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ECONOMIC PROCESSES AND IMPACT OF HUMAN PROPENSITIES – ECONOMETRIC PERSPECTIVE

The article explores the two types of propensity theories with respect to economic activities. According to the main hypothesis, such category as propensity gives the possibility to take into account certain aspects of human behavior. Econometric methods that give possibility of taking propensities into account are introduced. These methods are proposed for different types of statistical data (cross sectional, panel and time series data). The empirical example is given in which a model containing measures of propensities in a set of explanatory variables is compared to econometric model without such variables. The model in which the impact of propensities is taken into account turned out to be better in all the considered aspects (parameters' interpretation, goodness of fit, information criteria etc).

Keywords: *propensity; econometric analysis; impact identification; VECM and VAR models; panel data.*

JEL classification: *B22, B40, C01, C22, C23, E20, D01, D11.*

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ВПЛИВ ЛЮДСЬКИХ СХИЛЬНОСТЕЙ НА ЕКОНОМІЧНІ ПРОЦЕСИ: СПРОБА ЕКОНОМЕТРИЧНОГО АНАЛІЗУ

У статті надано огляд двох груп теорій людських схильностей в економічному контексті. Категорія "схильність" дає можливість врахувати вплив людського фактору на економічні процеси. Представлено економетричні методи, що беруть до уваги дану категорію. Такі методи можуть бути використані для різних видів статистичних даних (міжгалузеві, панельні дані, часові ряди). На практичному прикладі порівняно дві моделі – одна враховує людські схильності, інша – ні. За всіма показниками – інтерпретація параметрів, критерій відповідності, інформаційний критерій тощо – модель з урахуванням людських схильностей продемонструвала вищу точність.

Ключові слова: *схильність; економетричний аналіз; визначення міри впливу; моделі VECM і VAR; панельні дані.*

Табл. 3. Рис. 1. Форм. 19. Літ. 12.

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ВЛИЯНИЕ ЧЕЛОВЕЧЕСКИХ СКЛОННОСТЕЙ НА ЭКОНОМИЧЕСКИЕ ПРОЦЕССЫ: ПОПЫТКА ЭКОНОМЕТРИЧЕСКОГО АНАЛИЗА

В статье дан обзор двух групп теорий человеческих склонностей в экономическом контексте. Категория "склонность" позволяет учесть влияние человеческого фактора на экономические процессы. Представлены эконометрические методы, которые учитывают в своих расчётах данную категорию. Данные методы могут быть использованы для различных видов статистических данных (межотраслевые, панельные данные, временные ряды). На практическом примере сравнены две модели – учитывающая человеческие склонности и не учитывающая. По всем показателям – интерпретация параметров, критерий соответствия, информационный критерий и т.п. – модель с учётом человеческих склонностей продемонстрировала более высокую точность.

Ключевые слова: *склонность; эконометрический анализ; определение меры влияния; модели VECM и VAR; панельные данные.*

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1. Introduction

It seems that in economic theory there is a need to find tools enabling the analysis of impact of some aspects of human behavior on socioeconomic processes. Propensities could be treated as a proposal of such a category. What is propensity? According to the proposed definition, propensity is a "slope of attitude" towards something (or somebody) increasing a probability of certain events (Hozer, Doszyn, 2004). How could the impact of human propensities be taken into account? An answer to this question depends on the nature of statistical data (type of econometric model being estimated). The influence of propensity should be estimated differently in case of spatial data models, time series models and panel data models. The issues connected with econometric procedures are discussed in the next sections.

2. Chosen theories of propensities

The philosophy literature offers generally, the two types of propensity theories, which are mostly used in probability theory. The first group consists of the theories based on the findings by K. Popper. According to him, propensity is a disposition that is a result of all important factors in a given situation. This disposition produces frequency that is an estimate of a propensity. In this attitude propensity is a characteristic of a whole situation.

The second group includes theories stating that propensity is a characteristic of an object. This view was proposed by C. Peirce. In economic analysis, a single person or a group of people is assumed to be an object. Human propensities depend mostly on internal (psychological) structures of people or, in other words, on subjective factors. In this article propensity is a property of a given person (or groups of people). Propensity is treated as a specific set of psychological features that increases probability of certain events.

In economics propensities were introduced by J.M. Keynes in his famous book "General Theory of Employment, Interest and Money" (Keynes, 2003). He proposed such categories as marginal and average propensities (to consume, save, invest, money storing). According to J.M. Keynes propensity to consume should be understood as a functional dependency between consumption expenditures and income (Keynes, 2003). J.M. Keynes treated propensity as a functional dependency between certain variables and this dependency is a result of both objective and psychological factors. J.M. Keynes theory could be assigned to the first group of propensity theories, where propensities are related to whole situations. Subjective (psychological) features of people (human propensities) are just the factors that create propensity of a whole situation.

K. Popper tried to find the objective theory of probability that could provide objective probabilities for single events (singular probabilities). The advocates of frequency theory of probability denied that objective probabilities for single events could be introduced. According to them, probabilities are limiting frequencies of events that could be estimated in long (infinite) collectives. K. Popper made a suggestion that singular probability might be taken as equal to its probability (frequency) in a collective as a whole.

In frequency interpretation probability there is a property of sequence (collective). In K. Popper's interpretation of propensity, generating conditions are considered as endowed with a propensity to produce observed frequencies. Popper's theory

means that it's legitimate to introduce probabilities on a set of conditions even if the number of experiments is not large. It is not possible in the frequency interpretation of probability.

C. Peirce thought that propensities are properties of objects (dices, coins, human beings): "to say that the die has a "would-be" is to say that it has a property, quite analogous to any habit that man might have. Only the "would-be" of the die is presumably as much simpler and more definite than the man's habit as the die's homogenous composition and cubical shape is simpler than the nature of the man's nervous system and soul" (Gillies, 2000).

In C. Peirce's view propensity describes property of an analyzed object. In case of human beings propensities are mostly psychological properties. Human propensities manifest themselves as certain patterns of behaviors.

The same concept is used in the presented article where propensities are understood as factors describing psychological aspects of human behaviors that make probabilities of certain events higher. Propensities are generalized psychological causes of events. When objective circumstances are determined, propensities increase probabilities of given occurrences. Propensity could be treated as a category that enables analyzing impact of psychological features on socioeconomic events. This attitude to propensity is analogous to C. Peirce's conception where propensities are treated as properties of objects (dices, coins, human beings) and not as characteristics of situations.

3. Econometric methods of analyzing the impact of human propensities on economic regularities[2]

The type of econometric tools that could be used in analyzing the impact of human propensity on economic processes depends on the knowledge about given propensity. It is much easier to determine the influence of propensity whether a priori knowledge about certain propensity is available. This a priori knowledge could originate from psychological, sociological, medical, cultural or anthropological studies.

Propensities could be quantitatively presented in various manners. For instance, propensity might be expressed as a dummy variable equal one if a given object (person, collectivity) exhibits propensity and zero otherwise:

$$s_i = \begin{cases} 1, \text{if i - the object has propensity,} \\ 0, \text{if i - the object doesn't have propensity.} \end{cases} \quad (1)$$

In many cases econometricians have to use aggregated data. Propensity could be then measured by means of frequency and trigonometric method (Hozer, Doszyn, 2004). In frequency method propensity is calculated by the following formula:

$$s_{fi} = m_i / n_i, \quad (2)$$

where:

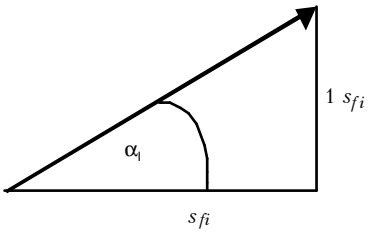
s_{fi} – frequency measure of propensity of i-th collectivity,

m_i – number of objects (people) that have propensity in i-th collectivity,

n_i – number of all objects (people) in i-th collectivity that might have propensity.

[2] Considerations presented in this section are the development of the ideas presented in (Doszyn, 2012).

Propensity could be also presented by means of a trigonometric measure. In case of the trigonometric method propensity is defined as a specified angle (see Figure 1).



Source: individual study.

Figure 1. **Trigonometric interpretation of propensity**

Propensity is measured by means of angle α_i. Tangent of this angle is obtained as follows:

$$tg\alpha_i = \frac{1 - s_{fi}}{s_{fi}}, \tag{3}$$

s_{fi} – frequency measure of propensity of a given object (collectivity).

It could be easily seen that the higher is propensity, the higher is the "slope" (and lower is the angle α_i). Trigonometric method should be treated as a supplementary mode of presenting intensity of the analyzed propensity.

If we possess a priori statistical knowledge about certain propensity, we could add a certain variable to econometric model as an independent variable. Depending on the type of statistical data propensity in form of variables (1) and (2) might be used. Estimates of the parameters next to such variables inform us about the impact of given propensity on the analyzed process.

In case of spatial data model with a priori knowledge about propensity in the form of frequency measure of propensity (s_{fi}), the impact of propensity could be estimated as:

$$y_i = \sum_{j=0}^{k} \alpha_j x_{ji} + \alpha_{k+1} s_{fi} + u_i, \tag{4}$$

y_i – dependent variable,

x_{ji} – independent variables,

a_j – parameters ($j = 0,1,\ldots,k+1$),

u_i – error term.

Variable s_{fi} tells us about the intensity of propensity and α_{k+1} informs about the impact of propensity on the analyzed process. Of course, econometric models could contain many propensities as independent variables, if this is sensible.

In case of spatial data models propensities of many objects in one time period might be analyzed. If we have time series data for one object, we could analyze propensities of this object in many time periods.

Economic time series are very often integrated and cointegrated (Hendry, Juselius, 2001; Johansen, 1991; Johansen, 1995). Let's say that we have the system of two variables:

$$y_t = \alpha_0 + \alpha_1 x_t + \alpha_2 s_t + u_t, \tag{5}$$

where u_t is the white noise process. Values of y_t are increased by a factor $\alpha_2 s_t$ which is an impact of a certain propensity s_t. Similarly, variable s_t could be a dummy variable $s_t = 1$ if a given object shows propensity in period t and $s_t = 0$ otherwise. What is important, the impact of propensity in case of time series data (for one object) could be analysed only if a priori knowledge about certain propensity is available.

Let's assume that variable x_t follows random walk with drift:

$$x_t = \gamma + x_{t-1} + \xi_t, \tag{6}$$

where ξ_t is independently and identically distributed process with zero mean and constant variance.

If variables y_t and x_t are cointegrated, it is possible to write equations (5) and (6) in a VAR form (Doszyn, 2012):

$$\begin{pmatrix} y_t \\ x_t \end{pmatrix} = \begin{pmatrix} \alpha_0 + \alpha_1\gamma \\ \gamma \end{pmatrix} + \begin{pmatrix} 0 & \alpha_1 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} y_{t-1} \\ x_{t-1} \end{pmatrix} + \begin{pmatrix} \alpha_2 & 0 \\ 0 & 0 \end{pmatrix} \begin{pmatrix} s_t \\ 0 \end{pmatrix} + \begin{pmatrix} u_t + \alpha_1\xi_t \\ \xi_t \end{pmatrix} \tag{7}$$

or in the VECM form:

$$\begin{pmatrix} \Delta y_t \\ \Delta x_t \end{pmatrix} = \begin{pmatrix} \alpha_0 + \alpha_1\gamma \\ \gamma \end{pmatrix} + \begin{pmatrix} -1 & \alpha_1 \\ 0 & 0 \end{pmatrix} \begin{pmatrix} y_{t-1} \\ x_{t-1} \end{pmatrix} + \begin{pmatrix} \alpha_2 & 0 \\ 0 & 0 \end{pmatrix} \begin{pmatrix} \Delta s_t \\ 0 \end{pmatrix} + \begin{pmatrix} u_t + \alpha_1\xi_t \\ \xi_t \end{pmatrix} \tag{8}$$

It is worth to notice that in VECM we have differences of variable (Δs_t) that shows presence of propensity. Whether we add variable s_t to the model (8), the result would be an accumulation of impact of propensity in time, what is rather unlikely.

Previous procedures are justifiable if we have a priori knowledge about propensities. But how to analyze the impact of propensities in other cases? Sometimes we suspect that an analyzed process should be modified by an impact of propensity but we do not have information originating from other kind of studies. The following procedure gives us a possibility to take impact of propensity into account in such cases.

Influence of propensities is often present in case of spatial or panel data where we have the effects from actions of many different objects (people). Let's say that we have the following model for spatial data:

$$y_i = \sum_{j=0}^{k} \alpha_j x_{ji} + u_i, \tag{9}$$

where

y_i – dependent variable,

x_{ji} – independent variables (external, objective factors), $j = 1,2,..k$,

a_j – parameters ($j = 0,1,\ldots,k$),

u_i – error term,

$i = 1,2,\ldots n$, n – the number of objects.

Model (9) should contain all important, external, objective factors. The impact of given propensity might be analysed by means of dummy variables d_p:

$$\begin{cases} d_p = 1 \text{ if } p = i \\ d_p = 0 \text{ if } p \neq i \end{cases}. \tag{10}$$

Variable $d_p = 1$ for object p and $d_p = 0$ for all remained $(n - 1)$ objects. Index p equals $1,2,\ldots n$, respectively.

The following procedure is proposed to take the impact of propensity into account (Doszyn, 2012):

1) estimation of n models of the type:

$$y_i = \sum_{j=0}^{k} \alpha_j x_{ji} + \gamma_p d_p + u_i, \quad (11)$$

where $p = 1,2,\ldots,n$.

2) verification of the following hypothesis in all n cases:

$$H_0 : \gamma_p = 0 \quad (12)$$

$$H_1 : \gamma_p > 0. \quad (13)$$

If H_0 is rejected for variable d_p, this variable is in next step added to the model (9) as an independent variable.

After the addition of variables d_p to the set of independent variables these two steps are repeated for remained dummy variables. The whole procedure stops when in all considered cases there is no reason to reject H_0 (or the degree of freedom is too small to add another dummy variable as an independent variable).

Eventually we obtain the following econometric model:

$$y_i = \sum_{j=0}^{k} \alpha_j x_{ji} + \sum_{l} \gamma_l d_l + u_i, \quad (14)$$

where d_l are these variables d_p for which hypothesis (12) in all undertaken steps was rejected. After the implementation of the presented procedure we could find objects in which the level of the analyzed occurrence is higher than in other objects. In some cases we could treat this as a verification of a hypothesis stating the impact of specified propensity.

In case of panel data the influence of propensities could be estimated by means of models with fixed effects. In fixed effects models we might assume that propensities manifest themselves by individual effects (if model contains all significant, external, objective factors).

Fixed effects model could be written as:

$$y_{it} = \sum_{j=1}^{k} \beta_j x_{jit} + \alpha_0 + \sum_{i=1}^{n-1} \alpha_i d_i^* + \varepsilon_{it}, \quad (15)$$

y_{it} – depended variable,

x_{jit} – independent variables (objective, external factors), $j = 1,2,\ldots,k$,

α_0 – common constant term,

β_j, α_i – parameters, $i = 1,2,\ldots,n-1$,

$d_i^* = d_i - d_n$ – dummy variables,

d_i – dummy variable equal 1 for i-th object and 0 otherwise,

d_n – dummy variable for omitted object n,

ε_{it} – error term.

In model (15) it is assumed that:

$$\sum_{i=1}^{n} \alpha_i = 0 \quad (16)$$

$$\alpha_n = -\sum_{i=1}^{n-1} \alpha_i. \quad (17)$$

Parameters α_i next to transformed dummy variables d_i^* inform to what extent the level of the analyzed process is higher (in comparison to "average" level) due to object's specificity. In some cases this specificity might be a result of certain propensity which gives possibility to determine propensity's influence.

4. Empirical example

To verify whether taking propensity's measures into account makes an econometric model better, two models were estimated: the model with propensities as an independent variable and the model without such a variable[3]:

$$\ln \hat{y}_i = \underset{(-2,335)}{-13,029} + \underset{(2,377)}{0,486} \ln x_{4i} + \underset{(1,931)}{2,346} \ln x_{5i} + \underset{(3,875)}{0,450} \ln x_{6i} \quad (18)$$

$$\ln \hat{y}_i = \underset{(0,049)}{0,066} + \underset{(3,843)}{0,676} \ln x_{4i} + \underset{(4,924)}{0,715} \ln s_{ci} + \underset{(1,842)}{0,236} \ln s_{ai}. \quad (19)$$

where

y_i – average expenses (in zl per person) for tobacco and alcoholic beverages in voivodeships in Poland in year 2004,

x_{4i} – average disposable income,

x_{5i} – price index of tobacco and alcoholic beverages,

x_{6i} – share of urban population,

s_{pi} – frequency measure of propensity to smoke cigarettes (fraction of adults who smoke cigarettes every day),

s_{ai} – frequency measure of propensity to drink alcohol (fraction of adults who drink alcohol 1–4 times a week or more often).

Variables y_i and x_{4i} were corrected due to inflation and presented in the prices of 2009 year. All estimates, except constant term in (19), are statistically significant (significance level $\alpha = 0,1$).

It is easy to notice that the addition of $\ln s_{pi}$ and $\ln s_{ai}$ eliminates variables $\ln x_{5i}$ and $\ln x_{6i}$. It is worth to add that estimate next to $\ln x_{5i}$ is positive and quite high which is not consistent with the economic theory. After frequency measures of propensities were added, variable $\ln x_{5i}$ was eliminated.

What could it mean? Propensity to smoke cigarettes and drink alcohol could make consumers insensitive to changes of prices for these products. Propensities might have caused that prices weren't so important. Adding frequency measures of propensities eliminates also differences by place of living (variable $\ln x_{6i}$).

Model (19) with propensities in the set of explanatory variables has lower standard error (S_e) and higher adjusted determination ratio (R^2). On the basis of the empirical significance levels in F-test we could say that explanatory variables' combinations were important (Table 1).

Table 1. **Standard error (S_e), adjusted determination ratio (R^2) and empirical significance levels in F-test in models (18) and (19)**

Statistics	Model (18)	Model (19)
S_e	0,062	0,054
R^2	0,819	0,863
p_{emp}	0,000	0,000

Source: own calculations.

The values of logarithm of likelihoood function (LW) and information criteria such as AIC, BIC and HQC were better in case of model in which the influence of propensities is taken into account (Table 2).

[3] In the brackets t values are presented.

Table 2. **Logarithms of likelihood functions (LW) and information criteria in case of model (18) and (19)**

Criterium	Model (18)	Model (19)
LW	24,001	26,235
AIC	-40,002	-44,470
BIC	-36,912	-41,380
HQC	-39,844	-44,312

Source: own calculations.

In case of both models hypothesis stating normality of residuals as well as hypothesis assuming homogeneity of residuals can't be rejected (significance level $\alpha = 0,1$) (Table 3).

Table 3. **Empirical significance levels in Doornik-Hansen test (normality of residuals) and White test (homogeneity of residuals) in models (18) and (19)**

Statistics	Model (18)	Model (19)
Doornik–Hansen test	0,784	0,499
White test	0,390	0,123

Source: own calculations.

Generally, the model (19) with frequency measures of propensities as an independent variable is better in all considered aspects. In model (19) the estimates of parameters have better interpretation, goodness of fit is higher and information criteria have more desirable values.

Concluding remarks

Economic processes depend both on subjective (psychological and sociological) and external, objective factors (income, prices, interest rates etc). In many cases psychological and sociological causes might be identified with human propensities.

In the presented concept propensity could be viewed as a set of psychological features making probabilities of certain events higher in given objective circumstances. It is different than in most theories of propensities analyzed mainly in probability theory where propensities characterize not psychological features but whole situations. Also in J.M. Keynes' view, propensities depend not only on subjective but also on objective factors.

The main objective of the article was to propose econometric tools enabling the identification of the impact of human propensities on socioeconomic processes. A method of analysing the impact of propensities is related to a priori knowledge about propensities. That kind of knowledge could originate from psychological, sociological, anthropological, medical or cultural studies. If we possess a priori knowledge about propensities we could add certain variables representing propensities to a set of explanatory variables of an econometric model.

If a priori knowledge about propensities is not available, we could use the procedures proposed in this article to verify the hypothesis about the influence of propensity. Also panel data models with fixed effects might be used in the situation of lack of a priori knowledge about propensities.

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