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# Assessing sovereign debt default by efficiency

Annageldy Arazmuradov [1]

*Department of Economics and Management of Technology, Faculty of Engineering, University of Bergamo, via Marconi 5, 24044 Dalmine, BG, Italy*

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ABSTRACT

Since an external debt constitutes a high share in developing country's GDP its efficient use affects the national output production. This study evaluates the feasibility of technical efficiency to be used as an ex-ante predictor of debt default risk assessment. We present evidence that improvement in production efficiency derived from traditional data envelopment analysis (DEA) have positive partial effects in reducing the financial failure for 65 developing countries. In addition, we found that US Fed interest rates play a significant role in increasing the default likelihood. The probability models display a reasonable ex-post prediction accuracy of actual defaults which is around 78%. Overall, results suggest that DEA efficiency metrics could serve as candidate variables for forecasting sovereign debt risk.



## 1. Introduction

Development of early warning systems (EWS) indicators for external debt became an important topic in the international economics literature since the 1980s (Erbe & Schattner, 1980). The importance of external (sovereign) debt for economic growth is undeniable for developing nations as it accounts for 30–90% of their national outputs. However, debt is subject to default by governments and increases fiscal burden, and debt finance makes the country bear the full burden of domestic shocks.[2] Eaton, Gersovitz, and Stiglitz (1986) pointed out that default is more due to unwillingness to pay than to insolvency or lack of liquidity. Moreover, in the presence of moral hazard and adverse selection, incomplete information presents difficulties for creditors to assess debtors' true ability to repay a debt. It was recognized that the debtor countries' borrowing level, default or repayment decisions are intimately bound to economic growth prospective (plans) and savings decisions (Freeman, 1979). In addition, it is widely acknowledged that poor management is among the main reasons of financial failure (Xu & Wang, 2009). Since debt contributes a big share to borrowers' GDP it is intrinsically linked to the productive capacity of a country. In this sense, it is highly likely that inefficient use of economic resources makes countries prone to renege on their debt contracts. In the present author's opinion, the resources use effectiveness (i.e. production efficiency) of the borrowing country could contribute to discern incomplete information. Therefore, we think that the strategic use of external debt is directly linked to economic performance and therefore influences the deficit, unemployment and default.

*E-mail address:* annageldy.arazmuradov@unibg.it

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[2] The study by Eaton and Fernandez (1995) provide a review of sovereign debt literature. For a recent in-depth review on sovereign debt and default the reader is advised to consult Tomz and Wright (2013). Aguiar and Amador (2013) analyze the economic model of debt with implications of limited enforcement. Hatchondo, Martinez, and Sapriza (2007) discuss the costs of sovereign default and its possible determinants. Among them they point out to high cost of borrowing, availability of resources and political situation fluctuations.

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Departing from above ideas this paper incorporates technical efficiency scores derived by data envelopment analysis (DEA) into debt default risk evaluation.[3]

The aim of our study is to broaden the current knowledge on debt risk assessment. With this in mind we consider three objectives. First, to estimate and compare candidate efficiency measures by using activity analysis method, DEA. Specifically, we compute three types of efficiency scores. They are Banker, Charnes and Cooper model (BCC), slacks-based model (SBM) and free disposal hull (FDH).[4] Second, we are interested in checking the effect of derived efficiency scores on the probability of external debt default. To this end, we test whether the probability of default is associated with better efficiency. Third, we check to what extend simple probability techniques with DEA efficiency as an explanatory variable could predict the historical debt defaults by employing Logit, Probit and discrete-time proportional hazard (Hazard) models.

Identifying the possibility or occurrence of default is also important for preventing additional costs arising from so called *last minute defaults*, i.e. when default occurs it is late to recover it or part of it. Realizing the near default moment is critical for creditor to recover some initial debt with various degree of likelihood which, in turn, would directly depend on accuracy of forecasting. If knowledge on the current state of a country is not adequate to predict default, we need an advice on future costs of default. This kind of information, as was mentioned before, is linked to country's growth plans, i.e. maximization of GDP. And exactly for this reason we propose the idea of efficiency that could be understood as maximizing the national output (GDP) while efficiently managing the external debt. The advantage of DEA efficiency measure is that it allows deriving a performance score by using multiple input and output factors, versus single financial/economic ratios. Lastly, the DEA model (next section) accommodates variables with different measurement units, permits negative variables and exempts the researcher from specifying the exact functional form, e.g. Cobb-Douglas or translog.

Previous work on external debt default on macroeconomic level has only focused on using financial indicators in assessing debt risk. For example, Manasse, Roubini, and Schimmelpfennig (2003) define the probability of debt crises by employing Logit and CART statistical methodology. Fioramanti (2008) studies external debt default by non-parametric artificial neural networks (ANN) and concludes that it could reasonably explain the default cases. Manasse and Roubini (2009) show how to define a rule of thumb for sovereign debt assessment. Celasun and Harms (2011) has found that the share of private debt in sovereign borrowing is likely to reduce the default. Jorra (2012) empirically shows how the IMF program could increase debt default probability by 1.5–2%. Chuang and Ho (2013) develop a new sovereign debt risk measure basing on a network concept and applied it to countries reporting to Bank for International Settlements (BIS). They conclude that their index is feasible in quantifying the systemic risk. Eichler and Hofmann (2013) analyze how decentralization affects the sovereign debt default and found that higher levels of political and fiscal decentralization increase the default risk. Catão and Milesi-Ferretti (2014) show that net foreign liabilities (NFL) to GDP ratio is a good predictor of debt crises. They conclude that FX reserves reduce the probability of crises. Chakrabarti and Zeaiter (2014) provide a detailed analysis of sovereign debt default determinants. They use extreme bound analysis (EBA) technique applied to 190 countries over 1970–2010 period and find that sovereign debt defaults are associated with output growth, export earnings, debt service ratio, reserves, inflation, exchange rate, trade deficit, corruption, and democratic accountability. Savona and Vezzoli (2015) employed a two-step regression-tree technique to study 66 emerging economies (1975–2010) that outperformed all previously applied (Logit, stepwise Logit, noise-to-signal ratio and regression trees) models in predicting the debt default episodes. Schaltegger and Weder (2015) study the effect of fiscal adjustment and IMF on sovereign debt default in the short-run analyzing 104 counties between 1980 and 2008. They argue that revenue-based adjustments tend to reduce the probability of default by 35–55% in the short-run.

So far all the contributions discussed above had used various financial ratios to estimate the country's or company's debt/credit default risk. It has not yet been established whether improvements in efficiency is negatively related with risk of default. This paper proposes the use of data envelopment analysis (DEA) efficiency scores as a complement to existing debt default predictors. This idea was widely applied in microeconomic studies. The notion to employ DEA to classify firms into distressed and non-distressed appears in Cielen, Peeters, and Vanhoof (2004) and Paradi et al. (2004). Later, additive DEA models with financial ratios as an outputs and inputs were proposed by Premachandra et al. (2009) to predict the bankruptcy of firms. Their technique was improved by Shetty et al. (2012) who employed the directional distance function (DDF) DEA modeling. The authors introduce an idea of a bankruptcy frontier, i.e. the firms that are on that frontier are prone to bankruptcy and the ones inside it are less so. Psillaki, Tsolas, and Margaritis (2010) show how to incorporate the DEA efficiency scores with Logit models to predict probability of credit defaults of French firms. Recently, Li et al. (2014) investigate the predictive capacity of DEA-born corporate efficiency measures by decomposing the technical efficiency (TE) onto pure technical efficiency (PTE) and scale efficiency (SE). They compute the likelihood of default by a Logit model using TE as predictor variables on the second step and find that efficiency scores are useful predictors.

The present study contributes to the sovereign debt literature by proposing a flexible methodology to be used by debt analysts in measuring the effect and probability of sovereign debt defaults and crises. Our proposed empirical strategy is to estimate debt efficiency scores by DEA and evaluate the default risk by employing several probability models. If the

[3] The application of data envelopment analysis (DEA) to study probability of bankruptcy , credit default on firm-level could be found in Premachandra, Bhabra and Sueyoshi (2009), Sueyoshi and Goto (2009), Shetty, Pakkala and Mallikarjunappa (2012), Li, Crook and Andreeva (2014), Paradi, Wilson and Yang (2014), and Mousavi, Ouenniche and Xu (2015).

[4] We restrict our analysis to basic DEA models because the study is a preliminary attempt. Obviously, other efficiency models such as stochastic frontier analysis (SFA), fuzzy DEA, CNLS or StoNED approached are to be experimented in future research.