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MEASURING SOVEREIGN RISK WITH LABOR FORCE AND LABOR PRODUCTIVITY: APPLICATION TO EMERGING MARKETS

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Abstract: In this study, we highlight the importance of labor force and labor productivity as two key determinants of nations' sovereign risks, and in particular for emerging markets. These vibrant macroeconomic factors have received little attention in the literature of sovereign risk. To remedy that, we (1) formalize an intuitive approach for measuring creditworthiness of countries based on the progression of maximum borrowing capacity with several explanatory variables, among them labor force and labor productivity, (2) track the advancement of sovereign debt, and (3) envisage the intersection point of the two pathways as an incident of sovereign default. We motivate our endeavor, provide an extensive review of the relevant literature, develop and justify our sovereign risk universal framework, illustrate our scheme with a contemporary case of sovereign default in Greece, conclude, and suggest further avenues of exploration.

Keywords: Sovereign Risk; Labor Force; Labor Productivity; Borrowing Capacity; Emerging Markets; Sovereign Debt

JEL Classifications: E24, J21, H63, O50

1. INTRODUCTION

In this study, we highlight the importance of labor force and labor productivity as two key determinants of nations' sovereign risks, and in particular for emerging markets. These vibrant macroeconomic factors have received little attention in the literature of sovereign risk. To remedy that, we (1) formalize an intuitive approach for measuring creditworthiness of countries based on the progression of maximum Borrowing Capacity (BC) with several explanatory variables, among them labor force and labor productivity, (2) track the advancement of Sovereign

Debt (SD), and (3) envisage the intersection point of the two pathways as an incident of sovereign default. We shall motivate our endeavor, provide an extensive review of the relevant literature, develop and justify our sovereign risk universal framework, illustrate our scheme with a contemporary case of sovereign default in Greece (a country that was classified as a developed nation, but in light of continuous income declining, downgraded to an emerging market), conclude, and suggest future avenues of exploration.

The challenge of correctly assessing sovereign creditworthiness has become especially important in recent years, not only because some of the largest debt issuers and investors in international capital markets are governments, but also because the respective ratings assigned to countries are often serve as upper bounds to corporate borrowers from the respective nationalities.[1] In addition, accurate measurements of sovereign default risk can occasionally provide vital information towards the expected performance of the corresponding stock markets.[2] Furthermore, the globalization of world economies in the past decades has expanded international investment alternatives into foreign bonds issued in non-traditional currencies and consequently has magnified the importance of truthfully gauging nations' risk of default.[3]

Although the literature stipulates numerous analytical approaches for determining sovereign default risk, as surveyed hereafter, there is a high level of disparity among credit rating agencies when assessing sovereign default risk. The prevalent inconsistency can be attributed both to the wide uncertainty involved in measuring this type of risk as well as to the general disagreement on a comprehensive assessment methodology and the chief explanatory variables. We therefore contribute to the literature of sovereign risk by drawing attention to two key macroeconomic determinants, labor force and labor productivity, that assist in shaping nations' expected operating surplus, and thus significantly influencing countries' maximum BC. These economic elements attain greater importance among emerging markets. To the best of our knowledge, these two vibrant macroeconomic factors have received little recognition in the literature of sovereign risk thus far.

Labor force accounts for the number of people who are employed, and those unemployed individuals who are actively searching for work. It includes all of those people who are available and willing to work, and have recently looked for jobs. Labor productivity measures the hourly output of a country's economy by charting the real Gross Domestic Product (GDP) produced by an hour of labor. It is generally linked to savings and investment in physical capital (tools, equipment, and facilities available for work), new technologies (assembly lines, automation, and computation processes), and human capital (education and specialization in the workforce). Labor productivity is computed by dividing the total output by the total number of labor hours.[4]

In the following sections, we organize our study as follows. We first provide background on the topic by reviewing the relevant literature on sovereign risk. Through the incorporation of the two key macroeconomic variables, labor force and labor productivity, we describe the dynamic relationship between a nation's BC and its SD, motivate our unique selection of explanatory variables, formulate the typical paths of the underlying forces, and identify a sovereign failure point by integrating the two processes of maximum BC and short-term SD. We then illustrate our framework over empirical reports taken from the recent incidents of sovereign debt crises in Greece during 2010 and 2015, conclude, and draw future lines of related research.

2. LITERATURE REVIEW

In this section, we survey the relevant literature, deliberate various concepts for measuring sovereign default risk, and discuss the advantages and the limitations of existing sovereign risk models. In light of the mounting demand for applicable tools that can assess sovereign credit risk, the economic literature has provided over the years an immense volume of studies within this arena. Most of these articles can be classified as broad analyses of sovereign risk determinants, inquiries of sovereign ratings, structural sovereign risk models (many of them leaning on the contingent claims framework), comparative enquiries of sovereign yield spreads across different regions, and various analytical methodologies of sovereign risk.[5] Our present study belongs to the first class of inquiries probing for core sovereign risk determinants.

2.1. Sovereign Risk Determinants

Among the more recent scholars that explore determinants of sovereign risk, Babbel (1995) sets the criteria for sovereign debt insurability, examines numerous international defaults from 1956 to 1994, illustrates a hedging mechanism as an alternative to insuring sovereign-guaranteed debt, and further lists 69 explanatory variables for sovereign debt defaults. Cantor and Packer (1996), however, conduct a regression analysis to measure the relative significance of eight explanatory variables that are repeatedly cited by rating agencies (Moody's Investors Service and Standard & Poor's) as the key determinants of sovereign risk. The authors conclude that these eight well-defined criteria are sufficient to portray a clear vision of a nation risk of default. In particular, the authors state that measures of per-capita income, GDP growth, inflation, fiscal balance, external balance, external debt, economic development, and default history can capture the true essence of sovereign risk.

Min (1998), on the other hand, finds that a broader set of macroeconomic variables including domestic inflation rates, net foreign assets, terms of trade

index, and real exchange rates can also affect sovereign risk. Aizenman and Marion (2004) theoretically demonstrate that in the presence of sovereign risk, political considerations influence external borrowing and international reserve holdings. The authors formulate the relations between these factors and show that a greater likelihood for opportunistic behavior by future policy makers and political corruption reduces the demand for international reserves and at the same time escalates nations' external borrowing.

Among others, Kamin and von Kleist (1999), Geyer, Kossmeier, and Pichler (2004), and Remolona, Scatigna, and Wu (2007) provide robust evidence that sovereign risk is affected by various global determinants. McGuire and Schrijvers (2003) and Uribe and Zue (2006) further detect that worldwide factors transmit external shocks to individual country risk through the respective sovereign ratings. Longstaff, Pan, Pedersen, and Singleton (2007) utilize a large sample of credit default swap (CDS) spreads across 26 developed and emerging markets and empirically discover that this common sovereign risk measure is mostly affected by external forces and not so much by idiosyncratic risk elements. The authors report that sovereign credit spreads are predominantly associated with the U.S. stock and high-yield bond markets, the ad-hoc global risk premia, and the corresponding capital flows. In contrast, the authors testify that nations' CDS spreads are weakly related to their own domestic economic measures. Pan and Singleton (2008) also reveal that the sovereign credit spreads of Mexico, Turkey, and Korea are highly correlated with a measure of the U.S. market volatility (as captured by the Chicago Board Options Exchange (CBOE) Volatility Index (VIX)).

Baldacci, Gupta, and Mati (2008) present a relatively simple theoretical framework to couple both political and fiscal factors as well as their interaction with global financial circumstances to sovereign risk. The authors validate this scheme over a panel of 30 emerging market economies from 1997 to 2007. Hilscher and Nosbusch (2010) focus more on the volatility of terms of trade and discover a statistically and economically significant explanatory power of the volatility of macroeconomic fundamentals. In particular, the authors find that sovereign credit spreads tend to be higher among countries that have recently experienced adverse terms of trade shocks, and vice versa. In addition, this latter study confirms earlier findings in the literature, in which global factors such as VIX and a country's history of default are both highly influential when determining sovereign risk. Segoviano, Caceres, and Guzzo (2010) further analyze debt sustainability and the management of sovereign balance sheet.

Wehinger (2010) provides a broad outlook at sovereign risks, as heightened by financial sector weaknesses and ongoing deleveraging by banking systems worldwide. Estrella and Schich (2011) develop a valuation framework (based on concepts of contingent claims analysis) that examines the interconnections between

the value of sovereign and bank debt, which arise through sovereign guarantees for banks. The authors conclude that when the implicit support for the debt of a cross-section of 100 large European banks is higher, the bank's stand-alone creditworthiness is lower, but the sovereign's credit quality is higher.

Due to somewhat inconsistent findings in prior studies, concerning the most significant determinants of sovereign credit risk, and because we direct the present exploration to construct a universal yet comprehensive framework, we consider that a nation's risk of default relies on a relatively modest set of commonly used macroeconomic measures. However, we also attach labor force and labor productivity as two vital components of sovereign risk. We shall portray the explicit composition of these variables and their assumed trajectories within the next section.

2.2. Sovereign Credit Ratings

A handful of scholars explore how variations in sovereign credit ratings can influence or reflect on countries' risk of default. Cantor and Packer (1995) discuss agency disagreements and consequently public controversy over specific sovereign rating assignments.[6] Larraín, Reisen, and von Maltzan (1997) use both panel data analysis and standard event study methodology and provide empirical evidence that changes in sovereign ratings have a significant impact on international financial markets by affecting private capital inflows into emerging markets. Kräussl (2001) discusses the role of credit rating agencies during the recent financial crisis and argues that sovereign ratings do not add much to the dynamics of emerging market crises.

Hu, Kiesel, and Perraudin (2002) show how to combine inclusive information about sovereign defaults for deriving estimates of sovereign transition matrices. Hu, Kiesel, Perraudin, and Stahl (2002) contrast the informational content of judgmentally determined sovereign ratings produced by a private sector bank and by the rating agency Standard & Poor's, with ratings derived from econometric analysis of sovereign default.

Alexe, Hammer, Kogan, and Lejeune (2003), however, point to multiple weaknesses in common sovereign credit ratings and develop an independent non-recursive country risk rating system. The authors state that country risk ratings published by different agencies (such as Moody's, Standard & Poor's, Fitch, Institutional Investor, Euromoney, or Dun & Bradstreet) lack of transparency, and their real content are habitually unexplained and difficult to interpret. Furthermore, the authors claim that these sovereign ratings are derived by unknown macroeconomic factors, they fail too often, and they are typically biased, since certain credit rating analysts may personally favor specific geographic regions. Moreover, history reveals that rating agencies have been too slow to react to some economic developments, while occasionally these agencies overreact

by excessively downgrading countries, hence triggering further destabilization by themselves.[7] In addition, the rating agencies could suffer from conflicts of interest due to the fact that the evaluated nations pay the ordinary fees for obtaining their own sovereign credit ratings.

Block and Vaaler (2004) examine the hypothesis that political business cycle theory is relevant to private foreign lenders in developing countries. The authors find that credit rating agencies tend to downgrade developing countries sovereign ratings more often in election years, and they do so by approximately one rating notches. The authors also realize that bond spreads are typically higher in the 60 days before an election compared to spreads in the 60 days after an election. In general, agencies and bondholders view elections negatively, increasing the cost of capital to developing countries.

Vaaler, Scharge, and Block (2006) empirically examine whether and how opportunistic and partisan political business cycle considerations explain election-period decisions by credit rating agencies publishing sovereign ratings in developing countries. The authors realize that elections themselves generally prompt rating downgrades, though election-period agency downgrades (upgrades) are more likely with right-wing (left-wing) incumbents. Biglaiser and DeRouen (2007) examine how neoliberal reforms in 16 Latin American countries from 1992 to 2003 impact sovereign credit ratings after controlling for macroeconomic and political determinants. The authors find that, among all neoliberal policies, only trade liberalization positively and consistently affects sovereign bond ratings.

Hill, Brooks, and Faff (2007, 2010) explore agency variation in credit quality assessments by employing sovereign ratings data over 129 countries from 1990 until 2006. The authors realize that disagreements usually confined to either one or two notches on the rating scales. Hill and Faff (2010) assess the relative sovereign credit-market activity of the major agencies from 1990 until 2006 across 101 countries and find that Standard & Poor's tend to be more active, provide more timely rating assessments and offer more new information than either Fitch or Moody's. Gültekin-Karakas, Hisarciklilar, and Öztürk (2011) use random effect ordered probit modeling to criticize the reliability of sovereign ratings. Eijffinger (2012) and Zheng (2012) further question the objectivity of rating agencies when assigning sovereign credit ratings.

Paudyn (2013) examines how credit rating agencies have contributed to the recent European sovereign debt crisis, and how the "austere politics of creditworthiness" convey effects, which seek to censure political discretion through normalizing risk techniques aligned with the self-systemic, and thereby self-regulating, logic of Anglo-American versions of capitalism. Erdem and Varli (2014) use both linear and ordered response analyses and further identify the relevant macroeconomic factors behind the sovereign credit ratings of some global

emerging markets (Brazil, China, India, Indonesia, Mexico, Russia, South Africa, and Turkey) assigned by Standard & Poor's as budget balance scaled by GDP, GDP per capita, several governance indicators, and international reserves scaled by GDP. Fuchs and Gehring (2017) use sovereign ratings from nine different credit agencies to test whether these agencies assign higher ratings to their home countries, as well as to their economically, geopolitically, and culturally aligned countries. Their findings support a positive bias to those related nations.

2.3. Structural Models of Sovereign Risk

Despite the fact that sovereign debt differs remarkably from corporate debt, a distinctive strand of the literature has derived various structural forward-looking models of sovereign default risk. Several studies construct sovereign risk schemes from the stochastic contingent claims approach originally proposed by Merton (1974) for assessing corporate credit risk. Several related articles, including Merton (1977), Kupiec (2002), and Chan-Lau, Jobert, and Kong (2004), identify systemic-type risks within nations' financial sectors. In particular, Gray, Merton, and Bodie (2007) employ a universal contingent claims framework to analyze and manage the financial risks of a national economy while relying on a number of risk transmissions and monetary ties among the corporate sector, the banking industry, the nation's government, and the respective pension system. These economic dependencies essentially degrade the validity of earlier linear models in light of possible multicollinearity.[8]

Other versions of sovereign structural models are further presented by Karmann and Maltritz (2002), Huschens and Karmann (2007), and Jeanneret (2008). Gapen, Gray, Lim, and Xiao (2008) also develop a contemporary contingent claims model, which can be used to measure and analyze sovereign risk stemming from the public sector marked-to-market balance sheet. Leaning on this approach, the latter authors derive a set of key sovereign credit risk indicators that include distance to distress, probability of default, credit yield spreads, and market value of risky foreign currency-denominated debt. Duyvesteyn and Martens (2011), however, empirically test the common contingent claims model of sovereign risk over eight emerging market economies and find that the structural approach does not perform well in practice. Specifically, it underestimates sovereign credit spreads and often assigns a near-zero probability of default in contrast to observed CDS spreads. In addition, this latter study reveals that exchange rate volatility is a main determining factor of a nation's distance to default.

2.4. Sovereign Yield Spreads

A number of empirical studies including Boehmer and Megginson (1990) and Zhang (2003) emphasize the underlying factors affecting individual sovereign

credit spreads. Merrick (1999), Pagès (2000), Dullmann and Windfuhr (2000), and Keswani (2005) apply specified intensity-process models to price worldwide sovereign debt and international Brady bonds. Duffie, Pedersen, and Singleton (2003) utilize an efficient estimation methodology of a likelihood function and theoretically construct a model of the term structure of credit spreads on sovereign bonds that accounts for default, debt restructuring, and changes in perceived risk of future defaults. This model also accommodates different discount factors across various debt maturities. The authors explicitly criticize structural sovereign models, which directly capture the default incentives and solvency of the issuer, but normally do not have recourse to a bankruptcy code in the event of a sovereign default. Pan and Singleton (2008) further examine the time-series properties of default and recovery implicit in the term structures of sovereign CDS spreads. The authors of this latter study conclude that the yield spreads reveal not only the arrival rates of sovereign credit events, but also the conditional loss rates.

2.5. Other Analytical Approaches to Sovereign Risk

In light of the countless challenges to truthfully assessing nations' sovereign risk, as surveyed here, the economic literature also provides numerous attempts to model sovereign risk through other unique frameworks. Celasun, Debrun, and Ostry (2006) propose a fan-chart technique to analyze public debt sustainability, which depicts the magnitude of risks and projections of nations' debt as derived by uncertain economic circumstances and future policies. The authors present a simulation algorithm that can track the likely path of public debt with feasible economic shocks to growth, interest rates, and exchange rates.

Arellano (2007) describes a small open economy and builds a stochastic general equilibrium model that assesses sovereign default risk and its interaction with output, consumption, and foreign debt. In this particular scheme, default likelihoods and interest rates depend upon incentives for repayment of the debt, hence are endogenously determined by the sovereign government. Borri and Verdelhan (2008) use a principal component analysis to demonstrate the mechanisms underlying a nation's risk of default and subsequently stage a general equilibrium model of optimal sovereign borrowing and default.

Durdu, Nunes, and Sapriza (2010) present a theoretical model of sovereign default risk that captures not only interest rates and outstanding debt, but also recent news about future economic fundamentals. The presumption underlying this approach states that news shocks affect equilibrium outcomes since they presumably contain information about the future ability of governments to service their nations' respective debts. The suggested model empirically captures the hump-shaped relationship between sovereign default rates and the precision of news. Contrary to popular methodologies assessing sovereign risk through top-

down analyses, Altman and Rijken (2011) take a novel bottom-up approach to appraise sovereign default risk. Within this unique strategy, the authors focus on the financial condition and profitability of an economy's private sector as a central root of national wealth and evaluate the overall creditworthiness of sovereign nations by aggregating Z-metrics default probabilities for individual companies. Nonetheless, the authors acknowledge excluding from their analysis the financial industry, a vital influential sector within most developed and emerging economies.

More recently, Jiao and Li (2018) propose a hybrid sovereign default Markovian model that combines an accessible part that takes into account the evolution of the sovereign solvency and the impact of critical political events, and an inaccessible part for the idiosyncratic credit risk. The authors further introduce a generalized density framework for the hybrid default time and deduce the compensator process of default.

3. A GENERIC FRAMEWORK TO ASSESS SOVEREIGN RISK

To accentuate the importance of labor force and labor productivity in sovereign risk appraisals, we follow here the general practices of a well-documented and highly intuitive sovereign risk framework, as follows. A country's default risk is often measured by the likelihood that a nation's maximum BC will fall below its short-term SD (or alternatively by the probability that provisional SD will exceed the nation's full BC at some point).[9] This event would ordinarily categorize a country in sovereign default, as it is no longer able to service its immediate hanging obligations. We therefore aim to track the developments of both the BC and the short-term SD, follow their patterns of progression, and assess the chances for a future intersection between their two likely courses.

While SD is typically observable and therefore easier to follow, the pathway of a nation's BC is not that apparent, thus it is customarily appraised by scholars from numerous perceived macroeconomic, social, and geopolitical variables. This approach is taken by Reinhart, Rogoff, and Savastano (2003), who develop a "first broad-brush measure" for the upper boundary of nations' BC based on external debt, a chronological average of Gross National Product (GNP), inflation history, sovereign default and restructuring history, and a consensus of economists and sovereign risk analysts.[10] We aim hereafter to confine a coherent dynamic relationship between the nation's short-term SD and the country's BC. Thus, we shall cluster a set of influential variables that shape the nation's maximum BC, while further embedding the two (vital among emerging markets) macroeconomic measurements of labor force and labor productivity.

While different studies have utilized various variables that may affect sovereign risk measures, we prefer to remain loyal to the most prominent quantifiable factors. For example, the willingness of governments to service their

nations' external debts is evidently a legitimate determinant of sovereign default risk. However, we have decided to exclude this element from our analysis due to the following reasons. First, it is virtually impossible to measure this qualitative factor. Suggested proxy variables may only capture a very limited prospect of this property. This tangible obstacle makes the incentive to pay a nation's debt a highly conjectural ingredient in sovereign risk models. Second, recent years have prompted adequate examples where neighbor countries and other global systems impose political, social, and economic burdens on international borrowers and in fact compel nations to service their outstanding debt or alternatively substitute them for other forms of obligations.[11] These exogenous forces often supersede endogenous incentives to avoid paying international loans.

In general, a nation's maximum BC can be analytically derived by aligning it with the nation's current reserves added to the present value of its projected operating surplus, hence its future operating receipts minus expenditures, discounted at the most recent interest rate charged by international lenders on the respective sovereign bonds.[12] More formally, we can define:

$$BC = Current\ Reserves + \frac{E[Operating\ Receipts - Expenditures]}{(1 + Interest\ \ Rate\ Charged\ on\ the\ Most\ Recent\ Loans)^{T}}, \tag{1}$$

where T denotes the visible time horizon that corresponds to the expected operating surplus.[13] When operating expenditures include a series of sovereign bonds or other international obligations with different maturities, we can estimate with the Macaulay duration, for instance.

When examiners untangle the different modules of BC, nations' current reserves typically include both monetary savings within different currencies and real properties, which often include emergency stockpiles of precious metals like gold, silver, or platinum, and other natural resources like oil, coal, tungsten, nickel, cobalt, or manganese, but can also be territorial assets.[14]

When assessing the expected operating receipts, analysts usually incorporate numerous determinants, including likely changes within the current account balance, which defines the difference between a nation's total export and import of goods services and transfers; a forecast of the global climate, which contains different competitive and contagion effects; the nation's exchange rate regime and its fiscal strategy, which largely comprises future tax collection capabilities; the nation's growth opportunities (both the mean and the variance of the real GDP growth rate are sometimes considered); the nation's assets liquidity, which principally includes access to worldwide capital markets; and other relevant regulatory policies and trade practices.

When projecting the future operating expenditures, credit inspectors often embed several factors, including the nation's debt structure, the general performance of the financial sector, the inflation rate, the overall monetary firmness, the real lending rates, the nation's political efficiency and stability, business bureaucracy measures, various regional and international disputes (including potential military conflicts, though some are truly unforeseen, such as the conflict between Russia and Ukraine in 2022), and the nation's transparency, corruption, and cronyism levels. The assigned weights for the different modules of expected operating receipts and expenditures can vary from one nation to another and should be independently examined.[15]

In addition, we aim hereafter to associate a nation's maximum BC to its constantly varying labor force and continuously changing labor productivity. These two key macroeconomic factors affect the future tax collection (realistically assuming rather stable tax rates over time) and with it the economic strength of nations. Since natural resources are essentially limited, expected operating surplus and therefore BC is largely dictated by these two determining factors of labor force and labor productivity among numerous nations, but in particular across many emerging markets.

According to various publications by the World Bank, many countries around the world are expected to experience significant drops in their respective labor forces and labor productivities.[16] For example, the World Bank forecasts that from 2015 until 2050, countries like Ukraine, Poland, and Hungary will likely suffer near 35% decrease in their respective labor forces (defined as ages 20 to 64), and in addition about 20% decrease in their labor productivities. Over this time, Japan, South Korea, and Spain are believed to face roughly 30% cuts in their corresponding labor forces, and around 20%, 7%, and 8% reductions in their labor productivities, respectively. Italy, Russia, and China are projected to bear between 22% and 28% drops in their labor forces, combined with 7% to 12% falls in their respective labor productivities.[17]

Overall, we attempt to identify those variables that have a particular significant impact on nations' operating surplus, and should therefore receive greater attention. Thus, a nation's Expected Operating Surplus (*EOS*) can be expressed as a function of Labor Force (*LF*), Labor Productivity (*LP*), GDP Growth (*GDPG*), Inflation (*INF*), terms of trade index (both Import Value Index and Export Value Index denoted as *IVI* and *EVI*, respectively), External Balance on Goods and Services scaled by GDP (*EBGS*), and annual percent change in the S&P Global Equity Indices (a comprehensive global determinant, hereafter *SPGEI*). To remain parsimonious and to avoid possible multicollinearity issues, this relationship is therefore estimated through a cross sectional over time regression, as follows:

$$EOS_{\tau} = \alpha + \beta(LF_{\tau-1} \times LP_{\tau-1}) + \gamma GDPG_{\tau-1} + \delta INF_{\tau-1} + \lambda(EVI_{\tau-1} - IVI_{\tau-1}) + \eta EBGS_{\tau-1} + \omega SPGEI_{\tau-1}, \quad (2)$$

under the standard assumptions of this type of linear regressions, where measurements at present time τ and time-lags (τ–1) are specified for the dependent and independent variables. Once the *EOS* is forecasted along a visible time horizon, it is discounted to present time and then added to the current reserves to depict a nation's maximum BC as described in equation (1).

4. EMPIRICAL ANALYSES

We deploy our empirical exploration over two recent events of sovereign debt crisis in Greece from 2010 and 2015 (one may consider these incidents as one continuous predicament).[18] In 2010, Greece announced it might default on its debt, threatening the viability of the Eurozone. To avoid actual sovereign default, the European Union (EU) then loaned Greece enough capital to continue making debt payments. An actual sovereign default episode occurred, however, after the new government of Greece (elected on January 2015) unilaterally halted all negotiations and rejected a second bailout agreement from members of the Eurozone and the IMF (throughout June 2015). Consequently, the European Central Bank (ECB) decided to stop its emergency liquidity assistance to Greek banks, which further caused stock indexes worldwide to tumble, fearing Greece's potential exit from the EU. Since the Greek debt crisis began in 2010, European authorities, the IMF, and other private organizations have loaned Greece nearly 320 billion Euros. From February 2015 until February 2019, Greece has repaid only 41.6 billion Euros out of its sovereign debt. As of February 2019, Greece has 294.7 billion Euros left in sovereign debt with scheduled payments stretching until 2060 (roughly uniformly distributed over the years).

We therefore assemble the necessary data for our analyses from multiple sources, as follows. The World Bank supplies annual records of World Development Indicators from 1960 until 2018. Among them we find *LF* (total), *GDP* (current U.S. Dollars) and *GDPG* (annual percent), *INF* (consumer prices, annual percent), *IVI* and *EVI* (for both, the year 2000 is set as 100), *EBGS* (percent of GDP), and *SPGEI* (annual percent change). This dataset also includes the Current Reserves (total, including gold in current U.S. Dollars) of Greece. The Organization for Economic Co-operation and Development (OECD) provides us more historical records of *LP* (GDP per hour worked in U.S. Dollars) and the Operating Surplus of Greece (in Millions of Euros). To synchronize all observations to be denominated with the same currency we utilize the historical charts of MacroTrends for exchange rates. The databases of CEIC and Trading Economics offer past information on the *SD* (scaled as percent of GDP) of Greece. Various publications by the WSJ

assist us in classifying the years, maturities, amounts, rates, and specific debtholders, including the IMF, the ECB, the European Investment Bank (EIB), Treasury bill holders, Eurozone governments, the European Financial Stability Facility (EFSF), the European Stability Mechanism (ESM), and other private investors.[19]

After combining all of these data sources, we extract the short-term value of the *SD* in Greece before and around the years 2010 and 2015 (our focal points of interest).[20] We present the full data (for clarity we focus on selected years, from 2000 until 2017) of the explanatory variables for the operating surplus throughout **Figures 1 – 8**. To generate a sufficient number of observations for the era preceding these two events of SD crises, for the regression analysis in equation (2) we further deploy a standard interpolation bootstrapping technique hence we artificially increase the frequency of records by converting annual data into semi-annual data (thus generating mid-year pseudo observations).[21] We report the correlation matrix of the relevant variables in **Table 1** and organize the subsequent empirical findings of the regression analysis from equation (2) in **Table 2**. To comprehend the isolated influence of labor force and labor productivity on the expected operating surplus of Greece throughout these years, we run another regression analysis without their interaction term and report the results in **Table 3**.

In **Table 1**, we detect a significant and highly positive correlation of 0.866 between the interaction term of labor force and labor productivity and the expected operating surplus in Greece. As anticipated, this is our first evidence for a robust influence of the two labor-related key macroeconomic factors on the future operating surplus of nations. This association joins already known relationships between operating surplus and GDP growth rate (GDPG), terms of trade index (the gap between Export Value Index (EVI) and Import Value Index (IVI)), and External Balance on Goods and Services scaled by GDP (EBGS).

In **Table 2**, we witness further evidence for the meaningful impact of labor force and labor productivity on the expected operating surplus, and through that on the BC of Greece. The coefficient for the interaction term of labor force and labor productivity is positive and highly significant. At the same time, we refute multicollinearity by examining the Variance Inflation Factors (VIF) along the explanatory variables; they are all well under the known threshold of ten.

In **Table 3**, we reconfirm the profound relationship between the two labor-related macroeconomic factors, labor force and labor productivity, and the expected operating surplus in Greece over the inspected years. We do that by contrasting both the F-values and the adjusted R-squares from **Table 2** and **Table 3**. We realize that without labor force and labor productivity as independent variables, the model significance is sharply reduced (although it remains highly robust with respective F-values dropping from 93.43 to 32.54). However, these

two explanatory variables account for about 20% of the variation in the expected operating surplus of Greece over the examined years (with respective adjusted R-squares reducing from 0.8865 to 0.6895).

We also test a predictive model for expected operating surplus while having lagged labor force observations but without lagged labor productivity records. In this experiment, we obtain F-value of 36.65 and adjusted R-square of 0.7508, where the coefficients of both *INF* and *GDPG* are not statistically significant. This tryout serves as additional confirmation that both labor-related macroeconomic variables, labor force and labor productivity, are essential for achieving optimal forecasting strength towards a nation's expected operating surplus.

Next, we visually display the actual operating surplus and the current reserves of Greece from 2000 until 2017 in **Figures 9 – 10**. We finally present the maximum BC (generated by equation (1) with the expected operating surplus discounted to present time and then added to the current reserves), and the short-term SD of Greece from the end of 1998 until the end of 2016 in **Figure 11**. The two pathways of BC and SD clearly intersect immediately after 2010 and during the middle of 2015 (and henceforth) indicating incidents of sovereign credit default.

Within this framework, we can now make use of two straightforward analytical tools, as follows. We first define Distance to Sovereign Default (DSD) as a percentage ratio, as follows:

$$Distance\,to\,Sovereign\,Default = Max\left\{\frac{Borrowing\,Capacity - Sovereign\,Debt}{Borrowing\,Capacity}, 0\right\}, \tag{3}$$

which displays a controlled scale of the safety distance between the two vital courses of BC and SD. The lower the DSD, the closer a nation is to sovereign default. This is evident by the DSD of Greece reaching absolute zero in early 2011, towards the end of 2014, during the middle of 2014, and henceforth. Accordingly, we present a recent time line of the DSD for Greece in **Figure 12**.

Subsequently, we can also define Probability of Sovereign Default (PSD) as:

$$PSD = 1 - DSD = 1 - Max\left\{\frac{Borrowing\,Capacity - Sovereign\,Debt}{Borrowing\,Capacity}, 0\right\}, \tag{4}$$

which portrays a complementary sovereign risk assessment though in a somewhat more intuitive way, hence over a domain of . This measurement, however, does not add new information beyond the DSD.

5. SUMMARY AND CONCLUSIONS

In this study, we have attempted to draw attention to two dynamic macroeconomic variables, labor force and labor productivity, and demonstrated their importance when weighing sovereign risks of nations, and in particular for emerging markets. We have illuminated the significance of these two labor-related determinants by embedding them as explanatory variables into a generic sovereign risk assessment framework, and by exposing their unique contribution to the model's predictive power over recent cases of sovereign debt crises in Greece during 2010 and 2015. We conclude that both labor force and labor productivity deserve to be key ingredients of sovereign risk models henceforth.

For future lines of research, we recommend that intrigued scholars explore the influence of both labor force and labor productivity over countries other than Greece and along diverse periods in the history (if meticulous data is available). Further examining if differences arise across markets and times, and revealing the underlying reasons for possible discrepancies could also be appealing and benefit various sovereign credit risk models and analysts.

Notes

1. Peter and Grandes (2005) report that in South Africa, for instance, sovereign risk serves as the single most considerable factor of corporate default premia. Cowan, Valenzuela, and Borensztein (2007) associate sovereign credit ratings to private ratings in emerging markets. Canuto, Mohapatra, and Ratha (2011) also elaborate on that.
2. Kaminsky and Schmukler (2002) and Ferreira and Gama (2007) detect a robust effect of a country's sovereign rating on its stock market returns. Andrade (2009) provides analytical formulas relating emerging market stock price per earnings (P/E) ratios and expected returns to the respective average yield spread in sovereign bonds. The author corroborates some of the model predictions over data from nine emerging markets listed on J.P. Morgan's EMBI+ index from 1998 to 2007. Jeanneret (2011) further shows that sovereign risk reduces the value of equities, raises financial leverage, and increases equity volatility.
3. A Wall Street Journal (WSJ) article from Dec. 12th, 2011, named "Europe Banks Sit in a Tangled Web," reports that in 2011, European banks sold a total of €178 billion worth of credit default swaps on sovereign bonds issued by Greece, Ireland, Italy, Spain, and Portugal. Cantor and Packer (1995) also discuss this globalization perspective.
4. Other measurements such as labor mobility and labor diversity may improve the predictive strength of a nation's BC, but embedding these additional variables creates undesirable econometric problems such as multicollinearity and endogeneity. We therefore focus our attention merely towards labor force and labor productivity.
5. The economic literature also includes a large number of theoretical studies that primarily focus on the incentives faced by sovereign debtors to service their outstanding debt. Due to limited space, we have decided to exclude these articles from the current survey.

6. Agency disagreements are rather common. For example, a WSJ article from September 22th, 2017, titled "S&P Downgrades China's Credit Rating," describes a recent credit downgrade to China's sovereign creditworthiness by Standard & Poor's, from AA-minus to A-Plus, thus matching the view of Moody's Investors Services, which lowered China's rating in May of that year, and Fitch Ratings, which did so in 2013.
7. A WSJ article from August 12th, 2011, named "Raters Fail to See Defaults Coming," examines worldwide sovereign failures over 35 years and concludes that both chief credit rating agencies, Standard & Poor's and Moody's, drastically underestimate one-year sovereign default risk in the vast majority of cases.
8. These time-honored linear sovereign default risk models mostly use logistic regressions and discriminant analyses as in Frank and Cline (1971), Feder and Just (1977), Feder, Just, and Ross (1981), and Schmidt (1984).
9. Whenever SD is measured as a percentage of GDP, then BC should be scaled accordingly.
10. In their study, the authors intermittently use the synonyms "safe debt threshold" and "debt intolerance" for a nation's BC and further explain that "*understanding and measuring debt intolerance is fundamental to assess the problems of debt sustainability, debt restructuring, capital market integration, and the scope for international lending to ameliorate crises*."
11. In September 2011, the Italian parliament passed a €54 billion austerity package after it spent months trying to appease European regulators. In November 2012, Greek authorities accepted a new €13.5 billion austerity bill (by raising the retirement age to age 67 while previously raised from 60 to 65 in 2010, slashing various benefits, scrapping some pension funds, and further cutting the minimum wage) to secure much needed aid from the European troika.
12. Throughout their publications, the Network of Associations of Local Authorities of South-East Europe (NALAS) endorses this intuitive approach.
13. When financing arrangements comprise a grace period, a temporary operating deficit is permitted. However, a permanent structural deficit is prohibited, since the ergodic properties of this scenario clearly lead to insolvency.
14. During the recent global financial crisis, to pay its immense Euro-debt, Greece attempted to liquidate some of its 6,000 islands off its coast, many of which are uninhabited.
15. The Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce provides further specifications on how to estimate the nation's current receipts and expenditures as well as historic figures of these measurements.
16. The World Bank states that global labor participation rate has been on a steady decline since 1990 although women entered the labor force in large numbers between 1960 and 2000.
17. These common views are further supported by other worldwide organizations and reported on websites such as www.oecd.org, www.McKinsey.com, www.Forbes.com, and www.worldpopulationreview.com.

18. Morgan Stanley Capital International (MSCI) index reclassified Greece from a developed market to an emerging market in 2013. There are other contemporary sovereign default instances around the globe, but we are able to demonstrate our present framework over Greece mainly because of the available and inclusive data on it.
19. The WSJ provides an informative timeline for Greece's debt on https://graphics.wsj.com/greece-debt-timeline.
20. We arbitrarily deem the short-term value of debt as one third of the entire SD still hanging, as the term "short-term" in the contexts of sovereign debt and borrowing capacity is essentially undefined. For robustness, we also use other classifications of short-term SD, yet the results are not materially different from those reported hereafter.
21. This procedure is not mandatory for our analyses, though we think that it reassures our empirical findings.

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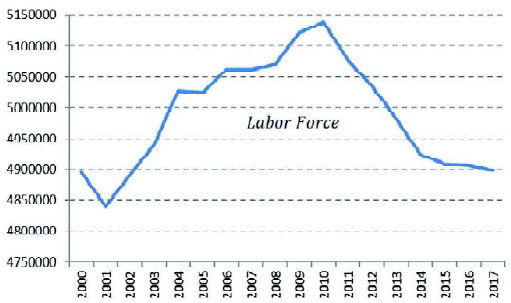
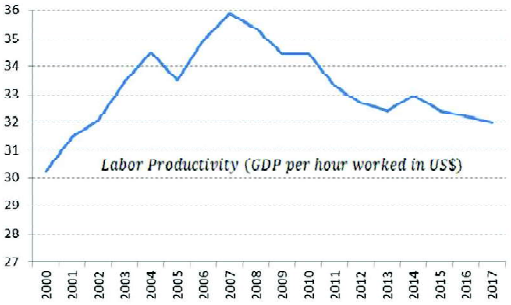
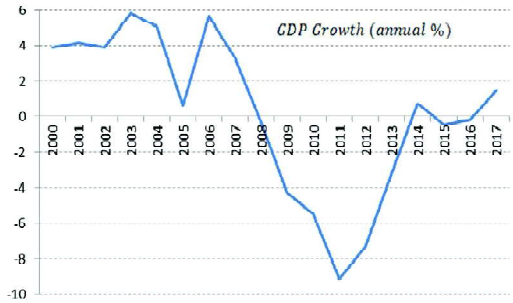
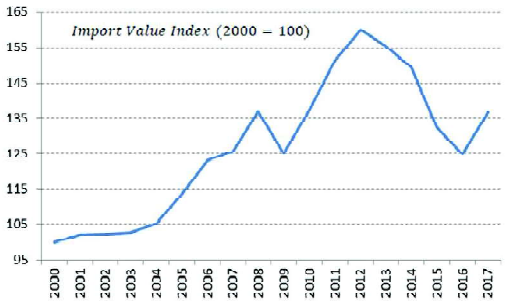
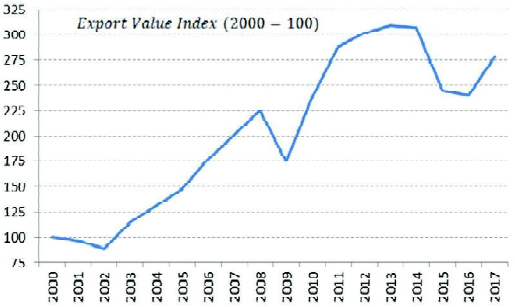
Figures 1 – 8
Explanatory Variables for Expected Operating Surplus of Greece 2000 – 2017

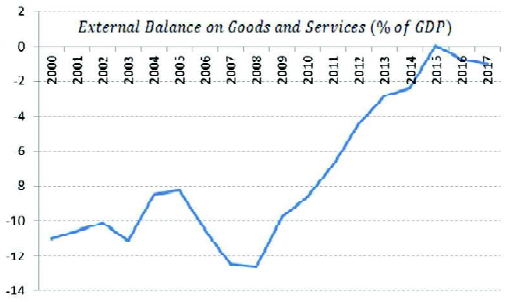


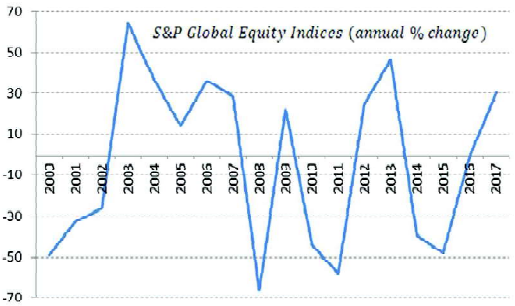












Figures 9 – 10

Actual Operating Surplus and Current Reserves in Greece

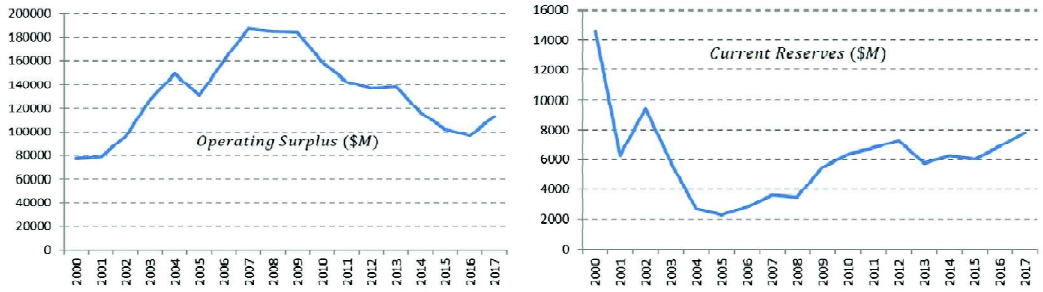


Figure 11

Computations of Borrowing Capacity and Short-Term Sovereign Debt for Greece

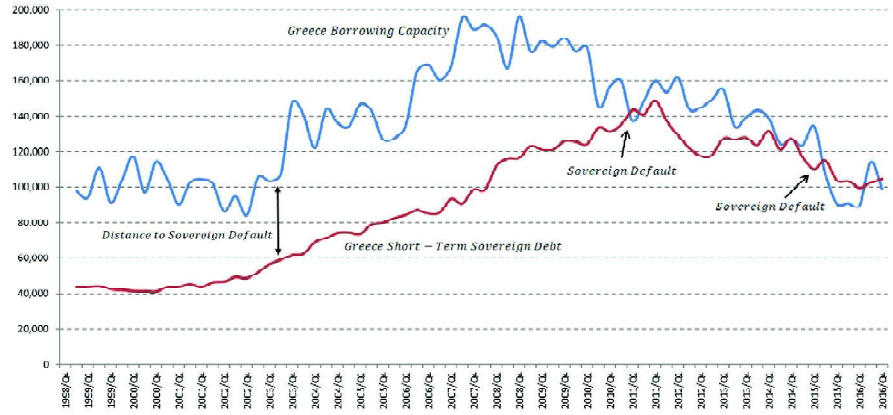


Figure 12

Distance to Sovereign Default in Greece

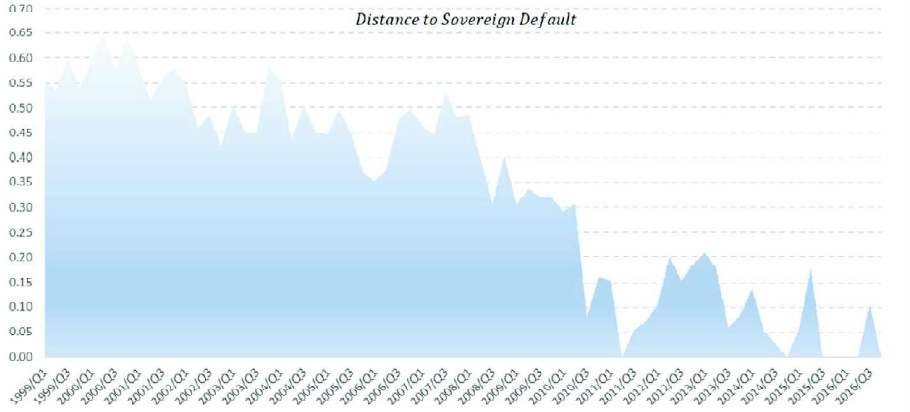


Table 1: Correlation Matrix for the Variables Shaping the Expected Operating Surplus

	EOS_{τ}	$(LF_{\tau-1} \times LP_{\tau-1})$	$GDPG_{\tau-1}$	$INF_{\tau-1}$	$(EVI_{\tau-1} - IVI_{\tau-1})$	$EBGS_{\tau-1}$	$SPGEI_{\tau-1}$
EOS_{τ}	1						
$(LF_{\tau-1} \times LP_{\tau-1})$	0.866 ***	1					
$GDPG_{\tau-1}$	-0.293 **	-0.214 *	1				
$INF_{\tau-1}$	0.157	0.063	0.249 **	1			
$(EVI_{\tau-1} - IVI_{\tau-1})$	0.357 ***	0.349 ***	-0.737 ***	-0.654 ***	1		
$EBGS_{\tau-1}$	-0.285 **	-0.164	-0.444 ***	-0.875 ***	0.691 ***	1	
$SPGEI_{\tau-1}$	0.029	-0.079	0.358 ***	0.140	-0.282 **	-0.151	1

The table presents the Pearson correlation coefficients between all pairs of independent and dependent variables in our regression analyses. Measurements at present time and time-lags are specified.

Table 2: Regression Analysis Results for Expected Operating Surplus with LF and LP

Explanatory Variables	*Coefficients (Significance Level)*	*Standard Error*	*t-Value*	*Variance Inflation Factor*
Intercept	-184,683 (***)	18,557	-9.95	0
$(LF_{\tau-1} \times LP_{\tau-1})$	1,512.176 (***)	140.673	10.75	1.836 < 10
$GDPG_{\tau-1}$	-1,538.602 (**)	621.641	-2.48	3.560 < 10
$INF_{\tau-1}$	-4,313.935 (**)	1,978.678	-2.18	6.454 < 10
$(EVI_{\tau-1} - IVI_{\tau-1})$	269.307 (***)	63.819	4.22	6.640 < 10
$EBGS_{\tau-1}$	-7,382.503 (***)	1,046.941	-7.05	6.875 < 10
$SPGEI_{\tau-1}$	168.458 (***)	39.695	4.24	1.171 < 10
Number of Observations: 72				
F-Value: 93.43 (***)				
Adjusted R-Square: 0.8865				

The table presents the empirical findings in Greece from the cross sectional over time regression analysis:

$EOS_{\tau} = \alpha + \beta(LF_{\tau-1} \times LP_{\tau-1}) + \gamma GDPG_{\tau-1} + \delta INF_{\tau-1} + \lambda(EVI_{\tau-1} - IVI_{\tau-1}) + \eta EBGS_{\tau-1}) + \omega SPGEI_{\tau-1})$, where Expected Operating Surplus (EOS) is expressed as a function of Labor Force (LF), Labor Productivity (LP), GDP Growth (GDPG), Inflation (INF), terms of trade index (both Import Value Index and Export Value Index denoted as IVI and EVI, respectively), External Balance on Goods and Services scaled by GDP (EBGS), and annual percent change in the S&P Global Equity Indices (a comprehensive global determinant, SPGEI). Measurements at present time ? and time-lags (τ-1) are specified for the dependent and independent variables, and

***, **, and * indicate statistical significance of 0.01, 0.05, and 0.10 level or better, respectively. Validation of the standard Normality assumption for the error terms is deployed along the following histogram (and by inspecting the p-values of the respective Shapiro-Wilk, Kolmogorov-Smirnov, Cramer-von Mises, and Anderson-Darling statistical tests):

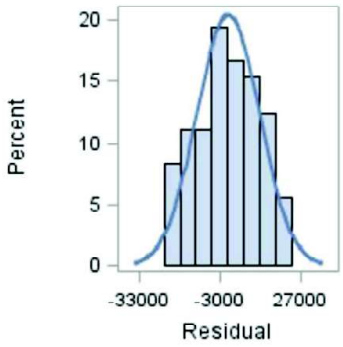


Table 3: Regression Analysis Results for Expected Operating Surplus without LF and LP

Explanatory Variables	*Coefficients (Significance Level)*	*Standard Error*	*t-Value*	*Variance Inflation Factor*
Intercept	50.918	11,582	0.00	0
$GDPG_{\tau-1}$	-579.369	1,017.534	-0.57	3.486 < 10
$INF_{\tau-1}$	-4,310.579	3,272.697	-1.32	6.454 < 10
$(EVI_{\tau-1}–IVI_{\tau-1})$	651.178 (***)	87.691	7.43	4.583 < 10
$EBGS_{\tau-1}$	-12,051.000 (***)	1,575.589	-7.65	5.692 < 10
$SPGEI_{\tau-1}$	182.416 (***)	65.619	2.78	1.170 < 10
Number of Observations: 72				
F-Value: 32.54 (***)				
Adjusted R-Square: 0.6895				

The table presents the empirical findings in Greece from the cross sectional over time regression analysis:

$EOS\tau = \alpha + \gamma GDPG_{\tau-1} + \delta INF_{\tau-1} + \lambda(EVI_{\tau-1} - IVI_{\tau-1}) + \eta EBGS_{\tau-1} + \omega SPGEI_{\tau-1}$, where Expected Operating Surplus (EOS) is expressed as a function of GDP Growth (GDPG), Inflation (INF), terms of trade index (both Import Value Index and Export Value Index denoted as IVI and EVI, respectively), External Balance on Goods and Services scaled by GDP (EBGS), and annual percent change in the S&P Global Equity Indices (a comprehensive global determinant, SPGEI). Measurements at present time τ and time-lags (τ-1) are specified for the dependent and independent

variables, and ***, **, and * indicate statistical significance of 0.01, 0.05, and 0.10 level or better, respectively. Validation of the standard Normality assumption for the error terms is executed over the following histogram (and by inspecting the p-values of the respective Shapiro-Wilk, Kolmogorov-Smirnov, Cramer-von Mises, and Anderson-Darling statistical tests):