Elena MAČIULAITYTĖ

ECONOMETRIC MODELLING OF FISCAL SECTOR FINANCES

Summary of Doctoral Dissertation
Physical Sciences, Mathematics (01P)

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Vilnius LEIDYKLA TECHNIKA 2007

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

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1. General Characteristics of the Dissertation

Topicality of the problem. The accurate (exact) prediction of tax revenue is a very important task for state budget planning. Both underestimation and overestimation of the planned revenue could cause problems in case the revenue is used to finance government functions. The main and largest part of revenue is tax revenues which are collected from certain taxes. For the past four years the revenue from the profit tax was growing faster as compared with other tax revenues. Therefore its importance has also grown up: last year the share of profit tax revenue was 12 % of all the tax revenues. In the past few years planning of profit tax revenue was not very exact: the sum of the profit tax collected was considerably smaller or considerably larger than the planned profit tax revenue. The difference between the actual and planned revenue was about 12–56 % every year.

There are several related factors which aggravate profit tax revenue modelling. It is doubtful if the indicator of profit tax revenue is stationary. The assumption of the stationarity of indicators is usually made when applying econometric models to the indicators. This problem is caused by a frequent change of the Profit tax law. In addition, transitional processes, invoked by privatization, integration to EU, and etc were typical of the Lithuanian economy in the past few years.

Therefore very general equations used to describe the profit tax revenue of macroeconometric models of many countries are not relevant to model and predict the profit tax revenue in Lithuania. In order to predict budget revenues accurately, their modelling methodology needs to be created so as to be effective in the situation where regression relations are complicated while disposable series of observations are rather short (the quarterly profit indicators have been known since 1998 in Lithuania). Although the main attention is paid to the analysis of profit tax revenue, the two-stage modelling methodology presented here can be easily adjusted to the prediction of other tax revenues. It can also be widely adapted to the class of applied research where the models to be used were narrowed to very simple ones because of lack of observations though true regression relations are complicated.

Financed by the Lithuanian State Fund of Science and Studies, the project of “Mathematical Models of Lithuanian Economy to Predict Processes of Macroeconomy”, aimed at the creation of a macroeconometric model of Lithuanian economy, have been pursued for several years. The system of equations of the government finances sector is an important part of the project and the last part of the dissertation is dedicated to its formation.

Aim and tasks of the work. The objective of this dissertation is to develop the compound methodology of profit tax modelling and predicting, based on the use of legal information, economic information, and analysis of statistical relations.

Seeking for the objective of the work, the following tasks were dealt with:

1. To review the Lithuanian and other countries' experience of state finances modelling when different types of models (macroeconometric, microsimulation, etc) are used as well as to assess the suitability of the models presented in special works to model and predict the Lithuanian budget revenue components;
2. To analyse the order of regulation of the profit tax and its amendments, with a view to choose the basic tax elements that possibly have been influencing the tax revenue most and that are most important in specifying profit tax revenue models;
3. To develop and estimate the profit tax revenue models selecting the best approximating indicator of the true profit tax base;
4. To build and estimate the models of approximating indicators of the true profit tax base when using the profit indicator modelling and other experience;
5. To choose the best econometric model parameters estimation methods which yield the most accurate prediction;
6. To estimate the accuracy of profit tax revenue prediction, depending on the profit tax base indicator used and the modelling method, and to introduce the most appropriate algorithm for profit tax revenue modelling and prediction.

Methodology of research. In order to fulfil the main tasks of the work, mathematical and statistical methods were applied to research: statistical correlation analysis, verification of hypotheses, regression analysis, and cointegration analysis.

The systematic and comparative analysis methods have also been applied for analyzing the modelling experience of government finances sector and tax revenue indicators.

Novelty and practical use value. The compound methodology of profit tax revenue modelling and prediction is presented in the work the core of which consists of two-stage research. In the first stage, the profit tax revenue regression dependence of the tax base is modelled. In the second stage, the profit indicators that can stand for the profit tax base are modelled. The legal information on the tax regulation is used to construct the profit tax revenue models. Several ways of modelling the profit indicators have been presented.

The comparative analysis of model accuracy has been made and most promising models chosen based on the results of this analysis.

Based on the modelling experience of other countries, the econometrical model of the indicators of government finances sector has been created.

The results of the analysis, modelling, and prediction obtained in the dissertation are used in the work of The Department of Economic Analysis of the Government Office of the Lithuanian Republic, when providing prediction of the profit tax revenue. In addition, the compound methodology of profit tax revenue modelling and forecasting will be adapted to other tax revenue modelling and forecasting as a continuation of the research presented here.

The scope of the scientific work. The dissertation consists of introduction, four sections, conclusions, as well as of references and annexes. The volume is 110 pages. The dissertation is written in Lithuanian.

2. Contents of the Work

The first section **The Experience of State Finances Indicators Modelling** reviews the principles of international and national classification of the state finance system and government finance structure of Lithuania. The Lithuanian tax system is also described here: the basic tax elements, principles of taxation; and statistics on Lithuanian budget indicators are presented in the section. The state finances system and its elements modelling methodology, types of models used to model separate tax revenues and all the elements of state finances in one system in Lithuania and other countries are described as well. At the end of the section, application possibilities of the reviewed methods are discussed for case of Lithuania.

The whole work is based on the national classification of state finances defined by the national laws, since there are no sufficiently long data series on the state finance indicators classified by the international principles.

According to the Lithuanian laws and statistics, the main part of the national budget revenue consists of revenues from taxes. Every year, revenues from the four main taxes: personal income tax, profit tax, value added tax (VAT), and excise tax made up more than 90 % of all the tax revenue. The basic tax elements (tax object, tax subject, tax rate), the principles of tax calculation, due dates of tax payment, and permanent changes of tax regulation influenced the dynamics of tax revenues.

Various methods are applied in modelling of tax or tax group revenues. One of the purposes of microsimulation models is the estimation (calculation) of the total tax revenues. However the basis of microsimulation models is made up of very detailed micro level (i.e. personal, household or firm’s) data as well as of very detailed information on the tax system elements and regulation. Therefore, these models are designed to evaluate the primary and the secondary impact of policy changes on the budget revenue as well as on the distribution of income of persons (households) or firms, or between households and firms.

Elasticity models are often used to evaluate the effect of tax policy changes. The tax revenue change and the tax rate change are usually included into the models of this type where the impact on other economic indicators is analysed. On the other hand, the tax revenue change could be analysed due to tax base changes. Identification and estimation of the latter relation is important to budget formation and monitoring of tax revenue collection.

The error correction model based on the definition of tax elasticity (see P. Van den Noord, 2000) has been evaluated for the Australian economy (S. Kennedy et al., 2004)

$$\begin{gathered}\Delta \log M(t) = \alpha_0 + \alpha_1 \Delta \log R(t) + \alpha_2 \Delta \log B(t) + \alpha_3 \log M(t-1) + \\ \alpha_4 \log B(t-1) + \alpha_5 \log R(t-1) + \alpha_6 D_1(t-1) + \alpha_7 D_2(t-1),\end{gathered} \tag{1}$$

where M denotes the profit tax revenue, R is the tax rate, B is the profit tax base, and D_1, D_2 are dummy variables, here and in the sequel, Δ is the first-difference operator.

Simple extrapolation models when revenue is forecasted extending the linear revenue trend or a more sophisticated ARIMA type of models are used for tax revenue modelling (S. Ahmed, 2004). In order to estimate various special aspects, the tax revenue is usually described by regression models. For instance, Y. Hsing (1996) analyses the impact of the tax rate on the tax revenue. He assumes a nonlinear tax revenue dependence on the tax rate and verifies this assumption by evaluating the regression model

$$M(t) = \beta_1 R(t) + \beta_2 R^2(t) + \varepsilon(t) . \tag{2}$$

In general case, $M(t)$ denotes here the tax revenue or logarithm of this indicator, $R(t)$ is the tax rate or its logarithm. If the parameters β_1, β_2 are significant, β_1 has positive value and β_2 – negative, then the equation confirms that the tax revenue are growing until the tax rate reaches a certain level; the subsequent increase in tax rate does not bring any revenue gain.

Finances of the government sector as a part of the whole economy are modelled by the macroeconometric model of many countries: NBNZ-DEMONZ (D. Rea, 1996) of New Zealand, HERMIN HE4 (J. Bradley, A. Kangur, I. Kearney, 2001) of Estonia, BOF5 (A.Willman, M. Kortelainen, H.-L. Mannisto, M. Tujula, 1998) of Finland, LITMOD (D. Celov,

F. M. Andersen, et al., 2003) of Lithuania, etc. The government sector finance indicators are usually described by simple identities in the macroeconometric models: the indicator of revenue or expenditure is equal to the product of the indicator of revenue or expenditure base and the rate.

The second section **Modelling of the Profit Tax Revenue** describes factors that determine the profit tax revenue modelling and also presents the compound methodology of profit tax revenue modelling and forecasting. The first stage of profit tax modelling is described in detail: selection of explanatory indicators for the model, econometric models of the profit tax revenue, methods for model parameter estimation, and criteria for a selecting models. The profit tax models estimated their characteristics where three different profit indicators have been used as the tax base in these models are presented in the section.

Several factors such as nonstationarity of the profit tax revenue indicator, frequent amendments of profit tax regulations, rather short data series of economic indicators, the objective to employ legal and economic information, and etc, complicate the construction of profit tax revenue models. The author suggests solving of the problems of modelling of the profit tax revenue indicator by dividing it into two stages: estimation of the dependence of profit tax revenue regressions on the main profit indicators of economy and formation of prediction algorithms of the profit tax base. These stages make up the basis of the compound methodology of profit tax revenue modelling and prediction. After the correlation analysis of the profit tax indicator and several different profit indicators, three profit indicators of nonfinance enterprises have been chosen for the role of the profit tax base: operating profit (loss) OP, profit (loss) before tax PBT, profit before tax of profitable enterprises P.

Stage I. Modelling and prediction of the profit tax revenue. In order to predict the profit tax revenue indicator, it is necessary to find the profit tax function dependent on the tax base indicator B and various legal tax element indicators E_i for more accurate profit tax revenue M estimation (calculation)

$$M(t) = f\left(B(\cdot), E_i(\cdot)\right). \tag{3}$$

The profit tax revenue forecast is based on the prediction of the profit indicator obtained in the second stage.

Stage II. Modelling and prediction of the profit tax base indicator. The general form of the profit indicator model is

$$B(t) = f\left(Z(t), B(t-\tau)\right) + \xi(t), \tag{4}$$

where Z(t) denotes a vector of regressors chosen on the basis of economic theory and logics and by means of primary correlation analysis.

Econometric models. Several types of econometric models have been used for modelling the profit tax revenue and the profit indicator modelling.

Let $B(t)$ denote a regressand (the profit tax revenue or the profit tax base) and $Z(t)$ – a respective vector of chosen regressors at the moment t. The simplest linear regression model is of the following shape

$$B(t) = \theta^{T} Z(t) + \varepsilon(t), t = 1,..., n. \tag{5}$$

Here θ is the vector of model coefficients, $\varepsilon(t)$ is stochastic error uncorrelated with $Z(t)$. Since in the recent years the economy of our country has been growing fast, the variables of model (5) are not stationary. Therefore the model modification that describes the linear relations of relative economic indicators is noteworthy:

$$b(t) = \theta^{T} z(t) + \varepsilon(t), \tag{6}$$

where the lower case letter denotes the ratio between the corresponding indicator and the gross domestic product Y, $b(t)=B(t)/Y(t)$.

In recent years the vector error correction models have been evermore widely used to describe the growing economy. These models are usually applied to logarithmic economic indicators.

$B^{*}(t)$ is said to be cointegrated with the stochastic $Z^{*}(t)$, if there exists a coefficient vector β such that

$$B^{*}(t) = \beta_{i}^{T} Z^{*}(t) + u(t), \tag{7}$$

where $u(t)$ is a stationary (in a wide sense) process. Here and hereafter, the asterisk (*) denotes logarithmic transformation. Eq. (7) describes long term relations of B^{*} and Z^{*}. The variable $u(t)$ is treated as a measure of deviation from the long term equilibrium $B^{*}(t) = \beta^{T} Z^{*}(t)$. The error correction model describing short term fluctuations is constructed on the base of the cointegration relation. The general form of the error correction model is

$$\Delta B^{*}(t) = \alpha u(t-1) + A(L)\Delta B^{*}(t) + \gamma^{T} \Delta Z^{*}(t) + D(t) + \varepsilon(t)\ . \tag{8}$$

Here L denotes the lag operator: $L^{k} Z(t) = Z(t-k)$; $A(z)$ is a polynomial:

$A(L) = a_1 L + \cdots + a_p L^p$; $D(t)$ is a deterministic component, which includes deterministic time trend, seasonal index, etc; the vectors γ and β and coefficients α, $\alpha_1, \ldots \alpha_p$ are unknown parameters of the model; ε(t) denotes stochastic residual of the model, which does not correlate with other components on the right side of eq. (8). In addition, ε(t) is usually assumed as a white noise term.

Estimation of model parameters. In the applied research where linear regression schemes are used, the least squares parameter estimation methods are most common. To illustrate this method, the respective statistical estimate of the model (5) parameter is presented

$$\hat{\theta} = \arg\min_{\theta} \sum_{t} (B(t) - \theta^T Z(t))^2 \cdot w_t , \tag{9}$$

where w_t are chosen weights. In a particular case where $w_t \equiv 1$, the classical estimate of least squares method (LSM) is obtained.

In the econometric theory it is recommended to use weights in the case where the residual ε(t) is heteroskedastic, i.e. where its dispersion is not constant. However there is a practical aspect of choice of the weights w_t. The applied models are only an approximation of the reality (real relations). The relations between B and the vector of regressors Z are evolving, i.e., in the real economy even the parameters θ = θ(t). Since the aim of the model is to predict profit or profit tax revenue as accurately as possible, it is reasonable to seek a more accurate approximation in the near past, while the errors in further past are not that important. According to this logic, the weight function is supposed to be growing even if the residual ε(t) of the model is homoskedastic.

Along with the LSM, the median estimation is also used in this work. In the latter case, the estimates of model parameters are defined by the equality

$$\hat{\theta} = \arg\min_{\theta} \sum_{t} | B(t) - \theta^T Z(t) | . \tag{10}$$

The median estimations are more robust than the statistics of the type defined by eq. (9) which is very important in the Lithuanian case.

Criteria for model selection. When selecting the profit tax revenue models as well as profit tax models later on, two criteria were taken into consideration:

- significance of the model (correspondence to the economic logic),
- accuracy of model prediction.

The accuracy of model prediction is estimated by several statistics. **The mean relative quarterly indicators prediction error** for 2005 (called in the sequel **prediction error**) and **the mean relative yearly prediction error** for 2005 (called in the sequel **yearly prediction error**) have been obtained using the parameter estimates calculated by the observations until the end of 2004.

Undoubtedly, the yearly prediction error is not sufficiently reliable measure of model accuracy. Therefore in order to evaluate and compare prediction accuracy of models, the statistic $\bar{\delta}$ has also been calculated using a special crossvalidation procedure called *one leave out* or *jack-knife* method. Let us define it in the case of model (5) for illustration. Let $\hat{\theta}(\tau)$ denote the estimate of parameter θ obtained after eliminating the observation from the sample at the time moment τ. The statistic $\bar{\delta}$ is defined by the equality

$$\bar{\delta} = \sum_{\tau=1}^{n} |\,\delta(\tau)\,|\, c(\tau)\,, \tag{11}$$

where $\delta(\tau) = B(\tau) - \hat{\theta}^T(\tau) Z(\tau)$ and $c(\tau)$ are selected weights the sum of which is equal to 1. Two types of weights are used in the work: $c_1(\tau) = 1/12$ if τ stands for a quarter from the period of 2003–2005, and $c_1(\tau) = 0$, in other cases, or $c_2(\tau)$, which are linearly growing weights, if τ stands for a quarter from the period of 2003–2005, and $c_2(\tau) = 0$, in other cases.

The statistics $\bar{\delta}_J$ has been calculated to estimate prediction errors not of the quarterly, but yearly indicators. It is defined by the equality

$$\bar{\delta}_J = \frac{1}{3}\left(\left|\delta(J_1)\right| + \left|\delta(J_2)\right| + \left|\delta(J_3)\right|\right), \tag{12}$$

where $\delta(J) = \sum_{\tau \in J} \delta(\tau)$. Here J_1, J_2, J_3 stand for one of the respective years 2003, 2004, and 2005. In order to compare the accuracy of models with different indicators, the accuracy (error) statistics of particular models are presented in percentage.

The profit tax revenue function. In the profit tax revenue modelling, a great attention has been paid to profit tax regulation, because the laws that regulate profit tax were changed many times and the amendments usually affected and changed more than one tax element. When specifying profit tax revenue models, additional regressors have been constructed on the basis of the tax regulation for the period of 1998:1–2005:4: tax rate indicators ($R(t)$ $R_m(t)$), the tax base indicators for calculating the advanced profit tax payment and yearly profit tax ($B_0(t)$, $B_m(t)$), and dummy variables related with due dates for the tax payment ($D_3(t)$, $D_4(t)$).

According to the profit tax regulation, the profit tax revenue consists of several components: the profit tax advanced payment that could be divided into two parts, (yearly) profit tax payment, profit tax on dividends, profit tax at the source, and other profit tax payments. Assuming the insignificance of some components, the estimation of the profit tax revenue function can be started from the following linear regression model

$$M(t) = \alpha_1 \cdot R(t) \cdot B_0(t) + \alpha_2 \cdot R(t) \cdot B(t) + \alpha_3 \cdot R_m(t) \cdot B_m(t) + \varepsilon(t) \,. \tag{13}$$

The model parameters have been estimated by the weighted LSM using linearly growing weights. This kind of estimation was more suitable for all the other profit tax revenue models. The obtained model was not accurate enough because it took no account of seasonality typical of the profit tax revenue related to profit tax payment dates as well as for transfer of the losses (N), incurred in the previous years, to the current year, provided by the law, and of preferential tax rate on the profit used for investment (I), and possible return of overpaid profit tax or covering of other tax by it. The general form of the obtained model is as follows:

$$\begin{gathered} M(t) = \alpha_1 \cdot R(t) \cdot B_0(t) + \alpha_2 \cdot R(t) \cdot B(t) + \alpha_3 \cdot R_m(t) \cdot B_m(t) \cdot D_3(t) + \\ \alpha_4 \cdot R_m(t) \cdot B_m(t) \cdot D_4(t) + \alpha_5 \cdot R(t) \cdot N(t-3) + \alpha_6 \cdot I(t-4) \cdot D_0(t) + \\ \alpha_7 \cdot M(t-1) + \varepsilon(t). \end{gathered} \tag{14}$$

Here $D_0(t)$ is a dummy variable related to validity of the preferential tax rate. While estimating parameters of this model in view of each profit indicator, the number of parameters decreased after excluding insignificant indicators.

It is very likely that nonstationary residuals could be obtained by applying linear regression to model the profit tax revenue indicator $M(t)$. In order to avoid nonstationary errors, the indicators of the ratio between the tax or the profit and GDP have been analysed. Respective ratio indicators are denoted by lower case letters. So, better results have been obtained with this type of models

$$\begin{gathered} m(t) = \alpha_1 \cdot R(t) \cdot b_0(t) + \alpha_2 \cdot R(t) \cdot b(t) + \alpha_3 \cdot R(t) \cdot n(t-3) + \alpha_4 \cdot D_3(t) + \\ \alpha_5 \cdot D_4(t) + \alpha_6 \cdot i^2(t-3) \cdot D_0(t) + \varepsilon(t) \end{gathered} \tag{15}$$

in comparison with the models of primary non-ratio indicators.

The experience of many macroeconometric researches in different countries shows that ratios of macroeconomic indicators are rather stable, therefore the cointegration analysis applies to logarithmic indicators. The cointegration equation of logarithmic indicators have been constructed

$$M^*(t) = \beta_0 + \beta_1 (B \cdot R)^*(t)) + \beta_2 D_3(t) + \beta_3 D_4(t) + u(t)\,. \tag{16}$$

Here β_i denote coefficients after estimating of which by the LSM, the ADF test of the unit root showed the stationarity of the residual $u(t)$. Based on this cointegration relation, error correction models have been constructed and estimated, including (lagged) differences of logarithms of the various indicators ($M(t)$, $B(t)$, $B_0(t)$, $N(t)$, $I(t)$). The obtained error correction model

$$\begin{gathered}\Delta M^*(t) = -\alpha\left[M^*(t-1) + \beta_0 + \beta_1 (B \cdot R)^*(t-1) + \beta_2 D_3(t) + \beta_3 D_4(t)\right] + \\ \beta_4 \Delta (B \cdot R)^*(t-2) + \beta_5 \Delta (B \cdot R)_0^*(t-2) + \beta_5 \Delta (N \cdot R)^*(t-3) + \varepsilon(t)\end{gathered} \tag{17}$$

gave rather good results. Here and hereafter, the cointegration relation is indicated in square brackets.

Since the final accuracy of profit tax revenue prediction also depends on the prediction of profit indicators, several identified models of profit tax revenue have been selected. The model of ratio indicators of (15) type had the least errors

$$\begin{gathered}m(t) = \underset{(<0{,}001)}{6{,}308} \cdot b(t) \cdot R(t) + \underset{(0{,}022)}{3{,}789} \cdot b_0(t) \cdot R(t) - \underset{(0{,}004)}{2{,}937} \cdot n(t-3) \cdot R(t) + \\ \underset{(<0{,}001)}{0{,}017} \cdot D_3(t) + \underset{(<0{,}001)}{0{,}013} \cdot D_4(t) + \varepsilon(t).\end{gathered} \tag{18}$$

However having more observations in the future, this conclusion may be different. The coefficients are estimated here in the case where $B(t)$ is the profit indicator OP. Under each coefficient the significance level (p-value) is indicated in brackets. While analysing the prediction accuracy of model (18), next accuracy (error) estimates have been obtained: $\bar{\delta}$ =5,1 %, the yearly prediction error was 3,7 %.

The third section **Profit Tax Base Modelling and Profit Tax Revenue Prediction** describes the second stage of profit tax revenue compound modelling. Several most suitable quarterly profit indicators have been chosen for the profit tax base. Based on the practice of profit tax modelling described in various works and making use of the profit definition, regression models of profit indicators as well as that of profit ratio indicators, and error correction models have been constructed. Explanatory variables and their functions used in the various models of profit indicators are presented in the section as well. After choosing more accurate estimated models of the profit indicators, error statistics of the compound prediction have been calculated and the most accurate algorithm for profit tax revenue prediction established.

There are several possible true profit tax base approximating indicators which are announced every quarter by the Department of Statistics. However, according to the results of the primary correlation analysis, only three indicators have been chosen: OP, PBT, and P. The same econometric models, parameter estimation methods, and model selection criteria have been used for modelling the profit indicators as for the profit tax revenue.

The preliminary statistical analysis has shown a strong dependence of profit on GDP (*Y*), material investment (*I*) and wage fund (*F*). In some models, the significant regressors were export volume (*X*), and the bank credit average interest rate (*r*).

When estimating the export impact on profit, the moving average of export changes has been used as a regressor in this work

$$\tilde{X}(t) = \sum_{s=0}^{2\tau} \left(1 - \frac{|s-\tau|}{\tau} \right) \Delta X(t-s), \tag{19}$$

where τ is the time point at which the cross-correlation function $r(\tau) = \mathrm{cor}(\Delta B(t), \Delta X(t-\tau))$ reaches its maximum. It is also expedient to use moving averages for modelling the impact of material investment on profit when defining the capital

$$\tilde{I}(t) = \sum_{s<t} I(s) q(s,t), \tag{20}$$

where $\tilde{I}(t)$ is the value of intangible assets purchased in the time period *s*, and the multiplier $q(s, t)$ shows the share of the previous value of assets left at the moment *t*. It is determined on the base of expert opinion.

On the basis of the approximate formula of operating profit calculation, first of all the regression equation has been identified

$$B(t) = \theta_1 Y(t) - \theta_2 F(t) - \theta_3 I(t) + \varepsilon(t). \tag{21}$$

All the three regressors were significant and the estimates of parameters met the a prior assumption

$$\theta_i > 0, \quad i = \overline{1,3}. \tag{22}$$

As expected, the ADF test showed nonstationarity of errors. The model had very bad accuracy statistics. The additional regressor $X(t)$ reflecting the export influence improved the modelling accuracy. In order to stress the export influence on profit, several economy sectors, such as manufacturing and transport, were grouped into one sector. We call this group of sectors the production of which makes the major part of country export the first sector and the group of other sectors is called the second sector. $B_i(t)$ denotes the profit of the i-th sector. We also use this notation to denote other indicators. Thus, the economy profit is

$$B(t) = B_1(t) + B_2(t). \tag{23}$$

As shown by the analysis made, the profit forecast calculated with the aid of this decomposition is rather accurate. However, good results have been obtained when the indicators $B_1(t)$ and $B_2(t)$ were modelled in different ways. The profit indicator $B_1(t)$ was rather well described by the regression equation

$$B_1(t) = \theta_1 Y_1(t) - \theta_2 F_1(t) - \theta_3 \tilde{I}\ (t-2) + \theta_4 X(t-3) + \varepsilon(t) \tag{24}$$

while in the case of the second sector, this model gave quite poor results. The prediction accuracy of both the first sector profit and the whole economy profit has been improved after proceeding to the ratio indicators

$$b(t) = \theta_1 - \theta_2 f(t) - \theta_3 i(t) + \varepsilon(t). \tag{25}$$

Here as above, the ratio between the indicator and GDP is denoted by the lower case letter. Eq. (25) was expanded by including the bank credit average interest rate $r(t)$ and a dummy variable

$$d_1(t) = \begin{cases} 1, & \text{as } t_1 \le t \le t_2 \\ 0, & \text{in other cases.} \end{cases} \tag{26}$$

Here the time moment t_1 is the beginning of 1999 and t_2 is the end of 2000. The impact of the Russian crisis on the Lithuanian economy was highest during these years. So, the expanded model is

$$b(t) = \theta_1 + \theta_2 f(t) + \theta_3 i(t) + \theta_4 r(t-4) + \theta_5 d_1(t) + \varepsilon(t). \qquad (27)$$

Good results have also been obtained by applying the equations of (25) type to the sectors mentioned separately. In the case of the first sector, the additional regressor $\tilde{x}(t)$ (it is defined in a similar way as $\tilde{X}(t)$ in eq. (19) just replacing the absolute export difference indicator $\Delta X(t)$ by the relative ones $\Delta X(t)/X(t)$) was included

$$b_1(t) = \theta_1 + \theta_2 f_1(t) + \theta_3 \tilde{i}_1(t-3) + \theta_4 d_2(t) + \theta_5 \tilde{x}(t) + \varepsilon(t)\,, \qquad (28)$$

where the dummy variable

$$d_2(t) = \begin{cases} 1, & \text{as } t \geq t_3 \\ 0, & \text{in other cases.} \end{cases} \qquad (29)$$

Here t_3 denotes the beginning of 2004 when the foreign trade conditions changed. The credit rate variable $r(t)$ and seasonal dummy variables included into eq. (28) were not significant.

Applying the cointegration analysis, the error correction equation

$$\Delta B^*(t) = \alpha\left[B^*(t-1) + \beta_0 + \beta_1 Y^*(t-3) + \beta_2 \tilde{I}^*(t-4)\right] + \theta_1 \Delta Y^*(t-3) + \varepsilon(t) \qquad (30)$$

acquired not so bad accuracy properties.

The indicators of individual sectors cointegrate worse than that of the whole economy. Therefore modelling of the first sector profit indicators has not justified itself by this type of model, whereas the error correction equation of the second sector profit

$$\Delta B_2^*(t) = \alpha\left[B_2^*(t-1) + \beta_0 + \beta_1 Y_2^*(t-3) + \beta_2 \tilde{I}_2^*(t-2)\right] + \theta_1 \Delta Y_2^*(t) + \varepsilon(t) \qquad (31)$$

can be used for prediction of the variable B_2.

At the end of the work, the prediction errors of the profit tax revenue $M(t)$ have been obtained in the case, where the values of profit indicators used in the profit tax revenue models are not known, but are predicted using the profit models presented above. One of the most accurate profit tax revenue predictions has been obtained by applying a compound algorithm which consists of the equations

$$b_1(t) = -0{,}120 - \underset{(0{,}004)}{2{,}302} \cdot f_1(t) - \underset{(<0{,}001)}{0{,}591} \cdot \tilde{i}_1(t-3) + \underset{(0{,}041)}{0{,}042} \cdot \tilde{x} + \underset{(0{,}003)}{0{,}013} \cdot d_2 + \varepsilon(t), \tag{32}$$

$$\begin{aligned} \Delta B_2^*(t) = -0{,}608 \cdot \Big[& \underset{(<0{,}001)}{B_2^*(t-1)} + \underset{(<0{,}001)}{23{,}198} - \underset{(0{,}009)}{2{,}148} \cdot Y_2^*(t-3) - \underset{(0{,}015)}{1{,}263} \cdot \tilde{I}^*(t-2) \Big] + \\ & \underset{(0{,}078)}{0{,}586} \cdot \Delta Y_2^*(t) + \varepsilon(t), \end{aligned} \tag{33}$$

and the profit tax revenue model (18). In eq. (32), the modelled profit indicator is OP of the first sector; the model parameters have been estimated by the LSM. In eq. (33) the modelled profit indicator is OP of the second sector; the model parameters have been estimated by LSM. Based on the accuracy analysis, it could be stated, that using this algorithm the yearly prediction error will not exceed 6 % disregarding the influence of the errors of GDP and fund of wages forecast.

The fourth section **The Model of Government Sector Finances** presents the system of equations that describe the government finance sector. When constructing it, the modelling experience of other countries has been used for choosing the variables of equations.

In the macroeconometric models considered it was noticed that the government finance sector is usually described by similar equations independent of a country's economic peculiarities, assumptions of the model, etc. The adequacy of typical government finance equations to the Lithuanian data was verified by using similar indicators provided by the Statistical Department of Lithuania. It has been established that typical equations cannot be directly applied in the estimation of the government finance sector of Lithuania. The typical equations were replaced by stochastic models where the stochastic correction coefficient α was included into the model

$$GT(t) = \alpha \cdot RGT(t) \cdot BGT(t) + \varepsilon(t). \tag{34}$$

Here $GT(t)$ is the indicator of tax revenues or other government finances, $RGT(t)$ is the rate (exogenous), $BGT(t)$ is the base of the tax revenue or another indicator of government finances.

In addition, the linear regression models dominated in the macromodels analysed have been replaced by the error correction models since the latter models distinguished themselves for a better accuracy.

3. General Conclusions

- The compound methodology proposed for profit tax revenue modelling and prediction can solve modelling and forecast problems of this nonstationary indicator depending on various changes of regulating factors.
- The accuracy of models of both the profit tax revenue and profit indicators has increased after constructing linear regression models for the ratio of the initial indicators with GDP but not for the initial indicators.
- It has been found that good results of modelling and forecasting of the profit and the profit tax revenue can also be obtained when the relations of indicators are described by error correction models.
- The weighted least squares method with linearly growing weights is highly recommended for the estimating of the parameters of the models, though the median estimation method is also noteworthy.
- In order to stress the export impact it is reasonable to divide the whole economy into two sectors (the exporting sector and that for selling in the domestic market).
- The most recommended procedure of the profit tax revenue prediction at present includes equations (18), (32) and (33); moreover, it is reasonable to use the OP of nonfinance enterprises as the profit tax base (in the future this conclusion could differ in case we have more observation data and revise the models accordingly). Using this algorithm, the yearly prediction error should not exceed 6 % disregarding the influence of the errors of GDP and fund of wages forecast.

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VALSTYBĖS FINANSŲ EKONOMETRINIS MODELIAVIMAS

Mokslo problemos aktualumas. Tikslus mokesčių pajamų prognozavimas – labai svarbi užduotis planuojant biudžeto pajamas. Tiek sumažinta, tiek ir padidinta prognozė gali sukelti problemų skirstant asignavimus, vykdant numatytą valstybės funkcijų finansavimą. Didžiausia ir pagrindinė biudžeto pajamų dalis yra mokestinės pajamos, kurių sudedamosios dalys – pajamos iš atskirų mokesčių. Ketverius paskutiniuosius metus pelno mokesčio pajamos palyginus su kitais mokesčiais didėjo bene sparčiausiai, todėl išaugo šio mokesčio reikšmė – praėjusiais metais pelno mokesčiui teko 12 % mokestinių pajamų. Pastaraisiais metais pelno mokesčio planavimas nepasižymėjo tikslumu – pelno mokesčio pajamų buvo surenkama žymiai mažiau arba daugiau nei buvo planuota. Surinktų pajamų neatitikimas planuojamoms siekė 12–56 %.

Pelno mokesčio pajamų modeliavimą Lietuvoje apsunkina keletas susijusių veiksnių. Pelno mokesčio pajamų rodiklis vargu ar tenkina stacionarumo prielaidą, kuri paprastai daroma taikant ekonometrinius modelius. Tai susiję su dažna pelno mokestį reglamentuojančių teisės aktų kaita. Be to, pastaraisiais metais šalies ekonomikoje vyko struktūriniai pokyčiai, kuriuos sukėlė privatizavimo procesas ir integracija į Europos sąjungą.

Daugelio šalių makroekonometriniuose modeliuose naudojamos bendro pobūdžio pelno mokesčio pajamų lygtys nėra pats tinkamiausias pelno mokesčio modeliavimo ir prognozavimo būdas. Siekiant kuo tiksliau prognozuoti biudžeto pajamas reikalinga nauja jų modeliavimo metodika, kuri būtų efektyvi situacijoje, kai regresiniai ryšiai yra gana sudėtingi, o disponuojamos stebėjimų eilutės yra neilgos (Lietuvoje ketvirtiniai ūkio pelno rodikliai turimi nuo 1998 m.). Nors disertacijoje pagrindinis dėmesys skiriamas pelno mokesčio pajamų analizei, pasiūlyta pakankamai efektyvi dvipakopė jų modeliavimo metodika nesunkiai gali būti pritaikyta ir kitų mokestinių pajamų prognozavime. Apskritai ją galima adaptuoti gana plačiai taikomųjų tyrimų klasei, kai dėl stebėjimų stokos tenka apsiriboti paprastais modeliais, nors tikrieji regresiniai ryšiai yra komplikuoti.

Finansuojant Lietuvos Valstybiniam mokslo ir studijų fondui kelis metus buvo vykdoma „Lietuvos ekonomikos matematinių modelių makroekonominiams procesams prognozuoti“ programa[1], kurios vienas pagrindinių tikslų yra šalies ūkio makroekonometrinio modelio sukūrimas. Svarbi jo dalis yra valdžios sektoriaus finansų modelis, kurio sudarymui skirta paskutinė disertacijos dalis.

[1] Lietuvos VMSF remiama programa „Lietuvos ekonomikos matematiniai modeliai makroekonominiams procesams prognozuoti“ (registracijos Nr C-03004).

Darbo tikslas ir pagrindiniai uždaviniai. Šios disertacijos tikslas – sukurti sudėtinę pelno mokesčio pajamų modeliavimo ir prognozavimo metodiką, paremtą teisinės informacijos, ekonominės informacijos bei statistinių ryšių panaudojimu. Siekiant užsibrėžto tikslo buvo sprendžiami tokie uždaviniai:

1. išnagrinėti Lietuvos ir kitų šalių valstybės finansų modeliavimo patirtį, kai naudojami įvairaus tipo modeliai (makroekonometriniai, mikrosimuliaciniai ir pan.), įvertinti specialioje literatūroje pateikiamų modelių tinkamumą Lietuvos biudžeto pajamų modeliavimui ir prognozavimui;
2. išanalizuoti pelno mokesčio reglamentavimo tvarką ir jos kaitą bei atrinkti mokestinius elementus, dariusius galimai didžiausią poveikį mokesčio pajamoms, tyrimo rezultatus panaudoti mokestinių pajamų modelių specifikavimui;
3. sudaryti ir įvertinti pelno mokesčio pajamų modelius, parenkant tinkamiausią mokesčio bazės rodiklio artinį;
4. naudojantis pelno rodiklio modeliavimo patirtimi sudaryti ir įvertinti pelno mokesčio bazės artinių modelius;
5. parinkti geriausią modelių tikslumą lemiančius ekonometrinių modelių parametrų vertinimo metodus;
6. įvertinti pelno mokesčio pajamų prognozavimo tikslumą, priklausomai nuo mokesčio bazės rodiklio pasirinkimo bei to rodiklio modeliavimo būdo, ir pasiūlyti tinkamiausią pelno mokesčio pajamų modeliavimo ir prognozavimo algoritmą.

Tyrimų metodika. Siekiant atlikti numatytus darbo uždavinius buvo taikomi matematiniai, statistiniai tyrimo metodai: statistinė, koreliacinė analizė, hipotezių tikrinimas, regresinė analizė, kointegravimo analizė.

Analizuojant valstybės finansų rodiklių bei pelno rodiklio modeliavimo patirtį buvo taikyti lyginamosios analizės metodai.

Darbo mokslinis naujumas ir praktinė nauda. Darbe pasiūlyta pelno mokesčio pajamų modeliavimo metodika, kurios esmę sudaro dviejų pakopų tyrimas. Pirmajame etape modeliuojama pelno mokesčio pajamų regresinė priklausomybė nuo mokesčio bazės. Antrajame etape modeliuojami tie pelno rodikliai, kurie gali geriausiai aproksimuoti pelno mokesčio bazę. Mokestinių pajamų modelių sudarymui naudotasi teisine informacija apie mokesčio reglamentavimą. Pateikti keli pelno mokesčio bazės rodiklio modeliavimo būdai, atlikta jų tikslumo lyginamoji analizė ir atrinkti perspektyviausi.

Remiantis kitų šalių patirtimi sudarytas valstybės finansų rodiklių ekonometrinis modelis.

Šiame darbe atliktų tyrimų bei modeliavimo ir prognozavimo rezultatai naudojami Lietuvos Respublikos Vyriausybės kanceliarijos Ekonominės analizės departamento darbe, skaičiuojant pelno mokesčio pajamų prognozes. Tęsiant atliktus tyrimus, sudėtinę pelno mokesčio modeliavimo ir prognozavimo metodiką planuojama taikyti (adaptuoti) kitų mokesčių pajamų modeliavimui ir prognozavimui.

Disertacijos struktūra. Disertacinį darbą sudaro įvadas, keturi skyriai, išvados, literatūros sąrašas bei priedai. Disertacijos apimtis – 110 puslapiai. Disertacija parašyta lietuvių kalba.

Pirmame skyriuje apžvelgta Lietuvos valstybės finansų struktūra, mokestinė sistema. Šiame skyriuje taip pat aprašytos valstybės finansų modeliavimo metodikos, modelių tipai, taikomi Lietuvoje ir užsienyje modeliuojant tiek atskirus mokesčius, tiek ir bendrai vienoje sistemoje visas valstybės finansų sudedamąsias dalis. Pabaigoje aptartos apžvelgtų metodikų taikymo galimybės Lietuvoje.

Antrame skyriuje išdėstyti pelno mokesčio pajamų modeliavimą sąlygojantys veiksniai bei aprašyta pelno mokesčio pajamų modeliavimo metodikos esmė. Detaliai aprašytas pirmasis pelno mokesčio pajamų modeliavimo etapas: modelio aiškinančiųjų rodiklių parinkimas, pelno mokesčio pajamų ekonometriniai modeliai, modelių parametrų vertinimo metodai, modelių parinkimo kriterijai. Pateikti įvertinti pelno mokesčio pajamų modeliai, kai naudojami trys skirtingi pelno mokesčio bazės rodikliai bei jų charakteristikos.

Trečiame skyriuje aprašytas antrasis pelno mokesčio pajamų modeliavimo etapas, kai buvo sudaryti pelno rodiklių modeliai. Pagal parinktus pelno rodiklių modelius ir antrame skyriuje pateiktus pelno mokesčio pajamų modelius buvo suskaičiuotos sudėtinių pelno mokesčio pajamų algoritmų tikslumo statistikos ir parinktas tiksliausias mokesčio pajamų prognozavimo sudėtinis algoritmas.

Ketvirtame skyriuje pateiktos įvertintos originalios Lietuvos valstybės sektoriaus finansų sudedamųjų dalių paklaidų korekcijos lygtys.

Bendrosios išvados

1. Pasiūlyta pelno mokesčio pajamų sudėtinė modeliavimo ir prognozavimo metodika suteikia galimybę išspręsti šio nestacionaraus, priklausančio nuo įvairių reglamentuojamų faktorių kaitos, rodiklio modeliavimo ir prognozavimo problemas.
2. Tiek pelno rodiklių, tiek ir pelno mokesčio pajamų modelių tikslumas išaugdavo, jei tiesinės regresijos modeliai buvo sudaromi ne pirminiams rodikliams, o jų santykiams su sukurta pridėtine verte (bendruoju vidaus produktu).

3. Nustatyta, kad geri pelno mokesčio pajamų ir pelno rodiklių modeliavimo ir prognozavimo rezultatai gaunami ir tuo atveju, kai logaritmuoti rodikliai aprašomi paklaidų korekcijos modeliu.
4. Parametrų įvertinimui labiausiai rekomenduotinas apibendrintas mažiausiųjų kvadratų metodas su tiesiškai augančiais svoriais, tačiau vertas dėmesio ir medianinis metodas.
5. Siekiant išryškinti eksporto poveikį, visą mūsų šalies ūkį tikslinga skaidyti į du sektorius (eksportuojantį ir orientuotą į vidaus rinką).
6. Šiuo metu pelno mokesčio prognozavimui rekomenduotina naudoti (18), (32) ir (33) lygtis mokesčio baze parenkant nefinansinių įmonių ūkinės veiklos pelną (tačiau ateityje, turint didesnes duomenų imtis ir patikslinus modelius, ši išvada gali pasikeisti). Taikant šį algoritmą metinių pajamų prognozės paklaida turėtų neviršyti 6 %, neįskaitant bendrojo vidaus produkto bei darbo užmokesčio fondo prognozavimo paklaidų poveikio.

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ECONOMETRIC MODELLING OF FISCAL SECTOR FINANCES

Summary of Doctoral Dissertation
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