. Research taken by Dube et al. [2002] says a forward looking approach is developed for the establishment of competitive price considering the cost actor get kept under control. Structural modelling has its contribution in a vast scope of the study for establishing the market in the dynamic business environment. One of the research as the case study in restaurant business suggests that though the profit can be more

in the restaurant business but it is not returning a high profit because of the higher cost. A huge money goes as the cost in the industry, it is the case with most of the restaurants. A high cost involved because of competitiveness and to enhance the credibility. A restaurant can have the business and can have the high profit only having these two ways are cost management and efficiency improvement [Singh, Sahin 2017]. But mostly success of the business depends upon the cost base and a sound cost structure. Many food businesses have worked on the cost reduction at the time of economy downturn to keep the business viable [Singh, Mishra and Mishra 2014].

Research conducted by Singh [2017] contributes to the econometric model development based on the consistence of economic theory. The empirically tested model is consistent with variables of the economy aggregating with changing micro and macro parameters. The application of empirical data and model is estimating the demand in the economy. Study says that the data economic model must fitting with established theory justifying effects. Additionally the research says that the many variables are eliminated from the equation as the error term (Sahin and Singh 2017]. There are many research examined on the food demand [Dhehibi, Gil 2003; Sheng et al. 2008; York, Gossard 2004] representing traditional theoretical models shows the Almost Ideal Demand System (AIDS) model and its variations, Rotterdam, Working's models and Linear Expenditure System(LES) model. Simultaneous equation model (SEM) is not applicable when the price and quality is jointly evaluated. The most important cost in the restaurant business is the cost of quality, as defined by the quality management literature is the nonconformance of stated standard which is the failure cost [Schiffauerova & Thomson 2006]. Cost of quality explained in other words as total resources used by the organization under the quality standards having the consistency of performance [Bamford, Land 2006]. The cost of quality model is a preventive model represents the cost factors in different industry where it is very effective in hospitality industry [Weisinger et al. 2006]. Operations management principles advocates the restaurant business needs to have a very high quality of service that creates the customer value on a long run and business get the cost reduced and profitability increased [Bohan, Horney 1991]. The needful quality of the service can get improved vice-versa with the consideration of cost of quality with the continuous practice of improvements in required customer satisfaction standards [Kandampully et al. 2001].

Another research throws light on the short run costs importance for an organization to be profitable on a long run. For this the regulation and technical strength will be the most important issue [Sahin, Singh 2017]. A model named translog model indicating the features of incremental production costs which are more important for any firm facing challenges with standards and regulations. The change in economy effects the change in cost for a firm due to varying conditions. It is always suggested to companies to avoid to entering higher cost markets and more consideration should go to expenses. Innovation is the tool for the success

today for all the business to grow wherever it applied [Singh, Sahin 2019]. Though it is behind the curtain but needs to get a higher consideration for the establishment of a balanced cost system [Hjalager 2010]. The process innovation includes many activities like food and service technologies speeding up the cooking process, saving in the energy and labor, reduced waste production and better sanitation all together improving the cost performance [Rodgers 2007]. The innovation is contributing in maintaining the satisfaction level of customers with changing and diverse socio economic structure with strengthening the competition discussed by Cura, Singh, and Talaat [2017]. Marketing innovation is the area where the business should focus more diversifying the business orientation towards the market orientation. It can have the higher cost for the time being but will be the investment and will benefit the business on the long run.

RESEARCH PROBLEM

Though the business models are always presented considering the specific objective. Mostly the business models presented considering the profit and expenses. Many business models have been presenting with the derivation of cost factor stated by Singh and Mishra [2013]. Restaurant business is a very high cost intensive business where the fixed cost can be comparative lesser than the variable cost but the variable cost is generally much higher that leads to the many challenges for the business to be sustainable [Singh 2017]. During the literature study it is observed that there is not very sound study done which can be he base for the cost factor understanding and evaluation for a common person willing to understand the cost structure equation for the restaurant business. So extensive literature review showed the research gap as the need to develop an econometric model that can evaluate and justify the cost variables in the restaurant business mostly responsible for making the business viable.

Research Questions

- What are different cost factors involve with the restaurant business?
- Which cost is the most important to consider having the significant impact on the business?
- What can be the standard econometric model to incorporate cost factors?

Research Objectives

- To explore different cost variables in restaurant business.
- To find the importance of different cost factors with restaurant business.
- To develop an econometric model for standardizing the cost factor in restaurant business.

Research Methodology

Research presented here is quantitative study and based on deductive approach of variables. Financial concept has been considered as the variable where the cost structure of the restaurant has got the most important consideration, the study has worked to establish the equation for generic cost structure equation presentation [Singh 2017]. The cost structure variables are main indicators for establishing the relationship. A standard questionnaire is prepared for this specific study considering the agreement of restaurants on different variables. Conceptual clarity and understanding has been established based on extensive literature review from secondary sources. Questionnaire became the tool to collect primary data for the analysis. Descriptive research is presenting descriptive data analysis for the basic understanding of study by Singh and Mishra [2015]. A sample of 215 restaurants has been taken as the representative of industry. Variables and data get feed in the SPSS software for the analysis. Conceptualization itself has given the clarification for statistical testing, the data analysis has established the econometric model showing the cost variables relationship with the sales of the restaurant. Conceptually the cost sheet of accounting carries five dimensions namely Prime Cost, Works Cost, Cost of Production, Cost of Sales and Sales to calculate the complete cost structure. Here in this study an instrument is used to get the data and compressed it in a scale format considering the process for standardizing the absolute values.

ANALYSIS AND FINDINGS

Analysis is performed taking all variables in consideration, where the Cost and sales relationship is assessed with all cost dimensions [Singh, Mishra 2014]. Each test has different outcomes which has been formulated as equation for better understanding of the concept by Singh [2017]. Altogether thirteen regression analysis has been performed each factor has three sets of test, so four factors are forming twelve tests and the last test is performed as the outcome of the independent (Prime Cost, Works Cost, Cost of Production and Cost of Sales) variable to the dependent (Sales) variable final outcome.

The first test performed for assessing the Prime cost with its constituents where constituents are five in number considered for this specific case where all are showing very low value of contribution as shown as *Equation 1.1* below.

Equation 1.1 - Prime Cost with Constituents

$$Prime\ Cost = 2.331 + 0.2*PoRM + 0.2*PE + 0.2*RMC + 0.2*DWL + 0.2*DC,$$

where:
PoRM - Purchase of raw materials,
PE - Purchase expenses,
RMC - Raw materials consumed,

DWL - Direct wages labor,
DC - Direct charges.

Further Prime Cost Constituent items are checked its contribution and effect on Sales which has some positive and negative contributions as shown below in *Equation 1.2.*

Equation 1.2 - Sales with Prime Cost Constituents

$$Sales = 3.901 + 1.116*PoRM - 0.079*PE + 0.575*RMC - 1.077*DWL - 0.605*DC.$$

Finally a test performed taking all Prime Cost Constituents together as Prime Cost which shows a negative value means the Prime Cost is reversely effecting Sales as *Equation 1.3* presented below.

Equation 1.3 - Sales with Prime Cost

$$Sales = 5.085 - 0.941 * Prime\ Cost.$$

Above three equations *Equation 1.1, Equation 1.2* and *Equation 1.3* are the representation of Prime Cost and its constituent effecting Sales. Observing these three equations the basic understanding can get formed on the importance of Prime Cost involved in the total cost structure commonly for restaurants in Erbil city.

The second set of analysis performed taking Works Cost and the same way executed as earlier testing the contribution of Works Cost. Below *Equation 2.1* is presented having the contribution of constituent items where it's much lower than earlier as well having the value of 0.125 shows all constituents are equally effecting in the formation of Works Cost.

Equation 2.1 - Works Cost with Constituents

$$Works\ Cost = 1.471 + 0.125*FR + 0.125*FP + 0.125*IW + 0.125*SS + 0.125*OS + 0.125*FI + 0.125*FAD + 0.125*WCI,$$

where:
FR - Factory rent,
FP - Factory power,
IW - Indirect wages,
SS - Supervisor salary,
OS - Office salary,
FI - Factory insurance,
FAD - Factory asset depreciation,
WCI - Works cost incurred.

Below shown *Equation 2.2*, presenting the effect of Works Cost Constituents on Sales to get an idea about the importance and contribution of items with the Sales

value, where some constituents are positive contributor though some are negative contributors to this specific equation.

Equation 2.2 - Sales with Works Cost Constituents

$$Sales = 1.309 + 0.292*FR - 0.283*FP + 0.382*IW + 0.411*SS - 0.797*OS + 0.876*FI - 0.526*FAD + 0.301*WCI.$$

The final equation of this set is formed as *Equation 2.3*, where the consideration is given to the final Works Cost dimension and its effect individually to the Sales value. The equation shows that Works Cost is a higher contributor to the cost and having positive impact on sales.

Equation 2.3 - Sales with Works Cost

$$Sales = 0.667 + 0.796*Works\ Cost.$$

Above presented three equations as *Equation 2.1, Equation 2.2* and *Equation 2.3* are representing the Works Cost effect on Sales and moreover the constituent items contribution to Works Cost a well to the Sales. It is giving a very straight assumption about the contribution of different cost constituents to Sales and its importance for this specific case.

The third set of equations framed taking Cost of Production, where the first equation framed as *Equation 3.1*, representing the constituent items contribution to the Cost of Production showing all items are equally contributing though the contribution is very weak and much weaker in overall consideration.

Equation 3.1 - Cost of Production with Constituents

$$Cost\ of\ Production = -2.276 + 0.143*OR + 0.143*AD + 0.143*GC + 0.143*AF + 0.143*BC + 0.143*HS + 0.143*OE,$$

where:
OR - Office rent,
AD - Asset depreciation,
GC - General charges,
AF - Audit fees,
BC - Bank charges,
HS - House salary,
OE - Office expenses.

Below shown *Equation 3.2*, showing the representation of Sales with Cost of Production constituent items measuring its effect on Sales. The specific case here is showing a mixed result some items are negatively though the positive value is very high positive contributor.

Equation 3.2 - Sales with Cost of Production Constituents

*Sales = 1.093 + 1.244*OR - 0.720*AD + 1.123*GC - 0.560*AF*

*- 0.625*BC + 0.709*HS - 0.464*OE.*

The third equation of this set is showing the effect of Cost of Production on Sales which is presented as *Equation 3.3*, where it is clearly visible that the Cost of Production is contributing a sound positive way to the Sales.

Equation 3.3 - Sales with Cost of Production

*Sales = 1.225 + 0.671*Cost of Production.*

Above presented three equations as *Equation 3.1, Equation 3.2* and *Equation 3.3* are presenting the contribution of Cost of Production to the Sales where three different equations presented showing the individual contribution, the constituent formation and the overall effect as a factor for the restaurant business in Erbil.

Fourth set of equations are formed considering Cost of Sales with its constituent items, where the *Equation 4.1*, showing its minimal contribution as the constituent items though the constant value is negative but the presentation is clear understanding of constituent items contribution in the formation of Cost of Sales.

Equation 4.1 - Cost of Sales with Constituents

*Cost of Sales = - 1.804 + 0.143*SMC + 0.143*SMS + 0.143*TE + 0.143*A*

*+ 0.143*DME + 0.143*ST + 0.143*BD,*

where:
SMC - Sales man commission,
SMS - Sales man salary,
TE - Traveling expenses,
A - Advertisement,
DME - Delivery man expenses,
ST - Sales tax,
BD - Bad debts.

Below presented *Equation 4.2*, is providing the understanding of the Cost of Sales items effect on Sales factor, where it is very clearly visible that some items are positively effecting the Sales though a few are negatively effecting Sales.

Equation 4.2 - Sales with Cost of Sales Constituents

*Sales = 1.059 + 0.144*SMC + 0.287*SMS + 0.059*TE + 1.669*A - 0.462*DME*

*- 1.136*ST + 0.192*BD.*

The third *Equation 4.3*, of this set is showing the contribution of the Cost of Sales overall on Sales, where the equation shows that Cost of Sales is positive

contributor to the Sales. Specific to the contribution of Cost of Sales is 0.763 times of the Cost of Sales.

Equation 4.3 - Sales with Cost of Sales

*Sales = 1.012 + 0.763*Cost of Sales.*

Above shown three equations *Equation 4.1*, *Equation 4.2* and *Equation 4.3* are representing altogether the Cost of Sales factor and its relationship with Sales dimension. Three equations have clearly depicted constituent's formation part, the effect of factor items and individual effect on the Sales dimension.

The final outcome equation is *Equation 5*, has the complete calculation and presentation of Cost Factors namely Prime Cost, Works Cost, Cost of Production and Cost of Sales with its contribution to the Sales in this specific case of restaurant business.

Equation 5 - Sales with Cost Factors

*Sales = 0.795 + 0.219*Prime Cost - 0.669*Works Cost*

*+ 0.170*Cost of Production + 1.193*Cost of Sales.*

Altogether thirteen equations presented above where three equations are in four different sets presenting four factors of cost. The last equation presented as *Equation 5* is the outcome and the final calculation of contribution where Works Cost is negative contributor but other three cost factors are positive contributors in this specific case of study on restaurants in Erbil city.

CONCLUSION

Based on the analysis and findings the research can conclude on assumptions made prior to the research based on the research problem. The research problem formulated was to evaluate the cost viability of the restaurant business considering cost factors involved for making the business sustainable. Moreover to develop an econometric model for the understanding of elaborative cost structure of a restaurant business. This research has reached to the solution of this research problem by answering the research questions and full filling the research objectives. Different cost factors involved was the asked first research question, four cost factors namely Prime Cost, Works Cost, Cost of Production and Cost of Sales are most important for the restaurant business. Cost of Sales is the most important cost factor involved as per the Equation 5, it is a high increase of 1.193 units on 1 unit of increase in Sales. A significant difference with the Cost of Sales can have a significant positive impact on Sales and profitability has been the answer to second research question. A standard econometric model is developed as Equation 5 - Sales with Cost Factors, is the answer for third research question.

*Sales = 0.795 + 0.219*PrimeCost - 0.669*Works Cost*

*+ 0.170*Cost of Production + 1.193*Cost of Sales.*

Research objectives full filled as set for the research after exploration four cost factors identified and have been answered as the first research question in the above paragraph. Second and third objectives as well reached the goal answering the second and third research questions consecutively. Finally the research concludes that the restaurants are cost intensive business where much of care is required for making it sustainable. Based on this research the Prime Cost is the least important and not impacting much to the business means the increase in Sales has a very small increase in Prime Cost. Works Cost has the negative trend shows that there is increase in Sales will have the huge fall in Works Cost, which can be good for the health of the business. Increasing Sales has the small increase in Cost of Production, which is beneficial for the business. Cost of Sales is under question as it is much higher which shows the increase in Sales will increase is drastically ([Bradosti and Singh 2015]), here it needs much awareness and exposure to the market. One of the reason can be the higher advertising and marketing cost in the city as it is not exposed with the well-established facilities.

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RESPONSE DYNAMICS IN BUSINESS TENDENCY SURVEYS: EVIDENCE FROM POLAND

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Abstract: In this paper, trends, business cycle correlates and macroeconomic patterns in response rates are explored. Two groups of respondents taking part in the RIED (Research Institute for Economic Development of the Warsaw School of Economics) economic tendency survey are taken into consideration: industrial enterprises and households. Empirical analysis indicates that household response rates rise slightly with consumer price index, and decline during current expansion phase of the economy. Gender, geographical location and city / country residence are not factors in determining household response rate dynamics. In case of industrial enterprises, willingness to answer seems to rise when business conditions deteriorate, and vice versa, although this effect is small in terms of absolute values of correlation coefficients. Non-response is found to be higher when economy expands but the relationship is weak.

Keywords: economic tendency surveys, industrial enterprises, households, survey data, survey response, business cycle

JEL classification: C83, D10, D22, E32

INTRODUCTION

Studies of causes and consequences of survey non-response have a history just as long as surveys themselves (for an early example of quantitative analysis of non-response, see [Platek 1977]). Non-response is recognized to be the main source of non-sampling errors in surveys, and as generally it is not random, it introduces the element of self-selection and reduces reliability of surveys in terms of representativeness of results; hence importance of this subject within the field of survey data analysis.

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Causes of non-response are usually grouped in four categories:

- no-contact: failure to establish contact (for example, wrong address; bankruptcy in case of firms; change of residence in case of families),
- refusal: unwillingness of the prospective respondent to cooperate for any reason,
- not-able: circumstances preventing obtaining answers such as prospective respondents' temporary absence or lack of expertise, ill health, language barriers etc.,
- accidental loss of questionnaire and consequently all of the data or part of it.

The "refusals" seem the most interesting category to analyze because of the intentional nature of their behavior and hence opportunity to discover factors that determine it. What makes an individual person or a company representative decide to take part in an economic tendency survey? It turns out that empirical literature does not provide consistent insights into determinants of individual decisions to participate – or not – in economic tendency surveys. Such decisions are probably influenced by numerous factors, many of them unobservable, and therefore are difficult to quantify.

Empirical analysis presented in this paper is based on the RIED (Research Institute for Economic Development of the Warsaw School of Economics) 2006 – 2017 survey data. Prior studies of the RIED non-response focused on consequences of non-response, particularly in terms of non-response bias and representativeness issues (see [Białowolski et al. 2005; Kowalczyk, Tomczyk 2009]) and not its reasons or causes, and the few efforts to determine individual factors influencing response decisions did not prove successful. Empirical results indicate that information collected in RIED questionnaires does not allow to identify factors that influence industrial enterprises' individual decisions to participate in the survey (see [Tomczyk 2018]). The only statistically significant finding is a tendency of petroleum, chemical, pharmaceutical, rubber and plastic producers to be slightly more responsive than other companies.

Since efforts to determine individual factors of survey response have not led to definite results so far, I propose to inspect aggregated response rates. In this paper, the RIED response rates are examined in search for trends, seasonality, business cycle patterns or correlations with macroeconomic time series.

There is little empirical evidence available so far on behavior of response rates within the business cycle or their correlation with economic activity indicators (in case of enterprises) or indices of economic situation (in case of households). As far as I am aware, only one quantitative analysis of this type has been published. For the IFO Business Survey, Seiler [2010] finds that non-response among industrial firms is more frequent in economically good times, and cites similar results for households. This paper attempts to find macroeconomic patterns for the Polish economic tendency survey.

RESPONSE DYNAMICS OF HOUSEHOLDS

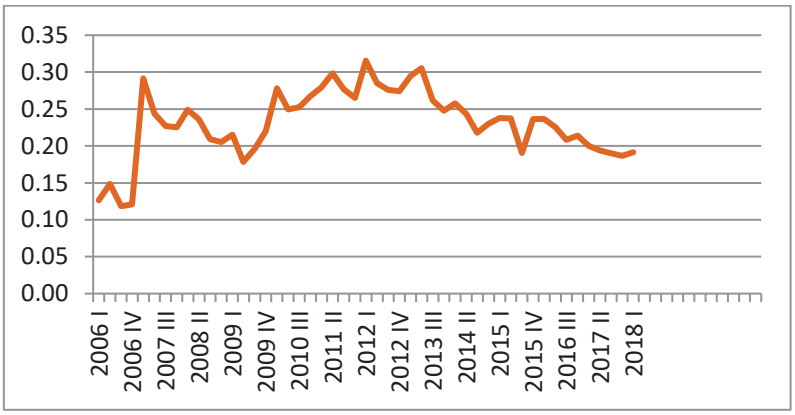
Response rates among households are assessed on the basis of quarterly data collected by the Research Institute for Economic Development (RIED) of the Warsaw School of Economics. Current questionnaire includes 15 basic questions consistent with the European Union guidelines, and additional questions concerning present economic situation. Survey questions are designed to evaluate current economic situation of a household, as compared to its situation 12 months earlier, and to formulate forecasts for the next 12 months. Survey is conducted in the first month of each quarter (that is, January, April, July, and October), and its results are reported in quarterly bulletins (see [Dudek 2017]).

The household survey has been launched in 1990 but data on numbers of questionnaires sent and received has been registered only since 2006. The following characteristics of respondents are available from the household survey database: gender, place of residence (city / village) and geographical region.

Let us define unit response rate (URR) following Thompson and Oliver [2012] as a percentage of total number of responding sample units to the total number of sample units drawn (gross sample).[1] Average response rate equal to 0.2313. It seems rather low but is consistent with other studies of response rates (see [Rasmussen, Thimm 2009; Seiler 2010; Czajka, Beyler 2016]), and in contrast to most of the literature, does not exhibit a long-term downward trend (see Figure 1). Decline in response rate has only begun in 2012 and continues until the end of the sample. There is no evidence of seasonality. Authors of the previous analysis of the RIED household response rates (see [Białowolski et al. 2005]) note variable response rates in 2000-2004 and attribute part of this effect to resampling. They do not find long-time trends or seasonality.

[1] Item non-response rate is not analyzed in this paper. Determinants of omitting individual questions probably differ from factors influencing decision not to answer at all. In postal questionnaires such as RIED economic tendency survey, as opposed to web questionnaires (where skipping questions is usually not allowed by the design of the web page) item non-response constitutes a separate and valid research problem.

Figure 1. Household response rate (2006 – 2017, quarterly data)



Source: RIED database

To verify whether there is any correlation between the willingness of households to take part in a business tendency survey and macroeconomic factors influencing economic environment and decisions of households, correlation coefficients with the following macroeconomic factors are considered:

- Average gross wages (AGW): average nominal gross wages in the economy, corresponding quarter of the previous year = 100 (with the lag of one: data for first quarter of 2006 is assigned to the April 2006 survey to provide respondents with time to take changes in wages into account),
- Consumer price index (CPI), corresponding quarter of the previous year = 100 (also with the lag of one),
- BAEL unemployment rate (UNEMPL).

The highest positive correlation is found in case of CPI: household response rate is correlated with consumer price index with a coefficient of 0.3048 which is statistically significant at the 0.05 significance level. Correlation with average gross wages is much smaller and negative, equal to -0.1672, and correlation with unemployment rate is almost zero (0.0060). It seems that none of the macroeconomic factors exhibits close relationship with household response rates, and the only noticeable pattern is the tendency of the survey addressees to become slightly more responsive as consumer prices rise.

Finally, let us examine household response rate with within the business cycle. Analyses of Polish business cycle (see [Gradzewicz et al. 2010; Drozdowicz-Bieć 2012]) agree that Polish economy enjoyed expansion from 2006 until the first quarter of 2008, then noted worsening of the economic conditions until February 2009 (with Poland pretty much immune to the world recession; see [Drozdowicz-Bieć 2012]. Since March 2009, Polish economy again continues in

a boom phase with a minor slowdown between May 2011 and December 2012[2]. It seems that household response rates were rising during the expansion periods of 2006 – beginning of 2008 and March 2009 – May 2011, and declining during the last expansion phase after December 2012. This final conclusion is consistent with Seiler's [2010] study in which he reports higher non-response in economically good times.

Slight decrease in response rates around business cycle turning points might be expected due to higher uncertainty but it does not show in the household response rate dynamics.

Response rates between men and women do not differ considerably; on average they are equal to 0.2323 and 0.2302 respectively, and follow the dynamics of total response rates. Since BAEL unemployment rates are available for men and women separately, correlation coefficients with unemployment rate can be calculated independently for both sexes. Correlation coefficients are equal to -0.0186 for men and 0.0464 for women, indicating that response rates among women increase with growing female unemployment and among men – decrease with growing male unemployment, but both effects are close to zero. Lack of statistically significant relationships between characteristics of households and their willingness to respond has been already noted in the literature: Wittwer, Hubrich [2015] find no significant differences in response rates with regard to social demographics (gender, age, household size, form of employment, or mobility).

Finally let us note that gender of the main survey addressee is recorded in the database while decision to answer the survey may have been taken (and responses provided, if any) by another member of the household. Consequently we do not know whether decision to take part in the survey was made by the person to whom the survey is addressed.

Data on respondents' place of residence is available for 2006 – 2009 only. For this period, response rates among city residents have been slightly higher than among villagers (0.2468 and 0.2093, respectively). Response rates were increasing, particularly in 2006/2007 and from the first quarter of 2009, which is consistent with the dynamics of total response rates.

In the prior study of the RIED household non-response rate, Białowolski et al. [2005] note the following response rates over the period 2000 – 2004: 28% for city residents, 24% for villagers. They also note that "(…) village respondents were initially more willing to participate in the survey than city respondents but they quickly got discouraged – most probably due to lack of incentive to participate" (p. 35). Higher participation of city respondents seems therefore a constant feature of the RIED household survey, in contrast to other studies. Cobben [2009], on the

[2] Source: Maria Drozdowicz-Bieć, private communication.

basis of extensive literature review, concludes that city residents are less likely to be contacted and to respond to questionnaires.

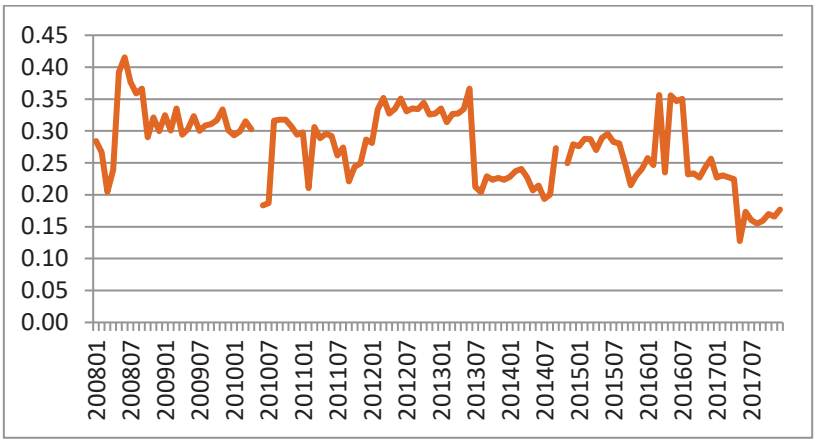
In RIED household survey, Poland is divided into six large geographical regions. In Central, Eastern and Northern regions of Poland response rate closely follows the shape of general response rate. Slightly higher variation is observed in response rates of households located in Southern, South-western and North-western regions. North-western region is characterized by the highest variance of response rates, with an unique peak in the second and third quarter of 2016, a trough right afterwards, and relatively high volatility until the end of the sample. South-western region, on the other hand, is characterized by alternating peaks and troughs across most of the sample. Since these two regions seem similar with respect to economic environment of households – they consist of the western voivodeships generally similar in terms of demographics, infrastructure and standards of living – reasons for minor differences in non-response dynamics noted above remain to be explained. Apart from minor variations between the regions, there seems to be no clear geographical determinants of household response rate dynamics. This finding is consistent with the prior analysis of the RIED household response rate: between 2000 and 2004, Białowolski et al. [2005] do not find evidence of regional variation.

RESPONSE DYNAMICS OF INDUSTRIAL ENTERPRISES

Response rates analyzed in this paper have been collected by the Research Institute for Economic Development (RIED) of the Warsaw School of Economics. Expectations and subjective assessments of changes in eight fields of business activity are collected by RIED through monthly business tendency surveys. The questions are designed to evaluate both current situation (as compared to last month) and expectations for the next 3 – 4 months by assigning them to one of three categories: increase / improvement, no change, or decrease / decline. On the basis of the percentages of responses, balance statistics are calculated, and then published in monthly bulletins (see [Adamowicz, Walczyk 2018]). The industrial survey has been launched in 1997 but data on numbers of questionnaires sent and returned is available only since 2008 with two missing observations: in May 2010 and October 2014.

Average response rate is equal to 0.2440 which does not differ from results noted in literature. In contrast to the RIED household response rate, and in agreement with general literature, it does exhibit a long-term downward trend – albeit slight (see Figure 2).

Figure 2. Industrial enterprises response rate (2008 – 2017, monthly data)



Source: RIED database

Individual characteristics of industrial enterprises surveyed by RIED do not permit disaggregated analysis. They are either too spread out (for example, firms can be classified into 25 categories out of 99 defined by the Code List of Classification of Business Activities in Poland) or too imbalanced (for example, share of public sector enterprises amounts to only 3.3% to 6.2% of the sample). Correlation between the respondents' willingness to provide answers and macroeconomic factors can be assessed, however, in order to verify whether worsening or improving conditions of operation influence response rates.

Monthly measures of general business conditions are described by the following indices:

- general business climate indicator (GBCI) of the Central Statistical Office (CSO) of Poland: a composite index calculated as an arithmetic average of the balances of the answers to questions from the monthly CSO questionnaire concerning current and expected economic situation,
- synthetic indicator (SI) of business climate, also published by the Central Statistical Office, calculated on the basis of seasonally adjusted and standardized answers to survey questions with the following weights: manufacturing industry (50%), services (38%), retail trade (6%), and construction (6%),
- RIED Economic Activity Indicator (EAI), calculated as a weighted average of seven sector indicators, with weights reflecting importance of a given sector in explaining seasonal variation in Gross National Product (see [Dudek, Zając 2012]): manufacturing industry ($^2/_9$), households ($^2/_9$), construction ($^1/_9$), trade ($^1/_9$), banking ($^1/_9$), agriculture ($^1/_9$) and car freight ($^1/_9$).

All three indices rise with improvement of business conditions and decline with their deterioration. Over monthly data 2008 – 2017, correlation coefficients of

response rate with GBCI, SI and EAI are negative and equal to -0.1736, -0.2340 and -0.4745, respectively. The closest relationship binds enterprises' response rate to the RIED Economic Activity Indicator. Generally, respondents' willingness to answer seems to rise when business conditions deteriorate, and vice versa, although the size of the reaction is limited. All three correlation coefficients are significant at the 0.05 significance level. This result, even though small in terms of absolute values of correlation coefficients, is confirmed in another analysis (see [Seiler 2010]). Author hypothesizes that this effect is due to the fact that in boom times the companies have less time to answer the questionnaire, being busy with filling orders. I would like to offer a complementary interpretation: that in worsening economic conditions enterprises are more willing to take part in tendency surveys and report their failing economic health, hoping, eventually, for government intervention or other forms of assistance.

Finally, let us examine enterprises' response rate with within the business cycle. The response rate has fallen sharply at the beginning of the current expansion phase: from 0.3662 in June 2013 to 0.2124 in July 2013 and, apart from the peak in mid-2016, has not climbed back to the levels from the last slowdown phase of May 2011 – December 2012. This again confirms the finding that non-response is higher when economy expands.

SUMMARY AND CONCLUSIONS

The aim of this paper was to verify whether business cycle phase and macroeconomic aggregates are relevant to enterprises' response rates in business tendency surveys, and whether worsening or improving economic standing of families influence response rates of households. Empirical analysis indicates that household response rates rise slightly with consumer price index, and decline during the latest boom phase in the economy – although the opposite effect is noted for the prior expansion period. Gender, geographical location and city / country residence are not factors in determining household response rate dynamics. In case of industrial enterprises, willingness to answer seems to rise when business conditions deteriorate, and vice versa, although this effect is small in terms of absolute values of correlation coefficients. Generally, non-response is found to be higher when economy expands but the relationship is weak. These findings confirm a result noted previously in the literature: that lower response accompanies economically good times, either because enterprises are too busy filling orders to bother with questionnaires, or because in poor economic conditions they are more willing to take part in surveys and report their failing economic health, hoping, eventually, for government intervention or other forms of assistance.

Since sabotaging economic growth for the purpose of increasing tendency survey response rates would be neither feasible nor ethical, what can be done to improve response rates of the RIED economic tendency survey?

Well-known and widely used methods of improving response rates are discussed in Phillips et al. [2016]. Establishing direct rapport with the addressees and gaining their support and understanding of the aims of the survey may induce them to participate in the survey more actively. Re-contacting non-respondents in particular may persuade them to become involved in the survey. Several authors (see [Curtin et al. 2005; Toepoel, Schonlau 2017]) point to the use of incentives. While most authors agree that incentives promote response, high incentives may consume a significant portion of a project's budget, and skew responses when provided only in order to obtain a payoff. They can also lead to higher, rather than lower, non-response bias if effective only for particular groups. Bańkowska et al. [2015] provide the following example: incentives may increase response rate in a household survey but could result in a higher proportion of poorer respondents, and if income correlates with the topic of the survey, this could lead to biased estimates.

Also, post-survey adjustment techniques, including imputation, extrapolation and weighting, have been developed and used to reduce non-response biases (see [Rasmussen, Thimm 2009; Toepoel, Schonlau 2017]). Recently two new approaches have emerged: responsive and adaptive survey designs meant to facilitate tradeoffs between survey quality and survey costs (see [Calinescu, Schouten 2016; Brick, Tourangeau 2018]), and a shift away from standardized surveys towards custom-made or personalized questionnaires in which various respondents are treated differently (see [Lynn 2017]). Efficiency of these approaches has yet to be tested empirically.

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