IOSR Journal of Mathematics (IOSR-JM)
e-ISSN: 2278-5728, p-ISSN: 2319-765X. Volume 15, Issue 3 Ser. I (May – June 2019), PP 30-35
www.iosrjournals.org

Panel Data Regression and Support Vector Regression for Analysing Indonesian Private External Debt

Zuherman Rustam, Janice Diani Putri
Department of Mathematics , University of Indonesia Depok 16424, Indonesia
Corresponding Author:Zuherman Rustam

Abstract:*Indonesian corporations have been borrowing large sums of money from foreign investors to such an extent in the past decade that the private debt ratio had reached 49% of Indonesia's total external debt by the end of 2017. Although this borrowing improved the performance of the firms involved and led to an increase in profits, it also resulted in debt value expansion, due to a trend of depreciating exchange rates in Indonesia. This paper employs Support Vector Regression, a machine-learning method, to study the relationship between factors which could affect corporate performance and compares the results with those obtained using the conventional panel data regression method. The study was carried out using data from the annual financial statements of 189 firms in Indonesia during the period 2011-2017.*

Date of Submission: 26-04-2019 Date of acceptance: 11-05-2019

I. Introduction

Indonesia's external debt has been rising in the past decade, with a 10.03% growth rate year on year. At first, this was dominated by public debt, but the private debt ratio started increasing in 2012, and had reached 49% of the total external debt by the end of 2017 [1].

On the one hand, the elevated levels of private debt improved the performance of the companies involved in borrowing, and increased their profit. There are two main reasons for this. Firstly, a company is expected to produce more when it has more capital. Secondly, according to the Mundell-Fleming model, a depreciation trend makes companies more competitive in terms of foreign competitors, especially export companies. This is known as the competitiveness effect [2].

On the other hand, it could expose these corporations to the latent risk of depreciation. The nominal value of the external debt inflates when depreciation takes place [3]. This is known as the balance-sheet effect [4]. When depreciation occurs and the size of the debt becomes too great, there is a risk that the company which owes the money might not be able to repay it. This phenomenon is known as currency mismatch, and is very dangerous in the sense that it can bankrupt the company. It can even lead to economic contraction and major unemployment when it happens to a large number of companies at the same time.

The main objective of this study is to find out whether the balance-sheet or the competitiveness effect is more dominant in Indonesian corporations, and to calculate an acceptable threshold for external corporate debt in terms of avoiding currency mismatch and developing a policy to maximise a company's profits. The Central Bank of Indonesia has traditionally analysed this problem using multivariate statistical methodology, specifically panel data regression [5,6,7]. The results were not sufficiently accurate, as the data were a combination of time series and cross-section data. For this reason, the present study made use of Support Vector Regression, a machine-learning method, to study the relationship between factors which could affect corporate performance, and to compare the results with those obtained using the conventional panel data regression method.

II. Material And Methods

The Central Bank of Indonesia (2011) derived the factors which affect a firm's performance from their balance-sheet equation [7].

At time 0,

$$A = L + W_0 \tag{1}$$

where A represents corporate assets, L represents liabilities and W represents net worth.
A firm's assets and liabilities might be in domestic or foreign currencies, so Equation (1) could be written as:

$$A_d + e_0 A_f = L_d + e_0 L_f + W_0 \tag{2}$$

where
A_d = assets in domestic currency (Rupiah)
A_f = assets in foreign currencies
L_d = liabilities in domestic currency (Rupiah)
L_f = liabilities in foreign currencies
e_0 = exchange rate (to USD) at time 0
Therefore, at time 1, Equation (2) could also be written as:

$$(1 + r_d^A)A_d + \left(1 + r_f^A\right).e_1 A_f = (1 + r_d^L)L_d + \left(1 + r_f^L\right).e_1 L_f + W_1 \tag{3}$$

$$W_1 = (1 + r_d^A)A_d + \left(1 + r_f^A\right).e_1 A_f - (1 + r_d^L)L_d - \left(1 + r_f^L\right).e_1 L_f \tag{4}$$

where r_d^A and r_d^L are interest rates for domestic assets and liabilities, while r_f^A and r_f^L are interest rates for foreign assets and liabilities.

Suppose $\delta_d = r_d^A - r_d^L$ and $\delta_f = r_f^A - r_f^L$, then

$$\begin{aligned} W_1 &= (1 + r_d^A)(A_d - L_d) + \left(1 + r_f^L\right).e_1\left(A_f - L_f\right) + \delta_d A_d + \delta_f e_1 A_f \\ &= (1 + r_d^L)(A_d - L_d) + (1 + r_d^L)e_0\left(A_f - L_f\right) - (1 + r_d^L)e_0(A - L) \\ &\quad + \left(1 + r_f^L\right).e_1\left(A_f - L_f\right) + \delta_d A_d + \delta_f e_1 A_f \\ &= (1 + r_d^L)W_0 - (1 + r_d^L)e_0\left(A_f - L_f\right) + \left(1 + r_f^L\right)e_f\left(A_f - L_f\right) + \delta_d L A_d + \delta_f e_1 A_f \\ &= (1 + r_d^L)W_0 + \left[\left(1 + r_f^L\right)e_1 - (1 + r_d^L)e_0\right]\left(A_f - L_f\right) - \delta_d A_d + \delta_f e_1 A_f \end{aligned} \tag{5}$$

Based on Equation (5), an empiric model can be built as follows:

$$EQ_{i,t} = \alpha_0 + \alpha_1\left[\left(A_f - L_f\right)_{i,t-1}.\Delta e_t\right] + \alpha_2\left(A_f - L_f\right)_{i,t-1} + \alpha_3\Delta e_t + \alpha_4 L_{i,t-1}^d + \alpha_5 r_{c_t} \tag{6}$$

If net foreign assets or NFA are defined as $A_f - L_f$, then Equation (6) can be written as:

$$EQ_{it} = \alpha_0 + \alpha_1\left[(NFA)_{i,t-1}.\Delta e_t\right] + \alpha_2(NFA)_{i,t-1} + \alpha_3\Delta e_t + \alpha_4 L_{i,t-1}^d + \alpha_5 r_{c_t} \tag{7}$$

where
$EQ_{i,t}$ = equity to asset ratio of company *i* at time *t*
Δe_t = Rupiah exchange rate (to USD)
$NFA_{i,t-1}$ = Net foreign asset to total asset ratio
$L_{i,t-1}^d$ = domestic liabilities to asset ratio
r_c = credit interest rate

The model in Equation (7) is expected to be able to measure corporate performance, which is represented by the equity to asset ratio (EQ). In other words, a firm's equity is determined by the following variables: NFA, exchange rate fluctuation, level of domestic debt, credit interest rate, and the interaction between NFA and the exchange rate.

The main objective of this study is to find the value of regression coefficients (α_1,α_2, α_3, α_4, and α_5) which measure the impacts of each factor on the firm's equity, and which can later be used to forecast the firm's equity in the following year if the values of dependent variables are known. In the present study, two methods were used to find these coefficients: panel data regression and Support Vector Regression.

After obtaining these coefficients, the extent to which a firm can have liabilities in foreign currencies without causing a decrease in its equity to asset ratio can be calculated by finding the first partial derivatives of Equation (7) with respect to the difference in exchange rate (Δe_t):

$$\frac{\partial EQ}{\partial \Delta e} = \alpha_1\left[(NFA)_{i,t-1}\right] + \alpha_3 \tag{8}$$

A firm's NFA threshold is the NFA value such that $\alpha_1\left[(NFA)_{i,t-1}\right] + \alpha_3 = 0$, or simply $-\frac{\alpha_3}{\alpha_1}$.

Panel data regression

Panel data is defined as a dataset in which the behaviour of entities is observed across time. It is also known as a combination of cross-section and time series data. The panel data regression model is similar to the ordinary least-squares multiple linear regression model (Woolridge, 1999), which takes the following form:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \epsilon \frac{\partial EQ}{\partial \Delta e} = \alpha_1 \left[(NFA)_{i,t-1} \right] + \alpha_3 \tag{9}$$

where $x_1, x_2, \dots, x_k$ are regressor variables, y is the response variable, β_0 is known as the intercept, β_j is known as the slope and ϵ is known as the error, which is the difference between the observed value y and the predicted value $\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k$.

To estimate the value of unknown parameters β_0, $\beta_1, \dots, \beta_k$, the least-squares function needs to be minimised:

$$S(\beta_0, \beta_1, \dots, \beta_k) = \sum_{i=1}^{n} \epsilon^2 = \sum_{i=1}^{n} \left(y_i - \beta_0 - \sum_{j=1}^{k} \beta_j x_{ij} \right)^2 \tag{10}$$

subject to

$$\frac{\partial S}{\partial \beta_0}_{\hat{\beta}_0, \hat{\beta}_1, \dots, \hat{\beta}_k} = -2 \sum_{i=1}^{n} (y_i - \hat{\beta}_0 - \sum_{j=1}^{k} \hat{\beta}_j x_{ij}) = 0 \tag{11}$$

and

$$\frac{\partial S}{\partial \beta_j}_{\hat{\beta}_0, \hat{\beta}_1, \dots, \hat{\beta}_k} = -2 \sum_{i=1}^{n} (y_i - \hat{\beta}_0 - \sum_{j=1}^{k} \hat{\beta}_j x_{ij}) x_{ij} = 0, \qquad j = 1,2, \dots, k \tag{12}$$

Least-squares regression is performed on some major assumptions:

1. The relationship between the response and the regressors is linear, at least approximately.
2. The error term ϵ has a zero mean and constant variance σ^2.
3. The errors are uncorrelated and normally distributed.

Gross violations of the assumptions could yield an unstable model in the sense that a different sample could lead to a totally different model with opposite conclusions [9].

Support Vector Regression

Support Vector Regression was developed by Vapnik[10], and is used to address target variables with real values. In contrast to the squared loss function in ordinary least-squares regression, ϵ-Support Vector Regression (ϵ-SVR) uses ϵ-insensitive loss function, in which errors smaller than ϵ will be omitted. It takes the following form: [10,11]

$$|y - f(x)|_\epsilon := \max\{0, |y - f(x)| - \epsilon\} \tag{13}$$

The model mathematics of SVR is

$$\min_{w,b} \frac{1}{2} \|\omega\|^2 + C \sum_{i=1}^{n} (\xi_i^+, \xi_i^-) \tag{14}$$

subject to

$$\begin{gathered} \mathrm{y_i} - \omega . x_i - b \leq \epsilon + \xi_i^+ \\ \omega . x_i + b - y_i \leq \epsilon + \xi_i^- \\ \xi_i^+, \xi_i^- \geq 0 \quad \forall i. \end{gathered}$$

The solutions to the above model are *w* (weight) and *b* (bias).

The decision function of SVR is:

$$f(x) = \mathrm{w.x} + \mathrm{b} \tag{15}$$

Data

This study uses data from the following sources:

Table 1. Data sources

Data	Source
Financial statements from 189 non-financial firms which went public on Indonesia Stock Exchange(IDX) from 2011 to 2017.	Indonesia Stock Exchange
Indonesian external debt statistics.	Indonesian Ministry of Finance
Exchange rates and interest rates.	Central Bank of Indonesia

III. Result

Table 2 were obtained by estimating the parameters for the model in Equation (7) with both methods.

Table 2. Panel data and Support Vector Regression coefficients

Variable	**Panel coefficient**	**SVR coefficient**
Interaction between net foreign asset ratio and exchange rate difference $(NFA \times \Delta e_t)$	0.0203029	0.652103159
Net foreign asset ratio (*NFA*)	0.6136893	0.793951493
Difference in exchange rates (Δe_t)	0.0701467	0.023527697
Domestic liabilities to asset ratio (L_d)	-0.6050588	-0.845872084
Credit interest rate(r_c)	-0.2196315	-0.027195784
Intercept (panel data regression) / Bias (SVR)	0.7845655	0.877221492

Therefore, the equation for predicting a firm's equity to asset ratio at time *t* can be formulated as follows: for the model estimated with panel data regression:

$$EQ_t = 0.78456550 + 0.0203(NFA_{t-1} \times \Delta e_t) + 0.61369(NFA_{t-1}) + 0.07015(\Delta e_t) - 0.60506\left(L_{d\,t-1}\right) - 0.21963\left(r_{c\,t}\right) = w.x + b \quad (16)$$

and for the model estimated with Support Vector Regression:

$$EQ_t = 0.877221 + 0.6521(NFA_{t-1} \times \Delta e_t) + 0.79395(NFA_{t-1}) + 0.02353(\Delta e_t) - 0.84587(Ld_{t-1}) - 0.0272\left(r_{c\,t}\right) \quad (17)$$

Firstly, Table 2 indicates that all the coefficients obtained from panel data regression have the same signs as their SVR counterpart. This means that both methods generally give the same information about the relationship between each regressor variable and the response variable. Positive coefficients indicate a positive correlation between the regressor variable and the response variable, while negative coefficients indicate a negative correlation between the regressor variable and the response variable.

The results in Table 2 lead to the conclusion that a firm's NFA has a positive linear relationship with its equity, so that the more assets they have in foreign currency in year *t-1*, the more equity they could have in year *t*. Conversely, the more foreign liabilities they have in year *t-1*, the greater the decrease in their equity might be in year *t*.

The difference in exchange rates also correlates positively with a firm's equity. When the domestic currency in which the firm operates is appreciated, the firm's equity will increase, and when the currency is depreciated, its equity will decrease. This difference in exchange rates has greater impacts on companies which are involved in large-scale foreign trade than on those which are not. With depreciation, exporters' profits could rise, since the value of their goods in the domestic currency will increase. On the other hand, in times of depreciation importers will spend more in domestic currency on buying the same amount of goods than they have to spend during normal times.

Interaction between NFA and difference in exchange rates (NFA $\times \Delta e_t$) is also positively correlated with a firm's equity. This proves that the balance-sheet effect is more dominant than the competitiveness effect in the observed firms when depreciation occurs. In other words, when depreciation occurs, the effect of debt value expansion is greater than the increase in profits which ensues, such that the firm's equity will decrease.

A firm's domestic liability is negatively correlated with its equity. A greater level of debt in year *t-1* will cause a greater decrease in its equity in year *t*.

Credit interest rate also correlates negatively with a firm's equity, especially in firms with domestic liabilities. This is because when the credit rate increases, the amount of debt they need to repay expands. An increase in credit interest rate might also encourage firms to opt for loans in foreign currencies, since foreign investors offer much lower interest rates than the domestic credit rate.

To evaluate the accuracy of both methods, we predicted each observed firms' equity to asset ratio in 2017 using Equation (15) for panel data regression and Equation (16) for SVR. We then compared it to their actual equity to asset ratio in their 2017 financial statements. To compare these methods, we calculated their RMSE (root mean square error) using the formula

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2} \tag{18}$$

where y_i is the actual equity to asset ratio of firm i, $\hat{y}_i$ is the predicted equity to asset ratio of firm i, and N is the number of observed firms.

The prediction obtained from panel data regression has an RMSE of 11.68%, while the prediction obtained from the SVR has an RMSE of 9.77%. The smaller RMSE value means the prediction obtained from the SVR model fits the actual data better than the panel regression model.

The NFA threshold can also be found from Equation (8). It is -3.5% for the panel data regression model, and -3.61% for the SVR model. In other words, this threshold represents the maximum amount of debt a firm could have without experiencing loss in their equity. If a firm's foreign liability to asset ratio is more than 3.61%, its equity will decrease on depreciation. The firms observed in this study have an average NFA to asset ratio of -7.89%, which means they are exposed to the risk of equity loss when depreciation occurs.

We also separated the samples into groups according to their exporter and importer status, and subjected them to the estimation process with SVR explained above. A firm was considered an exporter if its exports accounted for more than 25% of its revenue, and was otherwise considered a non-exporter. A firm was considered an importer if its financial statement mentioned an import fee, and was otherwise considered a non-importer.

From this, we obtained the following:

Table 3. Estimation for groups using Support Vector Regression

Status	NFA $\times \Delta e_t$	NFA	Δe_t	Domestic liabilities	Credit rate	Bias	NFA threshold
Exporter	-0.1137	0.7842	-0.0085	-0.8270	-0.0492	0.8163	-7.4%
Non-Exporter	0.6415	0.7867	0.0435	-0.8491	-0.015	0.8746	-6.7%
Importer	0.7405	0.7713	0.063	-0.8568	-0.0072	0.8891	-5.5%
Non-Importer	0.2224	0.8061	0.0124	-0.8441	-0.0078	0.8743	-5.6%

From Table 3 , all groups have a positive NFA coefficient, which indicates a positive correlation between net foreign asset ratio and equity. This means that the greater the foreign debt they have in the previous year, the greater the risk of a decrease in equity.

Differences in exchange rates have different effects on each group. When depreciation occurs, exporters might profit more, while other groups could experience loss. This is a result of the competitiveness effect. Exporters have more advantages than their competitors, since they are able to sell their products at lower prices, and the domestic value of their revenue also expands as a result of depreciation. The other groups could experience a decrease in equity when depreciation occurs. The importer group (which has the largest coefficient of all) could experience the greatest loss of all the groups, since these firms mainly import in order to purchase production factors. When depreciation occurs, the domestic value of their purchase will expand, which leads to an increase in operational expenses and a decrease in revenue.

For every observed group except exporters, there was also a positive correlation between equity and interaction between NFA and exchange rate difference. This proves the dominance of the balance-sheet effect over the competitiveness effect, which means that when depreciation occurs, a greater foreign debt to asset ratio will lead to a further decrease in the equity to asset ratio. On the other hand, exporters gain more when depreciation occurs. It is therefore clear that the competitiveness effect is more dominant than the balance-sheet effect in this group. When depreciation occurs, the loss caused by debt value expansion could be balanced by the increase in revenue.

It can also be concluded that, compared to non-exporters, exporters can have more debt in foreign currencies without a decrease in equity to asset ratio, while importers can allow themselves the lowest level of foreign debt of all groups. Importers should exercise great care in managing their level of foreign debt.

IV. Conclusion

The results of this study show that Support Vector Regression produces a better-fitting model than the more conventionally used panel data regression. However, both models generally provide the same information, specifically that the balance-sheet effect is more dominant than the competitiveness effect in Indonesian corporations when depreciation occurs. The results also show that depreciation is more advantageous for exporter companies than for non-exporters, while importers experience greater losses than non-importers.

We therefore recommend that firms manage their foreign debt to asset ratio carefully, and minimise their imported purchases in order to avoid the risk of equity loss and currency mismatch, and to help increase their exports.

Funding Statement

This research was financially supported by the Indonesia Ministry of Research and Higher Education, with a PDUPT 2019 research grant scheme, ID number NKB-1620/UN2.R3.1/HKP.05.00/2019

References

[1] **Kementerian KeuanganRepublik Indonesia** (2018). Statistik Utang Luar Negeri Indonesia. EdisiMaret 2018, v.02.
[2] **Bleakley, H., Cowan, K.** (2008). *Corporate Dollar Debt and Depreciations: Much Ado About Nothing*?" The Review of Economics and Statistics, MIT Press, vol. 90(4), pages 612-626, November.
[3] **Cespedes, L.F., Chang, R., Velasco, A.** (2004). *Balance Sheets and Exchange Rate Policy*. American Economic Review, vol. 94.
[4] **Krugman, P.** (1999). *Balance Sheets, the Transfer Problem, and Financial Crises*. International Finance and Financial Crises. Springer, Dordrecht, pp. 31-55.
[5] **Biro RisetEkonomi Bank Indonesia** (2006). *Balance-Sheet Effects of Exchange Rate Depreciation: Evidence from Non-Financial Firms in Indonesia.* Working Paper WP/06/2006, Bank Indonesia.
[6] **Biro RisetEkonomi Bank Indonesia** (2009). *Balance-Sheet Effects dariDepresiasi Nilai Tukarterhadap Perusahaan-Perusahaan Go Public di Indonesia*. Working Paper WP/04/2010, Bank Indonesia.
[7] **Biro RisetEkonomi Bank Indonesia** (2011). AnalisaPerilakuPembiayaanAsing dan DampaknyaTerhadapKetahananPerusahaan. Working Paper WP/12/2011, Bank Indonesia.
[8] **Woolridge, J.M. (1999)**. Econometric Analysis of Cross Section and Panel Data. MIT Press.
[9] **Montgomery, D.C., Peck, E.A., Vining, G.G.** (2012). Introduction to Linear Regression Analysis. Wiley.
[10] **Cristianini, N., Shawe-Taylor, J.** (2000). *An Introduction to Support Vector Machines and Other Kernel-based Learning Methods*. Cambridge University Press.
[11] **Bishop, C.M.** (2006). Pattern Recognition and Machine Learning. UK: Springer