SOME ASPECTS OF MODELING THE NON-OBSERVED ECONOMY

[a]ELENA L. FESINA, [b]VALERIYA L. VORONTSOVA, [c]SVETLANA F. KHASANOVA

Kazan Federal University, 18 Kremlyovskaya street, Kazan 420008, Russian Federation, Russia
email: [a]milen99@yandex.ru, [b]info@ores.su, [c]global@ores.su

Abstract :One of the problems on obtaining adequate parameters for a non-observed economy is the lack of scientifically based models of its evaluation. The generality of approach to this phenomenon is accompanied by a large formalization of models, what does not allow the true scale of the non-observed economy, its structure and development tendencies to reveal. The paper attempts to build a business model of a non-observed economy on the basis of modeling the transfer of non-cash funds to unaccounted-for cash money, as well as discriminating "logit" models. The mechanism for concealment of monetary resources using cash out transactions is a well-established business process that allows a taxpayer to use it as the main tool for conducting the most sophisticated transactions of a shadow nature. The authors discuss the issues of building the non-observed economy models at the micro level. It is pointed out that to date no adequate models of the non-observed economy have been developed. It is stated that the commonality of approaches to this issue is accompanied by a large formalization of models, what does not allow the true scale of the non-observed economy, its structure and laws of development to reveal. It is the authors' opinion that the use of the proposed non-observed economy models will provide reliable information on the latent processes taking place at enterprises in the conduct of their financial and economic activities with the purpose of taking adequate measures for the timely neutralization of phenomena that are not monitored by official statistics.

Key words: non-observed economy, latent processes, shadow cash flows, hidden wages.

1 Introduction

The key element of the non-observed economy are dummy short-lived companies, which close the inconsistencies of commodity and financial flows associated with the use of unaccounted cash funds by legally operating enterprises. One of the reasons for the spread of unaccounted cash turnover is the high level of taxation of wages in comparison with the low level of social guarantees. This contributes to the development of the practice connected with distribution of "backdoor" salary or wage payments which tend to increase in the conditions of inflation and growth of consumer prices. In particular, in the Republic of Tatarstan they entered the daily practice of payments in the wage system and account for more than 50% of the official wage (Pushkarev, 2017; Shekarbaghani, 2017).

The practice of "shadow" payments is especially common in the sector of small and medium-sized enterprises. At large enterprises, the distribution of shadow revenues associated with tax evasion is difficult, since a large number of potential beneficiaries of shadow wages increase the risk of spreading undesirable information. Therefore, the payment of shadow bonuses applies only to trusted representatives of the administration. However, imperfection of the current legislation and weak control over its use stimulate the desire of managers and major shareholders of large enterprises to regularly violate it, evade payment of tax obligations and expand the circle of potential recipients of "envelope" wages.

2 Methodology

To analyze a non-observed economy at the meso- and micro level, the authors have used materials of the Federal State Statistics Service, the Bank of Russia, the IMF, Deutsche Bank Research, the British Petroleum, the Bureau of Economic Analisys, the World Trade Organization, the Forest and Agriculture Organization (FAO) of the United Nation, the Center for Financial and Banking Research Institute of Economics of the Russian Academy of Sciences, as well as the results of other scientific research. An economic-mathematical approach is adopted that assumes the use of econometric and statistical methods of analysis in the capacity of the main approach to building the non-observable economy models: the method of relative and average values; variational, correlation-regression and dispersion methods; method of constructing dynamic series; index method; method of expert evaluation.

3 Results And Discussion

The non-observed economy problem is in spotlight in recent years. The results of the study show that the assessment of the non-observed economy is usually limited to its parameters at the macro level (Fesina, 2015; Villalobos Antunez, 2016).

In the fourth quarter of 2017, the authors conducted profound informal interviews and expert surveys of specialists and managers of small enterprises in the Republic of Tatarstan to study schemes of tax evasion which are in use there. In 2017, 12 enterprises used the cash-withdrawal scheme out of 20 small enterprises of the Republic of Tatarstan, and four of them resorted to it sometimes (Smirnov, 2016).

The main content of the cash withdrawal model is that a taxpayer enters into a contract with a dummy short-lived company to perform fictitious works (services). In accordance with the concluded agreement, the taxpayer makes a non-cash payment to the short-lived company that cashes them charging a certain percentage of the commission for this service. As a result of the transaction, the taxpayer receives money to its bank account, minus the commission of a dummy short-lived company in the form of unaccounted cash (Smirnov, 2016).

The study of the process of concealment and cashing of funds (Vorontsova et al, 2015) made it possible to distinguish the functions and distribution of responsibilities of the parties involved in this process (Table.1).

Table 1. The responsibility matrix of a business process for transferring non-cash funds to unaccounted-for cash

No.	Function	Base taxpayer enterprise	Front short-lived company-	Manager
1.	Formal transfer by the enterprise - taxpayer of monetary funds in a non-cash form to the front-line short-lived company	R	P	I
2.	Hand-over to the enterprise of a formal report on the work performed by a dummy short-lived company	P	R	I
3.	Illegal transfer of unaccounted cash to the enterprise - taxpayer by a dummy short-lived company	P	I	R

Note: R - responsible; P - participant; I - informant.

The authors have developed the non-observed economy model for a complex object (Vorontsova et al, 2016) under meso- and macroeconomic constraints, which allowed us to describe the movement of shadow money flows at the micro level (Vorontsova et al, 2016; Fesina & Kozlva, 2018).

A dynamic model of the complex object involves the use of three groups of quantitative indicators:

1. Indicators reflecting general aspects of financial and economic activities and obtained from official accounts (revenue from sales of products without VAT and excises, the average monthly wage of one employee, labor productivity, etc.).
2. Indicators reflecting specific aspects of financial and business activities, obtained from the reporting of control bodies, as well as audit reports (the number of cases of submission to the enterprise of a requirement for recovery of significant amount of taxes, tax liabilities, etc.).
3. Indicators reflecting aspects of atypical financial and economic activities, obtained as a result of in-depth informal interviews with representatives of law enforcement and control bodies (the proportion of work which is off-the-books in the total volume of work performed, the number of cases with reporting data distortion, the conclusion of fictitious contracts, manipulation of prices, costs, etc.).

At the first stage, the model provides for the division of the entire set of economic entities into classes, each of which consists of several enterprises with similar conditions for conducting financial and economic activities and the volume of production. To perform a comparative analysis of the enterprise performances in each class, a single reference enterprise is assigned, the data of which are specified on the basis of dynamic standards (Fesina, 2007). It is assumed that all parameters of the reference enterprises are distributed according to the normal distribution law. The indicators of financial and economic activity of enterprises in each class are compared with those of reference enterprises in accordance with the calculation procedures established by the model. As a result, a probabilistic distribution of enterprises with the most efficient and least efficient mode of functioning of its complex economic system is obtained.

At the second stage of modeling, the cut-off coefficients and cascade filters in the context of indicators from the second group are established for the enterprises with the most efficient and least efficient mode of operation. The cutoff coefficients are used to obtain the probabilistic distribution of enterprises from the point of view of nonspecific aspects of their financial and economic activities. This makes it possible to distinguish valent and suspicious enterprises among the valent enterprises, valent and invalent enterprises among suspicious enterprises, and suspicious and invalent enterprises among invalent enterprises. For newly obtained probabilistic distributions of enterprises, a block of cascade filters is introduced from the system of indicators characterizing latent phenomena in tax accounting and book-keeping.

At the third stage of the simulation, enterprises are subsequently filtered on the basis of indicators that reflect atypical aspects of their financial and economic activities. The cutoff coefficients for valent enterprises are zero, since they are not characterized by non-observed financial and economic activity; they are greater than zero for invalent enterprises, and for suspicious enterprises they are set in the form of a combination of indicators adopted for suspicious and invalent enterprises. This allowed us to obtain a three-dimensional probability distribution of valent, suspicious and invalent enterprises. An expert evaluation of hidden return derived from the officially recorded turnover was used as a cascade filter for valent and suspicious enterprises.

At the fourth stage of simulation, the adequacy of the distribution of valent, suspicious and invalid enterprises was checked using heuristic rules that reflect the criterial risk conditions for the valent enterprise (Bokun, 2016):

50 small business respondents participated in the restricted expert survey the result of which were grouped data used to obtain output quantitative characteristics of the business process for the formation of an unaccounted-for cash turnover,.

The expert survey provided information on the relationship between the two groups of indicators:

1. Gross income of a dummy short-lived company and the level of its commission;
2. The official release of products (works, services) and the level of its concealment.

In the process of preparing the questionnaires, the data on revealing the criminal cases related to the identification and cancellation of front-line dummy companies were used as the benchmarks for the relationship of the indicators of the first group.

Expert estimates obtained from the two groups of indicators X and Y are schematically presented in the form of a correlation matrix in Table 2.

Table 2. Correlation Matrix of Correspondence between X and Y

Y / X	Y_1	Y_2	Y_3	…	Y_n	$\sum n_{xi}$
X_1	n_{11}	n_{12}	n_{13}	…	n_{1n}	$\sum n_{x1}$
X_2	n_{21}	n_{22}	n_{23}	…	n_{2n}	$\sum n_{x2}$
X_3	n_{31}	n_{32}	n_{33}	…	n_{3n}	$\sum n_{x3}$
…	…	…	…	…	…	…
X_m	n_{m1}	n_{m2}	n_{m3}	…	n_{mn}	$\sum n_{xm}$
$\sum n_y$	$\sum n_{y1}$	$\sum n_{y2}$	$\sum n_{y3}$	…	$\sum n_{ym}$	$\sum n_{xy}$

where n_{ij} is the repeatability of the pairwise values X_i , Y_i.

Table 1 shows that each value of characteristic X corresponds to the distribution of Y and vice versa. The correlation matrix made it possible to determine the correspondence between the values of two expert values: X_1, Y_1 and X_2 , Y_2 in the form of a ranked discrete distribution series. For expert values X_1, Y_1, it is presented in Table 3, and for expert values X_2 , Y_2 - in Table 4.

Table 3. Distribution of expert values X_1 and Y_1

X_{ij}^1	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_{yi}^1	2.0	5.0	4.0	6.2	7.0	8.3	5.0	8.1 and more

Note:

X_{ij}^1 - gross income of a dummy short-lived company, cond. m.u.

X_{yi} - commission of the front short-lived company,%.

Table 4. Distribution of expert values X_2 and Y_2

X_{ij}^1	7.91	20.3	22.8	35.1	42.6	94.7	102.4	112.3
X_{yi}^1	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8

Note:

X_{ij}^1 - official release of products (works, services), cond. m.u.;

X_{yi}^1 - the level of concealment of officially produced products (works, services), %.

Expert assessments X and Y have been checked for compliance with the distribution laws. For each pair of them, a form of relationships is chosen. It was revealed that expert assessments X_1 and Y_2 obey the normal distribution law, and the expert estimates X_2 and Y_1 are, respectively, the lognormal and uniform distribution laws. The regression equation for the two

expert judgment groups X_1 and Y_1 and X_2 and $Y_{2\ is}$ is described by a sixth-degree polynomial:

For expert assessments of X_1 and $Y_{1,}$ the regression equation is represented by the following expression:

$\hat{y}_x$ = - 3E - 45 $_x{}^7$ + 3E + 24 $_x{}^3$ - 5E - 11 $_x{}^5$ + 7E - 0.9 $_x{}^2$ + 0.006 $_x{}^2$ + 2.38 $_x$ + 196.2

The coefficient of determination (R^2 = 0.893) indicates the adequacy of the mathematical model to empirical data. The significance of the determination coefficient is verified with the help of Fisher's F-criterion. It was revealed that $F_{obs.} > F_{cr}$, therefore, the condition of significance is satisfied.

For expert assessments of X_2 and $Y_{2,}$ the regression equation is represented by the following expression:

$\hat{y}_x$ = 2E + 14 $_x{}^5$ + 12E - 0,9 $_x{}^3$ - 9E + 1,9 $_x{}^6$ - 3,8 $_x{}^4$ + 7,9 $_x{}^5$ - 15,302 $_x$ + 104,321

The coefficient of determination (R^2 = 0.902) indicates the adequacy of the mathematical model to empirical data. It was revealed that $F_{obs.} > F_{cr}$, therefore, the condition of significance is also satisfied.

In the case when the endogenous variable, which appears as the non-observed economy, is not known, it could be expedient to use discriminant models "logit" and "robit" which are preferably supplemented with regression models. Models differ in what distribution function they use ("logit" - logistic, "robit" - normal). So, in the "logit" model, the probability of gaining growth in an non-observed economy is described by a logistic function that is mathematically written using the following expression:

$\exp(B^T X) / [1 + \exp(B^T X)]$,

where $X = (X_{1,} X_{2,...,} X_n)$ is a vector of explanatory variables;

$B = (B_{1,} B_{2,...,} B_n)$ is the vector of fixed coefficients;

^{T} is the sign of transportation.

The authors have built stochastic "logit" models for two and three variables from the whole set of responses and predictors. The results of calculations are presented in Table 5.

Table 5. Indicators of "logit" models of the non-observed economy in the municipal districts of the Republic of Tatarstan for 2017

Variable	Coefficient	T-stat	% progn	R^2 McFadden	Ln L	p-value	AIC	BIC	HQC
U_{16}	1.694	1,901	94.0	0.789	-7.23	0.000000	24.39	26.85	32,44
U_{17}	2.397	2,704							
U_{17}	2,890	2.134	91.8	0,726	-10.34	0.000000	29.65	44.18	36.67
U_8	0,001	1,305							
U_{17}	3,259	2,651	74.0	0.611	-8.28	0.000000	27.33	31.90	21.18
Do_{19}	2,834	2,311							
U_{17}	8,864	2,164	85.15	0.942	-4.36	0.000000	12.87	13.24	11.32
U_{15}	15,392	2,345							
U_{17}	4,856	5,138	92.7	0.518	-6.21	0.000000	13.42	19.10	36.83
Y_{18}	3.292	5,146							

Table 5 shows that the most significant responses that cause the development of the non-observed economy in the municipal districts of the Republic of Tatarstan are the variables $Y_{15\ and}$ U_{17} which belong to the segment of fictitious and criminal economy (Y_{15} - the number of manipulation cases with actually incurred costs; At_{17} - the number of investment fraud cases identified).

The authors have built stochastic "logit" models for three segments of the non-observed economy: hidden, underground, fictitious and criminal economy. Stochastic "logit" models by segments of the non-observed economy are built in the form of one-, two- and three-factor models with a different combination of structural factors. The results of calculations are presented in Table 6.

Table 6. Indicators of "logit" models for segments of the non-observed economy in the municipal districts of the Republic of Tatarstan for 2017

Variable	Coefficient	T-stat	% progn	R^2 McFadden	Ln L	p-value	AIC	BIC	HQC
X_1	0.026742	0.906	74.3	0.2067	32,44	0,075693	72.44	68.24	63.79
X_2	0.126798	3.142							
X_3	0,432,790	1.534							
X_2	0.234601	2,029	67.4	0.0953	26.95	0.024117	85.16	66.36	62,42
X_3	0,321983	0.556							
X_2	0.394709	4.506	83.9	0.0701	37.19	0.044110	78.34	73.51	64.90

Note:
X_1 - the latent economy; X_2 - underground economy; X_3 - fictitious and criminal economy.

Table 6 shows that the most adequate one-factor stochastic "logit" model with structural segment X_3 is fictitious and criminal economy.

4 Summary

The widespread distribution of cash out transactions is explained by the receipt of unaccounted-for cash by taxpayers in a non-cash form, what is associated with a minimal risk of their return (Bekker, 2015).

Decomposition of components of the business process for cashing of monetary resources received in absolute terms, and allows us to determine its output parameters in the form of underreporting of tax payments, hidden revenue, as well as hidden wages (Eliseyeva and Terekhov, 1998; Degtyarev, 2017). The results for the single-factor "logit" model analysis showed that, in the aggregate of predictors, the most important variables are those which determine the development of a fictitious and criminal economy, and in the aggregate of responses, are those which determine the development of a hidden economy. Single-factor "logit" models were built with various combinations of the most significant responses and predictors. The results of the calculations showed that if more than three variables are included in a model, it becomes non-stochastic.

5 Conclusions

A non-observed economy is a phenomenon inherent in all countries of the world. Today, it should be considered as a powerful socio-economic factor that has a major impact on all aspects of society. The shadow and official sectors of the Russian economy are tightly intertwined, and it is senselessly to analyze them in isolation from each other. Structural changes in the economy, the tax press and administrative pressure on business entities affect not so much the total volume of processes which are not monitored by official statistics, but rather the distribution of shadow flows between economic spheres.

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