The Signaling Effects of Sovereign Borrowing*

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Abstract

We provide empirical evidence for the signaling effects of sovereign borrowing on a country's default risk. Using the S&P sovereign rating as a proxy for default risk, we find significant state-contingent effects of sovereign debt growth on the country's rating, with the state being the country's recent fiscal performance measured by its government operating balance. Conditional on a good fiscal state, higher sovereign debt growth significantly improves the sovereign rating, indicating a positive signaling effect of sovereign borrowing that more than compensates for its direct effect of increasing a country's debt burden. Conditional on a poor fiscal state, higher debt growth significantly reduces the sovereign rating, even after the lagged rating, current government operating balance, sovereign bond yield, and other common determinants of sovereign rating are controlled for, which suggests a negative signaling effect of sovereign borrowing. We also provide a two-period model to rationalize these findings.

Keywords: sovereign borrowing, signaling, sovereign rating

JEL classifications: F34, G24, C23.

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1 Introduction

Can sovereign borrowing be informative about a country's default risk? This paper provides empirical evidence using the S&P sovereign rating as the proxy for default risk and a quarterly panel covering 21 advanced economies from 2000q2 to 2020q3. A higher sovereign debt growth rate is found to improve a country's sovereign rating if its government has good fiscal performance measured by its recent government operating balance. Conversely, if a country's government has poor fiscal performance, higher debt growth is found to decrease the sovereign rating even after relevant economic fundamentals are controlled for.

The literature has provided ample empirical evidence for the signaling effect of sovereign default on a country's default risk. A history of default (or the lack of one) is shown to be an important determinant of a country's sovereign rating and sovereign bond spread and helps predict future sovereign default.[1]

However, very limited empirical research has been done on the signaling effect of sovereign borrowing; this effect is challenging to identify for the following reasons. First, sovereign borrowing has a direct effect on a country's default risk; namely, more borrowing today implies a higher debt burden to be serviced in the future and therefore increases default risk. Separately identifying the signaling effect and this direct effect of sovereign borrowing requires controlling for the latter.

Second, unlike sovereign default, which always acts as a negative signal and increases default risk, sovereign borrowing may be associated with either a positive or a negative signaling effect. The sign of the signaling effect could be state contingent. It is thus crucial to identify the right contingent state to avoid pooling the positive signaling effect with the negative one and arriving at a spurious insignificant result.

Third, choosing a proper proxy for a country's default risk is important for identifying the signaling effect of sovereign borrowing. An ideal proxy should be sensitive to information about default risk that may not be captured by other observable factors. It should also be relatively free from default-risk-irrelevant factors that are hard to measure or control for.

We address these challenges by means of a set of innovations. First, we choose

[1]For examples: Reinhart et al. (2003), Dell'Ariccia et al. (2006), Borensztein and Panizza (2009), D'Erasmo (2011), Qian et al. (2011), Cruces and Trebesch (2013).

the sovereign credit rating as the proxy for a country's default risk. According to the rating methodology of the credit rating agencies, the sovereign rating reflects not only a sovereign government's ability but also its willingness to service its debt.[2] Relative to a country's short-term capacity for timely debt service, this willingness to repay debt affects a country's default risk in the longer term and is more sensitive to the signaling effects of sovereign borrowing.

Second, we identify a key economic state – a country's lagged government operating balance – that can differentiate the positive and negative signaling effects of sovereign borrowing. In particular, we interact a country's sovereign debt growth with its fiscal state, which can be good, normal, or poor, depending on whether the country's lagged government operating balance is above, within, or below one standard deviation around its whole-sample mean. These interaction terms allow us to identify a positive signaling effect of sovereign borrowing conditional on a good fiscal state and a negative signaling effect conditional on a poor fiscal state. Interestingly, no significant signaling effect is found if we do not condition on the fiscal state.

Third, we include the lagged sovereign rating, current government operating balance, and long-term sovereign bond yield in the set of control variables, in addition to other common determinants of sovereign rating identified by the literature and S&P's rating methodology. Having only advanced economies in our sample gives us the luxury of using quarterly data on these control variables and hence of better controlling for other economic channels that may affect the default risk and sovereign rating. As a result, we can more confidently interpret the estimated coefficients for debt growth as the signaling effect. Most notably, the identified signaling effect of higher debt growth under a good fiscal state is to *improve* the sovereign rating, which runs counter to the direct channel of increasing the future debt burden and thus default risk.

Our empirical analysis explicitly accounts for a possible reverse causal effect of sovereign rating on debt growth via the borrowing cost channel. We also use IV regressions to alleviate concerns for other possibly endogenous regressors. To address the potential omitted variable bias, we control for two confounding factors that could move the sovereign rating and sovereign debt growth at the same time and our empirical

[2] Our paper uses sovereign ratings by S&P Global Ratings, the methodology of which can be found at https://www.standardandpoors.com/en_US/web/guest/article/-/view/sourceId/10221157. Similar language is also used in Moody's and Fitch Ratings' sovereign ratings methodology.

results are robust. Therefore, these conditional significant effects of sovereign debt growth on sovereign rating are not a result of reverse causality or omitted variable bias. Furthermore, we show that the conditional signaling effects of debt growth are only weakly present (with the right signs but statistically insignificant) if we instead use the sovereign bond spread as the proxy for a country's default risk, which lends support for using the sovereign rating to capture the information about a country's default risk.

In the last part of the paper, we provide a stylized two-period model to rationalize the conditional signaling effects of debt growth found by our empirical analysis.

1.1 Literature Review

Our paper is related to the sovereign default literature in general and borrowing and default with private information in particular. The canonical model of sovereign default a la Eaton and Gersovitz (1981), Aguiar and Gopinath (2006), and Arellano (2008) predicts that more sovereign borrowing increases a country's default risk. Our empirical finding presents evidence contrary to this prediction, as higher sovereign debt growth is found to improve a country's sovereign rating when its government has good recent fiscal performance. This finding, however, can be viewed as evidence for a signaling effect of sovereign borrowing, where higher debt growth serves as a positive signal to creditors that the country possesses private information that reduces its future default probability. Moreover, such a signaling effect is contingent on good recent fiscal performance. When the government's recent fiscal performance is poor, we instead find a negative signaling effect of sovereign borrowing.

Existing models on sovereign borrowing and default with private information focus mainly on the default decision as the informative signal. Examples include Cole et al. (1995), Cole and Kehoe (1998), Sandleris (2008), D'Erasmo (2011), Egorov and Fabinger (2016), Phan (2017a), and Amador and Phelan (2021), among others. A few exceptions to this formulation are the works of Phan (2017b), in whose model the government can borrow to signal a favorable economic fundamental; Gibert (2016), who models fiscal austerity as signaling a country's creditworthiness in a certain information environment; Fourakis (2021), who considers three government decisions – default, borrowing, and whether to initiate restructuring – to be informative about the government's underlying preferences; and Morelli and Moretti (2022), who argue that default and inflation reports can signal whether the government is committed.

The focus of the theoretical literature on default as the primary signal is perhaps thanks to the ample empirical evidence of the signaling role played by a country's default history (see footnote 1). In contrast, the empirical evidence for the signaling effects of other government decisions is rather thin. Gibert (2016) finds evidence for fiscal austerity as a signal of a country's creditworthiness. Morelli and Moretti (2022) finds that inflation misreports from the Argentinian government are positively correlated with sovereign debt interest rates. Fourakis (2021) constructs an aggregate measure of debt issuance history and shows that it positively correlates with emerging market sovereign bond spreads and has predictive power for future default probability. Our paper contributes to this literature by identifying state-contingent signaling effects of sovereign debt growth on a country's default risk measured by its sovereign rating.

Our paper is also related to the empirical literature on the determinants of sovereign ratings.[3] There are two main strands in this literature in terms of the adopted econometric approach. One, dating back to Cantor and Packer (1996), converts ratings linearly to a numerical scale and applies linear regression methods. The other, dating back to Hu et al. (2002), treats ratings as discrete choices and uses the ordered probit/logit models for estimation. Our paper follows the first strand and uses pooled ordinary least squares (OLS) with fixed effects estimation. We choose this strand mainly to maximize the clarity of our analysis because the generalization of ordered probit to panel data is not straightforward due to the country-specific effect. Moreover, Mora (2006) and Afonso et al. (2011) use both the linear model and the ordered probit model in their estimations; the two models yield similar empirical findings in both papers. Our approach to estimation differs from those in this literature in that we incorporate sovereign debt growth in our regressions. More importantly, we interact debt growth with a fiscal dummy, which allows us to identify its state-contingent effects on the sovereign rating.

[3]Moor et al. (2018) provides a comprehensive overview of the literature on the determinants of sovereign credit ratings.

2 Empirical Specifications

In this study, we examine the signaling effects of sovereign borrowing on countries' default risk. We use sovereign rating as a proxy for creditors' perceived default risk of a country. Relative to alternative proxies, such as sovereign bond spreads or credit default swaps (CDSs), sovereign rating offers two major advantages.

First, S&P's rating methodology states that their "rating criteria incorporate the factors that we believe affect a sovereign government's *willingness* and ability to service its financial obligations to nonofficial (commercial) creditors."[4] This *willingness* to service its debt is what S&P refer to as a "sovereign's debt payment culture" and is a longer-term determinant of a country's default risk than its capacity for timely debt service. If sovereign borrowing does contain information about default risk beyond the government's current repayment capacity, sovereign rating should be an ideal indicator to reflect that. In S&P's methodology, the effects of such willingness are mainly factored in via human judgment. Our empirical investigation quantifies these effects.

Second, sovereign rating mainly captures a country's default risk, and S&P is explicit about the factors that enter its ratings methodology. This helps us to control for other economic channels that may affect default risk in order to identify the signaling effects of sovereign borrowing on sovereign rating. In contrast, asset-price-based proxies vary not only with default risk but also with risk attitude, liquidity, sentiment, speculation, etc.[5] There has been no consensus in the literature on how to measure or control for these additional factors. Hence, even if we find effects of sovereign borrowing on these asset-price-based proxies, it will be much more controversial to attribute these effects to signaling for default risk.

[4]https://www.standardandpoors.com/en_US/web/guest/article/-/view/sourceId/10221157

[5]For example, González-Rozada and Yeyati (2008) emphasize the importance of risk appetite and global liquidity in determining emerging market bond spreads. Borri and Verdelhan (2011) find that emerging sovereign excess returns increase with the correlation between past emerging bond returns and US market returns. Badaoui et al. (2013) shows that liquidity shocks can explain 44.32% of the variation in sovereign CDS spreads and 26.86% of that in sovereign bond spreads. Bocola and Dovis (2019) show that 13% of the change in Italian interest rate spreads during 2008-2012 was driven by self-fulfilling nonfundamental risk.

2.1 Baseline Regression

Our baseline regression model is specified as follows:

$$
\begin{aligned}
\text{(1)} \qquad \text{Rating}_{i,t} =& \lambda \times \text{Rating}_{i,t-1} + \alpha \times d_{i,t} + \sum_{j=P,N,G} \beta_j \times g_{i,t} \times \mathbf{1}^j_{i,t-1} \\
&+ \sum_{j=P,N,G} \theta_j \times \mathbf{1}^j_{i,t-1} + \mathbb{Z}_{i,t}\gamma' + \delta_t + \mu_i + \varepsilon_{i,t}.
\end{aligned}
$$

$\text{Rating}_{i,t}$ is the sovereign rating of country i at the end of period t. $d_{i,t}$ is the period-t debt-to-GDP ratio, and $g_{i,t}$ is the debt growth rate since the last period. $\mathbf{1}^j_{i,t-1}$ is the fiscal state dummy, which equals 1 if the fiscal state is poor ($j = P$), normal ($j = N$), or good ($j = G$) in period $t-1$. $\mathbb{Z}_{it}$ is a set of control variables. δ_t and μ_i are time and country fixed effects, respectively.

One natural concern with respect to our specification is that any significant effect of sovereign debt on the sovereign rating could be a result of reverse causality: what if period-t debt is affected by the period-t rating? A higher sovereign rating may reduce a country's borrowing cost and result in a higher debt growth rate.

Sovereign Rating: We address this concern by choosing the timing of variables to ensure that the period-t debt level or debt growth do not respond to contemporaneous changes in the sovereign rating. In particular, we employ higher frequency (daily) data for the rating and use the rating score issued on the last day of the quarter as the country's period-t sovereign rating. This minimizes the chance of period-t sovereign borrowing being a result of the end-of-period-t rating and maximizes the chance that the end-of-period-t rating incorporates new debt information from the same quarter. We also control for the lagged rating to capture the past information possessed by S&P on the country's default risk.

Sovereign Debt: Our main variable of interest is sovereign debt in terms of its current level and its most recent growth rate. Compared to the debt level, debt growth is more sensitive to a country's period-by-period decisions and hence could provide additional information about its default risk. We interact sovereign debt growth with the country's fiscal state in our regression so that the impact of sovereign debt growth on the rating could vary with the country's fiscal state, which we conjecture to be a crucial factor in its debt choice. We categorize the state as good if the government operating balance in period $t-1$ is one standard deviation above its whole-sample mean, poor if it is one standard deviation below its whole-sample mean, and normal otherwise. Notice that the fiscal state is determined by the lagged government operating balance, so that it is determined prior to the period-t debt growth rather than the outcome of it. The coefficients β_G, β_N, and β_P are thus interpreted as measuring the effect of sovereign debt growth on the rating conditional on good, normal, and poor fiscal states, respectively.

Control for Borrowing Cost: To further address the reverse causality concern, we control for the country's period-t borrowing cost, proxied by its period-t long-term sovereign bond yield, that could be affected by its period-t sovereign rating.[6] Controlling for the long-term sovereign bond yield also serves two additional purposes.

First, there could be information about a country's default risk that is not captured by the observable characteristics of the country. As sovereign bond yields are often used in the literature as a proxy for default risk,[7] including the long-term bond yield as a control variable helps to mitigate concerns over omitted variable bias in our regression.

Second, one may reasonably conjecture that all information about a country's default risk is reflected in its sovereign bond yield, making its sovereign rating an inferior proxy of default risk. By controlling for the sovereign bond yield, we can interpret our estimates as evidence that additional information about default risk is captured by sovereign ratings beyond that captured by the sovereign bond yield. This echoes the earlier mentioned S&P's rating criteria that incorporate factors affecting a sovereign government's *willingness* to service its debt.

Other Control Variables: The rest of the control variables are chosen based on S&P's published rating methodology, which states that a country's fiscal performance, external indebtedness and liquidity, economic growth prospects, and monetary policy effectiveness are all factors contributing to the rating. We proxy these factors with the

[6]We do not use the short-term bond yield because it is the monetary policy instrument in many economies and thus less susceptible to sovereign rating changes. In robustness section, we show our results when replacing the long-term sovereign bond yield with weight-average of long-term and short-term bond yield.

[7]Examples include Boehmer and Megginson (1990), Baek et al. (2005), Eichler and Maltritz (2013), and Gilchrist et al. (2021).

government operating balance, current account balance and fiscal reserve, real GDP growth rate, and inflation rate. In $\mathbb{Z}_{it}$, we also include a European Union (EU) dummy, which equals 1 if country i is in the EU and 0 otherwise.

2.2 IV Regression

To further alleviate the concern that the period-t regressors may be reversely affected by the end-of-period-t sovereign rating, we perform endogeneity tests on all possibly endogenous regressors, including the lagged rating, the debt-to-GDP ratio, the interaction terms of debt growth, and the government operating balance.

It turns out that the debt-to-GDP ratio and the government operating balance reject the exogeneity hypothesis. Our IV regression therefore replaces these period-t regressors with their 5 lags as instruments.

2.3 Potential Omitted Variables

Another concern for interpreting the effects of sovereign debt growth on sovereign rating as causal is the possibility that there are some time-varying omitted factors that affect both the debt growth and the sovereign rating.

To address this concern, we investigate two candidates of such time-varying omitted factors: the change of government, and the country's future growth prospect. In particular, we include each candidate as an additional control variable in both the baseline OLS regression and the IV regression to check whether the effects of sovereign debt growth on sovereign rating survive.

3 Data

We compile a quarterly unbalanced panel data set from various sources, including the International Monetary Fund (IMF), the Bank of International Settlement (BIS), Standard & Poor's (S&P), and the CEIC database. Our sample includes all advanced economies for which the relevant data (on the sovereign rating, debt, fiscal performance, etc.) are available.[8] It covers 21 countries and regions from 2000q2 to 2020q3,

[8] We also obtain data for Germany, Norway, Singapore, and Switzerland but have to exclude them as there is no variation in their rating data. We also exclude Greece due to its data issues exposed by

including Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Hong Kong SAR, Hungary, Ireland, Israel, Italy, Luxembourg, Netherlands, New Zealand, Portugal, Spain, Sweden, the United Kingdom, and the United States.

Hence, our panel features a small N (N=21) and a large T (T=80>N), which is why we adopt the fixed effects rather than the DPD model as our specification.[9]

We focus on advanced economies for two reasons. First, our main interest is on how sovereign debt affects creditors' perceived default risk proxied by the sovereign rating. Hence, the absence of sovereign defaults among our sample countries does not pose a problem as long as there is enough variation in their ratings. Second, advanced economies have data available at higher frequency (quarterly or monthly) and covering longer time spans than that of emerging economies, especially with respect to data on government debt and fiscal performance. This allows us to better control for other factors and identify the effect of sovereign debt on the sovereign rating.

The summary statistics of our data are reported in Table 1. We now describe these data in detail.

3.1 Rating Data

The dependent variable is S&P's Global Sovereign Rating. We obtain the daily rating data and use the end-of-quarter rating as the quarterly measure of a country's default risk as perceived by creditors. S&P's Global Sovereign Rating assigns each country a rating category ranging from class D (default) to class AAA (prime) and often associates the rating category with a rating outlook that takes the values of negative, stable, or positive.

Following the literature, we convert the rating categories to a linear numerical scale from 0 to 20, with 0 corresponding to class D. According to S&P, the rating outlook indicates its view regarding the potential direction of a sovereign rating change over the intermediate term (typically six months to two years).[10] As the rating outlook is changed more frequently than the rating category, we interpret the outlook as capturing positive or negative information about a country's creditworthiness that does not

the 2010 sovereign-debt crisis and the convolutions of events following the crisis.

[9]It is well known that with a large T, DPD suffers from the problem of too many instruments (TMI) due to the need to include the time fixed effect.

[10]www.spglobal.com/ratings/_division-assets/pdfs/guide_to_credit_rating_essentials_digital.pdf

yet warrant a change in category. With such an interpretation, we map the outlook categories {Negative, Stable, Positive} to a numerical scale {-0.5, 0, 0.5} and add it to the category score to obtain the total rating.

Figure 1 plots the time series of sovereign rating scores for all 18 countries in our sample. Note that most changes in scores are of a magnitude less than 1, indicating that most of the variation comes from the rating outlook. The autocorrelations of these rating series average 0.93. This high persistence motivates us to control for the lagged rating in our regression.

3.2 Debt Data

We use two sets of debt measures: the consolidated general government debt for the total amount of sovereign debt, and the four categories of government debt –short-term and long-term debt securities and loans – for the structure of sovereign debt.

3.2.1 Consolidated General Government Debt

We measure the total amount of sovereign debt by the quarterly series of consolidated general government debt from the BIS. Among various debt measures, we employ the gross nominal value of the general government debt stock in local currency at the end of each quarter.[11]

We use the nominal value of government debt so that it is not affected by variations in the market interest rate. This allows us to disentangle the effects of debt on the sovereign rating from the effects of the interest rate. Further, we focus on advanced economies and most of their sovereign debt is denominated in local currency, according to Abbas et al. (2014). The nominal value is in local currency instead of in USD so that exchange rate fluctuations do not affect the debt measure.

We use general government debt that consolidates the debt of central (federal), provincial (state), and local governments. According to the BIS, this consolidated debt measure better captures the actual debt burden of the sovereign government and makes it easier to compare debt sustainability across countries, because: first, the outstanding debt among public subsectors can often be netted out; second, the liabilities of state

[11]According to the BIS, only core debt instruments, including currency and deposits, loans, and debt securities, are considered.

and local government sectors are often guaranteed by the central government.

Last, we use gross government debt instead of net debt, as the latter is the net outcome of debt borrowing and government liquid asset accumulation. We do so not only to focus on the sovereign borrowing decision but also to avoid any controversy in classifying assets as being liquid or not.

Figures 2 and 3 plot two debt measures that are used in our regressions: the debt-to-GDP ratio and the debt growth rate, respectively.[12]

3.2.2 Debt structure

We combine multiple data sources – government finance statistics (GFS) from the European Central Bank, quarterly public sector debt (QPSD) from the World Bank, Hong Kong Monetary Authority, Statistics Canada, Bank of Canada, The Board of Governors of the Federal Reserve System, and Reserve Bank of Australia – to construct the quarterly dataset of the short-term and the long-term government bonds (debt securities) and loans. Figure 4 plot the stock series of the four debt categories.[13]

We classify debt as short-term if its residual maturity is shorter than or equal to 1 year. We use the net incurrence of each debt category (nominal value in local currency) as its flow measure whenever the data is available. When the net incurrence data is missing, we compute the flow measure by taking the difference in the stock of the debt category. We then measure the growth of each debt category using its current flow over the last-quarter total debt stock from BIS.

3.3 Government Operating Balance and Fiscal State

We construct the fiscal state dummy from data on the government operating balance – specifically, the net operating balance (NOB), which is the difference between revenue and spending of the general government.The NOB includes the interest payment on sovereign debt and hence better reflects the overall fiscal performance of the government. Moreover, the NOB excludes revenue and spending of net acquisition of

[12]The debt growth rates in a few countries exhibit some degree of seasonality, but clearly, seasonality does not account for the majority of the variation in debt growth. In our regression, we also include time fixed effects to absorb the potential effects of seasonality.

[13]New Zealand data is not available and some countries have missing data in certain quarters and debt categories.

nonfinancial and financial assets, so it does not necessarily equal the negative of our debt growth measure. For example, a country can run a positive operating balance but increase its debt by acquiring more assets. Similarly, a country can run a negative operating balance but decrease its debt by selling assets.

Our NOB-to-GDP data is mainly from IMF.IFS. Whenever there is missing data for some country, e.g. Israel, HKSAR, New Zealand, and Czech, we use the country's overall balance (OB-to-GDP, also defined as revenue - expense) data from CEIC instead.[14] To avoid the effect of seasonality in defining our fiscal state, we employ the commonly-used Census X-12 filter to obtain the seasonally-adjusted NOB-to-GDP for our regressions.

We then categorize the fiscal state as good if the seasonally-adjusted NOB-to-GDP in period $t-1$ is one standard deviation above its whole-sample mean, poor if it is one standard deviation below its whole-sample mean, and normal otherwise. In our sample, observations of good, normal, and poor fiscal states are roughly distributed in the ratio of 1 : 8 : 1.

Figure 5 plots the NOB-to-GDP (solid blue), together with the two one-standard-deviation lines (dotted blue) that we use to categorize the fiscal state. In the same figure, we also plot the fiscal sustainability gap (solid red) and the two associated one-standard-deviation lines (dotted red). The fiscal sustainability gap is a measure for the sustainability of government debt, constructed by Kose et al. (2022) using annual data of government fiscal balance and nominal output growth. Despite the difference in data frequency and construction, the two series exhibit strong co-movement and there is a big overlap of periods in which the series is above or below the one-standard-deviation lines. This observation lends an economic interpretation of our constructed fiscal state: a good fiscal state indicates that the government debt is highly sustainable; a poor fiscal state indicates the opposite.

3.4 Borrowing Costs

Our long-term government bond yield is from IMF.IFS. For the short-term government bond yield, we use the 3-month Treasury Bill (T-bill) Rate from CEIC whenever it is available. When the T-bill rate is not available, we use the 3-month interbank rate

[14]We also use the overall balance data from CEIC for the U.S. because the U.S. NOB-to-GDP data from IMF.IFS is a smoothed version of the raw data, in contrast with other countries in our sample.

from CEIC instead.

In constructing the weighted average bond yield, we use the shares of the short-term bond and the long-term bond among the total bond stock as the weights to the short-term and the long-term bond yields, respectively.[15]

3.5 Other Control Variables

We obtain quarterly data on the current account balance, and fiscal reserve from IMF.IFS, nominal and real GDP and inflation from CEIC. All level variables are normalized as percentage of nominal GDP. The real GDP growth is calculated on a year-over-year base. The inflation rate is on a quarter-over-quarter base.

4 Main Results

Tables 2 and 3 report the estimation results of our baseline regression and the IV regression. These results suggest that the sovereign ratings of our sample countries contain information about these countries' default risk beyond what is captured by their sovereign bond yields. Moreover, the extra information about default risk is affected by sovereign debt growth, and the information content varies with the country's fiscal state. Namely, when the fiscal state is good, higher debt growth reveals positive information that reduces the perceived default risk and therefore improves the sovereign rating; when the fiscal state is poor, higher debt growth reveals negative information and therefore decreases the sovereign rating. Moreover, digging into the debt structure reveals that the positive information from high debt growth in a good fiscal state is coming from a balanced debt portfolio, whereas the negative information in a poor fiscal state is mainly from high long-term loan growth.

4.1 Baseline Regression

We report the baseline estimation in Column 1 of Table 2. Consistent with the high persistence found in the sovereign rating data, the coefficient estimate for λ on the

[15]For Denmark, Luxembourg, Portugal, HKSAR, and New Zealand, there are missing values for the short-term and long-term bond shares. To maximize sample size, we use the sample mean of the economy's available bond shares as a proxy for the missing values.

lagged rating (0.951) is positive and significant at 1%. The coefficient estimate for the debt level (debt-to-GDP) is insignificant, a result that is attributed to our control for the lagged rating and that will be discussed later. The government operating balance is estimated to have a positive effect on the rating with a significance level of 5%.[16] Not surprisingly, we find the coefficient for the long-term sovereign bond yield to be negative and significant at 1%. An increase in the long-term bond yield by 1 percentage point is associated with a decrease in the country's sovereign rating score by 0.084. This is consistent with our intuition that both the sovereign bond yield and the sovereign rating reflect creditors' perception of country default risk.

We do not find any significant effect for the remaining control variables, including the real GDP growth,[17] the current account balance, the fiscal reserve and inflation.[18]

4.1.1 Significant Conditional Effect of Debt Growth

The estimated coefficient β_G for sovereign debt growth conditional on a good fiscal state turns out to be *positive* and statistically significant at 10%. An increase in the debt growth rate by 1 percentage point in a quarter significantly *improves* the country's contemporaneous sovereign rating score by 0.006 (0.56% of the mean change). This effect size is three-quarters of the positive effect of the government operating balance on sovereign rating.

Notably, this positive effect of debt growth on the sovereign rating sharply contrasts with conventional wisdom in the literature. In a canonical model of sovereign debt and default, higher debt growth means more debt to be serviced in the next period, which could increase the default risk and in turn decrease the sovereign rating. Therefore, one would expect a nonpositive coefficient for debt growth via this canonical channel. However, our empirical result shows that a country's debt growth not only affects its sovereign rating positively when its fiscal state is good but that the effect is statistically

[16]Many papers in the literature have similar findings (e.g., Mulder and Perrelli (2001), Mora (2006), Afonso et al. (2011)).

[17]This is because we control for the long-term government bond yield. Once we remove the long-term yield, the coefficient for the GDP growth turns to significantly positive at 1%.

[18]The literature on sovereign rating determinants has mixed evidence on these variables. For example, Cantor and Packer (1996) find an insignificant coefficient for the current account but a significant coefficient for inflation, while Ferri et al. (1999) and Mora (2006) find an insignificant coefficient for inflation but a significant coefficient for the current account. Afonso et al. (2011) find that the effect of the external reserve is insignificant in the short run but is significant in the long run.

significant and economically sizable.

Recall that we include the long-term government bond yield as a control in the regression. This rules out the possibility that the positive effect of debt growth on sovereign rating is due to the reverse causality via the channel of borrowing cost.

When a country's fiscal state is poor, the estimated coefficient β_P for sovereign debt growth turns out to be *negative* and statistically significant at 10%. An increase in the debt growth rate by 1 percentage point in a quarter significantly *decreases* the country's contemporaneous sovereign rating score by 0.011 (1% of the mean change).

Although this negative effect of debt growth works in the same direction as the canonical channel, the fact that the negative effect remains significant even after we control for the country's current borrowing cost, government operating balance, GDP growth rate, and lagged rating is revealing. If a country borrows only to smooth the effect of shocks to its economy, there should be no extra information about its default risk beyond what would be predicted by its economic fundamentals. Hence, once we control for the economic fundamentals with the set of control variables in our baseline regression, there should be no remaining significant effect of debt growth on a country's default risk and hence its sovereign rating. In fact, this is indeed the case for our estimated coefficient β_N for debt growth conditional on a normal fiscal state.

4.1.2 Informative Role of Debt Growth

We interpret these significant effects of debt growth on the sovereign rating as supporting evidence of the signaling effects of sovereign borrowing. In particular, conditional on a good fiscal state, higher debt growth reveals positive information about the country's default risk by suggesting that either the government is more likely to be a type with a low default risk or the government has private information about better future fundamentals. This positive information reduces the default risk perceived by creditors, resulting in a positive estimated coefficient β_G for the debt growth on the sovereign rating. Conditional on a poor fiscal state, higher debt growth reveals negative information about the country's default risk and hence decreases its sovereign rating. Therefore, the estimated coefficient β_P is significantly negative even after economic fundamentals are controlled for. Conditional on a normal fiscal state, debt growth does not offer an informative signal; therefore, its effect on the sovereign rating is absorbed by the economic fundamentals as control variables.

4.1.3 Insignificant Unconditional Effect

What is the unconditional effect of debt growth on sovereign rating? Column 2 of Table 2 reports the regression results with no interaction of debt growth with the fiscal state. Interestingly, the estimated coefficient for debt growth becomes insignificant despite the remarkable similarity of all the other estimated coefficients to those in Column 1.

To understand this sharp contrast in the estimated effect of debt growth, recall that the good and poor fiscal states have roughly equal numbers of observations – each accounts for 10% of the total observations. The estimated coefficients for debt growth in good and poor fiscal states have opposite signs but are at the same scale. Hence, when these effects are pooled in the estimation of Column 2, they cancel each other out and cause the unconditional effect to be insignificant. This weak unconditional effect highlights the importance of identifying the relevant state to interact debt growth in order to identify its state-contingent effects.

4.1.4 Different Signaling Effects across Debt Instruments

Recall that BIS debt data is consolidated general government debt that includes: currency and deposits, loans, and debt securities (bond). Our debt structure data covers short-term and long-term government loans and debt securities (bond), but not currency and deposits due to data availability issues.[19]

Column 3 of Table 2 reports the regression results of which we replace the debt growth with the growth of the sum of government bonds and loans. Columns 4-7 reports the results of which we interact the fiscal state with the growth of each category of government debt.

Comparing the regression results of the consolidated debt, the sum of bonds and loans, and the four debt categories generates new empirical results. In a good fiscal state, the effect of debt growth is the strongest for the consolidated debt (Column 1), becomes weaker when we strip away currency and deposits (Column 3), and turns insignificant when we narrow down to a single category of debt (Columns 4-7). This suggests that the positive signaling effect of debt growth is not driven by any particular debt category but rather by pooling all debt instruments together. In other words, it

[19] In particular, some countries, e.g., Canada, include the central bank as part of the general government. It will be misleading to count central bank's currency and deposits as government debt.

is the debt growth with a balanced structure that is perceived as a positive signal by the investors in a good fiscal state.

By contrast, in a poor fiscal state, the effect of debt growth is the weakest for the consolidated debt (Column 1), becomes stronger when we strip away currency and deposits (Column 3). When we narrow down to each category of debt, the growth of short-term and long-term government loans both have significantly negative coefficients (Columns 6 and 7), but the effect of long-term government loans is the strongest in terms of magnitude and statistical significance (1%). This suggests that the negative signaling effect in a poor fiscal state is mainly driven by the growth of long-term government loans.[20]

4.2 IV Regression

In our baseline regression, the potentially endogenous regressors include the lagged rating, debt-to-GDP ratio, interaction terms of debt growth, and government operating balance. We rule out the possibility of the lagged rating being an endogenous regressor by adding country fixed effects and performing an AR(1) test on the residuals of all our regressions to confirm the absence of serial correlation in the error term.

The remaining potentially endogenous regressors can be a result of reverse causality. Let y_{it} be the sovereign rating and x_{it} a regressor that could be reversely caused by y_{it} in our regression:

$$\begin{cases} y_{i,t} = \lambda y_{i,t-1} + \alpha x_{i,t} + \delta_t + \mu_i + \epsilon_{i,t} \\ x_{i,t} = \gamma x_{i,t-1} + y_{i,t} + v_{i,t} \text{ (reverse causality)} \end{cases} \tag{2}$$

Replacing $y_{i,t}$ in the second equation with the first equation, we obtain $x_{i,t}$ as a function of $(x_{i,t-1}, y_{i,t-1}, \delta_t, \mu_i, \epsilon_{i,t}, v_{i,t})$, which makes it clear that $x_{i,t}$ is correlated with the error term $\epsilon_{i,t}$ and hence is an endogenous regressor.

Following the literature on the dynamic panel data (DPD) model, we can use the lags of $x_{i,t}$ as its instrumental variables (IVs) because $x_{i,t-s} = f(\cdot, \epsilon_{i,t-s}, v_{i,t-s})$ is correlated with $x_{i,t}$ but not with the period-t error term $\epsilon_{i,t}$, conditional on $\epsilon_{i,t}$ not being serially correlated. We then preform Durbin–Wu–Hausman tests on all possibly en-

[20]This negative signaling is consistent with Perez (2017)'s model where long-term debt is less attractive to safe borrowers, particularly so in times of financial distress.

dogenous regressors to compare the IV estimates, where the potentially endogenous regressors are replaced by their instruments, with the baseline OLS estimates.

The Durbin–Wu–Hausman tests are done in two steps. In the first step, we instrument all possibly endogenous regressors with their lagged terms based on the most conservative assumption that they are all endogenous and then test the exogeneity of each one. The number of lags used as instruments for each regressor is set to 5 based on the model performance in four statistical tests: the underidentification test, overidentification test, weak IV test, and residual AR(1) test. We cannot reject the exogeneity hypothesis for any of the possibly endogenous regressors except for the NOB-to-GDP. In the second step, we treat the NOB-to-GDP as the only definitely endogenous regressor. We instrument the NOB-to-GDP and one other possibly endogenous regressor with their lagged terms and test whether we can reject the exogeneity hypothesis for the regressor in question. The number of lags used as instruments in each test varies with the possibly endogenous regressor in question and is chosen optimally based on the aforementioned four statistical tests. The result reveals that the debt-to-GDP is the only regressor in question for which we reject the null hypothesis of exogeneity.[21]

Based on these results, our IV regressions use 5 lags of the debt-to-GDP and the NOB-to-GDP to instrument their period-t values, respectively.

4.2.1 IV results

Table 3 reports the IV counterparts of the results in Table 2. The results are mainly inline with those of the baseline regressions, with the positive signaling effect strengthened and the negative signaling effect weakened.

Conditional on a good fiscal state, the positive coefficients of the consolidated debt growth and the growth of bond and loan become larger and more significant. A one percentage point increase of the consolidated debt growth (Column 1) improves the sovereign rating by 0.01 (0.74% of the mean change) and is statistically significant at 1%. The positive effect is weaker for the sum of bond and loan (Column 3) but is still statistically significant at 5%. When we narrow down to each category of debt growth, the positive effect becomes insignificant except for the short-term government bonds (Column 4), which is significant only at 10%. The IV results hence confirms that the

[21] We report the detailed results of these tests in the appendix.

positive signaling effect of debt growth in a good fiscal state has to do with a balanced debt portfolio.

Conditional on a poor fiscal state, the negative coefficients of the consolidated debt growth and the growth of bond and loan become insignificant. But the negative coefficients of the short-term and long-term government loans remain significant, with the former being significant at 10% and the latter at 5%. Hence, despite a weakened effect, the IV regression confirms that the negative signaling effect is mainly driven by long-term government loan growth in a poor fiscal state.

5 Alternative Specifications

This section addresses a few questions. First, whether the conditional effects of debt growth on sovereign rating are the results of the omitted variable bias. Second, whether our previous findings are robust to alternative control for borrowing cost, alternative fiscal state categorization, or dropping samples with IMF loans. Third, whether similar signaling effects of debt growth can be found in sovereign bond spread. Fourth, why we do not find the effect of debt-to-GDP on sovereign rating.

5.1 Two Confounding Factors

There could be time-varying factors that affect both sovereign rating and sovereign borrowing at the same time. For example, a change of government may improve the sovereign rating and at the same time, the new government could be more tolerant to sovereign debt than the old government.[22] Another example is the country's future growth prospect. If a country is expected to experience higher growth in the future, its sovereign rating will improve and the government of the country may borrow more even without any change in its borrowing cost. In this subsection, we show that the conditional effects of debt growth on sovereign rating remain significant after controlling for the aforementioned two confounding factors.

[22] We thank a referee for pointing us to this factor.

5.1.1 Change of government

We create a dummy variable to indicate whether a country has experienced a change in its government. In particular, when there was a replacement of the president or the prime minister, we set the country-quarter dummy to be 1 if the replacement is from a different political party, and 0.5 if the replacement is within the same party. In our sample, there are 58 observations taking the value of 1, and 30 observations taking the value of 0.5.

Table 4 reports the results of the baseline OLS regressions and the IV regressions. The estimated coefficients and their significance level are very similar to those reported in Tables 2 and 3. The dummy for government change does have a positive effect on the sovereign rating and the effect is more significant in IV regressions. This shows that a change of government improves sovereign rating but it does not take away the signaling effects of debt growth.

5.1.2 GDP growth rate forecast

We obtain the quarterly GDP forecast data from the Economic Outlook database of OECD. The specific variable we use is "GDP growth forecast by volume", which is the forecast of the quarter-over-quarter real GDP percentage growth (annualized). We then replace the current GDP growth rate in our regressions with the average GDP growth rate forecast of the next 8-quarters. Table 5 reports the results.

Again, the estimated coefficients and their significance levels are similar to those reported in Tables 2 and 3. The GDP forecast has a significantly positive effect (at 10%) on sovereign rating in OLS regressions and the effect remains positive but insignificant in IV regressions.

5.2 More robustness checks

This subsection investigates how robust our empirical results are to variations of the key variables in the regressions.

Alternative control for borrowing cost: In Table 6, we replace the government long-term bond yield with the weighed average bond yield as an alternative control for a country's borrowing cost. The results remain similar to those in Tables 2 and 3.

Alternative categorization of fiscal state: In our baseline OLS and IV regressions, we categorize the fiscal state using one standard deviation above and below the mean of NOB-to-GDP of a country. In this exercise, we vary the bandwidth for what qualifies to be good or poor fiscal states. In Table 7, we report the coefficients of key variables in interest when the bandwidth is 0.9, 0.95, or 1.05 times the standard deviation of NOB-to-GDP of a country. The larger the bandwidth, the more stringent is the qualification for a fiscal state to be good or poor. The most cases, the positive signaling effects of the consolidated debt growth and the growth of bond and loan, and the negative signaling effects of long-term government loan growth remain significant. Moreover, the results show that a more stringent qualification for the fiscal state to be good or poor strengthens both positive and negative signaling effects.

Dropping IMF Loan: Our earlier empirical results find that the long-term government loan growth has a strong negative signaling effect for country's default risk. It is natural to ask whether this is driven completely by countries taking up IMF loans in the time of crisis. To investigate it, we drop all country-quarter samples if the country is holding IMF loans in that quarter and rerun the regressions on the four categories of government debt.[23] The results are reported in Table 8. We continue to find that the growth of long-term government loans has a negative effect on sovereign rating with significance level at 1% when the fiscal state is poor.

5.3 Sovereign Bond Spread as a Dependent Variable

Thus far, we have established signaling effects of sovereign debt growth on a country's default risk in good and poor fiscal states, using a regression with the sovereign rating as the dependent variable. In this subsection, we investigate whether the sovereign bond spread – another popular measure for countries' default risk – is also affected by signaling effects of sovereign debt growth.

We answer this question by replacing the dependent variable in our baseline regression, equation (1), with the one-quarter-ahead sovereign bond spread (in percentage point) – the difference between a country's long-term sovereign bond yield and its

[23]According to IMF, these samples are Hungary (08Q4-10Q4), Ireland (10Q4-13Q4), and Portugal (11Q2-14Q2).

US counterpart,[24] with controls for two lagged terms of the sovereign bond spread.[25] We choose to use the one-quarter-ahead sovereign bond spread to avoid the contemporaneous interaction between the sovereign bond spread and sovereign borrowing as both data are at quarterly frequency. With the sovereign bond spread being one period ahead of all the regressors, our endogeneity test rejects all possibly endogenous regressors. We hence only report the OLS regressions results in Table 9.

The sovereign bond spread is persistent, with the estimated coefficients for the spread lagged one period being positive and those for the spread lagged two periods being negative. Higher debt-to-GDP increases next-quarter sovereign bond spread, whereas higher NOB-to-GDP and real GDP growth reduces next-quarter sovereign bond spread. All these effects are very intuitive.

Turning to the coefficients on debt growth, for both consolidated debt and the sum of bonds and loans, higher debt growth in good fiscal states reduces next-quarter sovereign bond spread whereas higher debt growth in poor fiscal states increases next-quarter sovereign bond spread. This is consistent with the signaling effects on sovereign rating but notice that the coefficients are all insignificant. When we narrow down to the growth of long-term government loans, it has significant positive effect on next-quarter sovereign bond spread in all fiscal states. But this significant positive effect turns insignificant once we drop the samples with IMF loans, indicating that such an effect is mainly driven by countries taking up IMF loans in the time of crisis.

There are two reasons why the signaling effects of sovereign debt growth are much weaker on sovereign bond spread than they are on sovereign rating. First, the sovereign bond spread can be affected by many other factors than a country's default risk (see footnote 5). Second, the sovereign bond spread is obtained at quarterly frequency, in contrast to the sovereign rating that is on a daily frequency. We have no control over the timing or the aggregation method that could differ substantially across countries in their reporting. This adds measurement errors in the data.

The takeaway message is that sovereign bond spread does capture some signaling effects of sovereign debt growth but the effects are a lot weaker than those captured by sovereign rating.

[24] We hence have to drop the US from our country sample in this regression.

[25] We control for two lags of sovereign bond spread so that the residuals are no longer autocorrelated.

5.4 Effect of the Debt Level

We now examine why our estimated coefficient for the debt-to-GDP ratio is insignificant when many studies in the literature have found that a higher debt level significantly reduces the sovereign rating.[26]

5.4.1 Omitting the Lagged Rating

We attribute the insignificant result to our control for the lagged rating, which absorbs the effect of the information content from the debt level on default risk. We include this control in light of the high persistence of the sovereign ratings in our sample – the autocorrelation is as high as 0.93 on average across countries.

Not controlling for the lagged dependent variable that has a strong persistence effect on the current dependent variable subjects the estimation to severe omitted variable bias and could lead to spurious significant results. In fact, Columns 1 and 2 in Table 10 show that once we drop the control for the lagged rating,[27] the effect of the debt level on the rating is estimated to be negative and significant at 1%.[28]

5.4.2 Alternative Measure for Debt-to-GDP

We also would like to rule out the possibility that our debt-to-GDP is a too-aggregate measure of debt since we are using the consolidated debt. To this end, we replace the aggregate debt-to-GDP with bond-to-GDP and/or loan-to-GDP. Columns 3-5 in Table 10 report the results. After controlling for the lagged rating, replacing the debt-to-GDP with bond-to-GDP and/or loan-to-GDP does not make its coefficient significant. Moreover, since the bonds and loans are only part of government debt, neither bond-to-GDP nor loan-to-GDP is a proper control for the current debt level. This introduces noises in the error term and makes the coefficients of the debt growth insignificant.

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[26]According to Table 1 in Moor et al. (2018), a negative effect of debt on ratings was reported almost unanimously in the literature before 2005, but more recent literature offers mixed evidence on whether the effect of debt is significant.

[27]Without a control for the lagged rating, the error in our regression is autocorrelated. To mitigate the problem of autocorrelated error, we adopt the Newey–West estimator with the Bartlett kernel and bandwidth equal to 8 so that the standard errors are autocorrelation robust.

[28]Mulder and Perrelli (2001) obtain similar findings with sovereign ratings for emerging economies. Using a panel vector autoregressive (PVAR) model, Boumparis et al. (2019) find a persistent negative effect of the debt-to-GDP ratio on the sovereign rating, but their panel data feature a small T (T=19).

6 A Simple Two-period Model

In this section, we provide a stylized two-period model to rationalize the conditional signaling effects of debt growth identified in our empirical analysis.

There are two periods. A government receives an endowment in each period to consume with a momentary utility $\ln(\cdot)$. The government can borrow in the first period to smooth consumption. The period-1 endowment X_1 is a random draw from a log-normal distribution with parameters μ and σ and density $f(\cdot)$. The endowment in period 2 is $\overline{X}+\varphi$ where $\varphi \in \{\varphi_H, \varphi_L\}$ and $\varphi_H > \varphi_L$. X_1 and φ are private information of the government. The government having φ_H is the H type and the government having φ_L is the L type.

After receiving the endowment in period 1, the government decides how much debt to borrow, B_2, based on a pricing schedule set by the creditors $q(B_2)$. The consumption level in period 1 is then $X_1 + qB_2$. In period 2, the government defaults the debt with an exogenous probability function: $D(\phi + B_2 - \varphi)$ where

$$D(y) = \begin{cases} 0 & \text{if } y \le \underline{y} \\ (y - \underline{y})/(\overline{y} - \underline{y}) & \text{if } y \in [\underline{y}, \overline{y}] \\ 1 & \text{if } y \ge \overline{y} \end{cases} \tag{3}$$

ϕ is an important parameter to be discussed later. If the government repays its debt, its period-2 consumption is $\overline{X} + \varphi - B_2$. If the government defaults, its period-2 consumption is $\lambda(\overline{X} + \varphi - B_2)$ with $\lambda \in (0, 1)$ as a punishment for default.[29]

The optimization for type i government is

$$\begin{aligned} \max_{B_2} \ln(X_1 + q(B_2)B_2) + & D(\phi + B_2 - \varphi_i) \ln(\lambda(\overline{X} + \varphi_i - B_2)) \\ & + (1 - D(\phi + B_2 - \varphi_i)) \ln(\overline{X} + \varphi_i - B_2) \end{aligned} \tag{4}$$

given the pricing function $q(B_2)$ set by creditors. This optimization yields a type-specific policy function $B_{2,i}(X_1)$.

The creditors do not observe the government type and have a prior that the government if of H type with probability ρ_1. After observing B_2, the creditors update their

[29] The punishment for default is necessary here to prevent the government from seeking to increase the default probability.

belief about government type to ρ_2 using the Bayes' rule

$$\rho_2(B_2) = \frac{\rho_1 \Pr(B_2|H)}{\rho_1 \Pr(B_2|H) + (1-\rho_1)\Pr(B_2|L)} = \frac{\rho_1 f(X_{1,H})}{\rho_1 f(X_{1,H}) + (1-\rho_1) f(X_{1,L})} \tag{5}$$

where $X_{1,H} = B_{2,H}^{-1}(B_2)$ and $X_{1,L} = B_{2,L}^{-1}(B_2)$.

The creditors are competitive and risk-neutral so that they price the defaultable debt according to:

$$q(B_2) = \frac{1 - [\rho_2(B_2)D(\phi + B_2 - \varphi_H) + (1-\rho_2(B_2))D(\phi + B_2 - \varphi_L)]}{1+r} \tag{6}$$

where r is the risk free rate.

The equilibrium of the model is defined by the fixed point between the government borrowing function $B_{2,i}(X_1)$ and the creditors' pricing function $q(B_2)$.

6.1 Conditional Signaling Effects

Our focus is on how the creditors' belief about government type ρ_2 is affected by changes in sovereign borrowing B_2. The government of H type has a lower probability of default than the L type. Therefore, if a higher B_2 increases ρ_2, it is positive signaling. If a higher B_2 decreases ρ_2, it is negative signaling.

In our simple two-period model, whether sovereign borrowing has positive or negative signaling effects depends on the parameter ϕ as in the default probability function $D(\phi + B_2 - \varphi)$. A low value of ϕ is associated with positive signaling effect, whereas a high value of ϕ with negative signaling effect. We interpret the value of ϕ as the fiscal state in our empirical analysis.

To see why it is the case, we first establish a result on the type-dependent borrowing functions. We then explain why the parameter ϕ is relevant.

Proposition 1. *Assume $\overline{X} + \phi > \overline{y}$:*

$$\begin{aligned} B_{2,H}(X_1) > B_{2,L}(X_1) \quad & \text{if } B_{2,H}(X_1) \leq \underline{y} + \varphi_L - \phi \\ B_{2,H}(X_1) < B_{2,L}(X_1) \quad & \text{if } B_{2,H}(X_1) \geq \underline{y} + \varphi_H - \phi \end{aligned}$$

Proof. See the appendix. □

To understand this result, we write down the first order condition of the government optimization problem:

$$\text{(7)} \qquad \frac{1}{X_1 + q(B_2)B_2}\frac{\partial q(B_2)B_2}{\partial B_2} = \frac{1 - D(\phi + B_2 - \varphi_i)}{\overline{X} + \varphi_i - B_2} + D'(\phi + B_2 - \varphi_i)\ln(\frac{1}{\lambda})$$

The left hand side is the marginal benefit of borrowing, which depends on X_1 but not on the government type. we denote it by $MB(X_1)$. The right hand side is the marginal cost of borrowing and is type-dependent. We denote it by $MC(\varphi_i)$. The marginal cost consists of three components: the probability of repaying debt $(1 - D(\phi + B_2 - \varphi_i))$, the cost of repaying debt $(\frac{1}{\overline{X}+\varphi_i - B_2})$, and the marginally-higher probability of bearing the default punishment $(D'(\phi + B_2 - \varphi_i)\ln(1/\lambda))$. The third component is 2nd order relative to the first two components and we construct the model such that it is identical for both types in the cases discussed here.

Intuition: Compared to the L type, the H type has a higher probability, but a lower cost of repaying debt. When $\phi + B_2 - \varphi_i \leq \underline{y}$, both types repay debt for certain so that the H type borrows more than the L type because it is cheaper for the H type to repay the debt. When $\phi + B_2 - \varphi_i \geq \underline{y}$, the probability component dominates the cost component so that the H type borrows less than the L type because it has a higher probability of repaying the debt.

The role of ϕ: The parameter ϕ is critical in determining the cutoffs in Proposition 1. With a sufficiently low ϕ, for most values of X_1, $B_{2,H}(X_1) \leq \underline{y} + \varphi_L - \phi$ so that the H type borrows more than the L type: $B_{2,H}(X_1) > B_{2,L}(X_1)$. With a sufficiently high ϕ, $B_{2,H}(X_1) \geq \underline{y} + \varphi_H - \phi$ for most values of X_1 so that the H type borrows less than the L type: $B_{2,H}(X_1) < B_{2,L}(X_1)$.

Belief updating: Recall that X_1 is also private information to the government. This prevents fully revealing the type after creditors observing B_2. Therefore, the type-dependent borrowing functions $B_{2,i}(X_1)$ need to be coupled with a distribution of X_1 to generate the belief updating rule $\rho_2(B_2)$ according to the Bayes' rule in (5). A bell-shaped log-normal distribution for X_1 together with the properties of type-dependent borrowing function in Proposition 1 will yield the desirable conditional signaling effects.

6.2 A Numerical Example

This subsection provides a numerical example for the conditional signaling effects of sovereign debt growth produced by the two-period model.

Table 11 contains the parameter values. Figure 6 reports the equilibrium functions when we set the key parameter ϕ to a low value of 0.76. The H type borrows more than the L type for all values of X_1 and ρ_2 is increasing in B_2. That is, higher B_2 improves the creditors' belief of the government being the H type. As the H type has a lower probability of default, there is thus a positive signaling effect of debt growth. Also note that a low value of ϕ indicates a lower default probability for both types of government. This can be interpreted as the fiscal state of the government being good. Therefore, the positive signaling of debt growth is conditional on a good fiscal state.

When we set the key parameter ϕ to a high value 5.35, which makes the default probability higher for both types of government, the equilibrium functions are reported in Figure 7. The H type borrows less than the L type for all values of X_1 and ρ_2 is decreasing in B_2. Therefore, there is a negative signaling effect of debt growth conditional on a poor fiscal state.

7 Conclusion

In contrast to the ample empirical evidence on the signaling effects of sovereign default, there is limited evidence on whether sovereign borrowing can be informative about a country's default risk. Our paper fills the gap in the literature by providing direct evidence for the conditional signaling effects of sovereign borrowing on a country's default risk proxied by its S&P sovereign rating.

Using an unbalanced quarterly panel of 21 advanced economies from 2000q2 to 2020q3, we show that a higher sovereign debt growth rate significantly improves a country's sovereign rating if its government has good fiscal performance, as measured by its recent government operating balance. This positive effect stands in sharp contrast to the conventional wisdom in the sovereign debt and default literature, according to which more sovereign borrowing increases a country's debt burden and thus should decrease its sovereign rating. We therefore interpret this finding as evidence of a positive signaling effect of sovereign borrowing. Moreover, this positive signaling effect is conditional on the country's recent fiscal performance being good. If the country's recent fiscal performance is poor, we instead find a negative signaling effect of sovereign borrowing: a higher sovereign debt growth rate significantly decreases a country's sovereign rating, even after the lagged rating, sovereign bond yield, and other relevant economic fundamentals are controlled for.

We hope our empirical findings on the conditional signaling effects of sovereign borrowing will stimulate more theoretical research on when and how sovereign borrowing could be informative about a country's default risk.

References

Abbas, SM Ali, Laura Blattner, Mark De Broeck, Asmaa El-Ganainy, and Malin Hu, "Sovereign Debt Composition in Advanced Economies: A Historical Perspective," *IMF Working Papers*, 2014.

Afonso, António, Pedro Gomes, and Philipp Rother, "Short-and long-run determinants of sovereign debt credit ratings," *International Journal of Finance & Economics*, 2011, *16* (1), 1–15.

Aguiar, Mark and Gita Gopinath, "Defaultable debt, interest rates and the current account," *Journal of international Economics*, 2006, *69* (1), 64–83.

Amador, Manuel and Christopher Phelan, "Reputation and sovereign default," *Econometrica*, 2021, *89* (4), 1979–2010.

Arellano, Cristina, "Default risk and income fluctuations in emerging economies," *American economic review*, 2008, *98* (3), 690–712.

Badaoui, Saad, Lara Cathcart, and Lina El-Jahel, "Do sovereign credit default swaps represent a clean measure of sovereign default risk? A factor model approach," *Journal of Banking & Finance*, 2013, *37* (7), 2392–2407.

Baek, In-Mee, Arindam Bandopadhyaya, and Chan Du, "Determinants of market-assessed sovereign risk: Economic fundamentals or market risk appetite?," *Journal of International Money and Finance*, 2005, *24* (4), 533–548.

Bocola, Luigi and Alessandro Dovis, "Self-fulfilling debt crises: A quantitative analysis," *American Economic Review*, 2019, *109* (12), 4343–77.

Boehmer, Ekkehart and William L Megginson, "Determinants of secondary market prices for developing country syndicated loans," *The Journal of Finance*, 1990, *45* (5), 1517–1540.

Borensztein, Eduardo and Ugo Panizza, "The costs of sovereign default," *IMF Staff Papers*, 2009, *56* (4), 683–741.

Borri, Nicola and A Verdelhan, "Sovereign Risk Premia," 2011.

Boumparis, Periklis, Costas Milas, and Theodore Panagiotidis, "Non-performing loans and sovereign credit ratings," *International Review of Financial Analysis*, 2019, *64*, 301–314.

Cantor, Richard and Frank Packer, "Determinants and impact of sovereign credit rating," *Economic Policy Review*, 1996.

Cole, Harold L and Patrick J Kehoe, "Models of sovereign debt: Partial versus general reputations," *International Economic Review*, 1998, pp. 55–70.

_ , James Dow, and William B English, "Default, settlement, and signalling: Lending resumption in a reputational model of sovereign debt," *International Economic Review*, 1995, pp. 365–385.

Cruces, Juan J and Christoph Trebesch, "Sovereign defaults: The price of haircuts," *American economic Journal: macroeconomics*, 2013, *5* (3), 85–117.

Dell'Ariccia, Giovanni, Isabel Schnabel, and Jeromin Zettelmeyer, "How do official bailouts affect the risk of investing in emerging markets?," *Journal of Money, credit and Banking*, 2006, pp. 1689–1714.

D'Erasmo, Pablo, "Government reputation and debt repayment in emerging economies," 2011.

Eaton, Jonathan and Mark Gersovitz, "Debt with potential repudiation: Theoretical and empirical analysis," *The Review of Economic Studies*, 1981, *48* (2), 289–309.

Egorov, Konstantin and Michal Fabinger, "Reputational Effects in Sovereign Default," *SSRN Electronic Journal*, 2016.

Eichler, Stefan and Dominik Maltritz, "The term structure of sovereign default risk in EMU member countries and its determinants," *Journal of Banking & Finance*, 2013, *37* (6), 1810–1816.

Ferri, Giovanni, L-G Liu, and Joseph E Stiglitz, "The procyclical role of rating agencies: Evidence from the East Asian crisis," *Economic notes*, 1999, *28* (3), 335–355.

Fourakis, Stelios, "Sovereign Default and Government Reputation," 2021.

Gibert, Anna, "The signaling role of fiscal austerity," 2016.

Gilchrist, Simon, Bin Wei, Vivian Yue, and Egon Zakrajšek, "Sovereign Risk and Financial Risk," *NBER Working Papers w29501*, 2021.

González-Rozada, Martín and Eduardo Levy Yeyati, "Global factors and emerging market spreads," *The Economic Journal*, 2008, *118* (533), 1917–1936.

Hu, Yen-Ting, Rudiger Kiesel, and William Perraudin, "The estimation of transition matrices for sovereign credit ratings," *Journal of Banking & Finance*, 2002, *26* (7), 1383–1406.

Kose, M. Ayhan, Sergio Kurlat, Franziska Ohnsorge, and Naotaka Sugawara, "A cross-country database of fiscal space," *Journal of International Money and Finance*, 2022, *128*, 102682.

Moor, Lieven De, Prabesh Luitel, Piet Sercu, and Rosanne Vanpée, "Subjectivity in sovereign credit ratings," *Journal of Banking & Finance*, mar 2018, *88*, 366–392.

Mora, Nada, "Sovereign credit ratings: Guilty beyond reasonable doubt?," *Journal of Banking & Finance*, 2006, *30* (7), 2041–2062.

Morelli, Juan Martín and Matías Moretti, "Information Frictions, Reputation, and Sovereign Spreads," 2022.

Mulder, Christian B. and Roberto Perrelli, "Foreign Currency Credit Ratings for Emerging Market Economies," *IMF Working Papers*, 2001, *01* (191), 1.

Perez, Diego J., "Sovereign debt maturity structure under asymmetric information," *Journal of International Economics*, 2017, *108*, 243–259.

Phan, Toan, "A model of sovereign debt with private information," *Journal of Economic Dynamics and Control*, 2017, *83*, 1–17.

_ , "Sovereign debt signals," *Journal of International Economics*, 2017, *104*, 157–165.

Qian, Rong, Carmen M Reinhart, and Kenneth Rogoff, "On graduation from default, inflation, and banking crises: elusive or illusion?," *NBER Macroeconomics Annual*, 2011, *25* (1), 1–36.

Reinhart, Carmen M, Kenneth S Rogoff, and Miguel A Savastano, "Debt intolerance," *Brookings Papers on Economic Activity*, 2003, (1), 1–75.

Sandleris, Guido, "Sovereign defaults: Information, investment and credit," *Journal of International Economics*, 2008, *76* (2), 267–275.

Table 1: Summary Statistics

Variable	Obs.	Mean	S.D.	Min	Max	Auto Corr
Rating	1,535	17.978	1.156	8.500	20.000	0.930
Debt	1,535	61.356	13.461	6.800	149.300	0.976
Debt Growth (quarterly p.p.)	1,535	1.711	3.910	−15.334	76.995	0.116
Good Fiscal State Dummy	1,535	0.107	0.289	0.000	1.000	0.402
Normal Fiscal State Dummy	1,535	0.794	0.388	0.000	1.000	0.362
Poor Fiscal State Dummy	1,535	0.099	0.286	0.000	1.000	0.330
Gov. Operating Balance	1,535	−1.498	3.203	−43.495	21.053	0.599
GDP Growth (annualized p.p.)	1,535	2.014	2.734	−21.568	29.093	0.778
Current Account Balance	1,535	−0.566	2.696	−31.859	32.499	0.759
Fiscal Reserve	1,535	12.665	3.947	0.317	134.362	0.934
Inflation (quarterly p.p.)	1,535	0.476	0.644	−3.025	3.803	0.069
LT Yield (annualized p.p.)	1,535	3.618	1.656	−0.480	13.223	0.974

[*] Debt, Government Operating Balance, Current Account Balance, and Fiscal Reserve are all normalized by the nominal GDP level of the same period and presented in percentage points.

Table 2: Main Regression Results: OLS

OLS	BIS	BIS	Bond+Loan	ST Bond	LT Bond	ST Loan	LT Loan
L(rating)	0.951***	0.951***	0.949***	0.950***			
	(0.008)	(0.008)	(0.008)	(0.008)			
Debt	−0.000	0.000	0.000	-0.0003			
	(0.001)	(0.001)	(0.001)	(0.0009)			
Debt Growth		−0.001					
		(0.001)					
$\mathbf{1}^G \times$Debt Growth	0.006*		0.005*	0.005	0.003	0.023	0.006
	(0.003)		(0.003)	(0.004)	(0.003)	(0.015)	(0.008)
$\mathbf{1}^N \times$Debt Growth	−0.001		−0.001	(0.001)	0.000	−0.005	−0.004
	(0.001)		(0.001)	(0.003)	(0.002)	(0.007)	(0.008)
$\mathbf{1}^P \times$Debt Growth	−0.011*		−0.026*	0.006	−0.008	−0.067*	−0.103***
	(0.007)		(0.015)	(0.032)	(0.014)	(0.040)	(0.038)
Operating Balance	0.008**	0.008**	0.013***	0.0094***			
	(0.004)	(0.004)	(0.004)	(0.003)			
Real GDP Growth	0.004	0.004	0.004	0.004			
	(0.004)	(0.004)	(0.004)	(0.004)			
CA Balance	−0.000	−0.000	0.000	0.001			
	(0.002)	(0.002)	(0.002)	(0.002)			
Fiscal Reserve	−0.000	−0.000	−0.001	-0.001			
	(0.001)	(0.001)	(0.002)	(0.002)			
Inflation	0.005	0.005	0.012	0.012			
	(0.017)	(0.017)	(0.017)	(0.017)			
LT Rate	−0.084***	−0.084***	−0.086***	-0.074***			
	(0.019)	(0.019)	(0.020)	(0.0198)			
Time Fixed Effects	YES	YES	YES	YES			
Country Fixed Effects	YES	YES	YES	YES			
Constant	1.055***	1.025***	1.248***	1.128***			
	(0.184)	(0.183)	(0.208)	(0.204)			
N	1535	1535	1400	1400			
R^2	0.994	0.993	0.994	0.994			
Robust std err in ()	*:p<0.100	**:p<0.050	***: p <0.01				

Notes: Regressions include an EU dummy that is not shown in the table.

Table 3: Main Regression Results: IV

IV	BIS	BIS	Bond+Loan	ST Bond	LT Bond	ST Loan	LT Loan
L(rating)	0.953***	0.953***	0.950***	0.949***			
	(0.008)	(0.008)	(0.008)	(0.008)			
Debt	0.001	0.001	0.001	0.000			
	(0.001)	(0.001)	(0.001)	(0.001)			
Debt Growth		−0.000					
		(0.001)					
$\mathbf{1}^G$×Debt Growth	0.010***		0.007**	0.010*	0.004	0.033	0.001
	(0.004)		(0.003)	(0.005)	(0.003)	(0.021)	(0.010)
$\mathbf{1}^N$×Debt Growth	−0.000		0.000	0.002	0.000	−0.004	−0.004
	(0.001)		(0.001)	(0.003)	(0.002)	(0.007)	(0.007)
$\mathbf{1}^P$×Debt Growth	−0.008		−0.021	0.011	−0.006	−0.072*	−0.148**
	(0.008)		(0.015)	(0.032)	(0.013)	(0.040)	(0.066)
Operating Balance	0.022***	0.022***	0.014**	0.014**			
	(0.006)	(0.006)	(0.007)	(0.006)			
Real GDP Growth	0.002	0.002	0.004	0.003			
	(0.004)	(0.004)	(0.004)	(0.004)			
CA Balance	0.000	0.000	0.001	0.001			
	(0.002)	(0.002)	(0.003)	(0.003)			
Fiscal Reserve	−0.001	−0.001	−0.002	-0.002			
	(0.001)	(0.001)	(0.002)	(0.002)			
Inflation	−0.005	−0.005	0.006	0.007			
	(0.017)	(0.017)	(0.017)	(0.017)			
LT Rate	−0.084***	−0.084***	−0.085***	-0.071***			
	(0.019)	(0.019)	(0.021)	(0.02)			
Time Fixed Effects	YES	YES	YES	YES			
Country Fixed Effects	YES	YES	YES	YES			
Constant	1.347***	1.329***	1.388***	1.388***			
	(0.197)	(0.198)	(0.215)	(0.211)			
N	1457	1457	1299	1299			
R^2	0.993	0.993	0.994	0.994			
Robust std err in ()	*:p<0.100	**:p<0.050	***: p <0.01				

Notes: Regressions include an EU dummy that is not shown in the table.

Table 4: Controlling for government changes

OLS	BIS	Bond+Loan	ST Bond	LT Bond	ST Loan	LT Loan
L(rating)	0.951***	0.949***	0.9497***			
	(0.008)	(0.008)	(0.0083)			
Debt	−0.000	0.001	-0.0003			
	(0.001)	(0.001)	(0.0009)			
$\mathbf{1}^G \times$Debt Growth	0.006*	0.005*	0.004	0.002	0.022	0.006
	(0.003)	(0.003)	(0.005)	(0.003)	(0.015)	(0.008)
$\mathbf{1}^N \times$Debt Growth	−0.001	−0.001	0.000	0.000	−0.005	−0.004
	(0.002)	(0.001)	(0.003)	(0.002)	(0.007)	(0.008)
$\mathbf{1}^P \times$Debt Growth	−0.012*	−0.026*	0.006	−0.009	−0.069*	−0.104***
	(0.007)	(0.014)	(0.032)	(0.014)	(0.040)	(0.037)
LT Rate	−0.085***	−0.093***	-0.0738***			
	(0.019)	(0.021)	(0.0198)			
Gov Change	0.034	0.046	0.0588*			
	(0.027)	(0.030)	(0.0305)			
IV	**BIS**	**Bond+Loan**	**ST Bond**	**LT Bond**	**ST Loan**	**LT Loan**
L(rating)	0.953***	0.949***	0.9485***			
	(0.008)	(0.009)	(0.0082)			
Debt	0.001	0.001	0.0001			
	(0.001)	(0.001)	(0.0009)			
$\mathbf{1}^G \times$Debt Growth	0.010***	0.007**	0.009*	0.004	0.032	0.001
	(0.004)	(0.003)	(0.005)	(0.003)	(0.021)	(0.010)
$\mathbf{1}^N \times$Debt Growth	−0.000	0.000	0.002	0.001	−0.004	−0.004
	(0.001)	(0.001)	(0.003)	(0.002)	(0.007)	(0.007)
$\mathbf{1}^P \times$Debt Growth	−0.008	−0.022	0.011	−0.007	−0.074*	−0.148**
	(0.008)	(0.015)	(0.032)	(0.013)	(0.039)	(0.066)
LT Rate	−0.084***	−0.092***	-0.0713***			
	(0.020)	(0.022)	(0.0197)			
Gov Change	0.039	0.059**	0.0498*			
	(0.027)	(0.029)	(0.0274)			
Robust std err in ()	*:p<0.100	**: p <0.05	***:p<0.010			

Notes: Regressions include other control variables as in the benchmark regressions.

Table 5: Controlling for GDP forecasts

OLS	BIS	Bond+Loan	ST Bond	LT Bond	ST Loan	LT Loan
L(rating)	0.948***	0.951***	0.9527***			
	(0.009)	(0.008)	(0.0082)			
Debt	−0.000	−0.000	-0.0004			
	(0.001)	(0.001)	(0.0009)			
$\mathbf{1}^G \times$Debt Growth	0.005*	0.005	0.005	0.002	0.023	0.005
	(0.003)	(0.003)	(0.005)	(0.003)	(0.015)	(0.008)
$\mathbf{1}^N \times$Debt Growth	−0.002	−0.000	0.001	0.001	−0.006	−0.005
	(0.002)	(0.001)	(0.003)	(0.002)	(0.007)	(0.008)
$\mathbf{1}^P \times$Debt Growth	−0.019*	−0.026*	0.005	−0.008	−0.069*	−0.102***
	(0.010)	(0.015)	(0.032)	(0.014)	(0.040)	(0.038)
LT Rate	−0.089***	−0.084***	-0.0703***			
	(0.023)	(0.021)	(0.0207)			
GDP forecast	0.010*	0.011*	0.0109*			
	(0.006)	(0.006)	(0.0061)			
IV	**BIS**	**Bond+Loan**	**ST Bond**	**LT Bond**	**ST Loan**	**LT Loan**
L(rating)	0.951***	0.951***	0.9499***			
	(0.008)	(0.008)	(0.0082)			
Debt	0.001	0.000	-0.0000			
	(0.001)	(0.001)	(0.0010)			
$\mathbf{1}^G \times$Debt Growth	0.009***	0.007**	0.010*	0.004	0.033	0.001
	(0.003)	(0.003)	(0.005)	(0.003)	(0.021)	(0.009)
$\mathbf{1}^N \times$Debt Growth	−0.000	0.000	0.003	0.001	−0.004	−0.004
	(0.001)	(0.001)	(0.003)	(0.002)	(0.007)	(0.007)
$\mathbf{1}^P \times$Debt Growth	−0.013	−0.021	0.011	−0.007	−0.073*	−0.148**
	(0.011)	(0.015)	(0.032)	(0.013)	(0.040)	(0.066)
LT Rate	−0.088***	−0.085***	-0.0704***			
	(0.021)	(0.023)	(0.0208)			
GDP forecast	0.005	0.006	0.0065			
	(0.006)	(0.006)	(0.0058)			
Robust std err in ()	*:p<0.100	**: p <0.05	***:p<0.010			

Notes: Regressions include other control variables as in the benchmark regressions.

Table 6: Robustness: control for weighted average sovereign bond yield

OLS	BIS	BIS	Bond+Loan	ST Bond	LT Bond	ST Loan	LT Loan
L(rating)	0.956***	0.956***	0.954***	0.955***			
	(0.008)	(0.008)	(0.008)	(0.008)			
Debt	0.000	0.000	0.000	-0.000			
	(0.001)	(0.001)	(0.001)	(0.001)			
Debt Growth		−0.002					
		(0.001)					
$\mathbf{1}^G \times$Debt Growth	0.006*		0.005	0.005	0.003	0.022	0.005
	(0.003)		(0.003)	(0.005)	(0.003)	(0.016)	(0.008)
$\mathbf{1}^N \times$Debt Growth	−0.001		−0.001	0.000	0.000	−0.004	−0.006
	(0.001)		(0.001)	(0.003)	(0.002)	(0.006)	(0.007)
$\mathbf{1}^P \times$Debt Growth	−0.012*		−0.027*	0.006	−0.008	−0.068*	−0.105***
	(0.007)		(0.015)	(0.032)	(0.014)	(0.041)	(0.038)
Wavg Rate	−0.078***	−0.078***	−0.082***	-0.069***			
	(0.018)	(0.018)	(0.019)	(0.018)			
IV	**BIS**	**BIS**	**Bond+Loan**	**ST Bond**	**LT Bond**	**ST Loan**	**LT Loan**
L(rating)	0.959***	0.959***	0.956***	0.954***			
	(0.008)	(0.008)	(0.008)	(0.008)			
Debt	0.002*	0.002*	0.001	0.000			
	(0.001)	(0.001)	(0.001)	(0.001)			
Debt Growth		−0.000					
		(0.001)					
$\mathbf{1}^G \times$Debt Growth	0.010**		0.006*	0.009*	0.004	0.033	0.000
	(0.004)		(0.003)	(0.006)	(0.003)	(0.022)	(0.010)
$\mathbf{1}^N \times$Debt Growth	−0.000		−0.000	0.002	0.000	−0.002	−0.005
	(0.001)		(0.001)	(0.003)	(0.002)	(0.006)	(0.007)
$\mathbf{1}^P \times$Debt Growth	−0.008		−0.022	0.013	−0.006	−0.074*	−0.155**
	(0.008)		(0.015)	(0.032)	(0.013)	(0.041)	(0.064)
Wavg Rate	−0.076***	−0.076***	−0.078***	-0.065***			
	(0.018)	(0.018)	(0.020)	(0.018)			
Robust std err in ()	*:p<0.100	**:p<0.050	***: p <0.01				

Notes: Regressions include other control variables as in the benchmark regressions.

Table 7: Robustness: alternative way to categorize fiscal state

BIS	OLS: 0.9	OLS: 0.95	OLS: 1.05	IV: 0.9	IV: 0.95	IV: 1.05
L(rating)	0.950***	0.950***	0.951***	0.953***	0.953***	0.953***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Debt	−0.000	−0.000	−0.000	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\mathbf{1}^G\times$Debt Growth	0.002*	0.002**	0.005*	0.002	0.003	0.009**
	(0.001)	(0.001)	(0.003)	(0.002)	(0.002)	(0.004)
$\mathbf{1}^N\times$Debt Growth	−0.001	−0.001	−0.001	0.000	−0.000	0.000
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)
$\mathbf{1}^P\times$Debt Growth	−0.013**	−0.013*	−0.012*	−0.010	−0.009	−0.009
	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.008)
LT Rate	−0.084***	−0.084***	−0.084***	−0.084***	−0.084***	−0.083***
	(0.019)	(0.019)	(0.019)	(0.020)	(0.020)	(0.019)
Bond+Loan	**OLS: 0.9**	**OLS: 0.95**	**OLS: 1.05**	**IV: 0.9**	**IV: 0.95**	**IV: 1.05**
L(rating)	0.949***	0.949***	0.949***	0.950***	0.950***	0.950***
	(0.008)	(0.008)	(0.008)	(0.009)	(0.008)	(0.008)
Debt	0.000	0.000	0.000	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\mathbf{1}^G\times$Debt Growth	0.002*	0.002*	0.003	0.002*	0.002*	0.005*
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
$\mathbf{1}^N\times$Debt Growth	−0.001	−0.001	−0.000	−0.000	−0.000	0.000
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)
$\mathbf{1}^P\times$Debt Growth	−0.024**	−0.026*	−0.035**	−0.020*	−0.021	−0.030*
	(0.012)	(0.013)	(0.015)	(0.012)	(0.014)	(0.017)
LT Rate	−0.086***	−0.087***	−0.086***	−0.085***	−0.085***	−0.084***
	(0.020)	(0.020)	(0.020)	(0.021)	(0.021)	(0.021)
LT Loan	**OLS: 0.9**	**OLS: 0.95**	**OLS: 1.05**	**IV: 0.9**	**IV: 0.95**	**IV: 1.05**
L(rating)	0.950***	0.950***	0.950***	0.949***	0.949***	0.949***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Debt	−0.000	−0.000	−0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\mathbf{1}^G\times$Debt Growth	0.004	0.004	0.001	0.003	0.003	−0.002
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.008)
$\mathbf{1}^N\times$Debt Growth	−0.011	−0.006	−0.004	−0.009	−0.005	−0.004
	(0.009)	(0.010)	(0.008)	(0.009)	(0.009)	(0.007)
$\mathbf{1}^P\times$Debt Growth	−0.081**	−0.098***	−0.107***	−0.093*	−0.133**	−0.160**
	(0.033)	(0.035)	(0.039)	(0.055)	(0.060)	(0.068)
LT Rate	−0.073***	−0.073***	−0.073***	−0.072***	−0.071***	−0.070***
	(0.021)	(0.020)	(0.020)	(0.021)	(0.020)	(0.020)
Robust std err in ()	*:p<0.100	**:p<0.050	***:p<0.01			

Notes: The benchmark regressions categorize fiscal state using one standard deviation around the sample mean of NOB-to-GDP. This robustness exercise varies the bandwidth from 0.9 to 1.05 times the standard deviation. Regressions include other control variables as in the benchmark regressions.

Table 8: Robustness: drop samples with IMF loans

OLS	ST Bond	LT Bond	ST Loan	LT Loan
L(rating)		0.954***		
		(0.008)		
Debt		-0.000		
		(0.001)		
$\mathbf{1}^G \times$Debt Growth	0.004	0.002	0.022	0.006
	(0.004)	(0.003)	(0.015)	(0.008)
$\mathbf{1}^N \times$Debt Growth	0.000	-0.000	-0.000	-0.002
	(0.003)	(0.002)	(0.005)	(0.005)
$\mathbf{1}^P \times$Debt Growth	0.020	-0.003	-0.057	-0.171***
	(0.032)	(0.013)	(0.037)	(0.048)
LT Rate		-0.093***		
		(0.024)		
IV	**ST Bond**	**LT Bond**	**ST Loan**	**LT Loan**
L(rating)		0.951***		
		(0.008)		
Debt		0.000		
		(0.001)		
$\mathbf{1}^G \times$Debt Growth	0.010*	0.004	0.034*	0.005
	(0.005)	(0.003)	(0.020)	(0.010)
$\mathbf{1}^N \times$Debt Growth	0.003	0.001	0.001	-0.002
	(0.003)	(0.002)	(0.005)	(0.005)
$\mathbf{1}^P \times$Debt Growth	0.022	-0.001	-0.065*	-0.212***
	(0.030)	(0.012)	(0.037)	(0.051)
LT Rate		-0.098***		
		(0.024)		
Robust std err in ()	*:p<0.100	**:p<0.050	***: p <0.01	

Notes: We drop the country-quarter sample if the country is having an IMF loan in that quarter. Regressions include other control variables as in the benchmark regressions.

Table 9: Next-quarter Sovereign Bond Spread as Dependent Variable

OLS	BIS	BIS	Bond+Loan	LT Loan	LT Loan (no IMF loan)
Spread	1.282***	1.283***	1.295***	1.262***	1.204***
	(0.056)	(0.056)	(0.062)	(0.059)	(0.061)
L(Spread)	−0.395***	−0.395***	−0.410***	−0.390***	−0.313***
	(0.048)	(0.048)	(0.052)	(0.050)	(0.052)
Debt	0.002**	0.002**	0.002**	0.003**	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Debt Growth		0.000			
		(0.002)			
$\mathbf{1}^G \times$Debt Growth	−0.012		−0.004	0.021**	0.016
	(0.007)		(0.005)	(0.010)	(0.010)
$\mathbf{1}^N \times$Debt Growth	0.000		0.000	0.027*	0.001
	(0.002)		(0.002)	(0.014)	(0.007)
$\mathbf{1}^P \times$Debt Growth	0.006		0.013	0.088***	0.064
	(0.008)		(0.013)	(0.033)	(0.055)
Operating Balance	−0.008*	−0.008*	−0.009*	−0.004	−0.005
	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)
Real GDP Growth	−0.008*	−0.008*	−0.010*	−0.009*	−0.010**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
CA Balance	0.001	0.001	0.003	0.001	0.001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Fiscal Reserve	0.002	0.002	0.001	0.001	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Inflation	0.012	0.011	0.007	0.007	0.018
	(0.020)	(0.020)	(0.021)	(0.021)	(0.021)
Time Fixed Effects	YES	YES	YES	YES	YES
Country Fixed Effects	YES	YES	YES	YES	YES
Constant	−0.807***	−0.782***	0.324**	0.278*	0.274
	(0.188)	(0.184)	(0.164)	(0.166)	(0.168)
N	1453	1453	1306	1308	1273
R^2	0.968	0.968	0.971	0.970	0.966
Robust std err in ()	*:p<0.100	**:p<0.050	***:p<0.01		

Notes: Regressions include an EU dummy that is not shown in the table.

Table 10: Alternative specifications for Debt2GDP

	BIS OLS	BIS IV	Bond	Loan	Bond&Loan
L(rating)			0.946***	0.955***	0.952***
			(0.008)	(0.009)	(0.010)
Debt	−0.057***	−0.058***			
	(0.005)	(0.005)			
Bond			−0.001		−0.001
			(0.001)		(0.001)
Loan				0.003	0.002
				(0.003)	(0.003)
$\mathbf{1}^G$×Debt Growth	0.010	0.010	0.005	0.005	0.005
	(0.014)	(0.016)	(0.003)	(0.003)	(0.003)
$\mathbf{1}^N$×Debt Growth	0.003	0.007	−0.002	−0.001	−0.001
	(0.005)	(0.005)	(0.002)	(0.002)	(0.002)
$\mathbf{1}^P$×Debt Growth	−0.014	−0.002	−0.015	−0.014	−0.014
	(0.018)	(0.021)	(0.011)	(0.011)	(0.011)
Operating Balance	−0.009	0.018	0.010**	0.011**	0.010**
	(0.015)	(0.044)	(0.005)	(0.004)	(0.005)
Real GDP Growth	−0.029	−0.042**	0.004	0.004	0.004
	(0.019)	(0.021)	(0.004)	(0.004)	(0.004)
Current Account Balance	−0.102***	−0.106***	0.000	−0.000	0.000
	(0.020)	(0.021)	(0.003)	(0.002)	(0.003)
Fiscal Reserve	0.064***	0.058***	−0.001	−0.001	−0.001
	(0.010)	(0.010)	(0.002)	(0.002)	(0.002)
Inflation	0.232***	0.197***	0.008	0.007	0.007
	(0.060)	(0.063)	(0.017)	(0.017)	(0.017)
LT Rate	−0.496***	−0.470***	−0.085***	−0.088***	−0.087***
	(0.064)	(0.062)	(0.019)	(0.020)	(0.020)
Time Fixed Effects	YES	YES	YES	YES	YES
Country Fixed Effects	YES	YES	YES	YES	YES
Constant	21.260***	21.639***	1.290***	1.031***	1.162***
	(0.533)	(0.750)	(0.203)	(0.212)	(0.235)
N	1535	1457	1369	1368	1368
R^2	0.897	0.901	0.994	0.994	0.994
Robust standard errors in ()	*:p<0.100	**:p<0.050	***:p<0.010		

Notes: Regressions include an EU dummy that is not shown in the table.

Figure 1: Rating plus Outlook Score

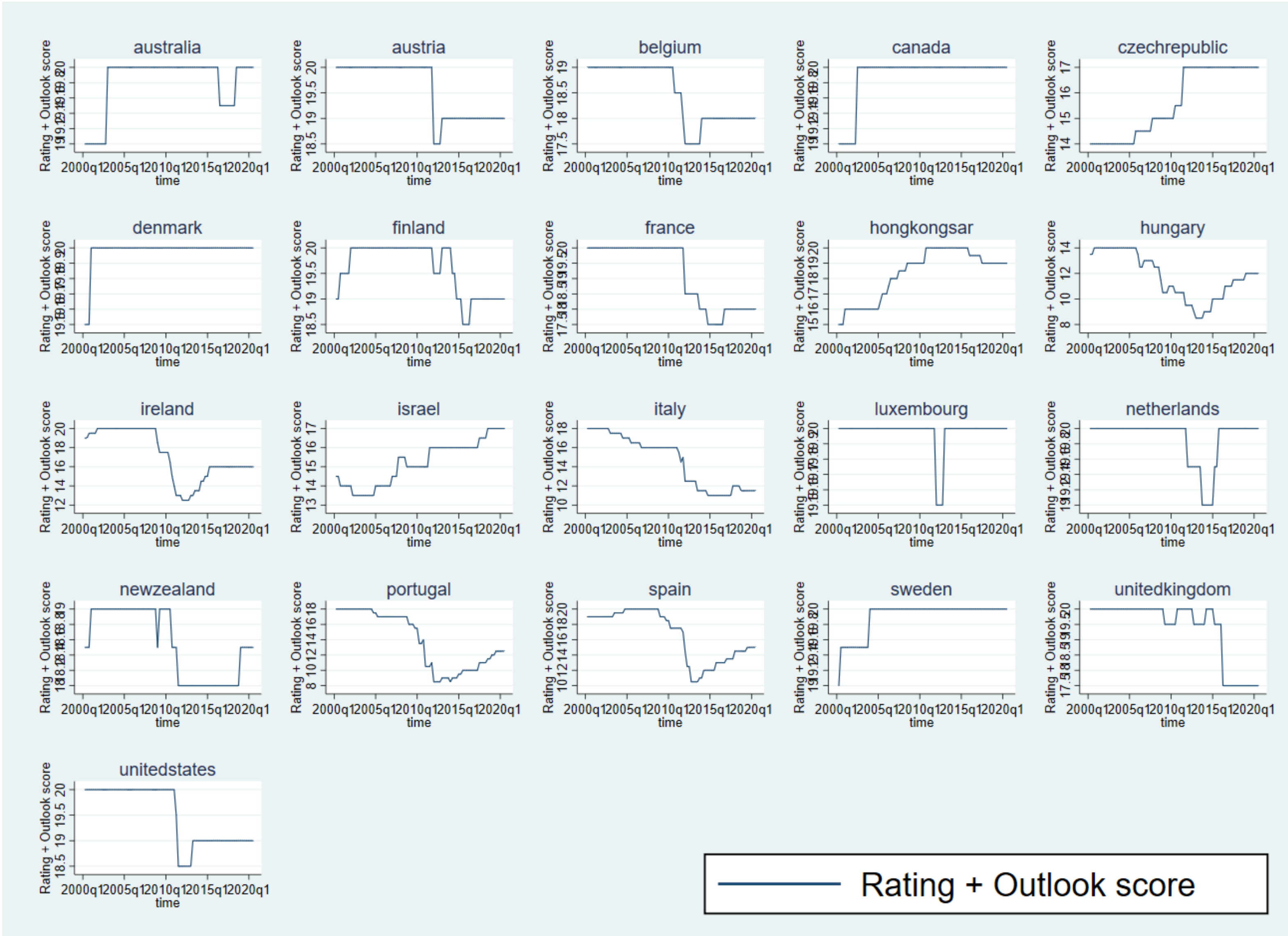


Figure 2: Debt-to-GDP Ratio

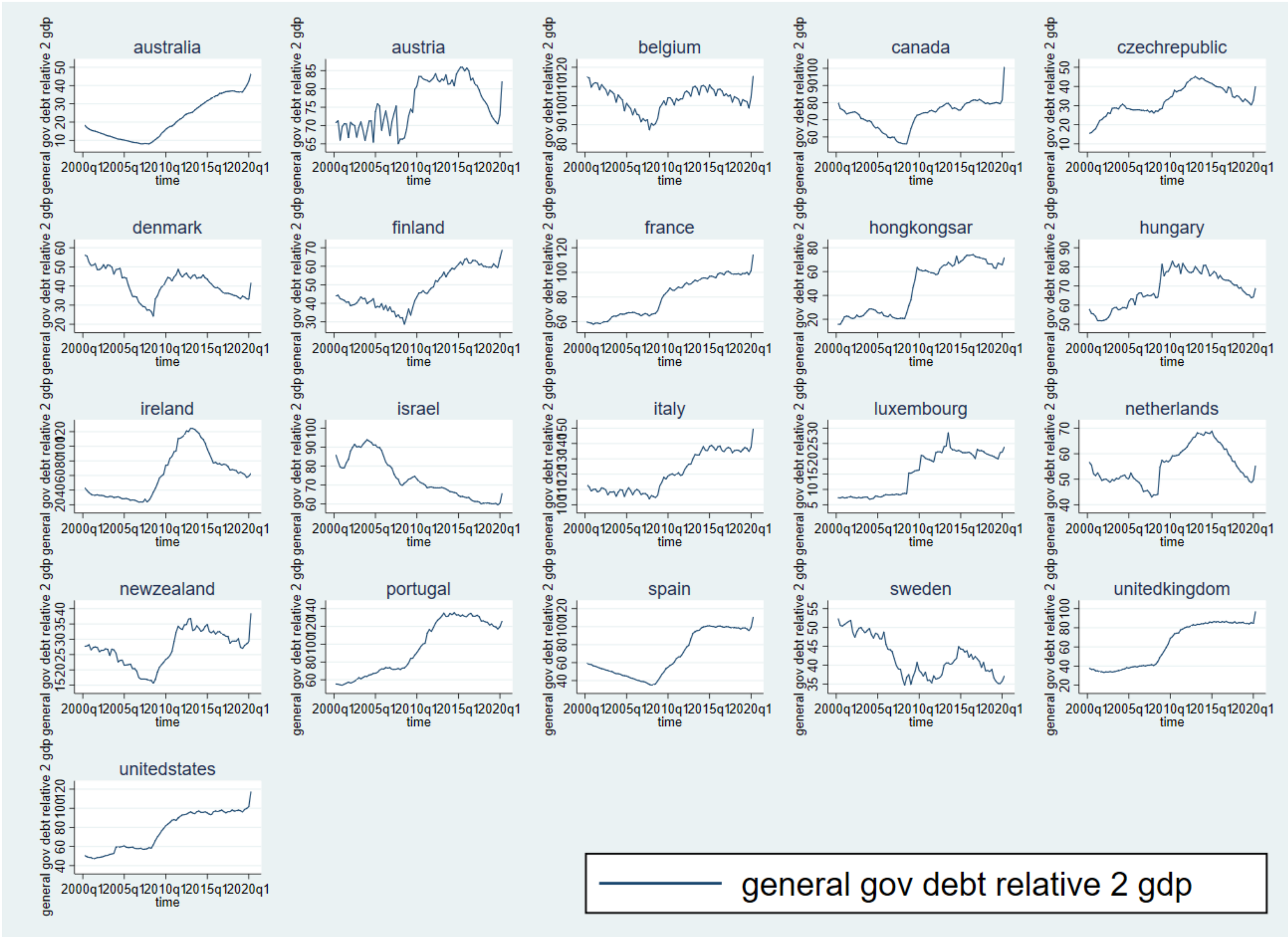


Figure 3: Debt Growth

Figure 4: Debt Structure: Stock of Four Debt Categories

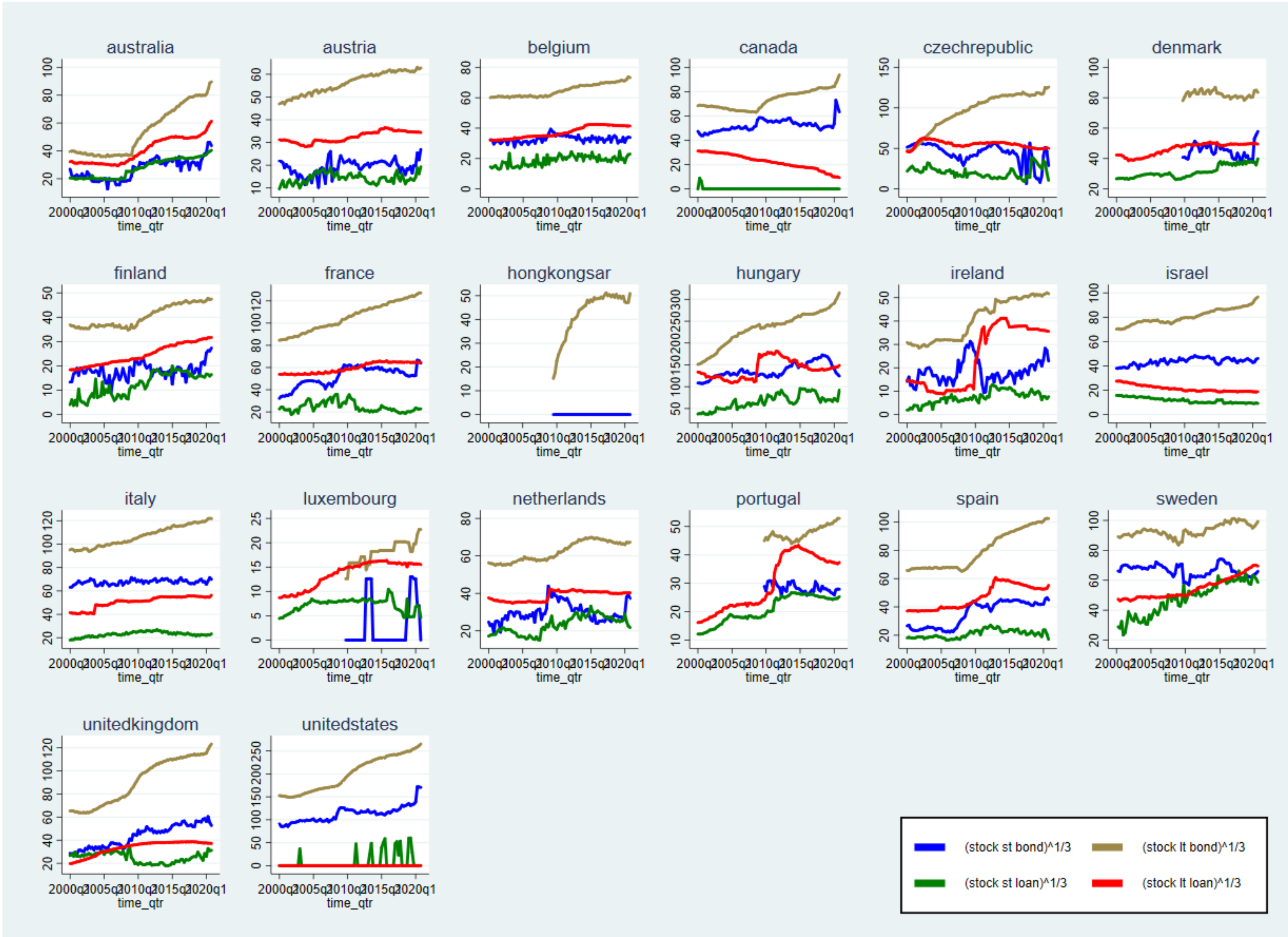


Figure 5: Net Operating Balance and Fiscal Sustainability Gap

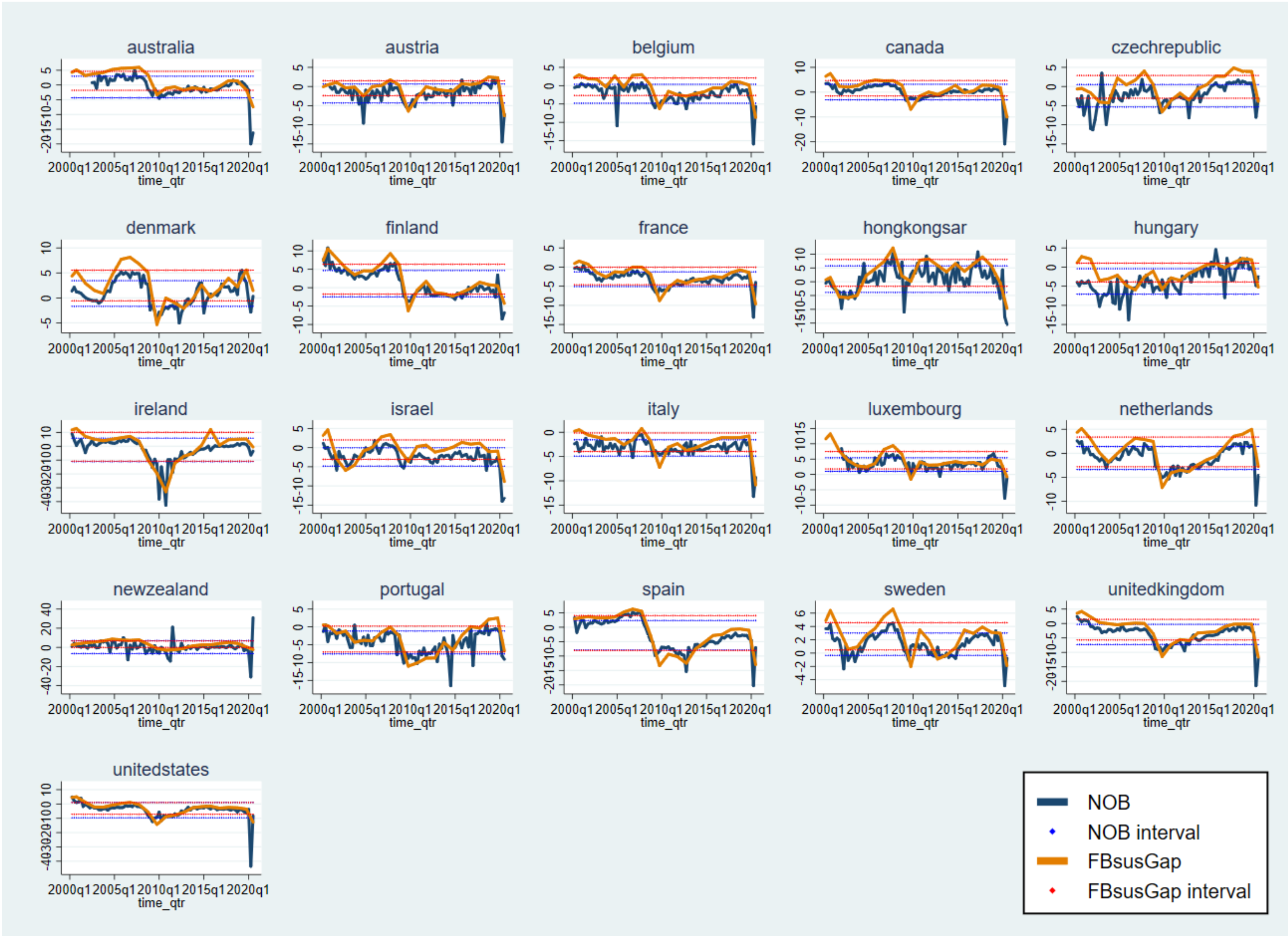


Table 11: Parameter Values

Parameter	μ	σ	$\overline{X}$	$\overline{y}$	$\underline{y}$	φ_H	φ_L	r	ρ_1
Value	1.5	0.2	8.92	8.92	4.46	0.81	0.09	0.02	0.5

Figure 6: Equilibrium Functions with Low ϕ

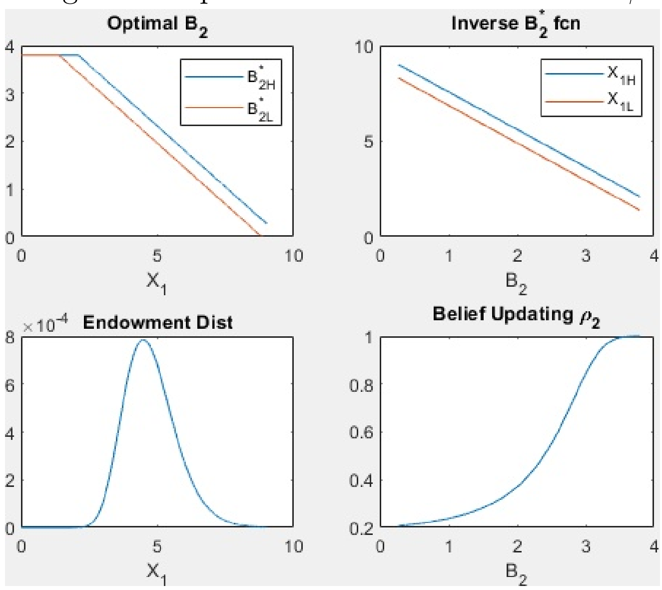
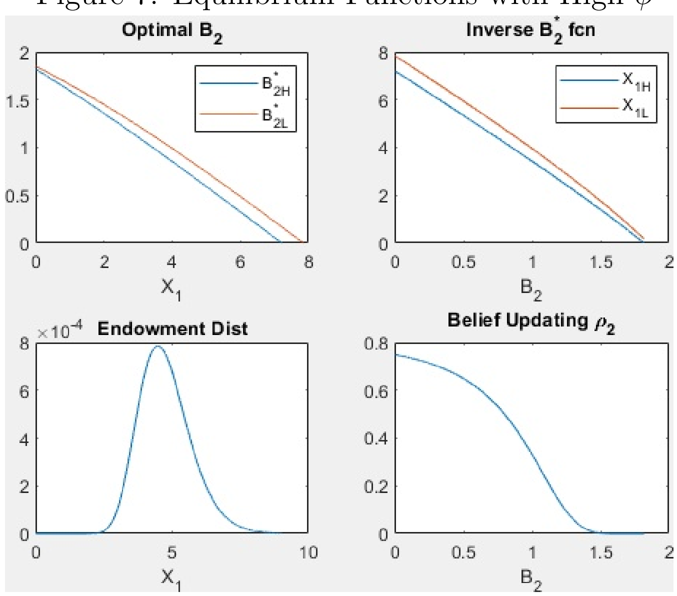


Figure 7: Equilibrium Functions with High ϕ



A Results of the Endogeneity Test

In Tables 12 and 13, we report the results of the endogeneity tests, which determine that the NOB-to-GDP and the debt-to-GDP are the only two variables that could be endogenous. In each setting with potentially endogenous variables, we choose the lag order for IVs by evaluating the model performance based on the results of four tests: underidentification test (UnderID), weak instrument test (WeakIV), overidentification test (OverID), and autocorrelation test (AR(1)). On top of the chosen good-performing lag specifications, we then determine the exogeneity or endogeneity of potentially endogenous variables based on the result of the endogeneity test (EndogTest). The details of the five tests are as follows:

- UnderID. The null hypothesis is that the model is not identified. Rejecting the null (p value less than 0.1) means that the instruments are "relevant", i.e., correlated with the endogenous regressors.

- WeakIV. The null hypothesis is that the instruments are weak, i.e., correlated with the endogenous regressors but only weakly. One can reject the null when the Cragg–Donald Wald F statistic is greater than the critical values. Rejecting the null means that the correlations between the IVs and endogenous variables are not weak.

- OverID. The null hypothesis is that the instruments are valid, i.e., uncorrelated with the error terms. Rejecting the null means that the IVs are correlated with the error terms and thus invalid.

- AR(1). The null hypothesis is that the series has no autocorrelation. Rejecting the null means that the series has first-order autocorrelation.

- EndogTest. The null hypothesis is that the specified endogenous regressors can actually be treated as exogenous. Rejecting the null means that the series should be taken as endogenous.

A good-performing model should reject UnderID and WeakIV and not reject OverID or AR(1). We use a $\surd$ symbol to indicate the good-performing results in the summary tables, Tables 12 and 13 below. For EndogTest, on the other hand, we use a $\surd$

symbol to indicate that the test reveals the potentially endogenous variable to indeed be endogenous. There are two things to note here. First, for the specification with more than three potentially endogenous variables, the critical value for the WeakIV test is not available. We skip the result of WeakIV in these cases when evaluating the model performance. Second, for the IV with lagged order 1, the OverID test is not feasible in that the IV with only one lag is the case of just identification, which is beyond the scope of the overidentification test. We skip the result of OverID in this case when evaluating the model performance.

Next, we report the two-step results of the endogeneity test.

Recall that in the first step, we instrument all five six potentially endogenous regressors with their lagged terms, conservatively assuming that they are all endogenous, and then test the exogeneity of each one. For the main regression, we have six potentially endogenous variables: debt-to-GDP (debt2gdp), the NOB-to-GDP (nob2gdp), three state-interacted debt growth terms (good/normal/poor), and the long-term interest rate. Since they share the same structure, we do not differentiate these three interaction terms when testing endogeneity and thus test their joint endogeneity.

In the first step, we find that the only endogenous variable with high possibility among the six tested variables is the NOB-to-GDP. The four rows of Table 12 report the results for endogeneity tests on the debt-to-GDP (debt2gdp), the NOB-to-GDP (nob2gdp), three interacted debt growth terms (interacted growths), and the long-term rate. Among four statistical tests, the model performs well in OverID test and AR(1) test, with the order of IV lags varying from 5 to 20. The NOB-to-GDP is determined to be endogenous under all good-performing model specifications, while the other suspects are determined to be uniformly exogenous. Because of the flaws of the model performance in UnderID test and WeakIV test, we conclude step one conservatively by taking the NOB-to-GDP as the only confirmed endogenous regressor and keeping all other suspects as potentially endogenous.

We treat the NOB-to-GDP as the only definitely endogenous regressor and move to the second step. In the second step, we instrument the NOB-to-GDP and one other potentially endogenous regressor with their own lagged terms and test whether we can reject the exogeneity hypothesis for each.

We cannot reject the exogeneity hypothesis for either of the remaining variables except for the debt-to-GDP. In the first row of Table 13, we find a rejection to the exogeneity hypothesis for debt-to-GDP when tested together with the NOB-to-GDP. In the second row, we confirm the joint endogeneity of NOB-to-GDP and debt-to-GDP for good-performing specifications with IV lagged orders from 5 to 20. From the third row to the fifth row, we confirm the exogeneity of the three interacted debt growths. First, the joint endogeneity test returns exogenous results for specifications with lagged IV orders from 5 to 20. We skip the evaluation of the result of the WeakIV test because the critical value is missing. According to Stock and Yogo (2002), the critical value for the WeakIV test is available for specifications with at most 3 endogenous variables. To make the WeakIV critical value available, we repeat the three-term joint endogeneity test by removing the NOB-to-GDP. Unfortunately, as shown in the fourth row, in the most favorable specifications with lagged IV orders determined at 9 to 10, the WeakIV test returns the result of IVs that are too weakly related. Despite the poor performance in WeakIV, the three interacted debt growth terms are determined to be exogenous. We further confirm the joint exogeneity by testing endogeneity solely on unconditional debt growth. Because the states of the economies used for the interactions are essentially predetermined, it is then sufficient to determine the exogeneity of the interacted debt growth terms by confirming that the unconditional debt growth is exogenous. The fifth row of Table 13 shows that unconditional debt growth can be taken as exogenous under the IV specification with lagged order from 5 to 20. The model performs well in terms of all four tests except for the WeakIV test. Last, we confirm that the long-term bond yield can be taken as exogenous under specifications with IV lagged orders from 5 to 11.

Table 12: Step 1 of Endogeneity Test

EndogTest On	Lag	UnderID	WeakIV	OverID	AR(1)	EndogTest	Holds For
debt2gdp	5	Not Reject × p=0.6866	NA* Cragg–Donald=2.9097	Not Reject √ p=0.5295	Not Reject √ p=0.3773	Not Reject × p=0.7199	lag 5-20
interacted growths	5	Not Reject × p=0.6866	NA Cragg–Donald=2.9097	Not Reject √ p=0.5295	Not Reject √ p=0.3773	Not Reject × p=0.9897	lag 5-20
nob2gdp	5	Not Reject × p=0.6866	NA Cragg–Donald=2.9097	Not Reject √ p=0.5295	Not Reject √ p=0.3773	Reject √ p=0.0096	lag 5-20
LT rate	5	Not Reject × p=0.6866	NA Cragg–Donald=2.9097	Not Reject √ p=0.5295	Not Reject √ p=0.3773	Not Reject × p=0.1580	lag 5-20

Table 13: Step 2 of Endogeneity Test

EndogTest On	Lag	UnderID	WeakIV	OverID	AR(1)	EndogTest	Hold For
debt2gdp	5	Reject √ p=0.0000	Reject √ Cragg–Donald=44.0638	Not Reject √ p=0.6651	Not Reject √ p=0.4617	Reject √ p=0.0318	lag 5-20
nob2gdp + debt2gdp	5	Reject √ p=0.0000	Reject √ Cragg–Donald=44.0638	Not Reject √ p=0.6651	Not Reject √ p=0.4617	Reject √ p=0.0021	lag 5-20
interacted growths	7	Reject √ p=0.0806	NA* Cragg–Donald=3.4684	Not Reject √ p=0.3317	Not Reject √ p=0.3236	Not Reject × p=0.8143	lag 7**
interacted growths***	9	Reject √ p=0.0895	Not Reject × Cragg–Donald=3.6270	Not Reject √ p=0.5815	Not Reject √ p=0.3967	Not Reject × p=0.7082	lag 9-10
debtGrowth	5	Reject √ p=0.0000	Not Reject × Cragg–Donald=6.7279****	Not Reject √ p=0.3991	Not Reject √ p=0.4963	Not Reject × p=0.5828	lag 5-20
LT rate	5	Reject √ p=0.0000	Reject √ Cragg–Donald=41.7749	Not Reject √ p=0.3717	Not Reject √ p=0.4593	Not Reject × p=0.1411	lag 5-11

√: good-performing result, meaning that the IV is relevant (UnderID), is not weak (WeakIV) or is valid (OverID) or that the model residual is not autocorrelated (AR(1)) or that the potentially endogenous variable being tested is endogenous (EndogTest);
×: bad-performing result, meaning that the IV is not relevant (UnderID), is too weak (WeakIV) or is not valid (OverID) or that the model residual follows a first-order autocorrelation process (AR(1)) or that the potentially endogenous variable being tested can be taken as exogenous (EndogTest).
*WeakIV is NA because Stock and Yogo (2002) list only the critical value for cases with at most 3 endogenous variables and 100 IVs; here, the number of our potentially endogenous variables is greater than 3.
**UnderID holds only for the lag 7, while other results hold for the lag 5-20.
****Conducted removing debt2gdp from the regression.
****According to the Stock-Yogo weak ID test critical values table, this F statistic lies between 10%-20% maximal relative IV bias.

B Proof for Proposition 1

When $B_2 \leq \underline{y} + \varphi_L - \phi$, $\phi + B_2 - \varphi_i \leq \underline{y}$ so that for both types, $D(\phi + B_2 - \varphi_i) = 0$ and $MC(\varphi_i) = (\overline{X} + \varphi_i - B_2)^{-1}$. Hence, $MC(\varphi_H) < MC(\varphi_L)$, and in turn, $B_{2,H}(X_1) > B_{2,L}(X_1)$.

When $B_2 \geq \underline{y} + \varphi_H - \phi$, $\phi + B_2 - \varphi_i > \underline{y}$ so that for both types, $D(\phi + B_2 - \varphi_i) > 0$. Notice that $D'(\cdot) = (\overline{y} - \underline{y})^{-1}$, comparing $MC(\varphi_i)$ is equivalent to comparing $\frac{1-D(\phi+B_2-\varphi_i)}{\overline{X}+\varphi_i-B_2}$. If $\overline{X} + \phi > \overline{y}$ and $B_2 = \underline{y} + \varphi_H - \phi$, $\frac{1-D(\phi+B_2-\varphi_L)}{\overline{X}+\varphi_L-B_2} < \frac{1-D(\phi+B_2-\varphi_H)}{\overline{X}+\varphi_H-B_2} < (\overline{y} - \underline{y})^{-1}$. $\frac{1-D(\phi+B_2-\varphi_i)}{\overline{X}+\varphi_i-B_2}$ is decreasing in $(B_2 - \varphi_i)$ iff $\frac{1-D(\phi+B_2-\varphi_i)}{\overline{X}+\varphi_i-B_2} < D'(\cdot) = (\overline{y} - \underline{y})^{-1}$. Therefore, $\frac{1-D(\phi+B_2-\varphi_i)}{\overline{X}+\varphi_i-B_2}$ is decreasing in $(B_2 - \varphi_i)$ when $B_2 \geq \underline{y} + \varphi_H - \phi$. Hence, $MC(\varphi_H) > MC(\varphi_L)$, and in turn, $B_{2,H}(X_1) < B_{2,L}(X_1)$.