Modelling local government unit credit risk in the Republic of Croatia

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Abstract

The objective of this paper is to determine possible indicators that affect local unit credit risk and investigate their effect on default (credit risk) of local government units in Croatia. No system for the estimation of local unit credit risk has been established in Croatia so far causing many practical problems in local unit borrowing. Because of the specific nature of the operations of local government units and legislation that does not allow local government units to go into bankruptcy, conventional methods for estimating credit risk are not applicable, and the set of standard potential determinants of credit risk has to be expanded with new indicators. Thus in the paper, in addition to the usual determinants of credit risk, the hypothesis of the influence of political factors on local unit credit risk in Croatia is also tested out, with the use of a Tobit model. Results of econometric analysis show that credit risk of local government units in Croatia is affected by the political structure of local government, the proportion of income tax and surtax in operating revenue, the ratio of net operating balance, net financial liabilities and direct debt to operating revenue, as well as the ratio of debt repayment and cash, and direct debt and operating revenue.

Keywords: credit risk, local government units, Tobit model, Croatia

1 INTRODUCTION

Do local units of self-government[1] have the capacity to borrow? For an answer to this question, it is necessary to establish a system for the evaluation of the credit risk of local units. Numerous theoretical and empirical research works speak amply of the importance of this problem. Competent government bodies – before they give guarantees for local unit borrowing – need to evaluate the credit risk of local units. In some countries, such as Mexico, a credit risk evaluation system has become an integral part of the institutional framework for local unit borrowing (Liu and Tan, 2009). There are several possible factors contributing to the importance of the estimation of local unit credit risk. They include fiscal decentralisation, the development of a market-oriented borrowing policy, a wish to augment creditworthiness, a search for better borrowing conditions and the strengthening of the legislative framework (Gaillard, 2009)[2].

[1] Below, the term local units will be used.

[2] Apart from the legislative framework, which is directed to the establishment of fiscal discipline at the local level, the regulation of the banking system in recent time contributes to the ever-greater importance of the assessment of local unit credit risk. Although the initial capital agreement (Basel I) of 1988 determined the basic parameters for risk management and capital adequacy, the Basel II regulatory framework gives detailed guidelines for the calculation of capital requirements (particularly for credit and operating risk). The first pillar of the Basel II regulatory framework (minimum capital requirements) sets the rules for computing credit risk through: (a) the standardised approach; (b) the foundation internal rating based approach; and (c) the advanced internal rating based approach. Each of these approaches serves, ultimately, to calculate capital requirements (what the banks have to set aside to cover risks of exposure to given loans). At the bottom of the calculation of capital requirements is the likelihood of default (credit risk) for each individual loan or debtor. In accord with this banks that – in any way at all – loan money to local units should have at their disposal (in the context of calculation of capital requirements) information about the credit risk associated with local government units.

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There is no system in Croatia for estimating local unit credit risk. Because of the absence of any information about local unit credit risk, it is hard to identify the successful local units and put them forward as good examples (Bajo and Primorac, 2009). Indirectly, the work of the Ministry of Finance in the assignment of consents and guarantees for local unit borrowing is made more difficult. One of the reasons for the non-existence of credit risk evaluation is the poor and undeveloped market for local bonds, local units thus being more apt to borrowing by loans with government guarantees. It is often superficially considered that local units are not risky debtors because the government gives guarantees for their borrowings. However, the existence of outstanding liabilities of local units indicates that they are not entirely prompt in settling their obligations. Although the claims of creditors are relatively safe, it is dubious how soon they will be able to collect. Since credit risk refers to the risk of claims either not being met at the due date or not being met in full, or both, every failure to meet the date of maturity can be characterised as realisation of credit risk. The Croatian Bankruptcy Law (OG 44/96, Art. 3, Para. 2) does not allow local units to go into bankruptcy although some local units' bank accounts are quite often frozen because of their failure to meet their liabilities. Although the financial crisis has resulted in a considerable diminution of the financial credibility of local units in Croatia, the insolvency of some cities even before the crisis confirms that this problem is present to a greater or lesser degree quite independently of economic circumstances. The reasons why Croatian cities' accounts were frozen between 2005 and 2011 include: failure to settle liabilities to suppliers (Ploče and Biograd); claims of banks arising out of loans they have made (Zlatar); invoked guarantees (Trogir); claims of the Ministry of Finance arising from claims for income tax refunds (Osijek); claims of proprietors for confiscated land (Dubrovnik) and so on. The city of Slavonski Brod shows that local unit insolvency can have much more serious consequences than account-freezing. Because the city was unable to meet its financial liabilities, its assets were sold at auction.

The credit risk of local units is on the whole not higher than the sovereign ceiling. Bearing in mind that central government will usually guarantee that the local units will meet their liabilities when the loans are being taken out, credit risk should not be much lower, either. However, the diverse status of local units within some state, the differences in fiscal capacities, population size and inadequately defined rules for the allocation of tax revenue and many other factors indicate considerable differences in their financial stability (Carnevale and Coulton, 2006).

The objective of the paper is to ascertain the indicators that to the greatest extent determine the credit risk of local units and to investigate their impact on the credit risk of local units in Croatia. The paper, then, tests out the hypothesis of the effect of different indicators on local unit credit risk in Croatia. Part two of the paper provides a theoretical framework for the evaluation of credit risk and an explanation of the selection of the appropriate method for evaluation. Part three describes the variables that might influence the credit risk of local units. Part four has a description of the model and the results of econometric analysis. In this part, the

parameters of the model are evaluated and the comparison of the model predicted and evaluated (real) value of credit risk is presented. Part five contains conclusions and recommendations for further research.

2 THEORETICAL FRAMEWORK

The evaluation of credit risk in academic and specialised literature appeared with much more seriousness in the middle of the 20th century. Yet in spite of the progress made by economic science, so far no consensus has been attained concerning the best methodology or the set of indicators (input variables) that ought to be used for an evaluation of the credit risk of a given group of debtors.

In the first papers concerning credit risk evaluation, authors attempted to predict debtor bankruptcy by using discriminant analysis (Altman, 1968; Carleton and Lerner 1969, as well as, Raman, 1981) and regression analysis (Hastie, 1972; Ohlson, 1980 and Zmijewski, 1984; Lewis, Patton and Green, 1988 and Anderson, 2007). A little earlier, Fisher (1959) used regression analysis for the investigations of the determinants of risk premiums on corporate bonds. Henley and Hand (1996) used cluster analysis (nearest neighbour method) and in recent times the more contemporary approaches of estimating risk by the application of neural networks (Odom and Sharda, 1990) and the genetic algorithm (Shin and Han, 1999; Shin and Lee, 2002; Ong, Huang and Tzeng, 2005), as well as support vectors (Huang et al., 2004) and fuzzy logic (Wang, Wang and Lai, 2005 as well as Hájek and Olej, 2007) have been used.

Table 1

Traditional approaches to the evaluation of credit risk

Method	Authors
Discriminant analysis	Altman (1968), Carleton and Lerner (1969), Raman (1981)
Linear regression (OLS)	Hastie (1972), West (1970), Fisher (1959)
Logit	Ohlson (1980), Lewis, Patton and Green (1988), Ederington (1985)
Probit	Zmijewski (1984), Jackson and Boyd (1988), Gentry, Whitford and Newhold (1988)
Cluster analysis	Henley and Hand (1996), Chatterjee and Barcun (1970), Hájek and Olej (2006)
Genetic algorithm	Shin and Han (1999), Shin and Lee (2002), Ong, Huang and Tzeng (2005)
Neural network	Odom and Sharda (1990), Piramuthu (1999), Baesens et al. (2003)
Support vector method	Huang et al. (2004), Min and Lee (2005)
Fuzzy logic	Wang, Wang and Lai (2005), Hájek and Olej (2007)

Note: Practical problems in the process of risk evaluation and continuous advances in research in this area have resulted in the persistent appearance of new, more contemporary evaluation models, among which there are structural models (KMV Credit Monitor and the hybrid Moody's RiskCalc), intensity-based or reduced form models (KPMG Loan Analysis System and Kamakura Risk Manager), value at risk models (Credit Metrics and Algorithmic Mark-to-Future) as well as mortality rate models (Credit Risk Plus).

Source: Authors' systematisation.

The first papers on local unit credit risk appeared in the 1970s and 1980s. Carleton and Lerner (1969), right at the end of the sixties, with their scoring model tested the effects of institutional organisational structure, population, various indebtedness indicators, and rate of tax collection of local units on their credit ratings. Hastie (1972) studied the influence of a somewhat larger group of independent variables (indebtedness, economic diversification, population growth and so on) on the yields of municipal bonds. Wallace (1981) considered the correlation of accounting indicators with borrowing costs; Ingram and Copeland (1982) expanded Wallace (1981) by using other variables; Benson, Marks and Raman (1984) examined the correlation of government regulation of accounting procedures and the costs of local unit borrowing. Capeci (1991, 1994) bore out the contention that the operating characteristics of local units are an important determinant of credit risk and indirectly of the yields on local unit bonds. A large number of recent researches Gaillard (2009), Lipnick, Rattner and Ebrahim (1999), Liu and Tan (2009) have confirmed the impact of different indicators of local units on their credit risk.

The credit risk of local units depends on numerous factors that, in principle, can be divided into a few groups. They are institutional framework, economic structure, governance and administration, finances and the budget and liquidity and long-term liabilities (Gaillard, 2009; Lipnick, 1999; and Liu and Tan, 2009). Pursuant to an analysis of indicators grouped into the individual sets, it is possible to quantify their impact on local unit credit risk. Although numerous academic investigations have tried to answer the question of which variables have the greatest impact on local unit credit risk, the fullest list of potential factors was nevertheless engendered by the practical implementation of the process of evaluating credit risk. Credit rating agencies Standard and Poor's, Moody's and Fitch Ratings systematised a list of indicators used during their estimation of local unit credit risk (appendix 1). Many of the determinants of credit risk actually reflect the specific features of individual countries and their institutional frameworks, and there is still not a single, generally accepted evaluation criterion.

This paper will examine not only the usual credit risk indicators but also the effect of one of such specific variables on the local unit credit risk in Croatia. In general, it is thought that a local unit is less risky if the share of its own sources of revenue in total income is greater. Accordingly, local units that rely to a large extent on unstable sources of income (intergovernmental transfers) are riskier. The problem of the allocation of aid funding to local units is particularly complex if the political aspects are taken into consideration. Numerous investigations from the end of the last century considered the interdependence of political economy and the allocation of aid. In the course of time two prevailing theories developed. Cox and McCubbins (1986), the founders of one of them, think that the ruling structure (central government) in its allocation of transfers privileges those local units in which it has political support (i.e. local units with a politically compatible gover-

nment). An alternative theory, the main representatives of which are Lindbeck and Weibull (1987) and Dixit and Londregan (1998), says that funding from the central budget is allocated to local units in which voter preferences are variable, i.e. local units in which swing voters predominate. Although it is still not clear which of these two theories is more correct, the issue of the effect of political factors on the allocation of aid from the central government budget to local units is an academic problem from the domain of political economy. Therefore, this paper will endeavour to ascertain if there is any influence from political factors on local unit credit risk in Croatia.

3 DETERMINANTS OF CREDIT RISK OF LOCAL GOVERNMENT UNITS

In Croatia there is no instrument for local government unit bankruptcy, as there is in some countries (in Hungary, for example), because of which the standard evaluation of credit risk on the basis of historical values of bankruptcy that either came about or did not come about (binary variable – dichotomous) is not possible. Hence, credit risk has to be approximated in some other way. Credit risk can be characterised as the risk of a debtor's obligations not being met in time and/or in full. This risk, then, can be approximated by the proportion of outstanding liabilities created within a year in total liabilities due in that year. Accordingly, the local unit credit risk can be approximated by the ratio of outstanding liabilities in a given year to total expenditure of local units arising in the same period[3] (*the default proxy*).

Local unit credit risk – approximated in the way described above – ranged in 2008 from 0% to 70.27% (table 2). The asymmetry coefficient (α_3) indicates a positively asymmetrical distribution of frequencies, which is as expected because of the nature of the statistical set. Local units are low-risk entities and the concentration of empirical values is reduced with a rise in credit risk. The mean value of a statistical set shows an average value of approximated credit risk of local units of 7.01%.

Table 2

Descriptive statistics of approximated credit risk for 2008

$\bar{x}$	x_{min}	x_{max}	σ	σ^2	α_3	α_4	N
0.0701	0.0000	0.7027	0.0952	0.0091	2.1864	6.8494	556

Source: Authors' calculation on the basis of financial reports of local units for 2008.

Data for the explanatory variables relate to 556 municipalities and cities in Croatia, and are calculated for 2008 pursuant to the financial reports of the local gover-

[3] In line with the modified accrual accounting system principle that is applied in Croatia (depreciation costs of long term non-financial assets are not recorded and expenditure are recorded on the accrual basis independent of payment) total liabilities due within a year can (for the sake of analysis) be identified with the total expenditure and expenses of that year.

nment units, of the Croatian Bureau of Statistics (economic and demographic data) and the State Electoral Commission (data about elections of members of the representative bodies of local and regional government). The dependent variable *default_proxy* is calculated as the ratio of outstanding liabilities of local units to total liabilities due in the observed period. Many factors potentially influence the variable *default_proxy* and the credit risk of local units. With the objective of identifying the main determinants of credit risk, a group of 27 independent variables is analysed (appendix 2, table A4), which by the inductive method is reduced to the 11 most relevant[4] independent variables (table 3).

Table 3
Specification of selected independent variables

Variable	Description	Expected effect
status	Binary variable that has the value of 1 if the local government unit is a city, 0 if a municipality	Negative
politika	Binary variable that has the value of 1 if the same political party is in power nationally and in the local government unit, otherwise 0	Negative
izvoz_BDP	Ratio of value of exports and GDP of the local government unit	Negative
lst_nst	Ratio of population size of local unit and total population of Croatia	Negative
une_lst	Proportion of unemployed in total population of local unit	Positive
pdoh_tp	Proportion of income tax revenue in operating revenue	Negative
nos_tp	Ratio of net operating balance and operating revenue	Negative
got_tr	Ratio of cash and operating expenditure	Negative
od_got	Ratio of debt servicing and cash	Positive
id_tp	Ratio of direct debt and operating revenue	Positive
nfl_tp	Ratio of net financial liabilities and operating revenue	Positive

Note: Value of GDP of local government units for all indicators is approximated on the basis of the number of inhabitants of the local unit and the per capita GDP of the county in which the local unit lies.

Source: Authors.

The institutional framework for local government in Croatia distinguishes local units that have the status of municipality or that of city. There are good reasons then to suppose that the actual status (of city or municipality) will a priori determine a larger or smaller credit risk of a local unit. Similarly it is supposed that in transition countries *politics* still has an important role in the financing of local

[4] In a calculation of the values of the indicators of the initial group (appendix 1) it was noticed that (because of the values obtained) certain indicators would not be entirely relevant for an estimate of credit risk (for example the numerator or denominator in most cases is 0). Similarly, probably because of the absence of exact information about local unit GDP and reliance on estimates, indicators based on local GDP proved on the whole to be less relevant.

units. In line with political criteria, favoured local units can be privileged in the system of financing, which means that their financial position (and also, indirectly, their credit risk) can be improved to the detriment of the others. Variables related to demographic indicators (*lst_nst* and *une_lst*) are interesting because the local units in Croatia on the whole rely on revenue from shared taxes (in particular on income tax), which is directly related to the demographic structure of the local units (number and structure of employed persons) while the proportion of exports in GDP (*izvoz_BDP*) reflects the economic development of the local unit. The proportion of income tax in operating revenue (*pdoh_tp*) shows self-sufficiency in the financing of a local unit (since a local unit with a greater proportion is less dependent on uncertain funding from the central government budget). Other indicators derived from operating revenue (*nos_tp, id_tp* and *nfl_tp*) show on the whole different aspects of the ability to finance liabilities and should in a very great measure determine local unit credit risk. Finally, liquidity indicators (*got_tr* and *od_got*) measure the capacity to finance operating expenditure and to service debt with the most liquid asset – cash.

Table 4

Descriptive statistics for 556 local government units in 2008

Variable	Mean value	Median	Maximum	Minimum	Std. dev.
default_proxy	0.0701	0.0314	0.7027	0.0000	0.0952
status	0.2284	0.0000	1.0000	0.0000	0.4202
politika	0.4532	0.0000	1.0000	0.0000	0.4983
izvoz_BDP	0.1094	0.0112	3.4545	0.0000	0.2883
lst_nst	0.0018	0.0007	0.1779	0.0000	0.0081
une_lst	0.0605	0.0537	0.2228	0.0027	0.0337
pdoh_tp	0.3908	0.3895	0.7748	0.0278	0.1549
nos_tp	-0.0393	-0.0261	1.8161	-0.9934	0.2153
got_tr	0.2613	0.1642	2.4765	0.0002	0.3139
od_got	1.3419	0.0000	1.0003	0.0000	7.3801
id_tp	0.0842	0.0000	1.2318	0.0000	0.1685
nfl_tp	-0.1313	-0.1084	1.1426	-1.8944	0.2755

Source: Authors' calculation.

The coefficients of correlation of the dependent variable and the eleven independent variables (potential determinants of local unit credit risk) are presented in table A5 (appendix 2). Signs of the coefficients of correlation are on the whole in accordance with the expected influence of the observed determinants on local unit credit risk – except for the indicator of the political structure of local government. The expected negative influence of political compatibility between local and national government was founded on the expectation that the ruling structure would in the allocation of aid funding from the national budget favour the local units in which it had political support, which would ultimately mean the financial capacity

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of such local units being greater (the credit risk should be smaller). The matrix of correlation partially confirmed this hypothesis because of the negative correlation of the variables *politika* and *pdoh_tp* (politics and income tax in operating revenue). This shows that aid funding from the central government budget will probably be more often sent to local units the government of which is compatible with the state government making the proportion of revenue from income tax in operating revenue for those local units smaller. However, the reasons for a positive effect of political compatibility between local and national government on the credit risk of local units remain to be explained. One reason might be a more tolerant approach when "favoured" local units are not prompt in their financial dealings because of cronyism while another might be linked with the expenditure side of their budgets, which is immoderate as a result of excessive demands.

4 MODEL FOR THE EVALUATION OF LOCAL UNIT CREDIT RISK

For the modelling of local unit credit risk, a number of statistical and non-statistical tools are used, the applicability of them depending on the data set. The dependent variable (local unit bankruptcy) is, for the aforementioned reasons, not observed directly. The value of the latent variable of interest (*default_proxy*[5]) is for a non-negligible part of the sample equal to zero (23.56%), and at the same time it is continuously distributed on the interval [0,1]. Because of the characteristic financial operations as well as of the status of local government units in the public sector, their credit risk is expectedly relatively low and there is not a single local unit with the value of the default proxy equal to 1. Hence for the analysis of local unit credit risk a censored regression model (the Tobit model) is used (Greene, 2008; and Wooldridge, 2006).

The credit risk of local units Y is a continuous random variable that has a positive value and can be zero with a positive probability. Furthermore, the calculated proxy of the local unit's credit risk (*default_proxy*) is a latent variable in the model. This is theoretically justified and has the aim of setting up the basic criteria for the determination of default (which could be identified with local unit bankruptcy). Over the course of time, this would enable the substitution of a continuously distributed variable credit risk proxy with a binary variable that would signify the ultimate realisation of default that either happened (1) or did not happen (0).

In cases when the variable Y is censored (restricted), the values in a given range are transformed into a single value. In the case of the current research, the dependent variable Y is censored to 0. If the latent variable – *default_proxy* – is signified by Y^*, then the observed variable Y is equal to the latent variable in the case in which $default\_proxy > 0$. It has to be mentioned that, because of the (theoretically justified) low value of the local units' credit risk, no values of $default\_proxy = 1$ are observed in the sample so the dependent variable in the model is not censored by the upper value of 1.

[5] Sometimes the expressions proxied credit risk or credit risk proxy are used in the article.

4.1 DESCRIPTION OF THE MODEL

Let us suppose that for every observation Y there is a latent variable Y^* which is described by the following regression model:

$$Y_i^* = \beta' X_i + \varepsilon_i, \quad i = 1,\ldots,556, \tag{1}$$

where $\beta' = (\beta_0, \beta_1,..., \beta_{11})$ are the unknown parameters of the model, $X_i = (1, X_1, X_2,..., X_{11})_i$, and the variables X_1, X_2,..., X_{11} are in order *status* (city or municipality), *politika* (binary variable that has the value of 1 if the political structure of the government at the local level is compatible with that at the national level – the same political party, otherwise having the value of 0), the proportion of local exports in local GDP (*izvoz_BDP*), the proportion of local population in the total population of the Republic of Croatia (*lst_nst*), the proportion of local unemployed in total local population (*une_lst)*, the proportion of income tax revenue in operating revenue (*pdoh_tp*), the proportion of net operating surplus in operating revenue (*nos_tpi),* the proportion of cash in operating expenditure (*got_tri),* the proportion of debt servicing in cash *(od_got),* the proportion of direct debt[6] in operating revenue (*id_tp*), the proportion of net financial liabilities in operating revenue (*nfl_tp*), while ε_i are independent identically distributed normal[7] random variables of zero expectation and variance σ^2. The conditional distribution of the latent variable Y^*, because of the normal distribution of errors ε_i, is also normal, with expectation $E\lfloor Y^* \mid X_i \rfloor = \beta' X_i$ and variance $Var\lfloor Y^* \mid X_i \rfloor = \sigma^2$. The results of the descriptive analysis of the variables $X_i = (1, X_1, X_2,..., X_{11})$ for all local government units in Croatia are presented in the previous chapter (table 4).

The dependent censored variable Y – which represents the credit risk of local units – is modelled with the left side censored data in the following way:

$$Y_i = \begin{cases} 0, & \text{if} \quad Y_i^* \le 0 \\ Y_i^* & \text{if} \quad Y_i^* > 0. \end{cases}$$

The unknown parameters of the model β and σ are estimated by maximising the likelihood function $L(\beta, \sigma, |Y_1,...,Y_N) = \prod_{i=1}^{N} f(y_i)$, or the log-likelihood function *log* L (β, σ, Y_1,..., Y_N) where y_1, y_2, ..., y_N are the realisations of the independent and equally distributed random variables Y_i, with $N = 556$ and f is the density function of each observation of the limited dependent variable Y_i taking into account that

[6] The term *direct debt* relates to all liabilities for bonds and loans and does not cover contingent liabilities arising from guarantees, outstanding liabilities and other indirect debt categories.

[7] In the case that errors are not normally distributed or are not homoscedastic, the estimators obtained by the maximum likelihood method will not be consistent. In this case the parameters will be estimated by maximum log-quasi-likelihood (QML estimator). The QML estimator is robust with respect to a false assumption about the distribution of the dependent variable, it is consistent and asymptotically normally distributed. At the same time, in the event of heteroscedasticity of errors, this can be indirectly modelled in the log-quasi-likelihood function.

only its values greater than zero are observed. Since the observed limited dependent variable cannot have a value of less than zero, the truncated distribution from which such values will derive refers to the part of the continuous distribution above zero and to the likelihood function of the discrete variable in zero. Hence for the estimation of the parameters it is necessary to find those values of parameters β and σ that maximise the following function

$$\ln L\left(\beta,\sigma\middle|Y_1,\ldots,Y_N\right)=\ln\prod_{i=1}^{N}f(y_i)=\sum_{i=1}^{N}\ln\left[\frac{1}{\sigma}\cdot\phi\left(\frac{y_i-X_i'\beta}{\sigma}\right)\right]\cdot 1_{(y_i>0)}+\sum_{i=1}^{N}\ln\left[1-\Phi\left(\frac{X_i'\beta}{\sigma}\right)\right]\cdot 1_{(y_i=0)} \quad (2)$$

where ϕ is the standard normal density function, Φ is the standard normal cumulative distribution function, and $1_{(Y>0)}$ denotes the indicator function that assumes the value of 1 on the set $\{Y>0\}$, and 0 on the set $\{Y=0\}$.

Marginal effects in the Tobit model, which represent the partial effect of an individual variable on the local unit credit risk, are not given by the values of the regression coefficients β, but by the expression (Greene, 2008; Wooldridge, 2006):

$$\frac{\partial E\left[Y_i\middle|X_i\right]}{\partial X_j}=\beta_j\,\Phi\left(\frac{\beta' X_i}{\sigma}\right). \quad (3)$$

According to expression (3) it follows that the marginal effects given with the Tobit model are equal to the product of the marginal effects of the latent variable Y^*, or the coefficients β, and the proportion of non-limit observations in the sample.

4.2 RESULTS OF ECONOMETRIC ANALYSIS

The results of econometric analysis obtained by maximising the log-likelihood function (2) for the Tobit model[8] are presented below. In the estimation procedure of the Tobit model, and in order to determine the asymptotic properties of the obtained estimators by the maximum likelihood method, there are two fundamental assumptions: errors are normally distributed and they are homoscedastic. In the first step in estimating the parameters of the model, the estimators are obtained by maximising the log-likelihood function (the ML estimator). If the assumptions of the model are met (normal distribution and error homoscedasticity), the ML estimators are consistent, asymptotically normal and efficient. In order to examine the properties and qualities of the estimator, the testing of the assumptions and general significance of the Tobit model is carried out with the use of Lagrange multiplier (LM) statistics[9] for testing Tobit specification as compared to the alter-

[8] For optimisation purposes, this research used, independently, the packages EViews 7 and Stata 10.1.

[9] Critical values of the LM test are determined by the parametric bootstrap method. Testing was carried out with the use of Box-Cox transformations of the dependent variable. In the calculation of LM statistics and the critical values of the test the *bctobit* programme procedure of the Stata 10.1 package was used.

native to the model that is not linear in its explanatory variables and contains an error that can be heteroscedastic and non-normally distributed. The test rejects the zero hypothesis, showing that the Tobit specification of the model assumptions is not suitable for consistent estimation of the parameters. In order to obtain consistent estimators the heteroscedasticity problem was addressed with direct modelling of heteroscedasticity using an exponential function in the log-likelihood function with $\sigma_i = e^{\tilde{x}_i\gamma}$, where, $\gamma = (\gamma_0, \gamma_1,..., \gamma_9)'$ and $\tilde{X}_i = (1, X_1, X_2, X_3, X_5, X_6, X_8, X_9, X_{10}, X_{11})$.[10] If the errors are not normally distributed, the problem is usually much more demanding for a Tobit model as compared with linear models, and for the purpose of its solution alternative estimates are proposed, as are various methods for testing such, potentially wrong, specifications of the model. Thus, in a second step of the estimating procedure, the parameters will be estimated by maximising the quasi log-likelihood function (QML), since quasi maximum likelihood estimator is robust with respect to a false assumption about error or dependent variable distribution. In this way, model estimators are obtained that are consistent and asymptotically normally distributed. However, the QML estimator is not asymptotically efficient, and the Berndt-Hall-Hall-Hausman (BHHH) numerical algorithm is used for the purpose of estimating the variance of the maximum log-likelihood estimator when the initial model is not accurately specified (Greene, 2008)[11].

Table 5 shows the estimated parameters of the Tobit regression model, the corresponding marginal effects and the corresponding standard errors. The table also gives the estimators obtained by the least squares method (OLS), in spite of their lack of consistency, since in empirical analysis it can be seen that the ML estimators can be obtained as a ratio of OLS estimators and the proportion of non-limit observations in the sample.[12] In addition, marginal effects for variables in the model that did not prove to be statistically significant have been excluded from the table.

In order to determine the marginal effects of explanatory variables on local unit credit risk it is necessary to calculate the adjustment factor $\Phi\left(\frac{\beta' X_i}{\sigma}\right)$ for coefficients in the case of continuous explanatory variables X_i (Greene, 2008).[13] For di-

[10] The variables X_4 and X_7, that is the percentage of local population in total population and the proportion of net operating surplus were removed from the modelling of variance since by their inclusion the numerical algorithm for the search of maximum function did not converge. Hence one variable at a time was excluded from the demographic structure (X_4 and X_5) and one of the indicators derived from operating revenue (X_7, X_{10} and X_{11}).

[11] For estimating the variance using the BHHH algorithm, STATA 10.1 and EViews7 were used independently; the initial conditions were specified by programme support and not modified in the special case.

[12] The results obtained by the OLS estimation, aimed at obtaining an outline insight into the sensitivity of the connection between local unit credit risk and its potential determinants, might indicate an initial guideline with respect to this and enable the monitoring of any possible improvements in the form of results obtained by the analysis of some other model, as well as the estimating procedure.

[13] The adjustment factor will be closer to the value of 1 when there are less observations for which Y_i=0 (there is no credit risk for a local unit, i.e. it is equal to zero). In the observed sample for 23.56% of local units the approximated credit risk is equivalent to zero.

screet explanatory variables – like the political structure of the government – the determination of marginal effects is not entirely simple, although an approximation with the use of an adjustment factor has proved to be very useful (Wooldridge, 2006). For the sake of determining the marginal effect of the political structure of government – represented in the model by a binary variable – on local unit credit risk, the expected credit risk will be calculated for both possible values of the variable *politika*={0,1} and the arithmetical means of the remaining significant variables in the model.

Table 5

Estimated parameters, corresponding marginal effects for Tobit regression models and corresponding standard errors

Independent variable	Linear regression	Tobit regression		
	Marginal effect	Coefficient	Marginal effect	Heteroscedasticity γ
konstanta	0.11341 (0.01398)	0.11945 (0.01585)	–	-1.92925 (0.18754)
politika	0.02034 (0.00778)	0.03196 (0.01202)	0.02072 (0.00674)	0.06310* (0.09789)
pdoh_tp	-0.11327 (0.02312)	-0.14739 (0.02726)	-0.10986 (0.02212)	-0.79302) (0.33011)
nos_tp	-0.0813 (0.02031)	-0.08130 (0.02065)	-0.06244 (0.01619)	–
nfl_tp	0.09054 (0.03276)	0.10141 (0.02494)	0.06975 (0.02447)	0.34842* (0.41046)
od_got	0.00086 (0.00038)	0.00094 (0.00022)	0.00063 (0.00015)	-0.02438) (0.01129)
id_tp	-0.05996* (0.03710)	-0.08766 (0.03361)	-0.05860 (0.02247)	0.02857* (0.52075)
status	-0.014052* (0.00885)	-0.01432* (0.01044)	–	-0.20347* (0.14148)
izvoz_BDP	-0.00403* (0.00938)	-0.00269* (0.01168)	–	-0.08131* (0.17230)
lst_nst	-0.102167* (0.17733)	0.12805* (0.12193)	–	–
une_lst	-0.07435* (0.10998)	-0.09160* (0.13094)	–	-1.14712* (1.18411)
got_tr	0.04827* (0.03886)	0.00958* (0.02480)	–	0.45402* (0.27288)
R^2	10.76%	–	–	–
Log-quasi likelihood		259.14428	–	–

** Not statistically significant for usual significance levels (1%, 5% and 10%).*

Source: Authors' calculation.

The obtained marginal effect comes to 0.02072 and represents the effect of the local units' government political structure on credit risk – all other variables of

interest being constant[14]. In other words, if the same political party is in power at local and at national level, it is expected that there will be an increase of the estimated credit risk of 2.1 percentage points. A positive correlation of the political structure of the government and credit risk reveals the fact that the financial operations of local units in Croatia are subject to political influence, i.e. that the irregular meeting of financial liabilities of some local government units is heightened from political reasons. The reasons for which local governments that are politically compatible to central government are more irregular in meeting their financial liabilities are unclear, although some of the possible causes of this phenomenon are explained in chapter 3.

The proportion of income tax revenue in operating revenue (*pdoh_tp*) shows the capacity of a local unit to collect revenue from its own sources, i.e. it shows its fiscal capacity. In general, fiscal capacity is one of the measures of local unit financial stability, so greater fiscal capacity results in smaller credit risk (as borne out by the results of econometric analysis). The ratio of net operating balance and operating revenue (*nos_tp*) is also negatively correlated with credit risk, for a greater net operating balance shows a surplus of revenue to operating expenditure. The ratios of debt servicing and cash (*od_got*) and net financial liabilities and operating revenue (*nfl_tp*) indicate debt burden, i.e. the capacity of servicing debt annuities in cash and the possibility of financing surplus financial liabilities over financial assets from regular activities (operating revenue). Larger values of these variables indicate greater exposure to debt and it is logical that as they rise, the value of credit risk also rises. Finally, the ratio of direct debt and operating revenue (*id_tp*) reflects the capacity to finance direct debt with operating revenue but the sign of the coefficient for this indicator is not entirely logical, i.e. a completely opposite sign was expected because a larger debt in proportion to operating revenue should result in greater credit risk.

4.3 RELATIONSHIP OF OBSERVED AND PREDICTED VALUES OF CREDIT RISK

With the aim of examining the fitting of the local unit credit risk model, the values of the *default_proxy* variable (approximation of credit risk, i.e. proportion of outstanding due liabilities in total due liabilities) will be compared with those predicted by the Tobit model for both characteristics of the political structure of local government (*politika={0,1}*). The values of the variables *pdoh_tp*, *nos_tp*, *nfl_tp*, *od_got* and *id_tp* are given for each value of the variable of interest. The predicted values for the *default_proxy* are calculated with the use of the relation (Wooldridge, 2006):

[14] Instead of evaluation in the arithmetic means of the explanatory variables, the marginal effect can be calculated for each value of the explanatory variables in the first step, and then finding the arithmetical mean of the obtained values. The value of the marginal effect of the explanatory variable in this case almost equals the value given in table 6.

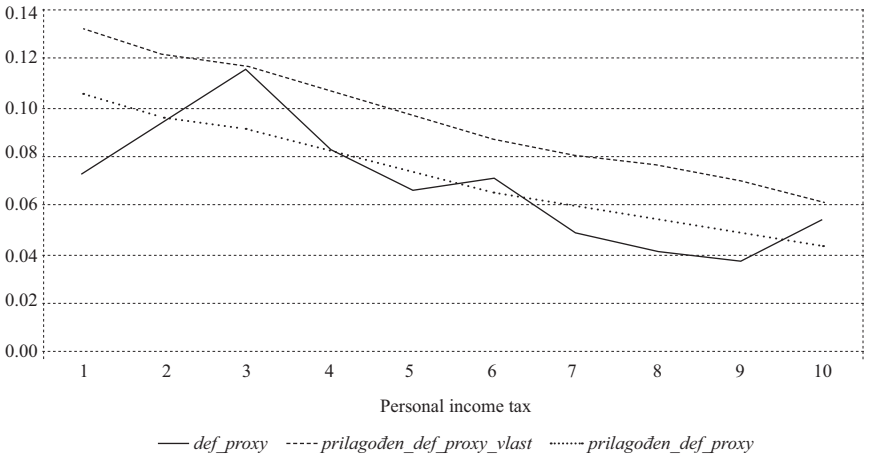
$$\hat{Y}_i = E\left[Y_i \mid X = X_i\right] = \Phi\left(\frac{\beta' X_i}{\sigma}\right) \cdot \beta' X_i + \sigma \cdot \phi\left(\frac{\beta' X_i}{\sigma}\right), \qquad (4)$$

in the estimated values of the corresponding coefficients.

Bearing in mind the fact that the marginal effect of the proportion of revenue from income tax in operating revenue in the Tobit model is by far the greatest, and in addition the frequency range of this variable is fairly broad (from 2.78% to 77.48%), the possible values of the proportion of revenue from income tax are divided into 10 equidistant categories. For each category of the proportion of revenue from income tax in operating revenue there are subsamples of real and predicted values of the *default_proxy* variable for which the mean value and the median in the corresponding subsample are calculated. In this way, it is possible to graphically display the predictive power of the Tobit model. Graph 1 shows the real and predicted values of the average credit risk of local government units. The variable *default_proxy* marks the average of observed values for the approximation of credit risk within individual categories. The variables *prilagođen_def_proxy_vlast* and *prilagođen_def_proxy* in the Tobit model indicate the predicted values of credit risk calculated in the mean values of the ascertained determinants in the case of compatibility and of incompatibility of the political structure of local and national government.

Graph 1

Real and predicted values of the average credit risk of local units



Source: Authors' calculation.

The expected values of credit risk in the case of political compatibility between local and national government (table 6) are on average above the observed values of the *default_proxy* variables for all categories of the proportion of income tax revenue in operating revenue. In the case of political incompatibility of local and

national government, the situation is considerably different – the expected values of credit risk for the Tobit model on the whole fluctuate around the existing *default_proxy* values.[15]

Table 6

Within-sample test of prediction strength in the mean value

K	N	*default_proxy*	A	B	C	D
1	21	0.0735	0.1313	0.1051	0.1348	0.1077
2	30	0.0949	0.1210	0.0957	0.1237	0.0976
3	61	0.1158	0.1163	0.0913	0.1226	0.0965
4	78	0.0824	0.1054	0.0814	0.1061	0.0817
5	105	0.0667	0.0961	0.0733	0.1012	0.0773
6	92	0.0710	0.0873	0.0658	0.0892	0.0669
7	68	0.0500	0.0813	0.0604	0.0800	0.0590
8	60	0.0419	0.0763	0.0561	0.0793	0.0584
9	37	0.0382	0.0697	0.0504	0.0697	0.0503
10	4	0.0545	0.0625	0.0445	0.0584	0.0411

Note: K – category of proportion of income tax; N – number of observations; A – prediction for default_proxy $\hat{Y}_i$ *(*$\bar{x}$*, politika* = 1*); B – prediction for default_proxy* $\hat{Y}_i$ *(*$\bar{x}$*, politika* = 0*); C – prediction for default_proxy* $\hat{Y}_i$ *(m, politika* = 1*); D – prediction for default_proxy* $\hat{Y}_i$ *(m, politika* = 0*).*

Source: Authors' calculation.

5 CONCLUSION

In Croatian scientific and expert literature, the determinants of the credit risk of local government units have not been investigated. The Croatian legislative background does not allow local units to go into bankruptcy, which makes it more difficult to investigate their credit risk. In this paper a measure for the approximation of credit risk of local units is defined (*default proxy*) as ratio of outstanding liabilities to all due liabilities in a given period, pursuant to which the existing credit risk of local units is quantified. Because of the characteristics of the dependent variable (*default_proxy*), an appropriate method for the estimation of the model's parameters is selected. The Tobit model is used to show the effect of the political compatibility of local and national government, the proportion of income tax in operating revenue, the ratio of net operating balance and operating revenue, of the net financial liabilities and the operating revenue, and of direct debt and operating revenue, as well as debt servicing and cash on the local unit credit risk. The main constraint on the research is the absence of any historical data about local unit bankruptcy, which should be expressed by a binary variable. Instead of an observed binary variable (which would enable the estimation of credit risk with the application of a logit or a probit model) the approximation of credit risk (the

[15] According to the authors' calculation, completely analogous conclusions are obtained in the case of an analysis of the predictive power of Tobit models based on the values of the median *m*.

default_proxy) which assumes continuous values in the interval [0,1], has been used. Apart from that, there are no publicly available data about the factors of local unit credit risk such as institutional framework, economic structure, governance and administration. In future research it remains to test the impact of other independent variables on local unit credit risk and resolve the problem of the dependent variable. The problem of the dependent variable could be solved by determining the critical value of the proposed approximation of credit risk on the basis of which local units could be categorised into risk groups, according to which the dependent variable might be directly observed and take on binary values. Future research might test out the impact of the mentioned indicators on local unit credit risk with the use of other methods – preferably from the realm of artificial intelligence.

The proposed model for the estimation of local unit credit risk could be improved. However, in this work local unit credit risk in Croatia is being studied for the first time, and it could be a good point of departure for further research. In addition, the results could be useful to the Ministry of Finance in issuing guarantees and giving consent for local unit borrowing and for the analysis of fiscal risks. The model of estimated local unit credit risk could be used as a good foundation for the calculation of the required yield on the local government bonds and the interest rates on local unit loans.

APPENDIX 1
BASIC DETERMINANTS OF LOCAL UNIT CREDIT RISK

TABLE A1

Most frequently used indicators by Standard & Poor's

1) Economy	**4) Financial flexibility**
1.1 Demographic structure	4.1 Legislative constraints
Population (total and as % of total)	4.2 Political constraints
Population growth rate	4.3 Limited flexibility because of planned spending
Old and young population (as % of total)	4.4 Other potential pressures and one-off revenue
1.2 Economic structure	Autonomous revenue as % of operating revenue
GDP (nominal)	Capital expenditure as % of total expenditure
GDP (production) and sectoral distribution of employees	Expenditure on labour as % of operating expenditure
Rates of employment and unemployment	Rise in operating expenditure
Employment at the biggest employers	Rise in operating revenue
1.3 Wealth	**5) Budgeting**
Per capita GDP	Operating balance as % of operating revenue
Per capita GDP as % of national or regional average (e.g. EU-27)	Balance after capital expenditure as % of total revenue
1.4 Growth possibility	Balance after borrowing as % of total revenue
Real GDP growth	**6) Liquidity and debt management**
Exports as % of GDP and export growth	6.1 Analysis of liquidity
Rise in investments	Cash and liquid assets as % of debt repayment
2) Support and predictability	Cash, liquid assets and loans as % of debt repayment
2.1 Predictability	Debt maturing within 12 months as % of liquid assets and loans
2.2 Equilibrium of revenue and expenditure	Cash and liquid assets as % of operating expenditure
2.3 Transparency and accountability	Cash surplus (before interest) as % of expenditure on interest
2.4 Fiscal policy	Liabilities as % of total expenditure
2.5 Exceptional support	Claims as % of total revenue
3) Administration and institutional framework	6.2 Debt management
3.1 Administrative sophistication	Structure of debt
3.2 Institutional legitimacy	Use of derivatives

7) Debt burden	8) Non-balance sheet liabilities
Expenditure on interest as % of operating revenue	8.1 Financial health of public corporations
Debt repayment as % of operating revenue	8.2 Quasi-governmental programs
Direct debt as % of operating expenditure	8.3 Public-private partnership
Net direct debt as % of operating revenue	8.4 Bailouts of private corporations
Net (tax covered) debt as % of consolidated operating revenue	
Net financial liabilities as % of consolidated operating revenue	
Direct debt as % of local GDP	
Total local debt as % of total local revenue	
Total debt (including guarantees) as % of operating revenue	

Source: Authors' systematisation on the basis of Standard &Poor's (2007).

TABLE A2

Most frequently used indicators by Moody's

1) Economic environment	**5) Debt**
Per capita GDP	Total direct and indirect debt (nominal)
GDP volatility	Net direct and indirect debt (nominal)
Governmental efficiency index	Net direct and indirect debt per capita
2) Institutional framework	Net direct and indirect debt as % of GDP
Predictability, stability, responsibility	Net direct and indirect debt as % of operating revenue
Fiscal flexibility (own sources of revenue)	Net direct and indirect debt as % of total revenue
Fiscal flexibility (spending)	Direct debt in foreign currency as % of direct debt
Fiscal adequacy (borrowing)	Short-term direct debt as % of direct debt
3) Management	Short term direct debt and long-term direct debt with variable interest rate as % of direct debt
Fiscal management	Average weighted maturity of direct debt (in years)
Investment and debt management	**6) Finances**
Transparency and information publication	Discretionary own source revenue as % of operating revenue
Institutional capacity	Intergovernmental transfers as % of operating expenditure
4) Economic fundamentals	Earmarked revenue as % of operating revenue
Per capita GDP	Interest payments as % of operating revenue
Population	Debt service as % of total revenue
GDP (nominal)	Net operating surplus as % of total revenue
Per capita GDP	Cash financing surplus as % of total revenue
Per capita GDP as % of national average	Gross borrowing need as % of total revenue
Per capita GDP (PPP)	Total per capita expenditure (nominal)
Real GDP (% change)	Total expenditure as % of GDP
Unemployment (%)	Primary balance as % of operating revenue
National unemployment	Gross operating balance as % of revenue
	Net operating balance as % of operating revenue
	Degree of own financing
	Capital spending as % of total expenditure
	Difference of compound (five-year) annual growth rate of total revenue and total expenditure
	Net working capital as % of total expenditure

Source: Authors' systematisation after Moody's (2008).

TABLE A3

Most frequently used indicators by Fitch Ratings

1) Institutional framework	**3) Finances**
Relation between administrative units	Revenue analysis
Centralisation/decentralisation	Expenditure analysis
Revenue structure	Trends in operating and current margins
Fiscal equalisation system	State of reserves
Flexibility of financial arrangements between local unit and central government	Liquidity
Kind of local government unit accountability	**4) Governance and administration**
Orientation to investment or operations	Institutional policies
Public functions in purview of local unit	Budgetary practice
Legal framework	Financial reporting and accountancy
Degree of autonomy	Political, tax and labour environment
Inflexibility of expenditure	Revenue and expenditure constraints
Demand for capital investment	**5) Economy**
Strength of institutional framework	Main economic generators
2) Debt and long-term liabilities	Employment
Indicators of indebtedness and the trends	Income and wealth
Future needs for capital and debt	Other demographic factors
Debt structure	Tax burden
Financing of pensions and similar payments	
Indirect risks and contingent liabilities	

Source: Authors' systematisation after Fitch Ratings (2010).

APPENDIX 2
POTENTIAL DETERMINANTS OF LOCAL GOVERNMENT UNIT CREDIT RISK IN CROATIA

TABLE A4

Initial set of independent variables covered in the research

No.	Variable	Description
1	*status*	Binary variable that assumes the value 1 if the local unit has the status of city, 0 if of municipality
2	*politika*	Binary variable that assumes the value of 1 if the same political party is in power nationally and locally, otherwise 0
3	*izvoz_BDP*	Ratio of value of exports and GDP of local unit
4	*LBDP_NBDP*	Ratio of local and national GDP per capita
5	*BDP_st*	Local GDP per capita of local unit
6	*lst_nst*	Ratio of population size of local unit and total population size of Croatia
7	*une_lst*	Proportion of unemployed in total local government unit population
8	*vp_tp*	Share of own source revenue (from taxation and administrative charges) in operating revenue
9	*pom_tp*	Ratio of transfers and operating revenue
10	*pdoh_tp*	Proportion of income tax revenue in operating revenue
11	*nos_tp*	Ratio of net operating balance and operating revenue
12	*tr_tp*	Ratio of operating expenditure and operating revenue
13	*tp_up*	Proportion of operating revenue in total revenue
14	*ur_up*	Ratio of total expenditure and total revenue
15	*nok_ur*	Ratio of net working capital and total expenditure
16	*ur_st*	Total expenditure per capita of the local unit
17	*ur_BDP*	Ratio of total revenue and GDP of local unit
18	*ki_ko*	Ratio of current assets and current liabilities
19	*got_tr*	Ratio of cash and operating expenditure
20	*od_tp*	Ratio of debt service and operating revenue
21	*od_got*	Ratio of debt service and cash
22	*id_ui*	Ratio of direct debt and total assets
23	*id_tp*	Ratio of direct debt and operating revenue
24	*nfl_tp*	Ratio of net financial liabilities and operating expenditure
25	*id_BDP*	Ratio of direct debt and GDP of local unit
26	*id_st*	Direct debt per capita of local government unit
27	*id_up*	Ratio of direct debt and total revenue

Note: Value of GDP of local government units for all indicators is approximated on the basis of the number of inhabitants of the local unit and the per capita GDP of the county in which the local unit lies.

Source: Authors.

TABLE A5

Correlation matrix for dependent and selected independent variables

	default_ proxy	status	politika	izvoz_ BDP	lst_nst	une_lst	pdoh_tp	nos_tp	got_tr	od_got	id_tp	nfl_tp
default_proxy	1.0000											
status	-0.1033	1.0000										
politika	0.1054	-0.0651	1.0000									
izvoz_BDP	-0.0693	0.2096	-0.0997	1.0000								
lst_nst	-0.0606	0.2495	-0.0555	0.0636	1.0000							
une_lst	0.0058	-0.0356	0.1501	-0.0921	-0.0416	1.0000						
pdoh_tp	-0.1958	0.2041	-0.0169	0.1498	0.1482	-0.0883	1.0000					
nos_tp	-0.1753	-0.0320	0.0253	0.0498	0.0178	-0.0270	-0.0294	1.0000				
got_tr	-0.0287	-0.1957	0.0854	-0.0551	-0.0607	-0.0416	-0.0844	0.3346	1.0000			
od_got	0.0350	-0.0174	-0.0199	0.0166	-0.0137	-0.0847	-0.0861	0.0567	-0.1292	1.0000		
id_tp	0.0265	0.2642	-0.0751	0.0720	0.0576	-0.1010	0.0816	-0.0577	-0.0639	0.0814	1.0000	
nfl_tp	0.0963	0.2347	-0.0823	0.0639	0.0626	-0.0277	0.1003	-0.2436	-0.6232	-0.0352	0.6289	1.0000

Source: Authors' calculation.

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