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# GOVERNMENT BORROWING, CAPITAL STRUCTURE AND LIQUIDITY POLICIES: EVIDENCE FROM IRAN

# EMPRÉSTIMOS DO GOVERNO, ESTRUTURA DE CAPITAL E POLÍTICAS DE LIQUIDEZ: EVIDÊNCIAS DO IRÃ

# PRÉSTAMOS GUBERNAMENTALES, ESTRUCTURA DE CAPITAL Y POLÍTICAS DE LIQUIDEZ: EVIDENCIA DE IRÁN

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## ABSTRACT

This paper investigates whether there is a significant relationship between government borrowing and firms' capital structure and liquidity in Iran as a developing economy. In addition, the most innovative aspect of our research is to inspect which source of government debt has the most impact on the firm's financing and liquidity policies. We carry out our inquiry on non-financial corporations listed in Tehran Stock Exchange from 2006 to 2017. The econometric model utilized in this study is the Generalized Method of Moments (GMM). We consider some other proved firm-specific and country-level factors as control variables in our model development according to the previous researches. Moreover, in addition to the econometric model, we harness Sobol' sensitivity analysis and Support Vector Regression (SVR) for selecting the most influential source of government borrowing to reveal whether econometric and machine learning methods have the same result in this case and to compare them. The econometric results evince that not only the total government borrowing and corporate liquidity have negative influences on leverage ratio as the determinant of capital structure, but also government debt to the bank sector and other lending institutes plays the most essential role. It also shows the affinity of capital structure and liquidity literature implicitly. Additionally, the SVR model indicates similar results to the econometric model.


**Keywords:** Capital structure, Government borrowing, GMM, Liquidity, SVR.


## RESUMO

Este artigo investiga se há uma relação significativa entre os empréstimos do governo e a estrutura de capital e liquidez das empresas no Irã como uma economia em desenvolvimento. Além disso, o aspecto mais inovador de nossa pesquisa é inspecionar qual fonte de dívida do governo tem o maior impacto nas políticas de financiamento e liquidez da empresa. Realizamos nosso inquérito sobre empresas não financeiras listadas na Bolsa de Valores de Teerã de 2006 a 2017. O modelo econométrico utilizado neste estudo é o Método Generalizado dos Momentos (GMM). Consideramos alguns outros fatores comprovados específicos da empresa e em nível de país como variáveis de controle no desenvolvimento de nosso modelo de acordo com as pesquisas anteriores. Além disso, além do modelo econométrico, aproveitamos a análise de sensibilidade de Sobol e a Regressão do Vetor de Suporte (SVR) para selecionar a fonte mais influente de empréstimos do governo para revelar se os métodos econométricos e de aprendizado de máquina têm o mesmo resultado neste caso e para compará-los. Os resultados econométricos evidenciam que não apenas o endividamento total do governo e a liquidez corporativa têm influências negativas no índice de alavancagem como determinante da estrutura de capital, mas também a dívida do governo com o setor bancário e outras instituições de crédito desempenha o papel mais essencial. Ele também mostra a afinidade da estrutura de capital e literatura de liquidez implicitamente. Além disso, o modelo SVR indica resultados semelhantes ao modelo econométrico.


**Palavras-chave:** Estrutura de capital, Financiamento do governo, GMM, Liquidez, SVR

**RESUMEN**

Este documento investiga si existe una relación significativa entre el endeudamiento del gobierno y la estructura de capital y liquidez de las empresas en Irán como economía en desarrollo. Además, el aspecto más innovador de nuestra investigación es inspeccionar qué fuente de deuda pública tiene el mayor impacto en las políticas de financiación y liquidez de la empresa. Realizamos nuestra consulta sobre sociedades no financieras que cotizan en la Bolsa de Valores de Teherán de 2006 a 2017. El modelo econométrico utilizado en este estudio es el Método Generalizado de Momentos (GMM). Consideramos algunos otros factores probados específicos de la empresa y a nivel de país como variables de control en el desarrollo de nuestro modelo de acuerdo con las investigaciones anteriores. Además, además del modelo econométrico, aprovechamos el análisis de sensibilidad de Sobol y la Regresión de vectores de soporte (RVS) para seleccionar la fuente más influyente de endeudamiento público para revelar si los métodos econométricos y de aprendizaje automático tienen el mismo resultado en este caso y compararlos. . Los resultados econométricos muestran que no solo el endeudamiento total del gobierno y la liquidez corporativa tienen influencias negativas sobre el coeficiente de apalancamiento como determinante de la estructura de capital, sino que también la deuda del gobierno con el sector bancario y otras instituciones crediticias juega el papel más esencial. También muestra implícitamente la afinidad de la literatura sobre la estructura de capital y la liquidez. Además, el modelo de RVS indica resultados similares al modelo econométrico.

**Palabras clave**: estructura de capital, endeudamiento público, GMM, liquidez, RVS.

## 1 INTRODUCTION

Budget deficit and how to finance government expenditures are among the most debatable issues in macroeconomics. Generating and monitoring an efficient debt market can lead to fundraising from individual and institutional investors in an efficient way. In developing countries, the lack of an efficient debt market causes inefficiency in government borrowing and it has destructive influences on the microeconomic level in comparison to developed countries. Friedman (1978) believes that government borrowing in short term could confront against fiscal crisis but in long term could destroy private investment, fluctuations in government debt can lead to change the relative returns on assets and this change depends on the substitutability of the assets in the investor's portfolio. The assets which are better alternatives of government debt (corporation debt) react more intensively in comparison to the assets which are weaker alternatives (corporation equity). On the other hand, government borrowing from the bank sector, increases money demand and interest rates

and reduces investments (Al-Majali, 2018). Furthermore, an increase in government borrowing causes a reduction in the opportunity cost of cash holding. Therefore, corporations tend to hold more cash (Krishnamurthy & Vissing-Jorgensen, 2012). The proximity of capital structure and liquidity literature in this facet is discussed in Opler et al. (2001).

In Iran and most Islamic countries, due to the prohibition of definite profit in fixed income securities because of the Islamic Shariah, the government borrows mostly from Central Bank, foreign sources, the bank sector and other lending institutes. Now, we intend to investigate the effects of government borrowing from mentioned sources on corporate financing decisions and capital structure policies. There are some resembling works in this field in developed countries (Graham et al., 2014; Ayturk, 2017; Liang et al., 2017). The most innovative aspect of ours is that we want to know which of the aforementioned sources of government debt have the most influence on corporate financing decisions. To achieve this goal, we harness both econometric and machine learning models. The econometric model used in the present study is Generalized Method of Moments (GMM) and the machine learning model is Sobol' sensitivity and SVR method. Moreover, we have done the same implementation for corporate liquidity policy. We expect that both corporate leverage and liquidity are influenced more profoundly by government debt to bank sector and other lending institutes because it has a direct impact on private sector.

The structure of this study comprises as follows: This section provides a brief introduction into the necessity, main goal and methods through which we reach the outcomes. In the theoretical background and literature review section, we explain the theories and previous works about capital structure, liquidity and crowding-out effects of government borrowing. The data and research methodology section demonstrates the data used in this study and research methodology of both econometric and machine learning approaches. The results section explains the results of processing and estimating the data via econometrics and machine learning. Eventually, in the conclusion and discussion section, we provide the final conclusion and proposals of the present study.

## 2 THEORETICAL BACKGROUND AND LITERATURE REVIEW

The theoretical background of this study is related to both crowding-out effects of government borrowing and capital structure.

A wide literature focuses on the realm of the crowding-out effects of government behaviors (Spencer and Yohe, 1970; Buiter, 1977; Friedman, 1978). We concentrate on the crowding-out effect of government borrowing. Elmendorf and Mankiw (1999) and Hubbard (2012) argue that budget deficits could lead to increase aggregate demand but prompt a rise in interest rates and eventually crowd out private investments. Nevertheless, Friedman (1978) discusses that government debt financing will crowd out corporate debt financing due to the substitutability of these assets. Fan et al. (2012) investigate the determinants of firms' capital structure in developing countries and express that government bond issues crowd out debt financing. Graham et al. (2014) use a dataset of accounting and market information of the U.S. over the last century, show that government debt negatively correlated with corporate debt and investment and positively correlated with corporate liquidity. Additionally, these relations are stronger in larger and less risky firms. On the other hand, government borrowing growth causes opportunity cost decrease of cash holding and it induces firms to hold more cash in the time of government borrowing ascending (Krishnamurthy and Vissing-Jorgensen, 2012). According to Graham et al. (2014), "when government borrowing increases the price of liquid assets relative to illiquid assets falls. This price decline reduces firms' opportunity cost of holding liquid assets and increases their cost of debt capital. Firms respond by reducing their purchases of illiquid assets (investment) and sales of liquid assets (debt), and increasing their holdings of liquid assets".

A comprehensive survey of American companies is conducted by Graham and Harvey (2001) and the results show that when managers think that interest rates are low, they start issuing new debts. This phenomenon is more valid for larger companies because they have a more complex treasury circle. Brounen et al. (2006) conduct a similar survey to identify the capital structure policy in Europe. They find similar evidence with European executives about market timing, albeit less strongly than Americans. Recent studies also consider macroeconomic factors that affect corporate financing (De jong et al., 2008; Fan et al., 2012; and Oztekin, 2015).

Recent empirical studies by Greenwood et al. (2010) and Badoer and James (2015) focus on the relationship between government and corporate debt maturity structures. The results of Badoer and James (2015) research show that the long-term debt of reputable companies and high-level companies are more sensitive to shocks in the supply of long-term

government bonds than other companies. They also find strong evidence that the increase in government debt supply only affects the long-term debt of reputable companies and not companies with limited funding. In addition, they found no link between the issuance of corporate short-term debt and the supply of government debt. Ayturk (2017) examines the impact of government borrowing on corporate financing in fifteen developed European countries from 1989 to 2014. His findings suggest a negative correlation between corporate debt and government borrowing. He also shows that there is no link between government borrowing and equity in developed European countries and that the long-term debts of reputable companies are more sensitive to government debt.

In the scope of capital structure, there are four accepted theories: Trade-off theory, Pecking-order Theory, Signaling theory and Market timing theory. The trade-off theory commences from studies of Modigliani and Miller (1958) and Modigliani and Miller (1963). This theory expresses that capital structure reflects the balance between debt tax benefits and bankruptcy costs. In fact, the main idea in this theory is that firms should determine debt and equity in the capital structure via trading off between benefits and costs. The hypothesis of trade-off theory is that if a firm finances all its activities by means of debt, it would be very beneficial for it; but the bankruptcy risk of using debt doesn't permit firms to do so. Firms following this theory have a capital structure target and move slowly toward this (Myers, 1984). Myers and Majluf (1984) are pioneers of the Pecking-order theory. The key element in this theory is information asymmetry inside and outside of firms (Baker and Martin, 2011). According to the Pecking-order theory firm's internal sources of financing are preferable in comparison to external sources and if a firm is obliged to harness external sources of financing, it prefers debt. As a result, the priority of financing sources is earnings, debt and equity, respectively. Myers and Majluf (1984) explain that managers who aim to maximize their firm's value, forbear from external financing via equity; considering their more information against shareholders and external investors. In the Pecking-order model in order to avoid adverse selection problems and losing value, firms with high-quality tend to finance their activities by means of internal sources. They don't intend to perform their high quality by changing capital structure. The Signaling theory demonstrates models in which capital structure acts as private signals (Ross, 1977). According to this theory, if high quality firms' managers with valuable investment projects or low bankruptcy risk issue debt for financing,

the market will discover it, reacts positively to debt issuance and this prompts to increase their share's price; Whereas, the market reaction to equity issuance will be negative. Making a decision about equity issuance depends on market circumstances. This idea with the studies of Baker and Wurgler (2002) creates Market timing theory. This theory emphasizes that adverse selection is different at different times. It means that in inconvenient economic conditions, firms don't issue equity; in the normal economic conditions they start it and in the economic boom, there is an acme for equity issuance. Empirical results of Bayless and Chaplinsky (1996) and Baker and Wurgler (2002) represent that there is a positive relationship between equity issuance and the business cycle. However, it is necessary to consider that despite studies that confirm a significant relationship between high market-to-book value with low debt issuance like Frank and Goyal (2004), high expected inflation would cause debt issuance to be cheap and increase the share of debt in the capital structure (Oztekin, 2015). In addition, in the existence of inflation, it is possible to undervalue the share because of investors' inflation illusion and this leads to enhance financing via debt (Ritter and Welch, 2002).

Numerous studies have been conducted on the factors that determine the capital structure of companies, each of which has introduced a series of variables as factors affecting the capital structure of companies. For example, Parson and Titman (2008) consider the debt ratio to be affected by the value of assets that can be pledged to obtain a loan, non-leverage tax shield, growth, monopoly, industry classification, size, volatility, and profitability. De Jong et al. (2007) examine firm-specific factors and country-specific factors that affect the debt ratio for forty-two countries (including developed and developing countries). The results of this study indicate that the factors affecting the capital structure in different countries are different and macroeconomic factors have both direct and indirect effects on the capital structure of companies. However, they include the tangibility of assets, business risk, company size, taxes, growth, profitability and liquidity as specific factors affecting the debt ratio and financial laws of countries, shareholders and creditors legal laws, bank-based or The financial system of countries, the rate of development of debt and stock markets, capital formation and GDP growth are considered as factors affecting the capital structure of companies. Frank and Goyal (2009) conduct a similar study on US public corporations from 1950 to 2003, which look at the median effect of industry debt, market value-to-book ratio of assets, tangibility of assets, revenue, logarithm of assets and the expected inflation indicates

the capital structure of companies. They also find that companies that distribute profits among their shareholders were less likely to borrow and use debt to finance it. Baker and Martin (2011) introduce tangible assets, firm size, growth opportunities, profitability, cash flow fluctuations, industry classification, tax considerations, corporate debt rating, debt market conditions, stock market conditions and macroeconomic conditions as factors determining the capital structure of companies. In this regard, Oztekin (2015) has examined the capital structure of companies in thirty-seven countries, the most important and significant determinants of which are company size, tangible assets, average debt ratio of industry, profitability and inflation. Dos Santos Cardoso and Pinheiro (2020) reveal that the recent Brazilian recession was relevant for the capital structure of the sectors studied, with inflation only being significant for the health sector. In addition, they verify that the company-specific variables have greater relevance in determining capital structure compared to the macroeconomic ones. Lussuamo and Serrasqueiro (2021) note that tangibility, age, liquidity, and non-debt tax shield are determining factors in the capital structure decision of SMEs in the province of Cabinda, Angola. Besides, they suggest that these firms follow the principles of pecking-order theory in capital structure decisions.

## 3 DATA AND RESEARCH METHODOLOGY

In order to address the intrinsic dynamic of financial data, we harness the first differenced two-stage GMM model for all of the studied equations. Our study period is from 3/21/2006 to 3/20/2017 and we investigate 149 firms. We include all non-financial firms listed in Tehran Stock Exchange that their data is flawless during the study period. Defining variables can be seen in detail in table 1. Meanwhile, we choose capital market return, government expenditures to GDP, inflation rate, ROA and tangibility of assets as control variables according to previous researches (Frank and Goyal, 2009; Graham, 2014; Oztekin, 2015; Ayturk, 2017).

**Table 1**
Defining variables

| variable | measurement criterion | unit | label |
|---|---|---|---|
| leverage | total debt/total assets | - | Lev |
| liquidity | current assets/current liability | - | Liq |
| government total debt to | government total | - | Total_Debt_to_GDP |

| | | | |
|---|---|---|---|
| GDP | debt/GDP | | |
| government debt to central bank | logarithm of government debt to central bank | billion Rial | Central_Bank_Debt |
| government foreign debt | logarithm of government foreign debt | million Dollar | Foreign_Debt |
| government debt to bank sector and other lending institutes | logarithm of government debt to bank sector and other lending institutes | billion Rial | Bank_and_Nonbank_Debt |
| capital market return | (market return in current year-market return in previous year)/market return in previous year | - | Cap_Market_return |
| government expenditures to GDP | government expenditures/GDP | - | Gov_Exp_to_GDP |
| inflation rate | yearly inflation rate | - | InfRate |
| interest rate | yearly interest rate | - | IntRate |
| ROA | net profit/total assets | - | ROA |
| tangibility | fixed assets/total assets | - | Tan |
| growth | (total assets in current year-total assets in previous year)/ total assets in previous year | - | Growth |
| size | logarithm of total assets | - | Size |
| debt interest | logarithm of debt interest | - | TaxS |

The data summary of variables is also available in the table 2.

**Table 2**
Data summary of variables

| variable | number of observations | mean | standard deviation | maximum | minimum |
|---|---|---|---|---|---|
| leverage | 1788 | 0.600679 | 0.210167 | 2.0210747 | 0.090347 |
| liquidity | 1788 | 0.184699 | 0.332444 | 4.861735 | 0.000479 |
| government total debt to GDP | 12 | 18.59167 | 13.59237 | 47.50000 | 8.900000 |
| government debt to central bank | 12 | 5.165151 | 0.178734 | 5.437433 | 4.961057 |
| government foreign debt | 12 | 4.115978 | 0.252929 | 4.457081 | 3.708183 |
| government debt to bank sector and other lending institutes | 12 | 5.610267 | 0.489851 | 6.306425 | 4.74939 |
| capital market return | 12 | 0.269016 | 0.389689 | 1.077122 | -0.209822 |
| government expenditures to GDP | 12 | 0.190556 | 0.027666 | 0.231211 | 0.146132 |
| inflation rate | 12 | 17.64167 | 8.247048 | 34.70000 | 9.000000 |
| interest rate | 12 | 17.12500 | 2.966782 | 24.00000 | 14.00000 |
| ROA | 1788 | 0.206096 | 0.134390 | 0.727888 | 0.318624 |
| tangibility of assets | 1788 | 0.274734 | 0.190273 | 0.938626 | 0.000563 |
| growth | 1788 | 0.171887 | 0.259330 | 3.250000 | -0.540000 |
| size | 1788 | 6.057960 | 0.723751 | 8.576994 | 4.427665 |
| debt interest | 1788 | 4.182437 | 1.310272 | 7.501212 | 0.000000 |

We construct the econometric equation as follows:

$$Lev_{it} = \alpha Lev_{i,t-1} + \beta_1 X_t + \beta_2 Y_{it} + \delta_i + \varepsilon_{it}; |\alpha| < 1, i = 1, \dots, 149, t = 1 \dots, 12 \quad (1)$$

Where $Lev_{it}$ denotes the dependent variable of the company i in year t, $X_t$ is the independent variable in year t, $Y_{it}$ is the vector of control variables, $\delta_i$ denotes the unobserved time-invariant heterogeneity and $\varepsilon_{it}$ is the idiosyncratic error component.

We aim to reveal if there is a relationship between firms' leverage ratio as the dependent variable and government total debt to GDP as the main independent variable. If the answer is yes, which source of government debt has the most effect on the leverage ratio. The cardinal sources are government debt to central bank, government foreign debt and government debt to bank sector and other lending institutes. Control variables including country-level and firm-specific variables are also considered in the models.

According to Opler et al. (2001), there is proximity in the literature of capital structure and liquidity. This propinquity stimulates us to add liquidity as another main independent variable to our econometric model.

Due to the potential complexity of financial matters, especially in developing countries and the novelty of using machine learning methods in this aspect in comparison to econometrics, we also decide to conduct machine learning for the present study and compare the results of these mentioned approaches. Sobol' sensitivity analysis which is based on variance analysis gets a mathematical model that has independent parameters cumulated in an input vector and a scalar dependent output (Sudret, 2008; Homma and Saltelli, 1996). A detailed explanation of Sobol' sensitivity analysis is discussed in Ansari and Akhoondzadeh (2019). It required an initial mathematical input and provides the sensitivity of the dependent variable to each of the independent variables in order. So, following Ansari and Akhoondzadeh (2019), we estimate study equations with GMM as the input for Sobol' sensitivity analysis. Additionally, the input parameters which are independent variables uniformly distributed in [mimimum, maximum] of each dependent variable are generated ten thousand times and these generated data have been normalized (limited to [0,1]). Eventually, the analysis selects the most significant features accordingly and the total sensitivity indices describe the total effect of an input parameter (Sobol, 1993; Sudret, 2008; Homma and Saltelli, 1996).

The SVR is the Support Vector Machine (SVM) specialized for regression and function approximation (Schölkopf et al., 2002). The results of SVR depend on some factors like the proper setting of meta-parameter, function Ɛ, the error penalty factor C, and the kernel function parameters (Wang et al., 2016). Furthermore, radial basis kernel function (RBF), $k(x, x') = \exp(-||x - x' 2/\sigma^2)$, has been used in this study and grid search procedure is harnessed to optimize C, Ɛ, and $\sigma$.

## 4 RESULTS

### 4.1 Econometric section

The GMM results are shown in table 3. Each column of table 3 indicates a single estimation with the target independent variable written on top of the column based on equation 1 and we bring them together in one table. For instance, the target independent variable in column 1 is government total debt to GDP. The coefficients and t-statistics can be observed.

**Table 3**
The results of estimating equation 1 with first differenced two-stage GMM model

| | government total debt to GDP | government debt to central bank | government foreign debt | government debt to bank sector and other lending institutes |
|---|---|---|---|---|
| government total debt to GDP | -0.000338*** (-3.177176) | - | - | - |
| government debt to central bank | - | -0.007590 (-0.430058) | - | - |
| government foreign debt | - | - | -0.010019 (-0.662544) | - |
| government debt to bank sector and other lending institutes | - | - | - | -0.008288*** (-2.541350) |
| liquidity | -0.051955*** (-6.500679) | -0.052034*** (-6.506517) | -0.052113*** (-6.517258) | -0.051941*** (-6.497123) |
| capital market return | -0.024932*** (-3.209478) | -0.025888*** (-3.225317) | -0.027570*** (-3.574625) | -0.024629* (-3.119045) |
| government expenditures to GDP | -0.265625 (-1.334811) | -0.357984* (-1.905216) | -0.370697** (-1.986838) | -0.342832** (-1.826833) |
| inflation rate | -0.000777* (-1.936596) | -0.000647 (-1.504577) | -0.000526 (-1.405709) | -0.000723** (-1.815363) |
| interest rate | -0.002177* (-1.664916) | -0.002561* (-1.892449) | -0.003448** (-2.178739) | -0.002061 (-1.485755) |
| ROA | -0.266539*** (-13.69522) | -0.265750*** (-13.65152) | -0.265326*** (-13.63035) | -0.266251*** (-13.67906) |
| tangibility of assets | -0.051799*** (-4.004263) | -0.051351*** (-3.965935) | -0.050682*** (-3.913916) | -0.052001*** (-4.014625) |
| growth | 0.012893 (1.315803) | 0.013075 (1.333683) | 0.013278 (1.354174) | 0.013030 (1.329587) |

| | | | | |
|---|---|---|---|---|
| size | 0.004599<br>(1.168704) | 0.003827<br>(0.971637) | 0.002997<br>(0.760554) | 0.004487<br>(1.134836) |
| debt interest | 0.004070*<br>(1.748980) | 0.004131*<br>(1.773896) | 0.004193*<br>(1.800781) | 0.004067*<br>(1.746714) |
| | J-stat: 53.03652 | J-stat: 59.59359 | J-stat: 55.46634 | J-stat: 59.12430 |
| | AR1 (m-stat):<br>0.0000<br>(-5.521623) | AR1 (m-stat):<br>0.0000<br>(-5.193127) | AR1 (m-stat):<br>0.0000<br>(-5.692936) | AR1 (m-stat):<br>0.0000<br>(-5.817195) |
| | AR2 (m-stat):<br>0.0876<br>(1.890849) | AR2 (m-stat):<br>0.3475<br>(0.939523) | AR2 (m-stat):<br>0.0911<br>(1.875246) | AR2 (m-stat):<br>0.0935<br>(1.856647) |

*,**,*** indicate 10%, 5% and 1% significance level respectively. Calculated t-statistics are in parenthesis.

First and foremost as shown in table 3, total government debt to GDP and liquidity have a significant impact on corporate leverage. Second, government debt to the bank sector and other lending institutes is a significant determinant of leverage ratio, while government debt to central bank and government foreign debt have no significant relationship with dependent variable. Besides, Sargan, Ar1 and Ar2 tests evince the validity of all four estimations in 10% significance level.

### 4.2 Machine learning section

We estimate all the equations -both in econometrics and machine learning section- using leverage ratio as the dependent variable, three studied sources of government borrowing and liquidity as independent variables and aforementioned firm-specific and macroeconomic control variables. Furthermore, we estimate three separate equations for these three dependent variables in these two sections because they are different sources of government debt and intrinsically mutually exclusive and bringing them in one equation is inconsistent. So, we use our GMM results shown in table 3 as the primary mathematical model to be the input for Sobol' sensitivity analysis.

In the next step, we conduct Sobol' sensitivity analysis to distinguish the strength of the impact of each independent variable on the dependent variable in order. Table 4 indicates the results.

**Table 4**
The results of Sobol' sensitivity analysis

| | government debt to central bank | government foreign debt | government debt to bank sector and other lending institutes |
|---|---|---|---|
| leverage (-1) | 1* (0.8750) | 1* (0.7222) | 1* (0.9031) |
| government debt to central bank | 4* (0.0151) | - | - |
| government foreign debt | - | 6 ($4.9655\times10^{-4}$) | - |
| government debt to bank sector and other lending institutes | - | - | 3* (0.0154) |
| liquidity | 3* (0.1039) | 3* (0.0114) | 4* (0.0122) |
| capital market return | 9 ($6.0521\times10^{-5}$) | 7 ($4.3700\times10^{-4}$) | 8 ($1.0998\times10^{-9}$) |
| government expenditures to GDP | 5 (0.0009) | 4* (0.0078) | 5 (0.0013) |
| inflation rate | 7 ($3.0752\times10^{-4}$) | 5 ($7.0950\times10^{-4}$) | 6 (0.0008) |
| interest rate | 8 ($6.3149\times10^{-5}$) | 10 ($1.7428\times10^{-4}$) | 9 ($1.0974\times10^{-9}$) |
| ROA | 2* (0.1058) | 2* (0.1219) | 2* (0.0586) |
| tangibility of assets | 6 ($7.2152\times10^{-4}$) | 8 ($2.5416\times10^{-4}$) | 7 ($7.3227\times10^{-4}$) |
| growth | 12 ($9.3218\times10^{-7}$) | 12 ($8.4457\times10^{-5}$) | 12 ($6.0556\times10^{-10}$) |
| size | 11 ($1.0026\times10^{-5}$) | 11 ($1.0004\times10^{-4}$) | 11 ($7.5627\times10^{-10}$) |
| debt interest | 10 ($1.2337\times10^{-5}$) | 9 ($2.1867\times10^{-4}$) | 10 ($1.0358\times10^{-9}$) |

Variables with * mark are selected by Sobol' sensitivity analysis. In each cell, the upper number indicates the variable rank and the lower number indicates the dedicated sensitivity.

As it can be observed in Table 4, Sobol' sensitivity analysis does not select our target variable (government foreign debt) in equation of column 2. So, we conduct SVR for equations of column 1 and 3. Additionally, the data was divided 70:30 for training and testing purposes.

In the present study, we use the grid search procedure to determine SVR meta-parameters including the loss function Ɛ, the error penalty factor C and σ parameters. For the equation of column 1, these parameters are obtained to be 0.0147, 64 and 32, respectively. The SVR $R^2$ and RMSE for test data are obtained to be 0.7645 and 0.0151, respectively. In estimating the equation of column 3 via the SVR method, the loss function Ɛ, the error penalty factor C and σ parameters are 0.0064, 62 and 62, respectively. The SVR $R^2$ and RMSE for test data are also 0.7962 and 0.0132, respectively. According to SVR results and considering the same dependent and independent variables except for our target variables (government

debt to central bank and government debt to bank sector and other lending institutes) in SVR inputs, government debt to bank sector and other lending institutes explains corporate leverage better in comparison to government debt to central bank due to the higher $r^2$ and lower rmse.

## 5 CONCLUSION AND DISCUSSION

As we mentioned above, the initial objective of this study is to ascertain whether government borrowing and liquidity are the determinants of firms' leverage in developing countries suffer from lacking efficient debt market like Iran; especially, countries with Islamic Shariah that issuing corporate debt or government debt with definite profits is illegal. The econometric results that can be observed in Table 3 indicate that total government debt to GDP and liquidity have a negative and significant impact on firms' leverage ratio that is correspondent with former works on developed countries. Furthermore, we probe the effect of government debt to central bank, foreign debt and debt to the bank sector and other lending institutes as substantial government borrowing sources on dependent variables and we find out that there is no significant relationship between government debt to central bank and foreign debt and corporate leverage and liquidity, while we acquire the significant and negative effect of government debt to bank sector and other lending institutes on leverage. This consequence means not only the aforesaid source of Iran's government borrowing is the most critical source for the corporate sector, but also attests the affinity of corporate capital structure and liquidity policies. Furthermore, the machine learning results denote the same results as the econometric section.

Our study manifests a cardinal determinant in this sphere. If governments of developing countries attempt to constitute an intense economy, they should consider the interdependency between the corporate sector and government, specifically in the realm of the debt market. On the other hand, intelligent corporate managers consider both firm-specific and macroeconomic factors before establishing capital structure and liquidity policies. To interpret the results, it is important to note that the bank sector and other lending institutes including social security organizations are more accessible sources of government borrowing and they are directly related to the private sector. Therefore, it crowds out private investment

more intensively in comparison to government borrowing from central bank or government foreign debt.

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