Faculty III: School of Economic Disciplines

Master Thesis

Belt and Road Initiative, Growth and Debt Distress in Recipient Countries

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Abstract

This paper starts with an analysis of the relationship between the Belt and Road Initiative (BRI) and the growth and debt distress in recipient countries and then puts forward a methodology of debt distress analysis for these countries. Empirically, the paper revisits the debt distress analysis model of Kraay and Nehru (2006) (henceforth KN), who suggest that a parsimonious combination of only three factors namely the debt burden, the quality of policies and institutions, and shocks can explain a substantial fraction of debt distress incidence. I find out that KN's model, when applied on my new sample of 120 BRI recipient countries from 1970 to 2020, performs a little worse with a lower out of sample predictive power, though all the core variables used in KN's model remain highly significant. By including in KN's model additional variables for country-specific effects and history effects, I increase the whole-sample power of explanation and prediction by 34.3 and 6.2 percentage points, respectively, and recommend this methodology for debt distress analysis in BRI recipient countries. Many important policy implications follow.

Keywords: Belt and Road Initiative, BRI, Chinese lending, debt distress, probit modelling
JEL Classification: F34, F37

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List of Abbreviations

ADB	Asian Development Bank
AEI	American Enterprise Institute and Heritage Foundation
BRI	Belt and Road Initiative
CCI	Corruption Control Index
CGIT	China Global Investment Tracker
CPEC	China Pakistan Economic Corridor
CPIA	World Bank's Country Policy and Institutional Assessment
DERL	Djibouti-Ethiopia Rail-Link
DOD	Disbursed and outstanding debt
DSF	Debt Sustainability Framework
EMEs	Emerging market economies
ESSAT	Environmental and Social Safeguards Advisory Team
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GNI	Gross National Income
GNP	Gross National Product
HICs	High income countries
HIPC	Heavily Indebted Poor Countries Initiative
IMF	International Monetary Fund
KN	Kraay and Nehru (2006)
LICs	Low income countries
LMICs	Lower middle income countries
MDB	Multilateral Development Bank
MDRI	Multilateral Debt Relief Initiative
MICs	Middle income countries
OOS	Out of sample
OPCS	Operations Policy and Country Services
PV	Present value
RMB	Renminbi (official currency of China)
ROL	Rule of Law
SBA/EFF	Standby Arrangements or Extended Fund Facilities
TOT	Terms of Trade
UMICs	Upper middle income countries
UNDP	United Nations Development Programme
WGI	World Bank Worldwide Governance Indicator

1. Introduction

China has recently passed all the other traditional official creditors like the International Monetary Fund (IMF) and the World Bank to become the biggest official creditor to developing countries. By 2018, developing and emerging economies have borrowed 380 billion US dollars from China, compared to 246 billion US dollars from Paris Club, and Chinese direct loans and trade credits reached approximately 1.6 trillion US dollars - nearly 2 percent of the world GDP (Horn *et al.*, 2020, 2019).

Belt and Road Initiative (henceforth BRI), which was officially adopted under Chinese Party Constitution as part of a resolution to achieve "shared growth through discussion and collaboration" in 2015, has become the main channel of Chinese lending since then. Under BRI, China announced to provide loans of around 8 trillion US dollars for foreign infrastructure projects in transportation, energy, and telecommunications sectors linking Europe, Africa, and Asia (Hurley *et al.*, 2019), and so far BRI has been among the most transformational trade policies in the world, which has connected 143 countries along its routes (*Profiles -Belt and Road Portal*, 2020). The finance from BRI can contribute largely to filling the infrastructure gap in many parts of the world. For example, the African Development Bank estimates that 130 to 270 billion US dollars per year is required to fill that gap in Africa (Brautigam, 2020).

While many scholars are optimistic about BRI's positive effects on trade and economic growth in recipient countries (Alden, 2005; Idun-Arkhurst and Laing, 2007; Mukwaya and Mold, 2019; Wang and Bio-Tchané, 2008), there is a major concern that these debt-financed investments will not generate sustainable beneficial impacts due to the high debt distress probability caused by BRI loans (Ameyaw-Brobbey, 2018; Hurley *et al.*, 2019; Monika, 2018; Sturzenegger and Zettelmeyer, 2006). Besides, BRI projects are also usually reported for low quality projects, society and environmental damages, labour discrimination (Ackerman, 2020; Githaiga and Bing, 2019; Kimkong and Sovinda, 2017; Sel, 2017; Var *et al.*, 2017; Xu, 2015; Zhao, 2020), and political perspectives reliance (Var *et al.*, 2017). Some scholars even relate BRI to the Neo-colonialism of 1960s (Monika, 2018).

Chinese lending and especially BRI loans are dissimilar to the loans from traditional lenders like the World Bank or the IMF in a way that they can increase the vulnerability to debt in borrowing countries and create no motivation for the public policy and institutional

improvement (Dunning, 2004), thus reducing the positive impacts (if any) of investments on growth. According to a recent study of Horn *et al.* (2019), 50 percent of China's lending is "hidden". This non- transparency complicates the debt management and together with the non-interference policy of China in the borrowing country's internal affairs, it allows corruption and inefficient use of capital, which means revenues generated from the investments can be insufficient to boost the growth and to pay back the debt (Pehnelt, 2007). Considering the fact that most BRI (recipient) countries fall below the 50th percentile in the TRACE Matrix[1] (Ackerman, 2020), such a "hands-off" policy of Chinese lending can be particularly harmful to the overall growth as well as the debt repayment ability of these borrowing countries.

Furthermore, a majority of BRI loans are at market terms with shorter maturities than traditional lenders, and often with collateral clauses that allow repayment by commodity (Bräutigam and Gallagher, 2014). For developing countries, commercial loans can significantly increase the burden of debt services, thus further worsen their debt repayment ability. In addition to that, most of BRI loans are contracted in US dollars or Renminbi (RMB), which makes the borrowers susceptible to exchange rate risks (Hurley *et al.*, 2019).

Even though raising severe concerns on debt distress in borrower countries, Chinese loans remain attractive for many reasons. The fact is that many risky debtors cannot get access to the international financial market anymore and resort to BRI for their infrastructure development investments. Besides, Chinese loans do not interfere with the borrowers' governance and institutions, which means faster approval of loans and this attracts the government leaders facing constrained timelines due to election (Hillman, 2018a).

Numerous studies have related the increasing debt burdens in poor countries to Chinese loans (Bandiera and Tsiropoulos, 2019; Horn *et al.*, 2019). Chinese lending alone accounts for a quarter of total bank lending to LICs and EMEs[2], who have in fact weak institutions and

[1] The TRACE Bribery Risk Matrix® (TRACE Matrix) measures business bribery risk in 200 countries, territories, and autonomous and semi-autonomous regions. The overall country risk score is a combined and weighted score of four domains: Business Interactions with Government; Anti-Bribery Deterrence and Enforcement; Government and Civil Service Transparency; and Capacity for Civil Society Oversight, including the role of the media. The countries and regions are ranked based on the overall score and a higher rank indicates a lower business bribery risk. Details can be found on the website: https://www.traceinternational.org/trace-matrix

[2] The classification of low income countries (LICs), lower middle income countries (LMICs), upper middle income countries (UMICs) and high income countries (HICs) in this paper is based on the World Bank's classification in 2019-2020. Details can be found on the website: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.

easily fall into debt distress (Hurley *et al.*, 2019; Pehnelt, 2007). According to the World Bank (2019), one-third of the BRI LICs that have their debt sustainability analysis done by the World Bank have a high risk of debt distress, and nearly two-thirds of BRI EMEs have the level of debt or gross financing needs beyond the thresholds (50 percent and 15 percent of GDP, respectively). The debt levels in LICs in recent years are approaching the points when the "Third World Debt Crisis" broke out in the early 1980s, and this has raised a serious concern among the traditional creditors, who have paid for the debt relief in the Paris Club, Heavily Indebted Poor Country (HIPC) Initiative and Multilateral Debt Relief Initiative (MDRI). For them, the risks of countries getting into another round of default must be avoided and debt distress possibility is therefore the main variable to be scrutinized (Hurley *et al.*, 2019).

Recently, by publishing the Debt Sustainability Framework for BRI participating countries (henceforth BRI-DSF) (Ministry of Finance of People's Republic of China, 2019), China has taken its first action regarding the debt distress problem in BRI recipient countries, which China has been continuously denying in the past. This reflects how pressing the debt distress problem has become in BRI recipient countries.

In assessing the debt distress probability, growth is a critically important variable. If the economic growth cannot fully cover the debt services, domestic spending and investments must be sacrificed, which in turn further hinders the growth and worsens the debt repayment ability (Bandiera and Tsiropoulos, 2019; Sturzenegger and Zettelmeyer, 2006). This not only harms the social welfare but also makes the countries unattractive to investors and put them in a difficult situation to get access to international financial market or concessional loans. As a result, they have to resort to other alternatives of higher interest rates or risky conditions, which makes them even easier to get into debt distress (Borensztein and Panizza, 2009; Juan, 2020; Reinhart *et al.*, 2003). The relationship between debt-financed investments and debt distress, taking into account the impacts of these investments on growth, is therefore particularly important and worth analysing, especially for such a big push program like BRI.

Quantifying the impacts of BRI on growth is however complicated, as while most of BRI investments (of huge amounts) will be disbursed in the medium term (5 years), leading to high debt burdens within a short period of time, the total impacts on growth from these debts

However, the World Bank does not have a list of emerging market economies (EMEs). The EMEs list can be found on Standard & Poor's website.

are usually to be seen in a much longer term (Bandiera and Tsiropoulos, 2019). Instead of trying to quantify BRI's impacts on growth, this paper will examine these impacts through literatures and case studies. My conclusion out of this first step is while the positive impacts of BRI on growth and trade have not been clear, the real risk of BRI-related debt distress and many incidences of BRI's negative impacts on environmental and social values have been observed. In an extreme case that the positive and negative impacts from BRI on growth balance each other, the overall impact of BRI (on growth) equals zero and the recipient countries are left struggling with a huge amount of debt.

Even in the cases of positive impacts on growth, as proved by many scholars, many countries still stand a high risk of debt distress (Bandiera and Tsiropoulos, 2019). Therefore, to prepare BRI countries with an easy-to-apply methodology of debt distress analysis is crucially important, which is also the central aim of this thesis paper. The debt distress analysis in this paper focuses on three questions:

1) What determines the debt distress in BRI countries?
2) Is a country-specific debt threshold better than a fixed one? If yes, how can we compute a country-specific debt threshold?
3) Will BRI financing add to the risk of debt distress in recipient countries?

To analyse the debt distress in BRI recipient countries, I revisit the probit model put forward by Kraay and Nehru (2006) (KN for short). KN's model uses the debt burden, policy quality and shocks as the key groups of explanatory variables to determine debt distress. I find out that KN's model, when applied on my new sample of 120 BRI countries from 1970 to 2020, works somewhat worse than when applied on KN's sample of 57 low income countries from 1970 to 2002. When run on different income groups, KN's model performs better for middle income countries (MICs, including both UMICs and LMICs) than for the other groups. I expect that the country and history effects can explain for the difference in the regression results between mine and KN's, which triggers me to try including in KN's model additional variables for these effects. KN's model with additional variables, or extended specifications, achieve a better power of explanation and prediction and are recommended if our aim is to have the best predictive power model rather than a parsimonious one.

This paper contributes in five main ways: first, it examines a number of case studies on BRI projects and provides the latest view on the role of BRI to the economic growth and debt

situation of recipient countries. Second, the paper challenges the debt distress model of KN with the most recent data set of 120 BRI countries, covering additional nearly two following decades. At the time that KN carried out their study, the major sources of external debt for developing countries are concessional loans from traditional official lenders like the World Bank or the IMF, while recently and especially in my sample of BRI countries only, these countries are becoming heavily dependent on commercial loans from China. I show that with the latest data focusing on BRI countries and the new situation, besides the combination of debt burden, policy quality and shocks, which remain highly significant, additional variables for country-specific effects and history effects should be considered as well.

Third, the paper attempts to extend KN's model with respectable improvements. By adding the variables for region, income group and historical debt payment performance to KN's base model, my extended specifications have increased the whole-sample power of explanation and prediction by 34.3 and 6.2 percentage points, respectively. The best extended specification is the one combining debt burden, shocks, region, income group and the historical financial performance. Interestingly, policy quality shows little significance here, which can be explained by the fact that policy effects could have already been included in the other variables.

Fourth, I show that a one-size-fits-all debt threshold for all countries cannot be the best way, because other factors like policies, shocks, country and history effects prove statistically significant and, in some cases, even more significant than debt burden variables. My extended specification is a simple way to predict a context-specific debt threshold for BRI recipients. This country-specific debt threshold provides crucial policy implications for both traditional and emerging lenders, as well as for the borrowers' informed decisions and debt management.

Finally, using the best extended specification to predict the probability of debt distress for the sample before and after the launch of BRI, I show that over half of BRI countries (33 out of 60) that have data available during the time period analysed (2014–2020) have increased the vulnerability to debt since BRI's launch. Among them, many have their debt distress probability jump up dramatically from lower than 25 percent before 2015 up to almost 100 percent and 12 countries have jumped beyond the unconditional probability of debt distress post PBI. BRI loans and a higher probability of debt distress have indeed a connection.

The remainder of this thesis is structured as follows. Chapter 2 presents an overview of BRI's mechanisms and impacts on growth and debt distress through literatures, data analysis and case studies. Chapter 3 explains the debt distress model, including a review of related literatures and a description of the data and methodology. Chapter 4 discusses the main results from the regressions using the model introduced in Chapter 3. The paper concludes with policy implications in chapter 5.

2. Belt and Road Initiative and its impacts on growth and debt distress

Box 1: Hambantota port in Sri Lanka

The Hambantota port is the major BRI project in Sri Lanka. It was envisioned to handle 20 million twenty feet (TEU) containers and to become among the busiest ports in the world in 2040. Its construction was divided into three phases. The first phase was from 2007 to 2010 and cost 360 million US dollars, 85 percent of which came from China Exim Bank at a fixed interest rate of 6.3 percent. The cost above did not include additional costs for feasibility study, land costs and payments of equipment. The second phase cost of around 750 million US dollars was funded by a loan at 2 percent interest rate also from China Exim Bank. The third phase was planned to be completed by 2023 but would be possibly not implemented (Wibisono, 2019).

In 2010 when Hambantota was open for commercial operation, there was a loss of more than 300 million US dollars. Hambantota continued to make a loss when only 34 ships came to the port in 2012 compared with 3,667 ships at the country's main harbor, Colombo port. The number of arriving ships increased to 281 in 2016, which was still much below its potential. One of the explanations for the loss is its isolated territory and there was no industrial activity in the vicinity to use the port, which should have been noticed through the feasibility study. By the end of 2016, Sri Lanka had a total external debt of 46.4 billion US dollars (57 percent of its GDP), out of which about 10 percent was owed to China (Brautigam, 2020). In 2017, its debt reached 77.6 percent of GDP, and in 2018, 12.3 billion out of 14.8 billion US dollars of national revenues was for maturing debt repayment (Ameyaw-Brobbey, 2018). The national budget deficit of 5.5 percent of GDP also worsened the debt situation. Having an alarmingly high level of external debt, Sri Lanka's requests for loans were rejected by many lenders like the IMF, Eurobonds, and India (Wibisono, 2019).

Under this pressure, in 2017, Sri Lanka agreed to have 1.12 billion US dollars of debt written off by China in exchange for a 99-year lease of Hambantota Port to China. The China Merchant Holdings got 70 percent ownership of the Hambantota Port and about 15,000 acres of an industrial zone nearby. After this deal, Sri Lanka further borrowed 1.5 billion US dollars from the IMF and 1 billion US dollars from the China Development Bank to pay for maturing debts in 2017. In 2018, Sri Lanka's total external debt reached 55 billion US dollars, with 17 billion of maturing debts by 2023. In fact, the debt burden in Sri Lanka has been partially due to the higher debt services from commercial Chinese loans under BRI, with the interest rate of 6.3 percent, compared to 0.25-3 percent of the World Bank's and the Asian Development Bank (ADB)'s loans and 1 percent or less for loans from India (Wibisono, 2019).

Corruptions and social issues related to BRI are also observed. Later in 2019, at least 7.6 million US dollars has been found to get its way from China Harbor's bank account to Rajapaksa's campaign team. China has recently also helped Sri Lanka against UN sanctions for human right abuses (Wibisono, 2019). Hambantota also sees a great number of protests from local workers against Chinese firms. For example, in January 2018, the local workers announced a hunger strike, followed by around 70 Sri Lankans protesting quietly outside the port's headquarter several days later, against the labour policies and the unrealised promise of providing jobs to the locals by Chinese firms (Hillman, 2018b).

The reason that I start this chapter with the case study of Hambantota in Sri Lanka is because it has been repeatedly quoted as a proof of BRI indebtedness and as having limited contribution to the recipient country's economic growth. The debates whether the case of Sri Lanka is typical of BRI or just an exception keeps going on, and an increasing number of studies are done examining the relationship between BRI, growth and debt distress. As the first step, I will summarise BRI's mechanism and impacts through existing literatures, my own analysis of Chinese lending's data, and case studies.

2.1. What do scholars say?

Calderón *et al.* (2015) find that each one percent of increase in infrastructure investment can increase the output in developing countries from 0.06 to 0.18 percent. However, Calderon (2009) notes that such impacts of investments on growth can largely depend on the investment modes and the country's conditions. For BRI, will the above impact be much lower due to the commercial base rather than concessional base of the loans?

A study from World Bank (2019) focusing on BRI economic corridors shows that under the most optimistic assumptions of the efficiency like full transparency, managed debt, and mitigated environmental, social and corruption effects, BRI corridors can in the long term improve trade and foreign investment by up to 9.7 percent and 7.6 percent in LICs, respectively, lifting 7.6 million people from extreme poverty and 32 million people from moderate poverty. Reed and Trubetskoy (2019) with their study on 68 BRI projects note that besides the factors like debt sustainability and policy quality, the success of BRI projects rests rather on the completion of the other projects, which is to be seen over the long run.

Bandiera and Tsiropoulos (2019), working with all BRI types of projects, have tried to derive the marginal productivity of BRI investments in the medium and long-term based on a panel data of 43 countries, using a constant elasticity production function, and the structural general equilibrium (SGE) model. By quantifying the impacts of BRI on growth and then including that in assessing debt distress, the authors can evaluate more accurately the overall impacts of BRI and the debt sustainability in recipient countries. In analysing BRI's impacts on growth, the authors take into consideration the trade costs change due to transportation infrastructure development by examining sectoral linkages, trade in intermediate goods and sectoral heterogeneity. According to the results from their study, only 8 out of 43 countries can have their economic growth boosted sufficiently to cover the BRI loans over the period 2019-2023. They estimate that even under very optimistic assumptions that BRI generates

positive impacts on growth and no negative impacts on credit rating, 12 out of 43 LICs and MICs show a strong connection between BRI borrowing and debt distress. Out of these 12 countries, 10 have already been intensely vulnerable to further lending before BRI, so BRI loans can worsen the debt situation in at least 2 countries.

Another study on BRI indebtedness that is worth reviewing is the work of Hurley *et al.* (2019), who examine the debt situation in 68 BRI countries using BRI project lending pipeline. By integrating BRI loans into each country's debt as of end 2016 and projecting the movement of the public debt to GDP, taking into account the terms of BRI loans, the authors conclude that eight countries are because of BRI loans at high risk of debt distress.

Although many studies have figured out a close relationship between BRI loans and debt distress in recipient countries, whether it is China's intention to bring the borrower countries to debt distress remains debated. Agatha *et al.* (2019) reviewed 40 cases of Chinese debt renegotiations and concluded that the incidence of Sri Lanka is an exception rather than a typical case of Chinese loans. No matter it is China's intention or not, it is the borrowing countries' responsibility to protect themselves from debt distress by first of all fully understanding the risks and opportunities sticking to each term of loans under BRI, which I will discuss in the following sub-chapter.

2.2. Breaking down Belt and Road Initiative's loans

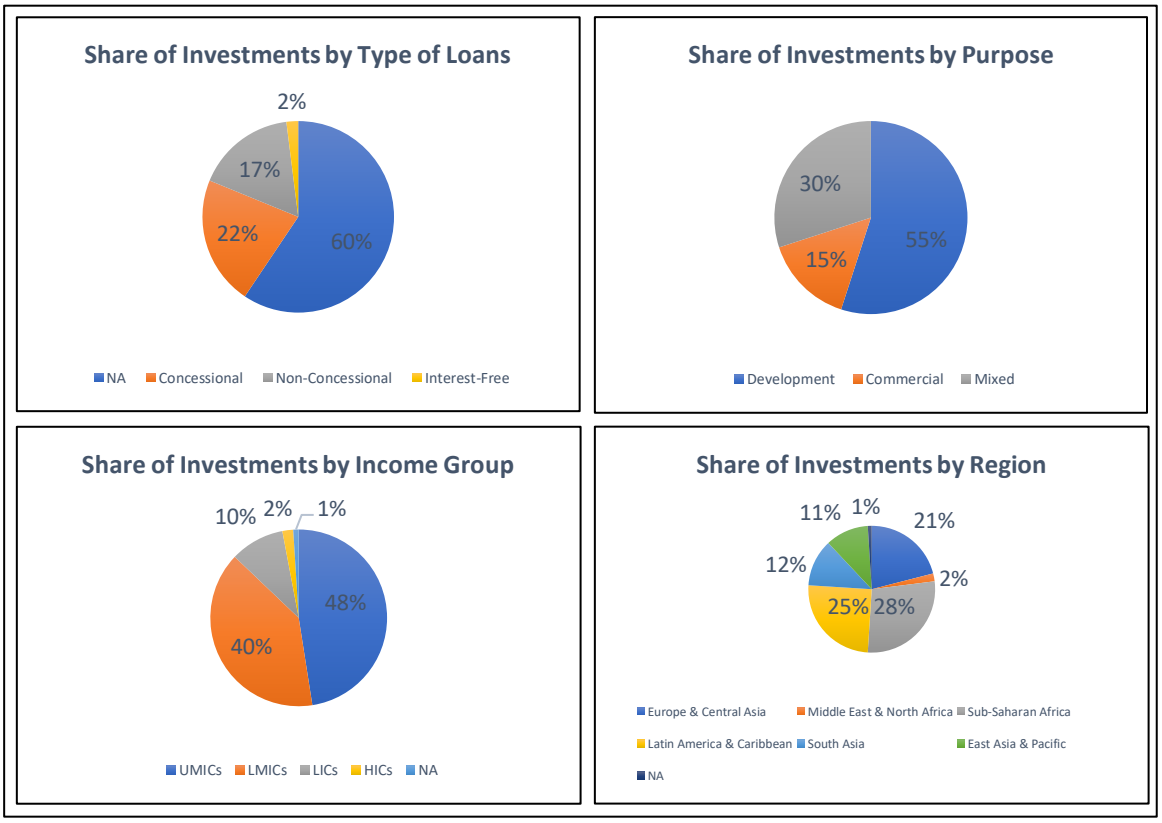
In assessing impacts of debt-financed investments, the information of terms of loans plays a pivotal role. Unfortunately, collecting data on individual BRI projects can be problematic due to the high non-transparency.

To give an overview of the structure and terms of loans of BRI, I use 3 different data sets. Note that I use the terms "loans" and "investments" interchangeably in this part because all the Chinese loans in these data sets are investments. The first data set includes 1700 investments from China to 124 countries from 2005 to 2020, gathered by the China Global Investment Tracker (CGIT) from the American Enterprise Institute and Heritage Foundation (AEI). This database just provides the data on the investment size and China's shares but gives no information on the types or terms of loans. Furthermore, due to the non-transparency of BRI projects, the data from AEI can reflect only a part of all BRI investments. The second data set is from the Research Lab at William & Mary's Global Research Institute (Aiddata), which provides details on 6190 Chinese investments to 172

countries from 2000 to 2014 regarding the type of projects, terms of loans including interest rate, grace period, maturity, grant elements, and the size of investments. However, this database does not indicate which investments are under BRI, and it just records the data until 2014. The last data set comes from the work of Horn *et al.* (2019), which is publicly available from the personal database website of Christoph Trebesch (2020), who has collected data on Chinese loans from all available sources and thus provides the best picture of Chinese overseas lending from 2000 to 2017. Many investments signed long before 2015 (when BRI was officially launched) have been rebranded as under BRI (Bandiera and Tsiropoulos, 2019), so having a look at the overall Chinese lending can also be helpful in understanding the mechanisms of BRI loans.

Even in these three largest databases (to the best of my knowledge) on Chinese investments, most of the loans do not have adequate information. For example, 31 percent of all investments in the AEI database are unclear whether they are under BRI or not, and 60 percent of the data from Aiddata have no information on the type of the loans.

Figure 1: Distribution of Chinese Investments

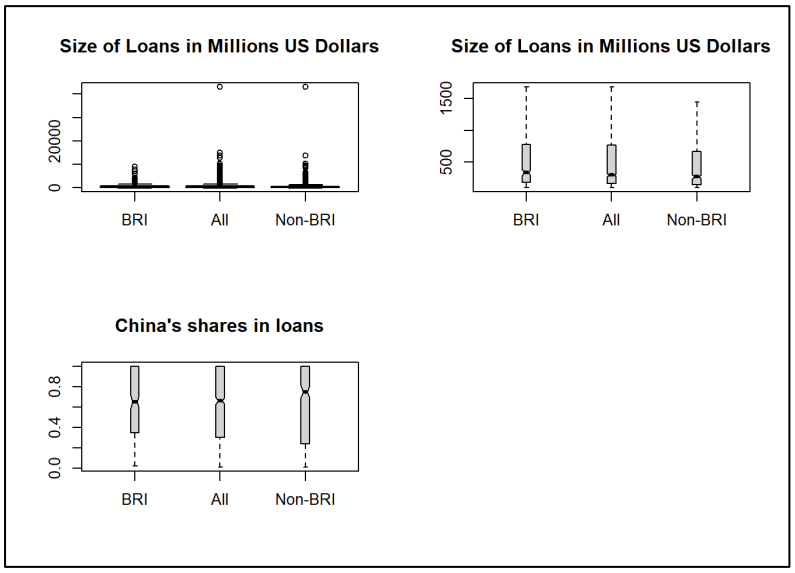


Source: Own Calculation

Figure 1 shows the distribution of Chinese investments by type and purpose of the loans, and by income group and region of recipient countries. As illustrated, only 40 percent of all loans have the information of their type available, out of which 22 percent are concessional compared with only 17 percent being non-concessional. China also provides interest free loans, but their share is negligible. In terms of the purposes of the loans, more than half of the loans are for development purposes and the loans for commercial means account for only 15 percent. We also see that Chinese loans are distributed unevenly, with 88 percent of all Chinese investments found in MICs. The three top regions receiving Chinese loans are Sub-Saharan Africa, Latin America & Caribbean, and Europe & Central Asia.

Figure 2 compares the size of loans and shares of China in the loans between BRI and non-BRI investments. After removing the loans unclear whether they are under BRI or not from the AEI database, we have 446 BRI and 713 non-BRI loans. Comparing these two groups of investments, we see that BRI investments have lower median share of China, which is 65 percent compared with 75 percent of non-BRI investments. However, the size of investments under BRI is higher, with the median of 340 million US dollars against 270 million US dollars for non-BRI.

Figure 2: Comparison of BRI and Non-BRI Loans

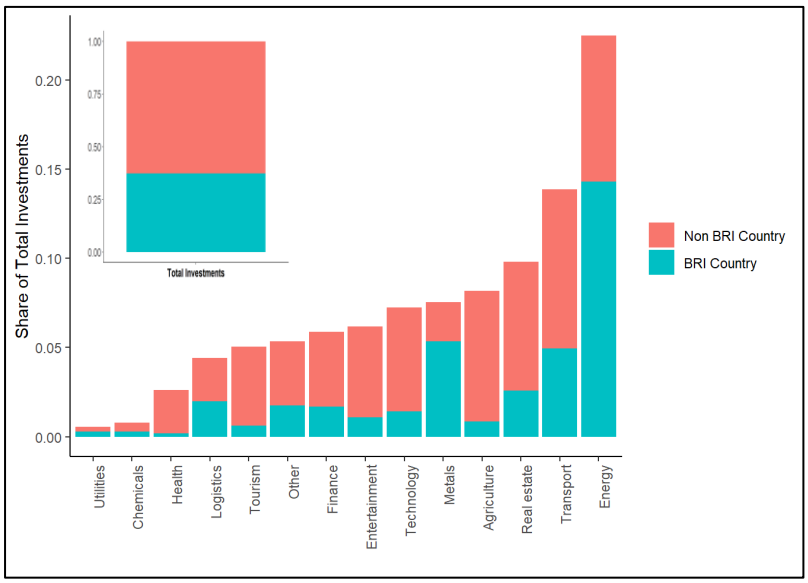


Source: Own Calculation

Note: Two upper panels describe the size of Chinese loans, with the panel on the right removing outliners to see a clearer gap between the median values of size of loans for BRI and non-BRI groups.

Figure 3 shows the allocation of Chinese investments by sector (still based on AEI database, removing all investments without information of BRI). Both BRI and non-BRI spread on 14 different sectors, however, non-BRI prevails for almost all sectors, accounting for 62.7 percent of total investments. Considering the fact that BRI has been the main channel of Chinese outward investments since 2015, and a lot of other investments made before 2015 have been rebranded as under BRI, the AEI's data on BRI investments can be inadequate. Let us now look at what we have.

Figure 3: Chinese Investments Allocation by Sector



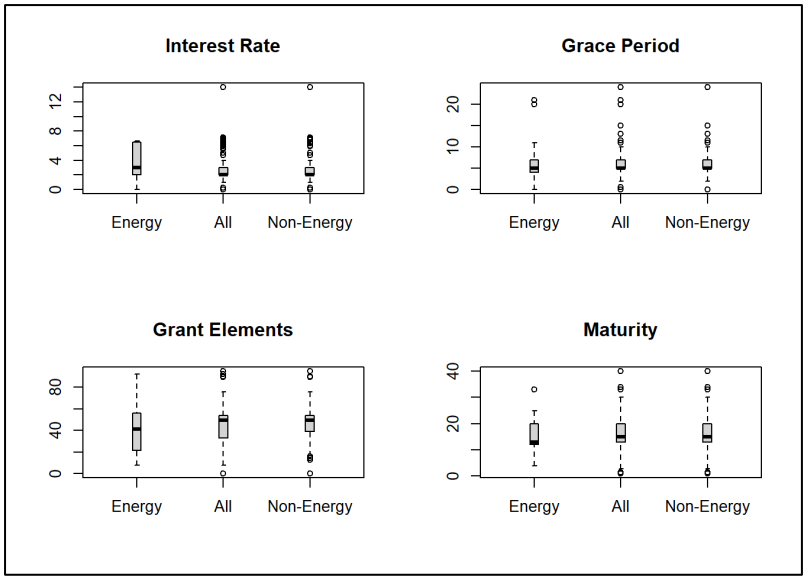
Source: Own Calculation

Energy and Metals get the highest share of BRI investments and are also the only two sectors that BRI investments exceed non-BRI. We also see that the distribution of investments for BRI just focuses on several key sectors while non-BRI sees a more even distribution. Interestingly, only 5.2 percent of total Chinese investments (including the investments with no information of BRI) are under technology sector, which confirms the claims of many scholars of the low rate of knowledge spill-over of Chinese investments.

I would like to compare the terms of loans of BRI and non-BRI loans. However, in the data set of Aiddata, which provides the information of terms of loans, it is not indicated which loans are BRI. Therefore, I compare the loans for only energy sector, which is the key sector of BRI projects, and all the other investments. The comparison is illustrated in Figure 4 below. Clearly, the terms of loans under energy sector appear less favourable than those

under the other sectors and also than concessional loans from official lenders like the IMF and the World Bank.

Figure 4: Comparison of Terms of Loans between Energy and Other Sectors



Source: Own Calculation

In particular, the median values of the interest rate, maturity, and grace period for energy sector are 3 percent, 13 years, and 5 years compared with 2 percent, 15 years, and 5 years for the other sectors, and compared with 2 percent, 40 years, and 10 years for the World Bank concessional loans for the small economy, respectively. The grant elements for loans in energy sector is also lower than non-energy sectors. Such loans of higher interest rate, lower grant elements, and shorter maturity and grace periods in energy sector that we observe in the data set are also typical BRI loans, which have been reported through media and case studies. We see that even though the structure of the Chinese lending above (based on only the fraction of data with available information) indicates a domination of concessional loans rather than non-concessional ones, the terms of the loans are not so favourable for the borrower countries, which is particularly true for BRI sectors like the energy sector.

Not more favourable, though, BRI loans have been welcome by many countries, most of which are from developing world. The next sub-section shows us what is happening in the real world.

2.3. Belt and Road Initiative's mechanisms

There are several key mechanisms of BRI loans and projects based on the literatures and case studies that I would like to discuss here, focusing on the traits that are closely connected with its impacts on growth and debt distress in recipient countries.

First, BRI loans entail a higher level of debt services. As discussed above, Chinese loans and especially the loans for BRI sectors like the energy sector usually have higher interest rates and shorter maturities and grace periods than the concessional loans from traditional creditors. This can explain the more than proportional increase in debt services payment in the sample when unreported Chinese debt is included in the study of Horn *et al.* (2019). In 2015, African governments took total loans of 32.8 billion US dollars, out of which 18 billion went to interest and principal payments. Financing investments by commercial loans with higher debt services is ill-advised for developing countries, as the revenue generated by these investments will be greatly absorbed by debt servicing and thus not sufficient to boost the growth, resulting in the inability of debt repayment. However, there has been a continuous decline in the concessional debt in Africa against a considerable increase in shares of commercial and other loans, indicating a trend of shifting to riskier loans for African countries, which could have been exacerbated by BRI (Onjala, 2018).

Second, an inefficient use of the funds or corruption is a critical issue observed in Chinese investment projects, including BRI. There are two key mechanisms of BRI loans that can either intentionally or unintentionally create place for corruption. One is the non-transparency, which can already be seen from the data sets of Chinese investments above. According to a recent study of Horn *et al.* (2019), half of China's lending is "hidden". This problem is even worse within company-company transactions, which is typical for BRI projects, hindering transparent reports and allowing corruption. Due to the non-transparency, not only growth is harmed through corruption, but the debtor countries are also not fully reported about their country's debt situation and can therefore not have informed decisions and face a higher risk of debt distress.

The other mechanism that enables corruption is the "hands-off" or "no string attached" policy of Chinese lending. Rather than a donor, China considers itself as a partner in "South-South cooperation" (Penny, 2020; Sautman and Hairong, 2007; UNDP, 2020) and has nothing to do with the local power dynamics as long as its benefits are maintained (Conley

et al., 2020). It also often sacrifices social and environmental safeguards for the profits (Hillman, 2018a). As governance and institution are crucially important to the efficiency of investment (Easterly *et al.*, 2004; Hurley *et al.*, 2019), China's non-interference in how the borrower uses the loans can allow room for bad governments to make use of the money for their own benefits. As a result, the borrower countries, especially those with high corruption and weak institutions, will not use the loans efficiently and therefore cannot gain enough income from the debt-financed investments to pay back the debt.

Box 2: Malaysia – A story of corruption

1MDB is Malaysia's national development fund launched by the former Prime Minister Najib Razak. In 2016, China gave loans to Najib to save 1MDB from insolvency in exchange for the rights to implement strategic projects in Malaysia, many of which were signed under BRI, according to senior Malaysian government officials. For example, 1MDB received loans of 2.3 billion US dollars from China after China General Nuclear Power Corp bought 100 percent of Edra Global Energy Bhd (the second-largest power producer in Malaysia). As of 2018, BRI projects worth nearly 100 billion US dollars had been announced in Malaysia (Ackerman, 2020).

It did not take long before 1MDB was found to have got engaged in serious corruptions in 2016 of 3.5–4.5 billion US dollars (Hope *et al.*, 2016). At least 1 billion US dollars was transferred through government agencies, banks, and companies linked to 1MDB to Najib's bank accounts (Balding, 2018). Later in 2019, China was found to influence the investigations on 1MDB's corruption and supported Najib to identify journalists involved in investigating the corruption in exchange for Malaysia raising the spending on the East Coast Rail Link by twice, paying 16 billion US dollars and approving other BRI projects of some more 18 billion US dollars (Wright and Hope, 2019).

After the 1MDB scandal, the opposition party's representative, and current Prime Minister Mahathir Mohamad, won election for the first time in 2018 since the country's independence due to such a strong response to Najib's corruptions. The new government then found out that while only an average of 13 percent of the pipeline project was completed, almost 90 percent of the costs had been already paid to Chinese companies, which means the payment was made according to timeline rather than real work progress. The new government also decided to cancel two largest BRI projects – a 20 billion US dollars railroad and a 2.3 billion US dollars natural gas pipeline (Ackerman, 2020).

According to Onjala (2018), Kenya loses 15–20 million US dollars per year in each sector of power and infrastructure (two key sectors of BRI projects) because of inefficient use of

capital. Another example is the BRI project in Hungary, Hungary-Serbia Railway, which is estimated to need from 130 to 2,400 years to start to generate profits (Hillman, 2018a).

Box 3: Djibouti–Ethiopia Rail-Link (DERL) – An example of failing feasibility studies

Djibouti is a small country but a hub of the most important ports in east Africa, connecting east Africa with the global economy. So far eight big countries have established military bases in Djibouti and China started its military base in Djibouti in 2017 (Wan *et al.*, 2020).

Since 1980s, China has been Djibouti's largest sources of foreign aids, especially in construction sector with many hospitals, schools, railway, and Ministry offices. Besides aids, China is also the leading lender to Djibouti, providing 77 percent of Djibouti's total external debt in 2017. China Merchant Group (CMG), a Chinese state-owned enterprise, has been responsible for constructing all ports of Djibouti-city, and has brought China's "Shekou model" to Djibouti, accompanied by exporting Chinese materials to this country. Among the BRI projects constructed by CMG, such as Hambantota port (Sri Lanka), Tin-can Island container terminal (Nigeria), Lomé container terminal (Gulf of Guinea), Kumport Terminal (Turkey), Djibouti's DERL leads in both scale and speed (Wan *et al.*, 2020). DERL, the 756-kilometer railway is the benchmark BRI project in East Africa so far, with the cost of around 3.5 billion US dollars, 70 percent of which was funded by China Exim Bank (Styan, 2020).

Djibouti's economic growth depends strongly on the trade connections with Ethiopia and other external sources. In 2019, more than 95 percent of goods were transported by the Ethiopia Shipping Lines (ESL) highway rather than DERL, and DERL could operate less than four times a week on average. Even worse, electricity shortage occasionally forced the train to move backward 20km on a slope until the power could restart. Furthermore, there has been no well-defined and -implemented railway management law in Ethiopia, leading to destruction of "common goods" and thus higher maintenance costs. As a result, DERL made a severe loss and could not finance itself, adding to the already heavy debt burden of Djibouti. All these could have been avoided in the first place by a careful project feasibility study.

The IMF report indicated that Djibouti's debt to GDP ratio has increased from 50 percent in 2014 to 85 percent in 2016, mostly from the BRI loans, and advised Djibouti against any additional borrowing. In 2017, however, Djibouti continued to get a loan of 340 million US dollars from China for the Doraleh Port project, raising its debt to GDP ratio to 87.1 percent in 2019 (Wan *et al.*, 2020).

Third, because economic interests besides political interests decide the BRI investment decision (Axel and Andreas, 2015; Dreher *et al.*, 2018), BRI loans have many conditions to maximize profits for Chinese companies and shift the risks to the borrowers. Among other things, most of BRI projects do not follow local procurement laws but the terms of Chinese loans. There is usually no competitive bidding, but a Chinese contractor will be designated (by China) for a specific BRI project. Then that Chinese contractor carries out its own feasibility study. Such a mechanism allows the manipulation of cost-benefit analysis and feasibility study, usually resulting in lower than actual up-front costs and later cost inflations.

Box 4: Standard Gauge Railway (SGR) – An example of cost inflation

Launched in 2013, SGR is the largest (BRI) infrastructure project for cargo and passenger transportation in Kenya. In 2014, Kenya got a loan of 3.233 billion US dollars from the China Exim Bank to cover 90 percent of SGR's cost (Githaiga and Bing, 2019).

SGR was divided into two phases, phase 1 of 472km Mombasa–Nairobi and phase 2 including 120km Nairobi–Naivasha (2A), 270km Naivasha–Kisumu (2B), and 107km Kisumu–Malaba (2C). The first phase cost 3.8 billion US dollars (5 percent of Kenya's GDP as of 2019) and was financed by a commercial loan of 1.633 billion US dollars and a concessional loan of 1.6 billion US dollars with a five-year grace period (Gu and Qiu, 2019) and a repayment period of 40 years. In return, the post-completion would be under China Road and Bridge Corporation (CRBC)'s operation – the company in charge of the project's construction, for 10 years. Like for all BRI projects, Chinese side decided the terms of loans and carried out its own feasibility studies, exempt from any competitive bidding process. Then they applied the complete designs of projects based on Chinese engineering standards (Onjala, 2018).

According to Ackerman (2020), while the SGR phase 1's cost can be inflated from 3 to 8 billion US dollars, the envisioned revenues of freight from 22 million tonnes per year have been recalculated and reduced to a third (8.76 million tonnes a year). In the meanwhile, SGR needs to serve at least 20–55 million tonnes annually to be able to service the 200 million US dollars of interest per year and still make small profits. Indeed, SGR's revenues were 44 percent less than initial calculation in the first year of commercial operation (2017–2018), making a loss of 100 million US dollars. With the principal getting mature in July 2019 and China rejecting phase 2's funding request, leaving the whole project uncompleted, SGR cannot finance itself and in 2018, Kenya further borrowed 750 million US dollars to cover other loans and interest payment (Gu and Qiu, 2019).

Box 4 (cont'd.)

To compare, Tanzania built the railway of similar length and through similar terrains at half SGR's cost (around 1.9 billion US dollars), even though the Tanzanian line is electric with better speed than Kenya's diesel SGR. In fact, there were many other proposals for SGR that were considerably more cost efficient, among which was a study by the World Bank, recommending rehabilitating or upgrading instead of building new railway stations and requiring land acquisition. Kenya, however, rejected all and chose the most expensive one proposed by China (Ackerman, 2020).

From 2013 to 2019, Kenya's debt to China went up continuously from 500 million to 5 billion US dollars. China has become Kenya's largest bilateral creditor, holding 72 percent of Kenya's total bilateral debt and 21 percent of its total external debt (Ackerman, 2020). In 2018, Moody's lowered Kenya's credit rating to B2 from B1 and listed it as among the countries that are the most vulnerable to losing access to Chinese loans. IMF also raised Kenya's risk of default from "low" to "moderate" and ended its access to a 1.5 billion US dollars credit (Ackerman, 2020).

In the meanwhile, SGR's impacts on growth do not show positive patterns. While the promise of CRBC to generate more than 30,000 jobs for the locals has not been realized, 5,000 Chinese workers already migrated to Kenya to work for the SGR project. Chinese workers trained for a week are also reported to be paid with higher salaries than the Kenyan who had been trained for three years. As a result, there are frequent protests and attacks on Chinese workers from local workers (Wafula, 2017). Besides, the trade imbalance caused by importing Chinese materials for SGR projects further worsens the current account deficit of Kenya. In 2017, for example, Kenya's imports from China reached 3,778 billion US dollars, covering around 23 percent of its total imports, compared to 96.7 million US dollars value of its export to China, which was equivalent to 1.68 percent of its total exports (Gu and Qiu, 2019).

Corruption and environmental damages caused by BRI projects are also crucial issues in Kenya. In 2018, seven officials from CRBC were found to get engaged in corruption. During SGR's phase 1, 10 elephants died when they crashed into trains. The BRI construction was also reported to drive wild animals like lions out of the Nairobi National Park. Even worse, elephant poaching and ivory smuggling incidences increased strongly since many Chinese workers entered Kenya. As a result, SGR phase 2 was delayed by the Kenya's National Environment Tribunal to wait for an environmental impact assessment to be done (Ackerman, 2020)

The terms of BRI loans also favour Chinese labour and materials rather than the local ones. The low local participation in BRI projects can impede the efficiency of investments in the local economy and hence growth and debt repayment ability. According to Hillman (2018a),

out of all recorded Chinese loans financed projects from 2000 to 2014, 89 percent are constructed by Chinese companies against 7.6 percent of local companies. To compare, 40.8 percent of projects funded by the Multilateral Development Bank (MDB) are implemented by local enterprises. The interest rate of the loans is also used to negotiate the share of Chinese labour used, with the interest rate being usually higher for the projects of low Chinese labour participation.

Finally, China has many terms to protect Chinese lenders against risks of bad debts like collateral clauses, circular lending, or setting the currency of US dollar or RMB. Around half of Chinese overseas lending is collateralized (Bräutigam and Gallagher, 2014), and 85 percent of Chinese loans from 2000 to 2017 are contracted in US dollars (Horn *et al.*, 2019). Collateral clauses allow for debt repayment in natural resources, especially oil (Adisu *et al.*, 2010; Alden and Davies, 2006; Brautigam, 2003). In some not very often cases, debt can be exchanged with land. For example, China wrote off debt of some unannounced amount for Tajikistan in 2011 for 1,158 square kilometres of land (Abdul, 2018; Hurley *et al.*, 2019).

In many risky cases, China disburses the loans directly to the Chinese companies implementing projects in the recipient countries instead of the recipient countries' bank accounts. In such instances, there would be in fact no out-of-China transactions, which makes the record of loans more difficult and the problem of the non-transparency becomes even worse. Under CPEC, for example, Adnan (2018) notes that "*not a dollar of the Chinse loans has entered Pakistani banking channel*." Such methods to guarantee repayment allow China a flexible and irresponsible approach in lending, and it is willing to give loans to even proven non-profitable projects or even countries in active conflicts, such as Syria and Yemen (Hillman, 2018a).

Overall, BRI, with many cases of "more expensive" loans being used inefficiently due to high corruption, accompanied by irresponsible project evaluation and implementation, obviously incurs inflated costs and less than expected revenues. All of this can put the financial viability of BRI projects and thus the impacts of BRI on growth and debt distress in recipient countries under a critical question.

Box 5: China–Pakistan Economic Corridor (CPEC) – A boom that does not last

Pakistan's total external debt increased sharply since CPEC's launch from an average of 53.53 billion US dollars between 2002 and 2015 to 92 billion US dollars in 2018, 88 percent of which was from commercial loans from China (Adnan, 2018; Monika, 2018). In 2017, it must get a loan of 10 billion US dollars for debt servicing, including 4.4 billion from China and it is estimated to borrow further 13 billion US dollars for debt servicing in 2019 (Adnan, 2018). Its current account deficit has also increased around sevenfold, largely due to CPEC-related imports of 19 billion US dollars, which can reach 27.8 billion by 2021 (Adnan, 2018; Pershing, 2019).

Due to the high debt level and current account deficit, Pakistan's boom in GDP growth rate (5.43 percent in 2018), which has been claimed by many Pakistani governmental officials to be thanks to CPEC, does not last long. Standard and Poor's predicted that Pakistan's growth rate would come back to its average of 3.6 percent in the 2019-2022 period, and its credit rating also got worse from a "B" to "B-" (Pershing, 2019).

In the meanwhile, CPEC's impacts on growth have proved limited and even adverse in the long run. CPEC electricity output is estimated to be 40 percent more expensive than a similar ADB-financed project in Jamshoro. The explanation for this higher than the market price is mainly because of the lack of competitive bidding. At this cost, CPEC's electricity can neither solve the energy crisis nor boost the growth for Pakistan (Pershing, 2019). Furthermore, the intensive participation of Chinese companies, who are allowed long-term tax exemptions in Pakistan and the policy of subsidized imports from China have crowded out many local contractors and pushed some to bankruptcy (Monika, 2018). As for the expectation of CPEC turning Pakistan into a high-value manufacturing hub, most of special economic zones (SEZs) remain unemployed, with limited development of information and communication technology (ICT) projects (Conley *et al.*, 2020).

Hurley *et al.* (2019) argue that loans to the private sector, even though claimed by many BRI countries' governments not to have any binding effects on the sovereign, must be eventually dealt with by the government if the private companies cannot pay back the debts, as observed in the case of the Vientiane-China high-speed railway. Horn *et al.* (2019) also show that the number of sovereign debt defaults, distress and restructurings involving Chinese loans is becoming more prevalent. In the meanwhile, debt write-offs in BRI are of limited amounts and usually accompanied by further lending, which does not help in the long run. For example, Tajikistan's debt in 2011 were wrote off, followed by an offer of another loan of 1 billion US dollars with a new infrastructure project from China (Agatha *et al.*, 2019).

As a result, the trend nowadays is that some of these borrowers become too dependent on China and endorse for China's international political positions regarding Taiwan's status, the South China Sea conflicts, Xinjiang and other human rights abuses (Agatha *et al.*, 2019; Conley *et al.*, 2020), and some have cancelled BRI projects, among the others are Malaysia with 23 billion US dollars projects, Myanmar with 3.6 billion US dollars hydro power station project, and Pakistan with 14 billion US dollars Diamer Bhasha Dam project (Abdul, 2018; Hillman, 2018a; Tweed, 2016).

Box 6: Kazakhstan – Strong disputes with the locals

From 2012 to 2017, Chinese investment in Kazakhstan has gone up substantially by seven times. Since 2015, many agreements between China and Kazakhstan have been signed. As of 2017, 12 industrial production sites have been transferred from China to Kazakhstan. Khorgos, the key BRI project in Kazakhstan, is an international dry port and was constructed on the Kazakh border in 2015, connecting Kazakhstan and the Chinese port of Lianyungang. With a planned capacity of 500,000 cargo containers, Khorgos is envisioned to become the world's largest dry port by 2020.

Despite such an intensive investment of China in Kazakhstan, the Kazakh have a very bad impression of China. In a survey by the Eurasian Development Bank in 2016, five out of six Kazakhs have a negative idea of China, and China is among the top three unfriendliest countries to them. In 2016, protests occurred in many regions of Kazakhstan against the new law allowing sales of land to foreigners, which was directly related to China's intention to purchase land in Kazakhstan. Furthermore, there have also been frequent clashes between the Kazakh and the Chinese workers due to the discontent on payment discrimination and labour treatment. January 2017, protests took place in Astana against marriages between Kazakh women and Chinese men, asking withdrawing the Kazakh citizenship of these brides and even taxing Chinese men 50,000 US dollars for marrying a local woman (Cheung and Hong, 2019).

According to Zhao (2020), as of 2018, 14 percent of BRI projects in 66 countries met public opposition regarding labour policies, construction quality, and concerns over national security. Due to the imperfect information collection, this percentage can be in reality much higher. Local resistance has led to infinite delays of BRI projects in many countries like Thailand, Indonesia, and Zambia. In 2012, for instance, many miners were shot by two Chinese supervisors and one Chinese supervisor was killed due to the wage dispute at a coal mine in Zambia (Balding, 2018; Githaiga and Bing, 2019).

Concluding this chapter, since 2015, 126 countries and 29 international organizations have signed cooperation agreements with China under BRI (BRI Official Portal, 2019). While BRI loans are planned to be fully disbursed by 2023, BRI's impacts on growth have not proved substantial and positive. So far, around one-third of BRI countries that have sufficient information for assessment are assessed as post-BRI vulnerable to debt, some of which have their already high debt vulnerabilities worsened (Bandiera and Tsiropoulos, 2019).

The World Bank (2019) indicates that BRI transport projects alone can help promote the global trade (in the long term) by 1.7–6.2 percent and raise the world real income by 0.7–2.9 percent if they are implemented fully efficiently, and if there is a sustained negative interest rate-growth differential and no BRI related fiscal risks materialized (Bandiera and Tsiropoulos, 2019). As discussed above, there have been too many obstacles between the reality and the above indication. BRI recipient countries therefore must protect themselves from falling into debt distress because of overborrowing, starting by preparing themselves an effective methodology of debt distress analysis. The next chapter discusses such an effective methodology.

3. Modelling the debt distress in BRI recipient countries

3.1. Relation to existing literatures

As mentioned above, this paper revisits the work of KN, who successfully put forward a simple model to assess risks of debt distress for LICs almost 2 decades ago. The reason for my choosing this work is because it provides a better approach in building the indicator of a country's debt distress. Instead of using the credit rating, for example from Moody's, which is not always available for all countries, the authors try to count the actual incidence of debt distress based on total long term arrears, debt restructures or reliefs with the Paris Club, and the IMF support under Standby Arrangements or Extended Fund Facilities (SBA/EFF) programs.

Obviously, the country's inability to service debts is reflected through either a high volume of long-term arrears or the country using external help (from the IMF or the Paris Club), or both. Besides the IMF support, which is usually used by many scholars as an indicator of difficulty in debt repayment, the Paris Club debt restructurings or reliefs should also be taken into account as the Paris Club only supports the extraordinary debt problems. It considers both financial factors like the balance of payments and external sources of financing, and macroeconomic conditions, and covers all the cases of the HIPC Initiative of the IMF (in Naples terms). By using the three above conditions, KN can identify events of severe difficulties in debt servicing and thus debt distress. Overall, KN's model is straightforward and easy to apply while the results are highly respectable, not restricted to only LICs.

Particularly in the base model, KN analyse the relationship between the dependent variable – debt distress incidence with 3 groups of core explanatory variables namely debt burden (represented by the present value of debt relative to contemporaneous exports (PV debt/exports) and total debt services to exports (debt services/exports)), policy (World Bank's Country Policy and Institutional Assessment – CPIA (ratings)) and shocks (real GDP growth). Working with the data of 57 LICs from 1970 to 2002, KN conclude that the policy quality explains much more than the debt burden for the incidence of debt distress in many cases, especially in poorer countries, and that policy improvements are as important as debt reductions. The out of sample (OOS) predictive power check also shows that the predictive power of the combined specifications of the above variables is significantly better than any univariate prediction.

In this paper, the only change that I make to KN's specifications is the replacement of CPIA ratings with the World Bank Worldwide Governance Indicators (WGI) Rule of Law (ROL) index due to the unavailability of the CPIA. KN show in their study that this replacement does not change their regression results, so my specifications can be basically considered as equivalent to KN's specifications, and I can use the specifications replacing CPIA with ROL, which I call the "core specifications", to test the performance of KN's base model on the new data sample. Later in the next chapter, I show that my regression results of the core specifications on the new sample are more or less the same with KN's base model on the old sample, except that the predictive power of my regressions is lower than KN's. Note that although keeping the regression results unchanged, ROL when replacing CPIA is somewhat less significant (than CPIA) according to KN, which can in part lead to the reduced predictive power above. Besides, the two data samples' difference can also play a part.

Given the difference between my data sample and KN's regarding the diversity of countries and the change of time, that KN focus their analysis on the debt distress in 57 LICs in the time period from 1970 to 2002, while I run regressions on 120 BRI countries, nearly 80 percent of which are MICs, I expect that not including country-specific effects and time or history effects can explain substantially the lower power of prediction of KN's model on my data. This expectation is also in accordance with the results of some robustness checks done by KN, which suggest that the income level and other country-specific effects, and the history effects can cause a variation of performance between the regressions.

For the robustness check on the income level, KN divide their sample into two sub-groups of low income and high income based on the median level of per capital income in the sample. KN find that all explanatory variables become slightly less significant for both sub-groups, and the magnitudes of the estimated effects of these variables also change. Particularly, policy's marginal effect on debt distress in low income group doubles that in high income group while the debt burden variables have a converse pattern, with a three-time higher marginal effect for richer countries than poorer ones. Though these effects are not strongly significant, this still suggests that income or development level of the countries in the sample can influence results of the regressions. KN indicate that the lower significance of the variables in the sub-samples may simply reflect the smaller sample sizes. However, I show later that KN's model can perform better for a specific income group rather than the whole sample, which means a smaller size does not necessarily lead to a worse performance

and income group really matters to the regressions' results. Besides, another robustness check done by KN also shows that controlling for unobserved country-specific effects causes some changes in the significance of the core variables. Excluding the country effects can be among the key reasons that KN's model has a lower power of prediction in the new data. This motivates me to add country-specific effects with the variables of income group and region to the regressions, which contributes to improving the performance of KN's base model.

As for the history effects, KN add to the base model the variable of the historical policy performance of the country, represented by the fraction of years with the inflation rate higher than 40 percent. KN find that the history indeed matters, though it does not dominate the effects of contemporaneous policy quality. From this point, I argue that both historical and contemporaneous policy performance are important, and not taking into account the history effects also explains partially for the poorer performance of KN's model on my data sample. Therefore, I try further adding a variable for historical financial situation of the country to the core specifications. With this I show that the added variable is highly significant and brings about a higher explanatory and predictive power for the specifications. Following I call the specifications of KN's base model with additional variables the "extended specifications".

KN also carry out a number of other robustness checks, using varied alternative indicators, including the face value of debt to exports, debt services to current government revenues, and debt services to non-gold reserves for the debt burden indicators; ROL index for policy quality; and terms of trade (TOT) growth and real deflation growth for shocks. They find that all the alternative variables are significant and do not affect the fundamental conclusions of the original regressions, though ROL index has a slightly lower explanatory power than CPIA as mentioned above and the PV debt measure performs better than the face value of debt. In this paper, besides acknowledging the results from these robustness checks, I perform two more robustness checks, one for policy quality replacing ROL index with the WGI's Corruption Control index (CCI) and another for debt burden indicator using the ratio of face value of debt to GNI (debt/GNI) in place of PV debt/exports. I show that both the core and extended versions of KN's model are robust to these alternative variables.

Another paper on determinants of debt distress worth reviewing is the one from Reinhart *et al.* (2003). Based on the data of over 100 countries from the 1820s, the authors show that, in

addition to current debt burden, institutional quality and especially the historical debt payment performance play the key role in determining the debt distress. This further motivates me to include a variable of history effects in the debt distress regressions. Also according to Reinhart *et al.* (2003), the property right index like the ROL index is strongly relevant as weak property right can lead to capital flight and tax avoidance, reducing domestic private investments and national revenues and worsening the debt payment capability. As mentioned above, I use ROL index in place of CPIA ratings and show that ROL index is highly significant in determining debt distress, which is consistent with Reinhart *et al.* (2003)'s findings.

Many other works on debt distress are about finding out a debt threshold. Debt threshold is a level of debt burden indicators (usually face value or present value of debt as a share of GDP, GNI, GNP or exports) beyond which the debt-financed investments cannot boost the growth anymore and the country risks falling into debt distress (Hurley *et al.*, 2019). Debt threshold is a very important concept as it helps the official lenders decide the grants and loans and it also plays a key role in determining debt distress probability of a country. In fact, debt threshold is usually overestimated for poor countries and it should also be much lower in poor countries than rich countries (Reinhart *et al.*, 2003). Corsetti *et al.* (2018), for example, suggested the debt threshold being 50-180 percent of GDP (for euro area) while Chudik *et al.* (2015) came up with the number of 50-60 percent of debt to GDP for developing economies. For EMEs, IMF (2020) suggested a debt threshold of lower than 31-39 percent of GNP. The debt threshold must be context-dependent, and it depends strongly on many factors like shocks, economic growth, and the terms of the loans (Kraay and Nehru, 2006). This thesis paper is also more interested in a country-specific debt threshold than a one-size-fits-all.

Besides the debt threshold, debt burden indicators are also a key variable in debt distress analysis. Studies on debt distress have long used total external debt and debt services (face value) as variables for debt burden (Bandiera and Tsiropoulos, 2019; Hurley *et al.*, 2019). In addition to that, the present value of debt (PV debt) is becoming an increasingly important indicator of debt burden. Many scholars claim its superiority to the face value because the face value of debt does not attribute the differences in repayment terms (Dikhanov, 2005). For this reason, many official lenders like the IMF and the Paris Club use PV debt measures for their debt operations. For example, the HIPC Initiative in 1996 adopted the PV

debt/exports of 150-250 percent as the official debt threshold, which was adjusted lower in the Enhanced HIPC in 1999 (Cohen, 1999; Underwood, 1990).

Dikhanov (2005) has calculated PV debt for all developing countries from 1980 to 2002 by applying specific interest rates tailored by currency, terms of loans, time and market information on a loan-by-loan basis to the flows of total external debt, using data from the World Bank's Debtor Reporting System database. In this paper, I also use PV debt as among the key variables of debt burden and use Dikhanov (2005)'s method to calculate PV debt for my data set.

3.2. Data and Methodology

3.2.1. Identifying debt distress episodes

In this thesis paper, to model the debt distress in BRI recipient countries and analyse BRI's role to debt distress incidence, I work with a data set of 159 countries over the period from 1970 to 2020, including 120 BRI and 39 non-BRI countries. Unless stated otherwise, all the regressions are done on a subset of 120 BRI countries. Non-BRI countries will be included when I would like to see the distinctions between BRI and non-BRI countries.

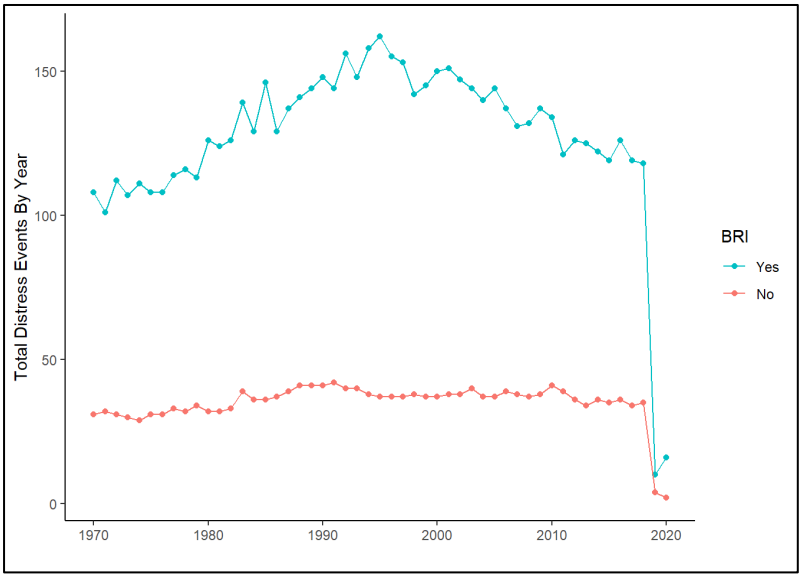
Following KN's approach, identifying debt distress episodes includes two steps: counting debt distress events for each country in each year, and counting debt distress episodes. I count the debt distress event as 1 if one or more of the three following conditions hold: (i) the country's sum of interest and principal arrears accounts for at least 5 percent of the stock of debt outstanding (henceforth arrears/DOD), (ii) the country takes debt restructurings or reliefs from the Paris Club, and (iii) the country receives a balance of payments support from the IMF under SBA/EFF that is equivalent to at least 50 percent of its the IMF quota. Note that the Paris Club debt restructurings or reliefs are based on three-year balance of payments projections by the IMF, so for each incidence of the Paris Club debt restructuring or relief, I count that year of incidence and the two subsequent years as of distress events.

For the data on arrears and debt, I use the arrears on long-term debt outstanding from official and private creditors, which are provided by the World Bank's International Debt Statistic database. The data on SBA/EFF programs and Paris Club debt restructurings or reliefs are obtained from the IMF Financial Data Query Tool and the Paris Club's website, respectively.

Now explaining for the threshold that we (KN and I) have chosen in the first condition, we choose a number that is substantially higher than that of a median country. The median value of arrears/DOD is 0.4 percent for KN's sample and 0.6 percent for my sample when pooling all countries in the sample for all years, so the threshold of 5 percent is already 8–10 times higher than the median values in both samples. As for the SBA/EFF in the third condition, the median value in both samples is zero for all countries-years pooling but increases to over 50 percent (52 percent for KN's sample and 59.7 percent for my sample) when looking at only countries with the incidents of SBA/EFF. By choosing the threshold of 50 percent, we can identify the values of top half of commitments to the IMF quota of all SBA/EFF programs.

Figure 5 shows the total number of debt distress events from 1970 to 2020, distinct between BRI and non-BRI countries. As can be seen, the plot covers many debt crises in history like the external debt crisis in Latin America and other developing countries in 1980s, the Asian and the Russian crisis in 1990s, and a part of the European sovereign debt crisis from 2008 to 2012.

Figure 5: Total Occurrences of Debt Distress Events by Year



Source: Own Calculation

After identifying all debt distress events, I count the debt distress episode as 1 if the distress events are observed in at least three consecutive years and then I exclude all temporary distress events of less than three consecutive years. This generates a total of 171 (debt) distress episodes for the whole sample and 137 distress episodes for the sub-sample of BRI

countries only. For the periods of non-distress events (none of the three above conditions occurs), I divide them into non-overlapping five-consecutive-year period, each of which I call a "normal episode". With this I get 469 and 348 normal episodes for the whole sample and for the BRI countries, respectively. With 137 distress episodes and 348 normal episodes, we have an unconditional probability of debt distress of BRI countries as the ratio of the total number of distress episodes out of the sum of all episodes being 28.2 percent, which is a little higher than that of KN's sample (20 percent).

The 137 distress episodes of BRI countries are listed in the Appendix A, where the average value of arrears/DOD, SBA/EFF and distress points as the average number of years under distress for each type of distress event throughout the episode are also presented.

3.2.2. The probit model and variables overview

KN do not explain why they choose the probit rather than the logit or other regressions, but I assume that their choice simply follows the norms. Logit regressions facilitate the interpretation of coefficients in terms of odds ratios, which makes them widely used in health sciences, while probit regressions allow accounting for non-constant error variances in more advanced econometric settings, which is preferred by economists. In many cases without advanced econometric applications, probit and logit regressions can yield similar inferences (Albright, 2015). To examine whether the conclusions of KN's regressions are still true for the new data sample, I would like to keep as much as possible from their original approach and therefore continue to use the simple probit model as their choice with the following notation:

$$(1)\ p[y_{ct} = 1] = \Phi(\beta' X_{ct})$$

out of that Φ(.) indicates the normal distribution function. y is the variable of Debt Distress, which takes the value of 1 for distress episodes, and 0 for normal episodes, while X represents a vector of debt distress determinants, with c standing for country and t for time (year), and β is a vector of parameters to be estimated.

In the base model, the vector X includes three groups of debt distress determinants with 4 core variables as discussed above, including debt burden indicators (PV debt/exports and debt services/exports), the policy quality (CPIA for KN's sample and ROL index for my sample), and the shocks (real GDP growth). Besides running the core specifications, I also

include additional explanatory variables to the regressions including the dummy variables for income group and region, and the variable of history effects (length of episodes).

In KN's paper, they simply took the data of PV debt from the work of Dikhanov (2005). As my sample includes more countries and extends the years through 2020, I have calculated the PV debt for my data set using the data on total long-term outstanding debt stock and grant elements from the World Bank database based on Dikhanov (2005)'s method. Dikhanov (2005) indicates that the present value of a loan can be calculated as the discrepancy between its face value and the grant elements. The details of the calculation methodology and the comparison between face value of debt and PV debt are illustrated in the Appendix B.

For the policy quality, KN use the CPIA ratings. Since the CPIA is not publicly available for a great number of countries, I use the ROL index instead, which has been proved by KN to keep the regression results the same when being used in place of CPIA (though with somewhat less significance). For the shocks, we both simply use real GDP growth in constant local currency, which can reflect both domestic and external shocks that the country experiences. In the regressions, we measure the debt distress determinants through their values at the beginning of each episode, which is the values in the first year of normal episodes, and the year prior to the first year of distress episode to avoid any potential endogeneity bias, acknowledging that the debt distress usually becomes worse from year to year during the episode. A summary of descriptive statistics for my regression data, which is the sub-sample of BRI countries only, is provided in Table 1.

It is interesting to see that an average distress episode lasts for over 10 years, which is relatively long, and the longest distress episode can be up to 47 years, which happens in Tanzania from 1972 continuously to 2018, mostly due to high arrears/DOD. I expect that this length of episodes can reflect closely the historical financial situation of the country. Later in the next chapter, I show that the variable of length of episodes proves remarkably significant in the extended specifications of debt distress model.

More importantly, through the clear contrast between the periods of distress and normal episodes as can be seen from the summary, we can confirm that the three conditions used to count distress events above help identify real severe cases of debt distress. The average arrears/DOD and the support of IMF under SBA/EFF, for example, is 20 times and 6 times respectively higher during distress than normal time. Or the real GDP growth in normal time

is on average 110 times higher than that during distress. Compared with KN's sample, there is a greater gap between distress and normal times in my sample of BRI countries.

Table 1: Statistical Summary of Data at The Beginning of Episodes for BRI Countries

Normal episodes							
	N	**Mean**	**St. Dev.**	**Min**	**P25**	**P75**	**Max**
Length of episodes (years)	348	5.000	0.000	5	5	5	5
Arrears/DOD	214	0.003	0.008	0.000	0.000	0.001	0.048
SBA/EFF	21	0.280	0.121	0.100	0.200	0.400	0.500
Consecutive years	348	25.986	13.491	5	15.8	36	49
PV debt/exports	127	0.990	0.864	0.000	0.351	1.363	4.883
Real GDP growth	123	0.044	0.048	-0.068	0.022	0.062	0.336
ROL index	68	-0.369	0.628	-1.737	-0.907	0.087	1.058
Debt services/exports	127	0.118	0.112	0.000	0.045	0.141	0.629
(Face value) Debt/exports	127	1.514	1.740	0.000	0.619	1.871	13.603
Debt/GNI	197	0.341	0.276	0.000	0.160	0.433	1.822
CCI	67	-0.434	0.595	-1.453	-0.808	0.009	0.988
Distress episodes							
	N	**Mean**	**St. Dev.**	**Min**	**P25**	**P75**	**Max**
Length of episodes (years)	137	10.547	10.122	3	3	14	47
Arrears/DOD	133	0.060	0.079	0.000	0.011	0.066	0.479
SBA/EFF	47	1.674	2.088	0.177	0.500	1.704	10.000
PV debt/exports	104	2.663	3.376	0.000	1.147	2.995	22.046
Real GDP growth	106	0.0004	0.077	-0.419	-0.021	0.048	0.138
ROL index	41	-0.620	0.613	-1.863	-1.109	-0.219	0.647
Debt services/exports	104	0.216	0.133	0.004	0.117	0.303	0.597
(Face value) Debt/exports	104	3.402	3.524	0.266	1.755	3.656	22.461
Debt/GNI	122	0.669	0.399	0.034	0.397	0.933	1.915
CCI	41	-0.665	0.540	-1.636	-1.067	-0.340	0.634

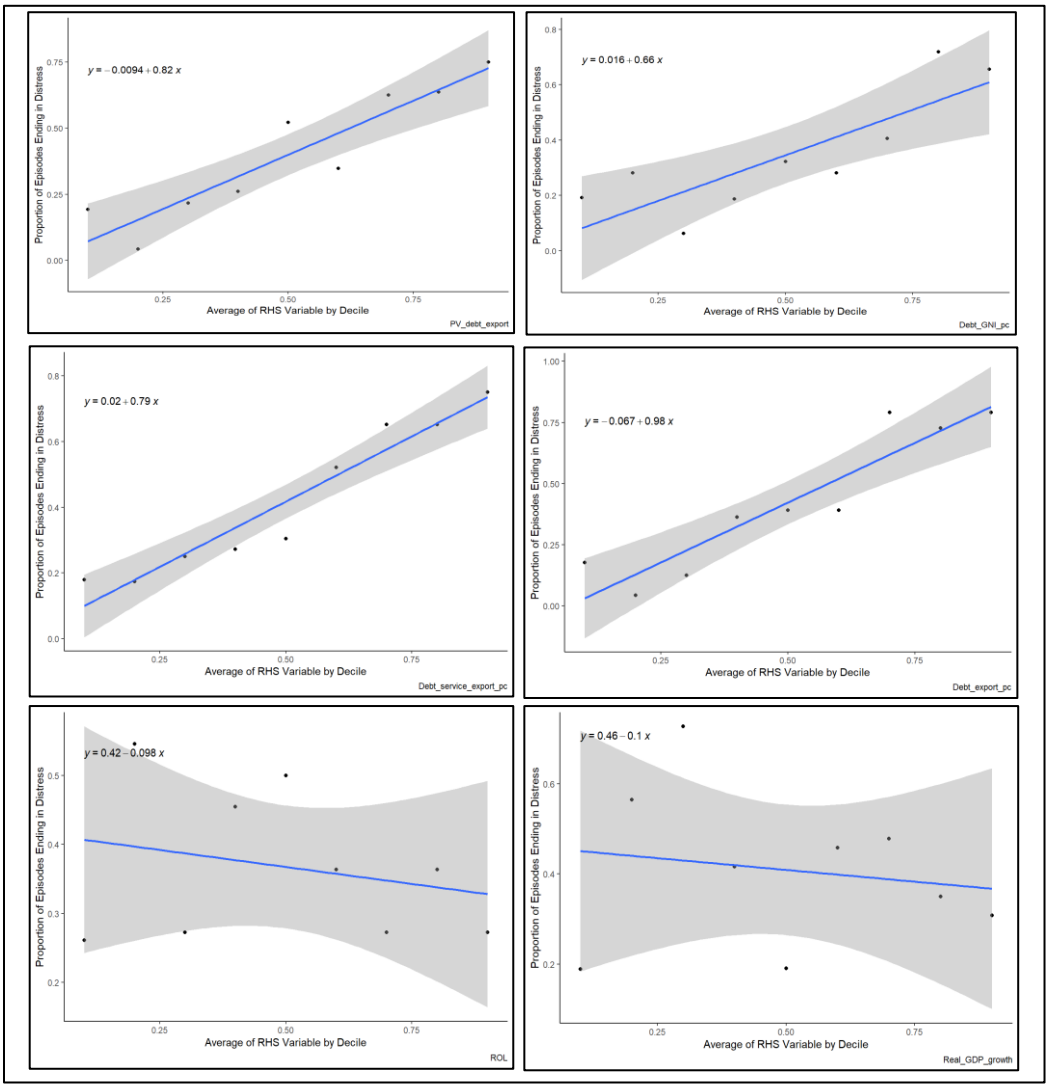
As a pre-regression step, I check the pairwise correlations between the core variables, still based on the sub-sample of BRI countries, and report the results in Table 2. Except for two variables of debt burden indicators having relatively strong correlation of 0.545, and policy quality and PV of debt being also somewhat correlated at -0.232, all the other correlation values are particularly small, which are quite similar to the results for the sample of KN. The low correlation among the variables indicates they are sufficiently independent and the partial effects of most of them are worth studying.

Table 2: Correlation Among Debt Distress Determinant Variables

	PV debt/exports	Real GDP growth	ROL index	Debt services/exports
PV debt/exports	1			
Real GDP growth	-0.067	1		
ROL	-0.232	0.056	1	
Debt services/exports	0.545	0.008	-0.098	1

Besides, I also look at the bivariate relationship between Debt Distress (y) and each of distress determinant variables (x), which are illustrated in Figure 6.

Figure 6: Correlation of Incidence of Debt Distress and Its Determinants



Source: Own Calculation

In each panel of this figure, the horizontal axis shows the average value of x by deciles and the vertical axis measures the average probability of episodes falling in distress by deciles of x. To compare with KN's sample, the BRI countries in my sample are much more vulnerable to debt. In the first upper left panel (captioned "PV_debt_export") of Figure 6, for example, the average share of distress observations in the top decile of PV debt/exports in my sample is 0.75 compared to just over 0.5 for KN's sample, which indicates that at a very high value of debt burden, only a quarter of the BRI countries in my sample do not fall into debt distress, while that number is almost a half in KN's sample.

All the other observations of KN regarding the relationship of variables hold in my sample of BRI countries. First, debt burden indicators are strongly positively correlated with the incidence of debt distress. Second, there is a linear relationship between all variables of debt burdens (PV debt/exports, debt services/export, face value of debt/exports and debt/GNI) and the probability of debt distress. Third, policy quality and real GDP growth are negatively correlated with the debt distress probability, though the patterns of linearity cannot be observed.

By now I have discussed the related studies, the data, and the model. I have briefly compared the results of the regressions of KN's model on their sample and mine and explained my ideas and plan. I have also described the data and preliminarily analysed the relationship between the core variables. Details on the results of the regressions and implied discussions follow.

4. Regression results and discussion

4.1. Determinants of debt distress

In this part, I will discuss the results of my regressions. Starting with the base model, I show that all core variables are statistically significant, which is consistent with KN's findings. The relative performance across specifications in my regressions is also similar to KN's, with the best specification combining all core variables. However, the overall predictive power of the model observed in my sample (of BRI countries only) is lower than in KN's sample. Then, I find out that when I extend the base model by adding the income group, region and the length of episodes as explanatory variables, the extended specifications have much higher Pseudo R-squareds and OOS predictive power.

4.1.1. Core specifications

4.1.1.1. Regression results

Table 3 presents the results of regressions using the core specifications. The first four columns show univariate probit regressions for each of the explanatory variables. We see that all 4 variables are highly significant in determining debt distress incidence, though policy quality seems to have the weakest explanatory power with Pseudo R-squared being only 2.2 percent when being used alone, possibly in part due to many missing values in the sample. In my sample, the univariate specification using PV debt/exports becomes much more powerful with Pseudo R-squared of 18.8 percent, more than doubling that in KN's sample. Note that KN already show that debt burden (policy quality) has more (less) impacts on debt distress in richer countries than the poorer. In my sample with around 80 percent of the countries being MICs compared with KN's sample of all LICs, PV debt/exports (ROL index) becoming more (less) powerful is consistent with the findings of KN. The columns (5), (6), (7) and (8) describe the partial effects of the explanatory variables, where for (5), (6), and (8) I remove in turn debt services/exports, PV debt/exports and ROL. Column 7 presents the combination of all 4 variables.

Though the change in most of the estimated coefficients is not large, which is consistent with the low pairwise correlations among explanatory variables discussed above, there can be still some interesting points from the change worth discussing here. As we can see, compared to the univariate specification, the absolute value of ROL index's coefficient more than doubles in all multivariate specifications, accompanied by a sharp increase in explanatory power,

represented by the Pseudo R-squareds raising from around 2 percent to 30–32 percent (column (3) compared with (5), (6), (7)). All the specifications with ROL index also have considerably higher Pseudo R-squareds than without ROL (column (5), (6), (7) compared with (8)). This confirms the claim of KN and many other scholars regarding the pivotal role of policy quality in determining debt distress, especially when combined with other factors.

Table 3: Determinants of Debt Distress in BRI Countries

	Dependent variable: Debt Distress							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PV debt/exports	0.483***				0.679***		0.395**	0.456***
	(0.062)				(0.161)		(0.188)	(0.115)
Debt services/exports		3.162***				4.199***	2.624**	0.477
		(0.453)				(1.003)	(1.253)	(0.789)
ROL index			-0.236**		-0.595***	-0.699***	-0.624***	
			(0.109)		(0.184)	(0.180)	(0.183)	
Real GDP growth				-6.332***	-4.708*	-5.286**	-4.796*	-5.474***
				(1.214)	(2.596)	(2.563)	(2.596)	(1.457)
Constant	-0.617***	-0.487***	0.043	0.344***	-0.630***	-0.474**	-0.695***	-0.338**
	(0.099)	(0.093)	(0.083)	(0.068)	(0.223)	(0.197)	(0.227)	(0.133)
Observations	231	231	109	229	84	84	84	185
Pseudo R-Squared	0.188	0.140	0.022	0.089	0.298	0.297	**0.324**	0.237
OOS Predictive Power								
Correct Predictions	0.519	0.468	0.338	0.403	0.636	**0.688**	0.675	0.597
True Positive	0.833	0.708	0.917	0.833	0.625	0.625	0.417	0.500
False Alarms	0.623	0.642	0.925	0.792	0.358	0.283	0.208	0.358
OOS Predictive Power (LICs)								
Correct Predictions	**0.647**	**0.647**	0.529	0.529	**0.647**	**0.647**	**0.647**	0.471
True Positive	0.818	0.818	0.727	0.727	0.818	0.818	0.818	0.364
False Alarms	0.667	0.667	0.833	0.833	0.667	0.667	0.667	0.333
OOS Predictive Power (LMICs)								
Correct Predictions	0.559	0.618	0.324	0.265	0.618	**0.765**	**0.765**	0.676
True Positive	0.857	0.714	1.000	1.000	0.571	0.429	0.429	0.429
False Alarms	0.519	0.407	0.852	0.926	0.370	0.148	0.148	0.259
OOS Predictive Power (UMICs)								
Correct Predictions	0.440	0.480	0.280	0.440	0.640	**0.720**	0.680	0.560
True Positive	1.000	1.000	0.800	1.000	0.600	0.600	0.600	1.000
False Alarms	0.700	0.650	0.850	0.70	0.350	0.250	0.300	0.550
OOS Predictive Power (MICs)								
Correct Predictions	0.525	0.559	0.271	0.322	0.627	0.712	**0.763**	0.644
True Positive	1.000	0.917	0.917	1.000	0.667	0.667	0.750	0.667
False Alarms	0.596	0.532	0.894	0.851	0.383	0.277	0.234	0.362

Note: Standard errors are in parentheses

*p<0.1; **p<0.05; ***p<0.01

Real GDP growth's coefficient decreases significantly when it is combined with PV debt/exports and ROL (column (5)) and decreases to a less extent in the column (6) when I

replace PV debt by debt services, and decreases to even a lesser extent in column (8), when I remove ROL and keep all the other variables. The real GDP growth also loses some of its significance when it is combined with ROL index. This indicates that a great part of shocks' impacts on debt distress has been absorbed by the policy quality variable, while the inclusion of debt services rather than PV debt can increase the coefficient of the shocks. Intuitively, the wise use of policy can hinder the negative impact of shocks on the debt situation while the increase of debt services can exacerbate the impacts of shocks.

As for the two variables of debt burdens, as expected, both have their impacts lowered when combined with the other due to their high correlation. PV debt appears to be a better choice than debt services measure as while PV debt remains highly significant for all specifications, debt services measure loses all of its significance in the specification in column (8). The more interesting point is that the magnitudes of the impacts of both debt burdens and policy quality become larger when they are combined. Obviously, a high level of debt burden can have much more destructive effect if it is managed by a bad policy. Or conversely, a low quality policy's impacts on the economy can be already worsened by high debt burdens. Improving policy quality through reforms is therefore as important as limiting debt burdens at a manageable level.

The remaining parts of the Table 3 illustrate the OOS predictive power of each specification for the whole data sample and then for each income group, excluding HICs due to the few number of observations in the sample. To examine the OOS predictive power, I first divide the sample into a train set, which includes all the data in 1970–2002, and a test set with the data in 2003–2020. I choose 2002 as the cut-off year because it is the last year in KN's sample, so in this way I can test the predictive power of the whole sample and at the same time see if doing regression on the train set of the same time as of K's study can predict well the future incidence of debt distress.

In details, I first run the regression of each specification on the data of the train set, then I use the estimated coefficients obtained from each regression to predict the probability of debt distress based on the new data in the test set. To test the power of prediction, I define the distress episode to occur (still following KN's approach) when the probability of debt distress is higher than the unconditional probability of debt distress in the train set. It is 28.2 percent for the whole sample and 25.7 percent for the train set, which is slightly higher than that in KN's sample (around 20 percent).

"Correct Predictions" indicates the share of all episodes (including normal and distress episodes) correctly predicted out of total number of episodes. "True Positive" reports the fraction of distress episodes correctly predicted (which corresponds to "Distress Events" in KN's study) and "False Alarms" shows the fraction of normal episodes predicted incorrectly as distress. The number in bold is the highest one compared to all other specifications. Because in debt distress analysis, predicting correctly for debt distress is equally important as for normal time, the "Correct Predictions" rate will be the key indicator of the predictive power of the specifications.

The whole-sample Correct Predictions rate in my sample with the range from 33.8 to 66.8 percent is lower than in KN's, ranging between 43 and 84 percent. Note that I have replaced CPIA index with ROL index, which can partially contribute to this discrepancy of performance. However, when we look at MICs, the highest predictive power is higher compared to the whole sample (76.3 percent compared to 68.8 percent), though still a little lower than the highest rate in KN's regressions. It seems that the income group difference can have impacts on the regressions' performance.

Furthermore, the time effect also has its role here. KN's work focused on LICs from 1970 to 2002. However, most of the countries in KN's sample has moved from low income to middle income as of 2020 (75 percent), leaving only 25 percent as LICs. This means, there has been a huge change in the economic situation of the countries in KN's sample since their study. Not only the economic situation, but the borrowing behaviour of the countries has changed profoundly as well. That China has emerged recently as the largest creditor to developing countries has significantly changed the structure of debt as well as the terms of loans observed in KN's sample through 2002. In KN's sample, most of the debt comes from concessional loans from traditional creditors like the World Bank or the IMF, as against my sample of BRI countries, who depend strongly on Chinese lending, most of which is on a commercial base. These changes complicate the debt distress analysis and make the simple specifications of KN not so powerful in the new data sample, requiring taking into consideration the history effects.

As discussed in the sub-chapter 3.1, my above remarks are consistent with the results from KN's robustness checks, which also suggest that the country and history effects can influence the regressions' performance. When it is the case, the poorer performance of my

regressions in comparison with KN's is explainable and improvable, and adding variables for country and history effects is worth trying.

Another observation is that the high True Positive rate is usually accompanied by a high False Alarms rate, which is particularly true for all the univariate regressions and for almost all specifications for LICs. In these cases, the specifications tend to overestimate the probability of debt distress. Other observations are broadly the same as KN's study. Consistent with the suggestion from Pseudo R-squareds, the combined specifications have much better predictive power than single predictor specifications. The best specification for MICs in my sample is also the best specification as suggested from KN's study, which includes all 4 core variables.

4.1.1.2. Robustness checks for the base model

Table 4 and Table 5 display the results of the robustness checks for the alternative measure of debt burden (debt/GNI) and policy quality (CCI). The choice of these alternative variables is mostly due to the availability of the data. Besides, considering the damaging impacts of corruption on growth and debt distress, and the fact that the corruption problem is severe in BRI projects, I would also like to look at the relationship between corruption and debt distress for the sample of BRI countries.

Table 4: Robustness Check for The Base Model: Alternative Policy Measure

	Dependent variable: Debt Distress							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PV debt/exports	0.483***				0.700***		0.406**	0.456***
	(0.062)				(0.160)		(0.185)	(0.115)
Debt services/exports		3.162***				4.355***	2.743**	0.477
		(0.453)				(1.007)	(1.249)	(0.789)
CCI			-0.193*		-0.542***	-0.654***	-0.582***	
			(0.112)		(0.184)	(0.184)	(0.186)	
Real GDP growth				-6.332***	-5.403**	-6.286**	-5.602**	-5.474***
				(1.214)	(2.603)	(2.601)	(2.623)	(1.457)
Constant	-0.617***	-0.487***	0.057	0.344***	-0.654***	-0.498**	-0.730***	-0.338**
	(0.099)	(0.093)	(0.084)	(0.068)	(0.228)	(0.202)	(0.233)	(0.133)
Observations	231	231	108	229	84	84	84	185
Pseudo R-Squared	0.188	0.140	0.014	0.089	0.292	0.291	**0.321**	0.237

Note: Standard errors are in parentheses

*p<0.1; **p<0.05; ***p<0.01

First, we see from Table 4 that the CCI is highly significant for all specifications but has a little weaker power of explanation (Pseudo R-squareds) than ROL index. CCI's magnitude of effects on debt distress is also slightly lower than ROL, and CCI also has negative

coefficients, meaning that a better corruption control can lower the probability of debt distress. Overall, the replacement of CCI for ROL index leaves the regression results almost the same, including the magnitude of effects of the variables and the performance of individual specifications.

Next, we look at the performance of debt/GNI in Table 5. This indicator of debt burden is also strongly significant for all specifications and has a marginally higher explanatory power compared to PV debt measure. Its magnitude of effects on debt distress incidence is more than three times higher than that of PV debt/exports. Combined with debt/GNI rather than PV debt/exports also raises the magnitude of effects and the Pseudo R-squareds of ROL index considerably, which can be mostly because of the somewhat correlation between ROL index and PV debt/exports that we observe in the Table 2.

Table 5: Robustness Check for The Base Model: Alternative Debt Burden Measure

	Dependent variable: Debt Distress							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Debt/GNI	1.608***				1.934***		1.464***	1.393***
	(0.189)				(0.383)		(0.418)	(0.285)
Debt services/exports		3.162***				4.199***	2.549***	1.754***
		(0.453)				(1.003)	(0.978)	(0.550)
ROL			-0.236**		-0.807***	-0.699***	-0.803***	
			(0.109)		(0.171)	(0.180)	(0.190)	
Real GDP growth				-6.332***	-5.624**	-5.286**	-4.730*	-5.833***
				(1.214)	(2.497)	(2.563)	(2.658)	(1.498)
Constant	-0.755***	-0.487***	0.043	0.344***	-0.883***	-0.474**	-1.018***	-0.604***
	(0.097)	(0.093)	(0.083)	(0.068)	(0.238)	(0.197)	(0.263)	(0.159)
Observations	319	231	109	229	95	84	84	182
Pseudo R-Squared	0.182	0.140	0.022	0.089	0.326	0.297	**0.366**	0.262
OOS Predictive Power								
Correct Predictions	0.519	0.468	0.338	0.403	**0.688**	**0.688**	**0.688**	**0.688**
True Positive	0.625	0.708	0.917	0.833	0.583	0.625	0.542	0.542
False Alarms	0.528	0.642	0.925	0.792	0.264	0.283	0.245	0.245
OOS Predictive Power (MICs)								
Correct Predictions	0.508	0.559	0.271	0.322	**0.712**	**0.712**	**0.712**	**0.712**
True Positive	0.917	0.917	0.917	1.000	0.500	0.667	0.667	0.750
False Alarms	0.596	0.532	0.894	0.851	0.234	0.277	0.277	0.298

Note: Standard errors are in parentheses

*p<0.1; **p<0.05; ***p<0.01

Although specifications with debt/GNI can achieve rather higher Pseudo R-squareds, before deciding that it is a better predictor of debt distress than PV debt/exports, we have to examine its predictive power as well. The highest Correct Predictions rate for the whole sample of the specifications using debt/GNI is 68.8 percent, which is exactly the same as the ones using

PV debt/exports. However, these alternative specifications can predict correctly only up to 71.2 percent of debt distress for MICs, which is lower than 76.3 percent Correct Predictions rate of the specifications with PV debt. Noting that our target group of analysis is MICs, which cover almost 80 percent of all BRI recipient countries and 88 percent of all Chinese investments, PV debt/exports is a superior indicator of debt burden to debt/GNI.

To conclude this part, all conclusions out of my regressions and KN's are the same, with the only difference observed in the OOS predictive power of the specifications, for which I expect that country and history effects can be a good explanation. Apart from acknowledging KN's robustness checks, I also show that KN's model is robust to other alternative measures of debt burdens and policy quality, and conclude that the best core variables remain PV debt/exports, debt services/exports, CPIA or ROL index in case of unavailability of CPIA, and real GDP growth rate.

In the next part, I modify the base model by adding country and history effects. In terms of the country effects, I include the income group and region dummies. For the history effect, the most relevant indicator in determining debt distress is the historical financial performance, according to Reinhart *et al.* (2003). In this thesis paper, instead of using the inflation-related variables as suggested by KN and Reinhart *et al.* (2003), I would like to use the length of distress and normal episodes variable to represent the historical financial performance or history effect, as it is directly related to the methodology that I use to obtain the dependent variable of Debt Distress.

The results of the extended specifications are discussed following.

4.1.2. Extended specifications

4.1.2.1. Regression results

Table 6 shows the results of my regressions using extended specifications. The core variables are kept, and the columns are arranged the same as Table 3, except that for each specification, I add dummies for region, income group and the variable of the length of episodes.

Comparing the core and extended specifications, first, the Pseudo R-squareds are respectably higher for all extended specifications (up to 66.7 percent compared to 42.4 percent for core specifications), which indicates a better explanatory power. As can be seen, all the added variables are significant for many specifications, with the dummies for income group showing a weaker significance.

Table 6: Determinants of Debt Distress in BRI Countries - Extended Specifications

	Dependent variable: Debt Distress								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PV debt/exports	0.731***				0.796***		1.330***	1.041***	1.032***
	(0.133)				(0.275)		(0.464)	(0.276)	(0.270)
Debt services/exports		4.129***				2.602	-4.990	-1.937	-1.830
		(0.932)				(1.695)	(3.100)	(1.845)	(1.815)
ROL index			-0.043		-0.171	-0.173	-0.412		
			(0.280)		(0.392)	(0.386)	(0.436)		
Real GDP growth				-6.785***	-5.127	-8.807	-1.743	-6.316**	-6.352**
				(2.194)	(5.834)	(5.747)	(6.017)	(3.189)	(3.145)
Region Europe Central Asia	3.394***	2.735***	3.191***	2.212***	3.150***	2.799***	3.803***	2.989***	2.931***
	(0.632)	(0.548)	(0.763)	(0.428)	(0.977)	(0.865)	(1.252)	(0.633)	(0.620)
Region Latin America Caribbean	1.889***	1.511***	1.770***	1.898***	1.618*	1.494**	2.007*	1.577***	1.519***
	(0.498)	(0.419)	(0.621)	(0.399)	(0.838)	(0.688)	(1.075)	(0.512)	(0.499)
Region Middle East North Africa	1.467***	0.859**	1.280**	1.060**	0.912	0.839	1.640	0.724	0.710
	(0.503)	(0.430)	(0.629)	(0.411)	(0.912)	(0.826)	(1.199)	(0.562)	(0.560)
Region South Asia	0.944*	0.653	0.707	0.478	1.049	0.930	1.076	0.458	0.549
	(0.497)	(0.438)	(0.641)	(0.382)	(0.891)	(0.763)	(1.087)	(0.522)	(0.502)
Region Sub-Saharan Africa	1.869***	1.311***	1.465**	1.180***	1.760**	1.427**	2.206**	1.674***	1.689***
	(0.468)	(0.384)	(0.570)	(0.343)	(0.812)	(0.650)	(1.084)	(0.471)	(0.439)
Income Group LMICs	-0.267	-0.528*	-0.722*	-0.335	-0.296	-0.685	0.167	0.199	
	(0.338)	(0.319)	(0.434)	(0.329)	(0.568)	(0.531)	(0.644)	(0.419)	
Income Group UMICs	-0.472	-0.895**	-1.123**	-0.869**	-0.592	-1.012	0.047	-0.048	
	(0.408)	(0.385)	(0.539)	(0.388)	(0.707)	(0.684)	(0.822)	(0.494)	
Income Group HICs			3.010						
			(235.035)						
Length of episodes	0.182***	0.173***	0.080	0.143***	0.007	0.029	0.014	0.134***	0.133***
	(0.050)	(0.045)	(0.055)	(0.037)	(0.076)	(0.069)	(0.079)	(0.047)	(0.046)
Constant	-3.536***	-2.412***	-1.395*	-1.369***	-2.314**	-1.067	-3.383**	-3.131***	-3.041***
	(0.701)	(0.555)	(0.737)	(0.492)	(1.166)	(0.928)	(1.563)	(0.720)	(0.573)
Observations	231	231	109	229	84	84	84	185	185
Pseudo R-squared	0.635	0.566	0.454	0.511	0.555	0.459	0.581	**0.667**	0.664
OOS Predictive Power									
Correct Predictions	0.697	0.697	0.553	0.618	0.553	0.645	0.645	**0.750**	0.697
True Positive	0.609	0.652	0.826	0.739	0.609	0.522	0.609	0.609	0.565
False Alarms	0.264	0.283	0.566	0.434	0.472	0.302	0.340	0.189	0.245
OOS Predictive Power (LICs)									
Correct Predictions	0.529	0.529	0.529	0.235	**0.647**	**0.647**	**0.647**		0.412
True Positive	0.545	0.364	0.727	0.273	0.818	0.818	0.818		0.182
False Alarms	0.500	0.167	0.833	0.833	0.667	0.667	0.667		0.167
OOS Predictive Power (LMICs)									
Correct Predictions	**0.800**	**0.800**	0.600	0.733	0.767	0.733	0.767		**0.800**
True Positive	0.571	0.714	0.429	0.857	0.571	0.571	0.571		0.571
False Alarms	0.130	0.174	0.348	0.304	0.174	0.217	0.174		0.130
OOS Predictive Power (UMICs)									
Correct Predictions	0.680	0.680	0.520	**0.800**	0.720	0.680	0.680		0.680
True Positive	0.600	0.600	0.600	1.000	0.200	0.400	0.400		0.600
False Alarms	0.300	0.300	0.500	0.250	0.150	0.250	0.250		0.300
OOS Predictive Power (MICs)									
Correct Predictions	0.712	0.712	0.559	0.678	0.593	0.695	0.661	**0.814**	0.797
True Positive	0.583	0.667	0.833	0.917	0.667	0.500	0.667	0.583	0.500
False Alarms	0.255	0.277	0.511	0.383	0.426	0.255	0.340	0.128	0.128

Notes: Standard errors are in parentheses. Region and Income Group are two dummy variables, with the base line for Region being "East Asia & Pacific" and for Income Group being "LICs". All Region dummies have positive estimated coefficients, suggesting the regions other than the baseline (East Asia & Pacific) can have higher debt distress probability, though not all effects are significant. As for the Income Group dummy, being other than LICs in almost (statistically significant) cases lead to a lower level of debt distress. HICs dummy's coefficient is not significant, highly due to low number of observations.

*p<0.1; **p<0.05; ***p<0.01

However, when I try removing the income group variable (Column (9)) from the specification with the highest rate of correct prediction (column (8)), although the Pseudo R-squared sees almost no change, the correct prediction rate for the whole sample decreases by almost 6 percent. This suggests keeping income group dummy in the regressions. Second, the Correct Predictions rate is also overall significantly higher, ranging from 0.647 up to 0.814 compared to 0.647–0.765 in core specifications. The highest Correct Predictions rate is still for the MICs, which is also the key group of BRI countries. Compared to the best core specification for this income group, extended one can increase the Correct Predictions rate by around 6 percent.

Interestingly, when we look at UMICs only, the debt distress can be predicted with 100 percent true positive rate and low False Alarms of 0.25, using the combination of real GDP growth, region and income group dummies and the length of episodes, all of which are highly significant. In other words, without even using the debt burden indicators, for the group of UMICs, with shocks, country's traits like region and income level, and the historical financial performance represented by the length of episodes (this combination can already have policy effects within itself), we can predict the debt distress with an overall correction of 80 percent. This observation is interesting as the debt distress analysis so far has always put a greater weight on the current debt burden than other factors.

Third, ROL index completely loses their significance in extended specification regressions. The specification in column (8) (the multivariate one without ROL index) generally beats the others on overall Pseudo R-squared and Correct Predictions, and it performs well for MICs with the Correct Predictions rate of 81.4 percent. It is also interesting to see that the length of episodes variable is highly significant as long as ROL is not included in the specifications. It seems that all the additional variables namely region, income group and length of episodes have their part in the loss of significance of policy effects.

As for the debt burden indicators, we see that while PV debt measure remains highly significant across specifications, debt services/exports become no longer relevant when it is combined with PV debt and the other variables. There are also just small changes in the coefficients of all variables in extended specifications compared to the core ones, with the exception for PV debt/exports, whose magnitudes of effects more than double in extended specifications. Intuitively, the country-specific effects of income level, region, and historical financial situation can exacerbate the impacts of debt burdens.

4.1.2.2. *Robustness check for extended specifications*

For the extended specifications, I also check for the alternative measure of debt burden with debt/GNI (Table 7) and policy quality with CCI (Table 8). The overall conclusions of the original extended specifications stay the same. Similar to the robustness check for the base model, the replacement of ROL index by CCI in extended specifications causes almost no change to the whole regression results. Like ROL index, CCI is also totally insignificant in extended specifications.

Table 7: Robustness Check for Extended Specifications: Alternative Policy Measure

	Dependent variable: Debt Distress							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Debt/GNI	1.990***				3.850***		5.680***	2.242***
	(0.304)				(1.194)		(1.687)	(0.589)
Debt services/exports		4.129***				2.602	-4.928*	1.880
		(0.932)				(1.695)	(2.821)	(1.296)
ROL index			-0.043		-0.942**	-0.173	-1.307**	
			(0.280)		(0.424)	(0.386)	(0.546)	
Real GDP growth				-6.785***	-10.996**	-8.807	-7.227	-6.072*
				(2.194)	(5.268)	(5.747)	(6.760)	(3.173)
Region Europe Central Asia	3.058***	2.735***	3.191***	2.212***	2.599**	2.799***	2.809**	2.760***
	(0.506)	(0.548)	(0.763)	(0.428)	(1.018)	(0.865)	(1.218)	(0.663)
Region Latin America Caribbean	1.443***	1.511***	1.770***	1.898***	0.985	1.494**	1.065	1.677***
	(0.377)	(0.419)	(0.621)	(0.399)	(0.757)	(0.688)	(0.793)	(0.496)
Region Middle East North Africa	0.694*	0.859**	1.280**	1.060**	-1.572	0.839	-1.920	-0.161
	(0.410)	(0.430)	(0.629)	(0.411)	(1.496)	(0.826)	(1.595)	(0.592)
Region South Asia	0.838**	0.653	0.707	0.478	0.897	0.930	0.766	0.688
	(0.394)	(0.438)	(0.641)	(0.382)	(0.761)	(0.763)	(0.829)	(0.492)
Region Sub-Saharan Africa	1.190***	1.311***	1.465**	1.180***	1.259*	1.427**	1.373*	1.410***
	(0.358)	(0.384)	(0.570)	(0.343)	(0.714)	(0.650)	(0.821)	(0.459)
Income Group LMICs	-0.346	-0.528*	-3.732	-0.335	-0.543	-0.685	-0.320	-0.196
	(0.267)	(0.319)	(235.035)	(0.329)	(0.587)	(0.531)	(0.684)	(0.422)
Income Group UMICs	-0.551	-0.895**	-4.132	-0.869**	-0.555	-1.012	-0.126	-0.726
	(0.341)	(0.385)	(235.035)	(0.388)	(0.824)	(0.684)	(0.947)	(0.509)
Income Group HICs			3.010					
			(235.035)					
Length of episodes	0.133***	0.173***	0.080	0.143***	-0.097	0.029	-0.139	0.127**
	(0.035)	(0.045)	(0.055)	(0.037)	(0.081)	(0.069)	(0.121)	(0.052)
Constant	-2.816***	-2.412***	1.615	-1.369***	-2.095*	-1.067	-2.661*	-2.860***
	(0.478)	(0.555)	(235.035)	(0.492)	(1.107)	(0.928)	(1.545)	(0.717)
Observations	319	231	109	229	95	84	84	182
Pseudo R-squared	0.555	0.566	0.454	0.511	0.650	0.459	**0.667**	0.653

Note: Standard errors are in parentheses

*p<0.1; **p<0.05; ***p<0.01

As for the debt/GNI, it is highly significant for all specifications, though the specification of only Debt/GNI with added variables (region, income group, length of episodes) has a lower

explanatory power than the one using PV debt/exports. Also similar to the robustness check for the core specifications, ROL's magnitude of effects increases sharply when combined with debt/GNI rather than PV debt/exports. Compared with original extended specifications where ROL index becomes irrelevant, ROL here gains some significance. This indicates that not only country-specific effects and history effects can influence ROL's impacts, but PV debt's impacts can to a small extend dominate ROL's, which is once again consistent with the correlation of these two variables.

Table 8: Robustness Check for Extended Specifications: Alternative Policy Measure

	Dependent variable: Debt Distress							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PV debt/exports	0.731***				0.800***		1.407***	1.041***
	(0.133)				(0.276)		(0.481)	(0.276)
Debt services/exports		4.129***				2.585	-5.553*	-1.937
		(0.932)				(1.706)	(3.186)	(1.845)
Corruption Control			-0.215		-0.227	-0.177	-0.555	
			(0.306)		(0.395)	(0.401)	(0.454)	
Real GDP growth				-6.785***	-4.693	-8.508	-0.287	-6.316**
				(2.194)	(5.857)	(5.804)	(6.143)	(3.189)
Region Europe Central Asia	3.394***	2.735***	3.170***	2.212***	3.150***	2.805***	3.912***	2.989***
	(0.632)	(0.548)	(0.766)	(0.428)	(0.966)	(0.861)	(1.261)	(0.633)
Region Latin America Caribbean	1.889***	1.511***	1.771***	1.898***	1.683**	1.544**	2.232**	1.577***
	(0.498)	(0.419)	(0.619)	(0.399)	(0.831)	(0.692)	(1.094)	(0.512)
Region Middle East North Africa	1.467***	0.859**	1.267**	1.060**	0.895	0.826	1.692	0.724
	(0.503)	(0.430)	(0.631)	(0.411)	(0.904)	(0.817)	(1.191)	(0.562)
Region South Asia	0.944*	0.653	0.720	0.478	1.064	0.934	1.141	0.458
	(0.497)	(0.438)	(0.645)	(0.382)	(0.881)	(0.758)	(1.084)	(0.522)
Region Sub-Saharan Africa	1.869***	1.311***	1.504***	1.180***	1.812**	1.459**	2.405**	1.674***
	(0.468)	(0.384)	(0.584)	(0.343)	(0.815)	(0.660)	(1.115)	(0.471)
Income Group LMICs	-0.267	-0.528*	-3.917	-0.335	-0.229	-0.648	0.369	0.199
	(0.338)	(0.319)	(235.035)	(0.329)	(0.595)	(0.563)	(0.695)	(0.419)
Income Group UMICs	-0.472	-0.895**	-4.265	-0.869**	-0.496	-0.972	0.338	-0.048
	(0.408)	(0.385)	(235.035)	(0.388)	(0.753)	(0.733)	(0.909)	(0.494)
Income Group HICs			3.010					
			(235.035)					
Length of episodes	0.182***	0.173***	0.081	0.143***	0.016	0.038	0.037	0.134***
	(0.050)	(0.045)	(0.055)	(0.037)	(0.075)	(0.068)	(0.079)	(0.047)
Constant	-3.536***	-2.412***	1.702	-1.369***	-2.515**	-1.186	-4.015**	-3.131***
	(0.701)	(0.555)	(235.035)	(0.492)	(1.256)	(1.032)	(1.749)	(0.720)
Observations	231	231	108	229	84	84	84	185
Pseudo R-squared	0.635	0.566	0.453	0.511	0.557	0.459	0.586	**0.667**

Note: Standard errors are in parentheses

*p<0.1; **p<0.05; ***p<0.01

To wrap up on this part of extended specifications, if the ultimate goal is to predict the debt distress with a parsimonious set of variables at an acceptable rate of correction, we can use

the base model as from Table 3 with the best specifications being the one including all core variables (column (7)) (for MICs only) or excluding PV debt/exports (column (6)) (for the whole sample). On the other hand, if we aim at the Correct Predictions rate as high as possible, I would recommend extending the base model, controlling for historical financial situation of the country and the country effects as illustrated in the extended specifications from Table 6 in this part. For BRI countries, especially MICs, the best specification would be combining the core variables, region and income group dummies, the variable for the length of episodes, and excluding ROL index (column (8)). I also show that the extended specifications, like the core ones, are robust to alternative measures of debt burdens and policy quality.

So far, we have seen that either using core specifications with debt burden indicators, policy quality and shocks or extended specifications with additional factors, assessing debt distress is definitely not a simple task. The debt distress in reality depends on many factors, which are highly context-dependent and therefore to aim at one debt threshold for all countries or even for a specific group of countries is not realistic. In the following sub-section, I would like to discuss this issue.

4.2. Deriving country-specific debt thresholds

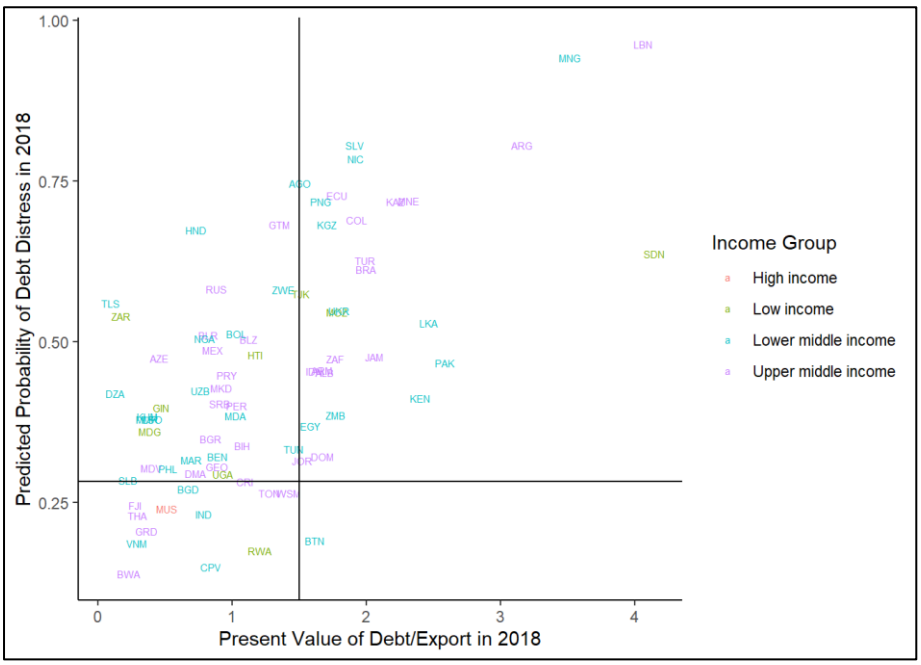
4.2.1. A one-size-fits-all debt threshold is not a good option

Through the regression results, we see that in addition to debt burden indicators like PV debt/exports or debt services/exports, other factors like policy performance, shocks, history of debt repayment and the country's region and income also matter in determining debt distress. To illustrate the difference between predicting debt distress based on debt burden indicators alone and based on a combination of variables, I plot the PV debt of all BRI countries as of 2018 as the latest possible year starting a distress episode (recall that a distress episode lasts for at least 3 consecutive years) against their probability of debt distress predicted by the extended specification with the highest overall predictive power (column (8), Table 6) based on their data in 2018 in Figure 7 below.

On the Figure 7, I also show the HIPC threshold of 150 percent of PV debt/exports as a vertical line, and the unconditional probability of debt distress of BRI countries of 0.282 as a horizontal line. Additionally, I also plot the countries distinct by their income group to show that the relationship between debt burden indicator and debt distress is also different

by income group. As can be seen, except for UMICs, the relationship between debt burden indicator and debt distress probability is completely not linear. More importantly, there are many countries with the debt burdens much lower than the threshold indicated by HIPC program (150 percent PV debt/exports), but with the probabilities of debt distress that are higher than the average, which can be in reality caused by low quality of policy, suffering a severe shock or any other country-specific reasons.

Figure 7: Debt Burden Indicator and Debt Distress



Source: Own Calculation

Using such a debt threshold for all countries can lead to underestimating (and overestimating) the debt distress probability in many countries and thus misleading conclusions on the country's debt situation and loans and grants decision. Therefore, a debt threshold that takes into consideration other factors like the policy quality, shocks, or other effects in addition to the debt burden is more relevant.

4.2.2. Deriving debt thresholds for a given probability of debt distress

With a model predicting well the probability of debt distress based on a combination of limited factors as the specifications discussed above, for any target of probability of distress, we can easily compute the debt threshold, either being PV debt/exports or debt services/exports, or any other relevant indicator of debt burden, such that the country does not go beyond a specific value of debt distress probability. For now, to keep it simple, I would look only at BRI MICs, which cover around 80 percent of BRI countries and therefore

can be a representative of the whole BRI sample. I start with the core specification with the highest predictive power as reported in Table 3 (column (7)), which includes all core variables (PV debt/exports, debt services/exports, ROL index and real GDP growth rate) as explanatory variables.

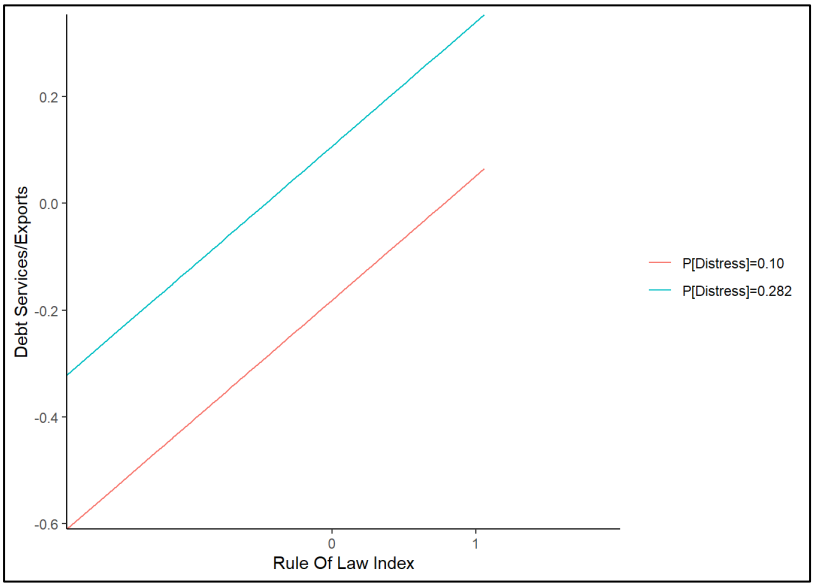
Assuming a middle income BRI country having a real GDP growth rate and PV debt/exports equivalent to the mean values of the group, I compute the debt services/exports for each value of ROL index on the horizontal axis, keeping the predicted probability of debt distress constant. This means, I would solve this equation:

$$(2)\ p = \Phi(\beta_0 + \beta_1 \text{ x PV debt/exports} + \beta_2 \text{ x debt services/exports} + \beta_3 \text{ x ROL index} + \beta_4 \text{ x real GDP growth})$$

for debt services/exports for each value of ROL index of the country, with the values of PV debt/exports and real GDP growth given, and p in this case equalling 0.1 and 0.282.

The result is plotted in Figure 8. I consider two levels of predicted debt distress probability, one being the unconditional probability of debt distress of BRI countries (0.282), which corresponds to the blue line, and the other being much lower (0.10), represented by the red line.

Figure 8: Adjusting Variables to Achieve Given Debt Distress Probability



Source: Own Calculation

Figure 8 describes many important implications. First, assuming the country aims at keeping the probability of distress equal to the unconditional debt distress probability, it finds itself

on the blue line. A move on the blue line to the right means both increasing the debt services/exports level and improving the quality of the policy. This can be interpreted as when the country would like to increase the debt burden but still keep the probability of debt distress unchanged, it must be balanced by an improvement in policy quality, which is represented by a higher level of the ROL index as in this case. Other way around, when the country improves its policy quality, it can tolerate a higher level of debt burden for a given debt distress probability.

Second, with given values of policy quality, real GDP growth rate, and PV debt/exports, we can compute a threshold of debt burden such that the country can maintain a specific probability of debt distress. Obviously, how we assess the country as "falling into debt distress" depends on the cut off distress probability that we use. For a higher (lower) level of cut off, a given policy quality can tolerate a higher (lower) level of debt burden. To understand this, we can look at the red line, which is the blue line shifting down when we lower the level of probability of distress. On the red line, for each value of ROL index, the country can deal with a lower level of debt burden compared to the blue line, because the country restricts itself to a lower probability of debt distress.

Note that the precise magnitudes of the effects of each variable on debt distress probability depend on all the estimated coefficients in the regressions, which are subject to margins of error and vary across specifications. This means, Figure 8 with the plot of an "imaginary average" country only serves to give a rough sense of the magnitude of the variables' effects but not their precise effects.

Next, I use the best extended specification (Table 6, column (8)) to compute a debt threshold (PV debt/exports) for each BRI country with the data on 2018, using a cut off level of debt distress probability of 1 percent. This means the debt threshold can be obtained by solving:

(3) $p = \Phi(\beta_0 + \beta_1 \text{ x PV debt/exports} + \beta_2 \text{ x debt services/exports} + \beta_3 \text{ x real GDP growth} + \sum_{i=4}^{5} \beta i \text{ x income group dummies} + \sum_{i=6}^{10} \beta i \text{ x region dummies} + \beta_{11} \text{ x length of episodes})$[3]

for PV debt/exports, where p is the targeted probability of debt distress and equals 0.01 in this case. Note that other arbitrary values of p can be chosen depending on the target of each

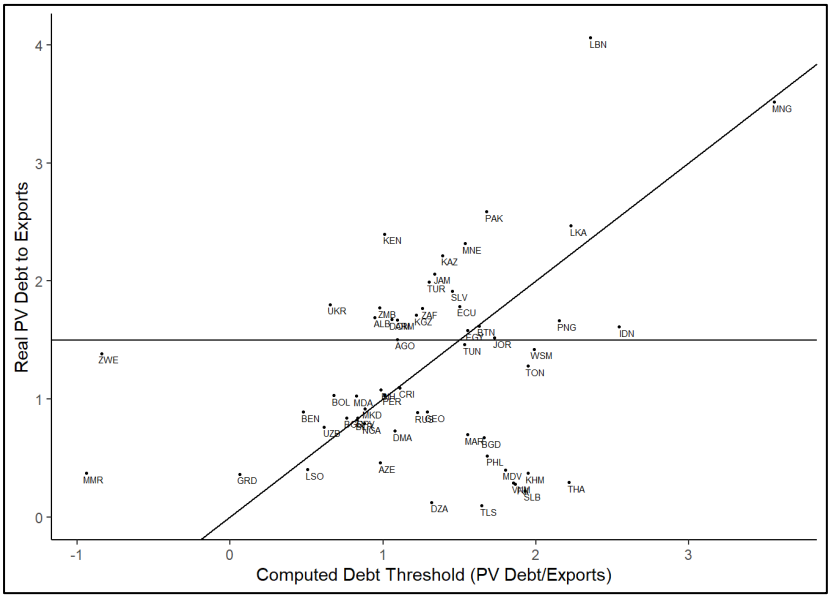
[3] Note that we have 2 dummy variables of income group: LMICs and UMICs, with LICs being the baseline dummy. For region, we have 5 dummies, with the baseline of "East Asia & Pacific" region.

country. In this case I target the country to have very low probability of debt distress. The results of the computation are presented in the Appendix C. Then I plot the computed debt thresholds against the real value of PV debt/exports of all calculated countries in Figure 9.

In Figure 9, I also put the debt threshold used by HIPC, which is 150 percent of PV debt/exports, as the horizontal line. The 45-degree line compares the debt threshold and the real debt level. All the countries lying above the 45-degree line have their debt burden higher than the debt threshold, therefore face a risk of debt distress. The larger the distance between each country above the 45-degree line and the line is, the more severe their debt situation is.

The difference between using a fixed debt threshold and the country-specific one is obvious. If we use the fixed debt threshold as suggested by HIPC, as of 2018, we could have underestimated the risk of debt distress in many countries like Zimbabwe or Angola and overestimated it in Indonesia or Papua New Guinea. With the country-specific debt thresholds, we see that a large number of countries with their debt burden under the HIPC threshold could have been classified as at risk of debt distress, as they lie above the 45-degree line.

Figure 9: Country-specific Debt Threshold



Source: Own Calculation

In this way, the debt threshold takes into account the individual country's debt burden (PV debt/exports, debt services/exports), shocks (real GDP growth), country effects (region, income group) and history effect (length of episodes), hence reflecting more precisely the country's debt situation and giving the lenders better information for their decisions on loans

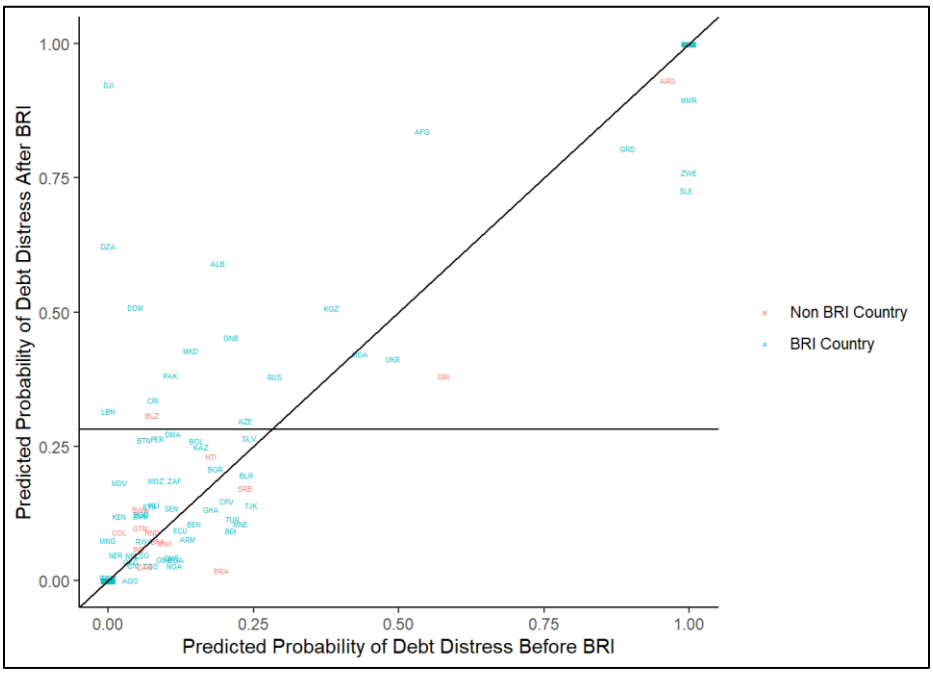
and grants. Also note that the above country-specific debt thresholds are computed based on the data in 2018 just to give an example of how we can compute context-dependent debt thresholds when we have available data at hand. For example, we can use the data from the projections done by IMF on the debt burden indicators and growth rates to calculate a debt threshold for any country in several years beforehand.

This far I have examined some specifications of the probit model suggested by KN in debt distress analysis, from which I come up with the best specification, answering what determines the debt distress and how to find a country-specific debt threshold in BRI countries. The last following sub-chapter deals with the last question: "Are BRI countries at higher risks of debt distress than the non-BRI?"

4.3. What roles do BRI loans play?

In this part, I would like to use the whole sample including both BRI and non BRI countries and check if the new loans from BRI worsen the debt distress situation in the borrowing countries. Take the year 2015 as the cut off year, when China officially announces BRI and strongly invests under this initiative, I use the best extended specification to predict the probability of debt distress right before 2015 and 5 years after 2015 and plot them against each other. Figure 10 shows the results.

Figure 10: A Comparison of Debt Distress Before and After BRI



Source: Own Calculation

I choose the period of 5 years because it is estimated that most of BRI investments will be disbursed completely in the medium term, which is 5 years (Bandiera and Tsiropoulos, 2019). The horizontal axis reports the predicted distress probabilities for the countries before 2015 and the vertical axis measures the predicted distress probabilities reflecting considerable additional lending from BRI. The horizontal line marks the unconditional probability of debt distress for the sub-sample of BRI countries (28.2 percent). The vertical distance above the 45-degree line for each country indicates the increase in distress probability after BRI compared to before.

Interestingly, while most of non BRI countries are around or much below the 45-degree line with the only exception of Belize, 55 percent (33 out of 60) of the BRI countries in the sample that have available data for analysis lie above the 45-degree line, out of which more than one-third (12 countries) lie beyond the unconditional debt distress probability. Take Djibouti as an example, its probability of debt distress went up from 0 to almost 1, which confirms a lot of case studies on the BRI-related debt distress in Djibouti. More importantly, most of the BRI countries that lie significantly high above the 45-degree line and above the unconditional probability of debt distress have the distress probability of less than 25 percent before BRI's launch, which indicates a big jump in their debt distress risks since then. Note also that as this compares before and after BRI's launch, the countries with already very high probability of debt distress or are already in debt distress before 2015 will possibly not go beyond the 45-degree line. In this way we can exclude the countries already in debt distress before BRI.

Overall, if we use the unconditional probability of debt distress as a threshold beyond which the country falls into debt distress, BRI loans have increased the vulnerability to debt in more than half of recipient countries, out of which 12 countries can fall into BRI-related debt distress. Among these 12 countries, many are frequently mentioned in BRI debt distress analysis such as Pakistan, Djibouti, or Kyrgyz Republic, which further confirms the indication of many scholars of the relationship between Chinese lending and debt distress in the borrowing countries. This finding also completes the discussion part of this paper. In the next chapter, I will present some important policy implications.

5. Conclusion and Policy implications

With the topic “Belt and Road Initiative, growth and debt distress in recipient countries”, this paper has in the first place (chapter 2) given an overview of the BRI’s characteristics and analysed BRI’s impacts on growth and debt distress in recipient countries through literatures and case studies. From this preliminary analysis, I show that BRI loans are fundamentally distinct from the loans of the official lenders like the World Bank or the IMF. Among other things, higher debt services, non-transparency, high rate of corruption in projects, no requirements for improved institutions, manipulated feasibility evaluation, failing cost-benefit analysis and cost inflation, strong disputes with the locals, low level of local labour participation, labour discrimination, and negative impacts on environment and society are observed for many case studies of BRI projects. Even in the most optimistic case of positive impacts of BRI on growth, risks of BRI-related indebtedness still exist, and BRI recipient countries need to prepare themselves with the understanding on debt distress analysis and management.

In the second part (chapter 3 and chapter 4), based on a study that had a convincing performance in debt distress prediction almost two decades ago, the paper puts forward a simple but effective methodology of debt distress analysis for BRI countries nowadays. In details, the second part of this paper deals with three key questions. First, what determines debt distress incidence in BRI countries? With a sample of 120 BRI countries in the time period from 1970 to 2020, I have shown that KN’s model can predict the debt distress at a significantly high rate of correction, especially in MICs, though not so high as for KN’s sample, through just 4 core variables namely PV debt/exports, debt services/exports, ROL index (or CPIA index for KN’s sample) and real GDP growth.

Furthermore, I also attempt to extend KN’s model, adding three other variables including region and income group dummies, and the length of distress and normal episodes. These extended specifications have higher Pseudo R-squareds and Correct Predictions rates. Similar to the core specifications, they also work the best for the sub-sample of MICs. Considering that MICs account for nearly 80 percent of BRI countries, these extended specifications can provide a good methodology to predict the debt distress incidence in BRI countries, with the rate of Correct Predictions rate of over 80 percent. In short, debt burdens, policy quality, shocks, country-specific effects, and history effects are the key determinants of debt distress. Note that the extended specification can help predict the debt distress more

accurately, but it does not give much meaningful policy implications, as there is not much the government can do about its country's nature and history effects. This means, debt burdens and policy quality remain the primary variables that the government can and should control to deal with debt distress.

Second, does a fixed debt threshold work? According to the empirical study in this paper, the answer is "no". I have illustrated that the one-size-fits-all debt threshold cannot help assess correctly the debt situation of a country. As many other scholars have proved, debt thresholds can be particularly high for some countries and low for the others. From my own calculation of debt thresholds for MICs in 2018, for example, Thailand can tolerate the level of PV debt of up to 221.54 percent of its total exports, while that number for Zimbabwe is even negative (-84.22 percent). By using a fixed debt threshold for all countries, we are putting too much weight on financial burden indicators but neglecting the other equally important factors, which can implicitly encourage low quality policies and exaggerate the amount of resources to be transferred.

The last question regards whether BRI countries face higher risks of debt distress. This paper has shown that more than half of the 60 BRI countries show higher vulnerability to debt due to higher debt burdens from BRI, out of which at least 12 countries show risks of debt distress post BRI. Therefore, it can be concluded that BRI financing has a part in causing debt distress in recipient countries.

This paper will conclude with some recommendations that China and other official lenders, and BRI recipient countries should consider as far as the success of BRI and the problem of debt distress in BRI recipient countries are concerned.

For China, it in fact has its own benefits in preventing debt distress in BRI countries. According to Scissors (2020), China's outward investments have been decreasing, and its national budget is more constrained due to the Covid-19 pandemic. The inability of the borrower countries to repay the debt can bring China a range of financial problems. Some of the very clear signals of the importance of debt sustainability in BRI recipient countries to China is its recent publishing the BRI-DSF and its more frequent participation in Paris Club's activities (Hurley *et al.*, 2019). There are a couple of policies that China should consider to help circumvent the debt distress problem in BRI recipient countries as followed.

First, as illustrated in this paper, rule of law and corruption control are particularly important to lower the probability of debt distress. Therefore, it is highly recommended that China

have a more responsible lending policy. This can start with the operational features like improving transparency and building standards for the procurement process and the concessionality of the loans. For example, a publicly available templates for financing arrangements under the BRI would be very helpful in promoting transparency and clarifying BRI to the world. Next, it can consider multilateralizing BRI by working closely with other official lenders like the World Bank or the IMF and fully participating in the Paris Club. This can signal a high willingness of China to reform BRI especially regarding the transparency. Besides, China can also build a comprehensive database of BRI projects, which provides all information regarding financing terms, size, sector, and planned investments.

Not less importantly, China should adopt more sustainable lending policy. For example, since the 1980s, the United States and many multilateral funds such as the Global Environment Facility have used the "debt-for-nature swaps", under which the debt is forgiven in exchange for the country's commitment to fund environmental protection activities (Hurley *et al.*, 2019). With the large number of participating countries under BRI, China can use such approach of debt relief to contribute enormously to the global sustainable development and promote its image to the world. With regard to the terms or conditions of the loans or the conditions for the debt relief, China should reconsider the conditions that are particularly unfavourable for the borrower countries. Such conditions like the imports of Chinese goods and services, including a high level of Chinese labour used in BRI projects can only worsen the debt repayment ability of the borrowers, which in turn harms the economy of China in the long run.

For the BRI recipient countries, first, they should also take measures to enhance transparency and constrain corruption, especially during the process of procurement and contract management. The government of the borrower countries should be proactive in establishing a better system of auditing, monitoring, and reporting. With the technology advancement nowadays, especially the internet-based and computerized tools like the application of blockchain in investment management, such a system can be easily created. A more transparent system of managing resources can prevent corruption effectively.

Second, the risks of debt distress caused by BRI loans exist, and the countries should take the selection and evaluation of the projects and loans seriously. BRI recipient countries, especially those already dealing with high debt levels, are advised against taking commercial

loans with high interest rates, which can drive them to debt distress or even default. As illustrated from the regression results, the debt burden indicators are particularly significant in determining debt distress, so countries should try to limit the debt burden level. For instance, they should try to gain access to grants and concessional loans, attract FDI, and increase public savings to finance the investment needs rather than borrowing. As for the project selection, they should only prioritize the country's development goals and focus on higher quality projects. More importantly, they should try to negotiate the deal in the way that serves the local economy growth such as a higher rate of local labour participation or the use of domestic materials. In order to be able to negotiate the best conditions for the country, the government should be proactive in attracting capital from different sources to give itself the power of negotiation.

Third, BRI countries should earnestly concern about the possible problems that BRI projects can bring to the environment and society like pollution, topographical, hydrological and biodiversity damages, and the disputes with the locals. They should address all the important issues and have measures to ensure that both lenders and borrowers follow the rules that are set before signing on a deal. As a reference, the Operations Policy and Country Services (OPCS) and Environmental and Social Safeguards Advisory Team (ESSAT) have formulated a comprehensive list of the best measures to prevent possible risks of foreign labour influx, among which are child protection and incorporating social and environmental protection measures and code of conduct for workers in the contracts (OPCS and ESSAT, 2016). The BRI recipient countries can consult the list and have their own list of priority issues under BRI projects.

Finally, among the debt distress determinant variables discussed above, policy quality is the one the BRI countries' governments can influence the most. BRI recipient countries should try to undertake reforms and improve their policy and institution so that they not only have more opportunities to receive grants and concessional loans, but they can also tolerate a higher level of debt burden and thus lower the risk of debt distress. Policy improvement is critically important not only to growth but also to the prevention of the debt distress. As the regressions show, a higher quality of policy and institution allows the country to deal with a higher level of debt burden and become more tolerable to debt. More importantly, the countries with better public policy and a lower level of debt burden can deal with shocks better and reduce the negative impacts of shocks on debt distress, while the effects from bad policy and high debt burdens usually exacerbate each other and make the debt situation of

the country much worse. Therefore, together with the effort to limit the level of debt, BRI countries should also try to improve their policy quality.

For the other official lenders, first, they should put more weights on policy quality when they decide on grants and loans and apply context-dependent debt thresholds rather than a fixed one. In this way, the resource transfers can become more efficient, ensuring that the financial help is provided to save countries from debt distress and at the same time to encourage countries to better their policy and institution. More specifically, they can tailor the terms of loans and grants based on the country's performance in the policy quality, growth rate, and other debt burden indicators, as well as on the risks of debt distress. Depending on the way the lenders tailor the grants and loans, different incentives can be created for the borrowing countries regarding improving their policy and institution.

In summary, BRI brings with it opportunities of cooperation and networks and potential impacts on growth in the long run, but many challenges remain to be faced before any success can be observed. This paper has attempted to set up the first step in tackling one of the major challenges – debt distress. With the methodology of debt distress analysis suggested in this paper, the BRI countries know what factors they can and should control to lower the debt distress probability, how severe their debt situation is, and how much debt they can still tolerate, all of which allow the country to have a long term plan for investment and macroeconomic development. As for the lenders, this methodology is a simple tool to give them a picture of debt distress in the borrower countries that is more context-specific and so helps the lenders to have a better-informed decision on loans and grants.

Note that this thesis paper has discussed the relationship of BRI and growth and debt distress in recipient countries at the beginning, but the model suggested at the end only serves the purpose of debt distress analysis, with a consideration that to empirically assess BRI's net impacts for the moment is too early and must be based on many assumptions. Without quantifying BRI's impacts on growth, the model cannot measure exactly BRI's impacts on debt distress as well, even though it can indicate a relationship between BRI loans and debt distress in the medium term. In the long run when BRI's impacts on growth are shaped, the inclusion of the quantified impacts of BRI on growth in the debt distress analysis can significantly improve the performance of the debt distress models for BRI countries. I leave this to future research.

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Appendix

A. Debt distress episodes

Table 9: Average Values During Distress Episodes

	Start	End	SBA/EFF	Arrears /DOD	Distress Point (Arrear)	Distress Point (SBAEFF)	Distress Point (Paris)
AFG	2006	2008		0.07	0.67	0	2
AFG	2010	2018		0.08	1	0	0.33
AGO	1989	2006		0.3	0.94	0	0.17
ALB	1992	2001		0.09	0.6	0.1	0.9
ARM	1994	1997		0.14	1	0.25	0
AZE	1994	1996		0.14	1	0.67	0
BDI	1970	1970	0.1	0	0	1	0
BDI	1998	2007		0.08	1	0	0.6
BDI	2009	2011		0.02	0	0	1
BEN	1970	1978		0.12	1	0	0
BEN	1983	2005		0.09	0.74	0	0.78
BGR	1990	1998		0.18	0.44	0.67	1
BIH	1998	2000			0	0.33	2
BOL	1982	1988		0.12	0.86	0.14	0.86
BOL	1990	1992		0.01	0	0	2
BOL	1998	2003		0	0	0.17	1
CIV	1984	1996		0.12	0.69	0.46	1.62
CIV	1998	2014		0.08	0.41	0	0.88
CMR	1987	1997		0.08	0.82	0.36	1.36
CMR	2001	2003		0.02	0	0	1
CMR	2006	2008		0.06	0.33	0	1
COG	1976	1979		0.06	0.75	0.5	0
COG	1985	2018		0.25	1	0.09	0.71
COM	1987	2015		0.18	0.9	0	0.31
CPV	1988	2002		0.09	1	0.07	0
CRI	1980	1985		0.06	0.33	0.67	1
CRI	1987	1991		0.16	1	0.6	1.2
CRI	1993	1995		0.05	0.33	0.67	1
DJI	1994	2010		0.06	0.76	0.06	0.35
DMA	2007	2009		0.07	1	0	0
DOM	1983	1999		0.12	0.88	0.24	0.35
DOM	2003	2006		0.02	0	0.5	1.5
DZA	1994	1996		0	0	0.67	2
ECU	1983	1994		0.16	0.67	0.58	1.5
ECU	2000	2005		0	0	0.33	1
EGY	1984	1993		0.11	0.7	0.3	0.6
EST	1995	1997	0.32		0	1	0
ETH	1991	2010		0.21	1	0	0.75
GAB	1986	1996		0.07	0.36	0.45	1.64
GAB	1999	2007		0.11	0.67	0.33	0.67
GEO	1995	1997		0.14	1	0.33	0
GEO	1999	2006		0.1	0.88	0	0.75
GHA	1970	1975		0.1	1	0	0
GHA	1996	1998		0.01	0	0	1
GHA	2001	2006		0.01	0	0	1.5
GMB	1984	1988		0.05	0.4	0.4	0.6
GMB	2003	2005		0.03	0	0	1
GMB	2007	2009		0.03	0	0	2
GNB	1981	2012		0.28	1	0	0.75
GNB	2012	2018		0.43	1	0	0.43

GRD	1985	2001		0.15	1	0	0
GRD	2006	2018		0.08	0.92	0	0.46
GUY	1970	1976	0.23	0.01	0	1	0
GUY	1978	2018		0.12	1	0.1	0.44
IDN	1970	1973	0.2	0.01	0	1	0.75
IDN	1997	2007		0.05	0.45	0.27	1.09
IRN	1982	1991		0.24	1	0	0
ISR	1974	1976	0.24		0	1	0
JAM	1977	1979	2.48	0	0	1	0
JAM	1984	2000		0.06	0.76	0.41	1.24
JAM	2003	2006		0.05	1	0	0
JOR	1989	1994		0.07	0.5	0.5	1.5
JOR	1996	1999		0.04	0	0.5	1.5
JOR	2002	2004		0.01	0	0.33	1
KAZ	1994	1996	0.83	0.03	0	1	0
KEN	1978	1980	1.84	0	0	1	0
KEN	1992	1996		0.04	0.4	0	0.6
KEN	2000	2002		0.03	0	0	1
KEN	2004	2006		0.03	0.33	0	1
KGZ	2002	2007		0	0	0	1
KHM	1981	1985		0.12	1	0	0
KHM	1988	2006		0.45	1	0	0.16
KOR	1970	1975	0.35		0	1	0
LBN	1986	1991		0.09	1	0	0
LBR	1970	1970	0.1	0	0	1	0
LBR	1972	1974	0.14	0	0	1	0
LBR	1979	2018		0.48	0.9	0.17	0.45
LKA	2005	2007		0	0	0	1
LSO	1994	1996	0.32	0	0	1	0
LTU	1992	1994	0.79		0	1	0
LVA	1995	1997	0.33		0	1	0
MAR	1980	1992		0.02	0.15	0.69	1.38
MDA	2005	2010		0.04	0.33	0.17	0.5
MDA	2012	2016		0.06	1	0.2	0
MDG	1980	2015		0.15	0.89	0.19	0.92
MKD	1993	1997		0.27	0.8	0.2	0.6
MKD	2000	2003		0.02	0	0.5	0.75
MKD	2015	2018		0.06	1	0	0
MLI	1971	1980		0.13	1	0.1	0
MLI	1982	1985		0.04	0.5	0.75	0
MLI	1988	2006		0.1	0.63	0.05	0.95
MMR	1988	2018		0.37	1	0	0.1
MNE	2001	2003			0	0	1
MOZ	1984	2010		0.16	0.96	0	0.89
MRT	1984	2018		0.18	0.97	0.09	0.69
NER	1983	1988		0.01	0	0.67	2.5
NER	1988	1990		0.04	0.33	0	2
NER	1992	2010		0.07	0.79	0.05	0.63
NER	2012	2014		0.06	1	0	0
NGA	1986	2007		0.17	0.59	0.18	0.68
PAK	1972	1974	0.35	0	0	1	2
PAK	1980	1983		0	0	0.5	0.75
PAK	1993	1995	0.46	0	0	1	0
PAK	1999	2001		0	0	0.33	2
PAK	2001	2003		0	0	0	1
PAN	1970	1975	0.29		0	1	0
PAN	1977	1980	0.75		0	1	0
PER	1970	1970	0.41	0	0	1	0
PER	1977	1980		0	0	0.75	0.75
PER	1982	1999		0.24	0.67	0.28	0.83

PHL	1970	1976	0.42	0	0	1	0
PHL	1983	1989		0.01	0	0.57	1.29
PHL	1991	1996		0	0	0.33	1
POL	2009	2011	11.33		0	1	0
RUS	1992	2002		0.12	1	0.36	1.36
RWA	1994	2007		0.08	1	0	0.64
SDN	1972	1974	0.41	0	0	1	0
SDN	1977	2018		0.57	0.98	0.1	0.29
SEN	1979	1983	1.48	0	0	1	1.8
SEN	1985	1987	0.52	0	0	1	3
SEN	1989	1991		0	0	0	3
SEN	1993	1996		0.05	0.5	0.25	1.5
SEN	1998	2000		0	0	0	2
SEN	2004	2006		0.01	0	0	1
SLB	2002	2011		0.09	1	0	0
SLE	1976	2003		0.16	0.82	0.18	0.96
SLE	2005	2018		0.19	1	0	0.21
SLV	1990	1993		0.01	0	0.75	0.75
SOM	1970	1970	0.26	0	0	1	0
SOM	1980	2018		0.58	0.97	0.13	0.15
SYR	1995	2001		0.46	1	0	0
SYR	2008	2018		0.35	1	0	0
TCD	1972	1997		0.11	0.85	0.04	0.35
TCD	2000	2003		0.05	0.25	0	0.75
TCD	2015	2017		0.02	0	0	1
TGO	1978	1990		0.04	0.38	0.54	1.85
TGO	1992	1997		0.06	0.67	0	1
TGO	2000	2010		0.17	0.73	0	0.82
TJK	1994	2002		0.13	1	0.11	0
TKM	1994	1996		0.17	1	0	0
TUR	1970	1970	0.83	0	0	1	0
TUR	1978	1980	3	0	0	1	3
TZA	1972	2018		0.22	1	0.06	0.45
UGA	1976	1983		0.07	0.62	0.5	0.75
UGA	1986	2004		0.08	0.89	0	0.95
UKR	1994	1998		0.04	0.2	0.8	0
UKR	2000	2004		0.03	0.2	0.2	0.6
UKR	2014	2018		0.17	1	0.6	0
URY	1975	1977	0.32		0	1	0
URY	1979	1981	0.25		0	1	0
VNM	1988	2005		0.26	1	0.06	0.17
WSM	1977	1979	0.3	0	0	1	0
YEM	1973	1978		0.07	1	0	0
YEM	1985	2005		0.17	0.95	0.1	0.43
YEM	2015	2018		0.12	1	0	0
ZMB	1981	2014		0.14	0.91	0.12	0.79
ZWE	1998	2018		0.37	0.9	0.1	0

B. Calculation of PV debt

This part summarises the method of PV debt calculation according to Dikhanov (2005).

PV debt is defined as *"the discounted value of a payment or stream of payments to be received in the future, taking into consideration a specific interest or discount rate. Present Value represents a series of future cash flows expressed in today's currency units."*

PV debt can be calculated in discrete form:

(4) $PV\ debt = \sum_{t=t_0}^{t_N} \frac{DS_t}{(1+d)^{t-t_0}}$

or continuous form:

(5) $PV\ debt = \int_{t_0}^{t_N} ds(t) e^{d(t_0-t)} \mathrm{d}t$

with DS standing for debt services, d for discount rate, t for time and N for the number of periods, which can be on a monthly, daily or any arbitrary base.

From the formula of PV debt, we see that PV debt has an additive monotonous linear relationship with debt services, which means that if debt services increase, PV debt also increases, and if discount rate is a constant value, the sum of PV debt for individual debt flows equals the present value of the sum of individual debt flows.

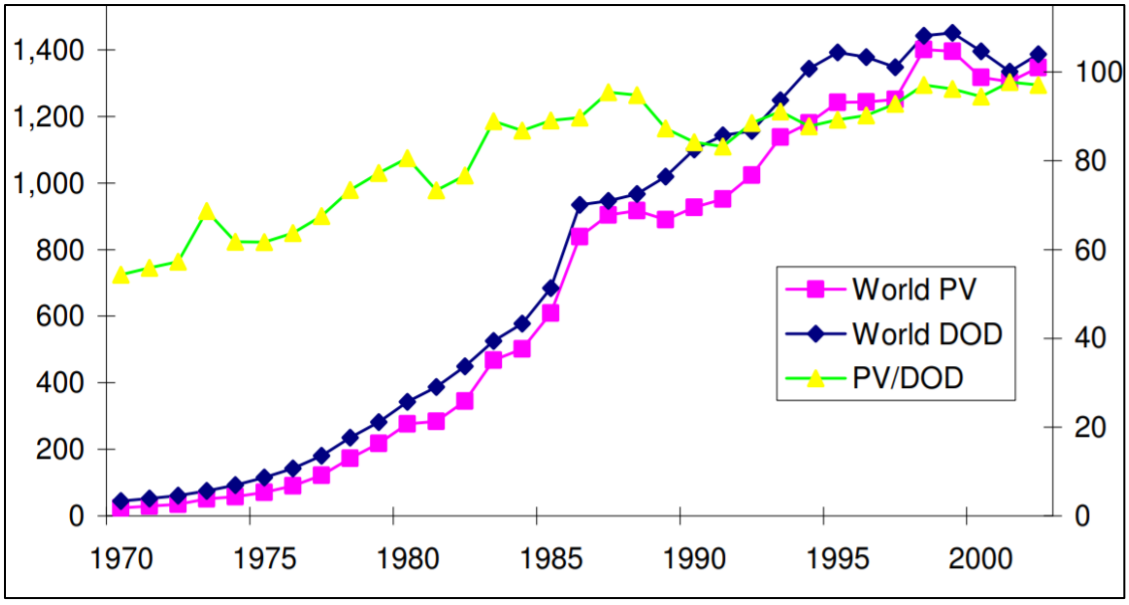
PV debt is equal to the face value of debt only when the discount rate is equal to the interest rate. Otherwise, there will be a discrepancy between the PV debt and the face value, which is called "Grant Element". Grant Element reflects financial terms of commitments like interest rate, maturity, and grace period, and measures the concessionality of a loan. For example, assuming the market interest rate of 10 percent, then a loan of an interest rate of 10 percent will have the Grant Element equalling zero, a no-interest loan will have the Grant Element being 100 percent, and a soft loan will have the Grant Element lying in 0–100 percent range.

PV debt can be calculated simply according to the following equation:

(6) $PV = dod_0(1 - GE)$

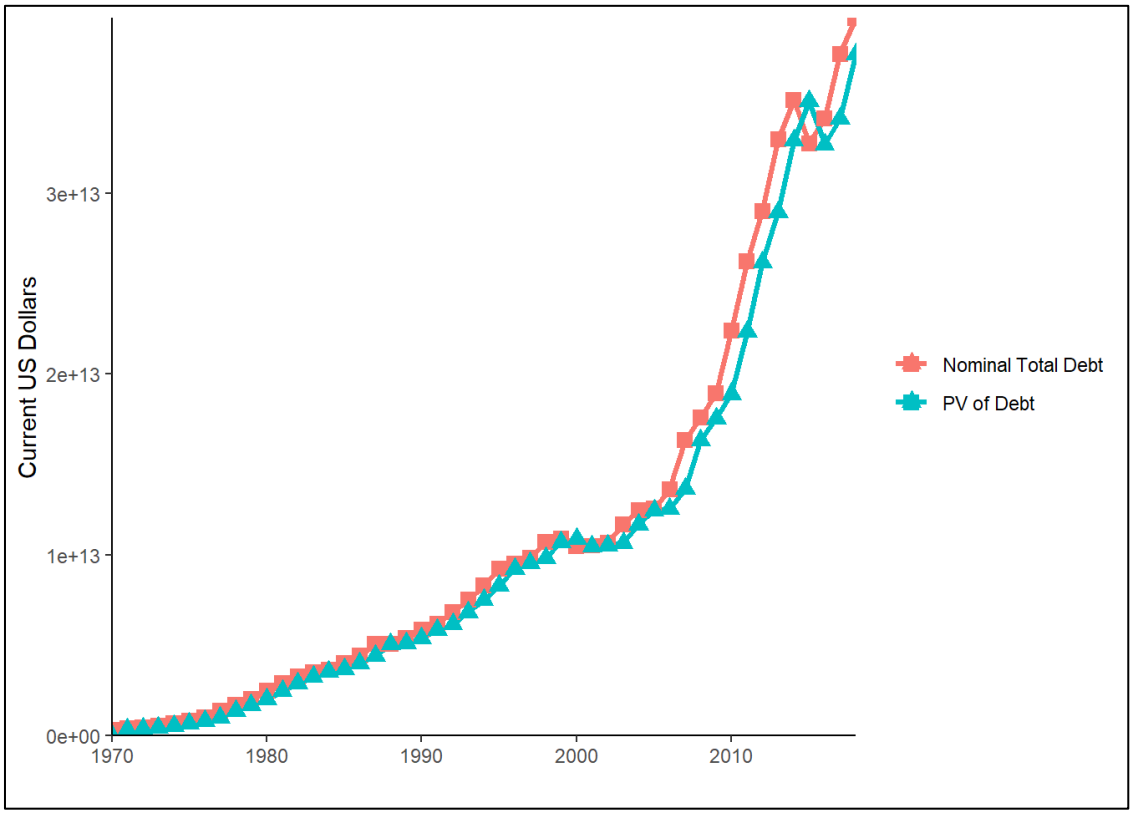
Figure 11 compares DOD and PV debt of developing countries for the period from 1980 to 2002, which is taken from Dikhanov (2005)'s study. Figure 12 compares DOD and PV debt for BRI countries based on my own calculation.

Figure 11: Developing World DOD and PV, 1980–2002



Source: Dikhanov (2005, p. 10)

Figure 12: DOD and PV Debt of BRI Countries, 1970–2020



Source: Own Calculation

C. Calculation of country-specific debt thresholds

Table 10: Country-specific Debt Thresholds, 2018

Country	Region	Income Group	PV debt/exports	Debt threshold
AGO	Sub-Saharan Africa	Lower middle income	1.50544	1.093653
ALB	Europe & Central Asia	Upper middle income	1.693128	0.946462
ARM	Europe & Central Asia	Upper middle income	1.67137	1.094273
AZE	Europe & Central Asia	Upper middle income	0.460549	0.980038
BEN	Sub-Saharan Africa	Lower middle income	0.890724	0.47698
BGD	South Asia	Lower middle income	0.673689	1.658689
BGR	Europe & Central Asia	Upper middle income	0.841926	0.760473
BIH	Europe & Central Asia	Upper middle income	1.075785	0.985658
BLR	Europe & Central Asia	Upper middle income	0.822411	0.830607
BOL	Latin America & Caribbean	Lower middle income	1.03138	0.677015
BTN	South Asia	Lower middle income	1.619335	1.628259
CPV	Sub-Saharan Africa	Lower middle income	0.84183	0.835384
CRI	Latin America & Caribbean	Upper middle income	1.095268	1.108682
DMA	Latin America & Caribbean	Upper middle income	0.728926	1.078805
DOM	Latin America & Caribbean	Upper middle income	1.672876	1.058549
DZA	Middle East & North Africa	Lower middle income	0.124873	1.318158
ECU	Latin America & Caribbean	Upper middle income	1.785388	1.498842
EGY	Middle East & North Africa	Lower middle income	1.581508	1.552019
FJI	East Asia & Pacific	Upper middle income	0.277051	1.864675
GEO	Europe & Central Asia	Upper middle income	0.890334	1.290066
GRD	Latin America & Caribbean	Upper middle income	0.362703	0.063802
IDN	East Asia & Pacific	Upper middle income	1.612964	2.54533
JAM	Latin America & Caribbean	Upper middle income	2.0605	1.338901
JOR	Middle East & North Africa	Upper middle income	1.519037	1.729049
KAZ	Europe & Central Asia	Upper middle income	2.216819	1.387586
KEN	Sub-Saharan Africa	Lower middle income	2.398238	1.009388
KGZ	Europe & Central Asia	Lower middle income	1.709881	1.216947
KHM	East Asia & Pacific	Lower middle income	0.370323	1.946564
LBN	Middle East & North Africa	Upper middle income	4.06237	2.357528
LKA	South Asia	Lower middle income	2.46824	2.228978
LSO	Sub-Saharan Africa	Lower middle income	0.403641	0.505113
MAR	Middle East & North Africa	Lower middle income	0.698785	1.550975
MDA	Europe & Central Asia	Lower middle income	1.02569	0.825186
MDV	South Asia	Upper middle income	0.399045	1.799421
MKD	Europe & Central Asia	Upper middle income	0.918231	0.880285
MMR	East Asia & Pacific	Lower middle income	0.371219	-0.9424
MNE	Europe & Central Asia	Upper middle income	2.319614	1.535303
MNG	East Asia & Pacific	Lower middle income	3.518255	3.560056
NGA	Sub-Saharan Africa	Lower middle income	0.791678	0.877184
PAK	South Asia	Lower middle income	2.588927	1.676555
PER	Latin America & Caribbean	Upper middle income	1.036077	1.010971
PHL	East Asia & Pacific	Lower middle income	0.519344	1.680887
PNG	East Asia & Pacific	Lower middle income	1.66324	2.153274
RUS	Europe & Central Asia	Upper middle income	0.885678	1.223796
SLB	East Asia & Pacific	Lower middle income	0.223159	1.926871
SLV	Latin America & Caribbean	Lower middle income	1.91587	1.451931
THA	East Asia & Pacific	Upper middle income	0.293623	2.215372
TLS	East Asia & Pacific	Lower middle income	0.095658	1.64284
TON	East Asia & Pacific	Upper middle income	1.278096	1.947379
TUN	Middle East & North Africa	Lower middle income	1.460209	1.534374
TUR	Europe & Central Asia	Upper middle income	1.989838	1.299124
UKR	Europe & Central Asia	Lower middle income	1.801612	0.653363
UZB	Europe & Central Asia	Lower middle income	0.762336	0.61399
VNM	East Asia & Pacific	Lower middle income	0.289314	1.853396
WSM	East Asia & Pacific	Upper middle income	1.422099	1.986691
ZAF	Sub-Saharan Africa	Upper middle income	1.766624	1.256243
ZMB	Sub-Saharan Africa	Lower middle income	1.77228	0.979246
ZWE	Sub-Saharan Africa	Lower middle income	1.385471	-0.84224

D. Regression results and robustness checks from KN's study

Table 11: Regression Results of KN's Base Model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PV Debt/Exports	0.317 (0.079)***				0.228 (0.086)***		0.064 (0.100)	
Total Debt Service/Exports		3.615 (0.720)***				4.011 (0.992)***	3.750 (0.991)***	3.341 (0.063)***
CPIA Rating			-0.627 (0.144)***		-0.514 (0.153)***	-0.652 (0.159)***	-0.625 (0.164)***	-.640 (0.144)***
Real GDP Growth				-7.178 (1.993)***	-6.670 (2.303)***	-5.075 (2.475)**	-5.009 (2.483)**	-3.358 (1.684)**
Constant	-1.206 0.162***	-1.580 (0.205)***	1.438 (0.506)***	-0.539 (0.126)***	0.915 (0.587)	0.765 (0.556)	0.630 (0.596)	0.801 (0.502)
# Observations	163	163	163	163	163	163	163	284
Pseudo R-Squared	0.087	0.184	0.127	0.085	0.234	0.348	0.350	0.242
Out-of-Sample Predictive Power								
Correct Predictions	0.51	0.67	0.67	0.43	0.70	0.84	0.84	0.69
Distress Events	0.90	0.80	0.60	0.80	0.70	0.70	0.70	0.90
False Alarms	0.55	0.35	0.32	0.63	0.30	0.13	0.13	0.34

Source: Kraay and Nehru (2006, p. 44)

Table 12: Robustness Checks for KN's Base Model: Alternative Debt Measures

	(1)	(2)	(3)	(4)	(5)	(6)
Face Value Debt/Exports	0.11 (0.06)*			0.11 (0.06)*		
Debt Service/Revenues		3.18 (0.89)***			3.01 (0.70)***	
Debt Service/Reserves			0.35 (0.08)***			0.33 (0.06)***
CPIA Rating	-0.54*** (0.15)	-0.64 (0.19)***	-0.52 (0.18)***	-0.54 (0.15)***	-0.75 (0.17)***	-0.52 (0.16)***
Real GDP Growth	-6.77 (2.27)***	-3.27 (3.02)	-4.48 (2.72)*	-6.77 (2.27)***	-0.22 (2.10)	-3.31 (1.90)*
Constant	1.12 (0.58)	0.64 (0.63)	0.66 (0.63)	1.12 (0.58)	1.09 (0.56)	0.58 (0.57)
# Observations	163	121	153	163	185	268
Pseudo R-Squared	0.21	0.26	0.30	0.21	0.19	0.23

Source: Kraay and Nehru (2006, p. 45)

Table 13: Robustness Checks for KN's Base Model: Alternative Policy and Shock Measures

	(1)	(2)	(3)	(4)	(5)	(6)
PV Debt/Exports	0.25 (0.08)***		0.27 (0.09)***	0.56 (0.14)***		
Total Debt Service/Exports		3.16 (0.58)***			3.90 (0.67)***	3.51 (0.64)***
CPIA Rating			-0.42 (0.16)***	-0.45 (0.18)***	-0.56 (0.15)***	-0.54 (0.15)***
KK Rule of Law Index	-0.36 (0.19)*	-0.42 (0.15)***				
Real GDP Growth	-6.97 (2.19)***	-3.77 (1.55)**				
Real Depreciation			-0.28 (0.85)		-1.47 (0.80)*	
Terms of Trade Growth				0.06 (1.40)		-1.21 (1.28)
Constant _CONS	-1.02 (0.18)***	-1.52 (0.19)***	0.29 (0.61)	0.11 (0.69)	0.25 (0.53)	0.26 (0.56)
# Observations Pseudo R-Squared	162 0.18	283 0.19	158 0.15	142 0.23	278 0.22	250 0.22

Source: Kraay and Nehru (2006, p. 46)

Table 14: Robustness Checks for KN's Base Model: Role of Level of Development

	(1)	(2)	(3)*	(4)*	(5)*	(6)*
			Low-Income Sample		*High-Income Sample*	
PV Debt/Exports	0.63 (0.16)***		0.043 (1.52)		0.200 (3.84)***	
Total Debt Service/Exports		3.69 (0.69)***		0.787 (2.75)***		0.772 (4.39)***
CPIA Rating	-0.50 (0.18)***	-0.51 (0.16)***	-0.162 (2.48)**	-0.241 (4.17)***	-0.076 (1.77)*	-0.058 (1.37)
GDP Growth	-5.68 (2.67)**	-3.88 (1.82)**	-1.386 (1.49)	-0.291 (-0.53)	-1.413 (1.76)*	-1.511 (2.47)**
Log(Real Per Capita GDP)	0.30 (0.21)	-0.22 (0.15)				
Constant	-2.04 (1.79)	1.96* (1.13)				
# Observations	144	258	81	139	82	145
Pseudo R-Squared	0.31	0.26	0.18	0.21	0.46	0.33

* These columns report estimated marginal effects. Absolute value of t-statistics associated with the underlying slope coefficients are reported in parentheses.

Source: Kraay and Nehru (2006, p. 47)

Table 15: Robustness Checks for KN's Base Model: Role of History

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PV Debt/Exports	0.54 (0.15)***		0.23 (0.09)**		0.23 (0.09)**			0.212 (0.087)**
Total Debt Service/Exports		3.25 (0.66)***		3.57 (0.65)***		3.33 (0.63)***		
CPIA Rating	-0.46 (0.18)**	-0.59 (0.17)***			-0.54 (0.16)***	-0.62 (0.15)***		-0.515 (0.155)***
GDP Growth	-7.01 (2.79)**	-2.76 (1.91)	-6.58 (2.32)***	-3.35 (1.65)**				-6.496 (2.305)***
Inflation History	2.08 (1.04)**	-0.17 (0.71)						
Average CPIA			-0.43 (0.28)*	-0.95 (0.22)***				
CPIA Deviation			-0.57 (0.22)***	-0.49 (0.16)***				
Average GDP Growth					-0.32 (7.31)	-6.99 (6.12)		
GDP Growth Deviation					-7.71 (2.63)***	-3.02 (1.76)*		
Fraction of years in default prior to 1980							2.306 (0.905)**	1.929 (1.021)*
Constant	0.21 (0.70)	0.61 (0.62)	0.62 (1.03)	1.80 (0.73)	0.72 (0.63)	0.90 (0.53)	-0.864 (0.120)***	0.839 (0.594)
# Observations	149	250	163	284	163	284	163	163
Pseudo R-Squared	0.31	0.22	0.23	0.26	0.24	0.24	0.04	0.26
P[Average = Deviation]			0.73	0.06	0.36	0.54		

Source: (Kraay and Nehru, 2006, p. 48)

CONFIRMATION

Hereby I confirm that I have composed the present thesis independently. I only have used the sources and means specified in this thesis. Especially from the internet, I only have used the denoted references. I have taken note of the section in the examination regulations concerning attempts to cheat.

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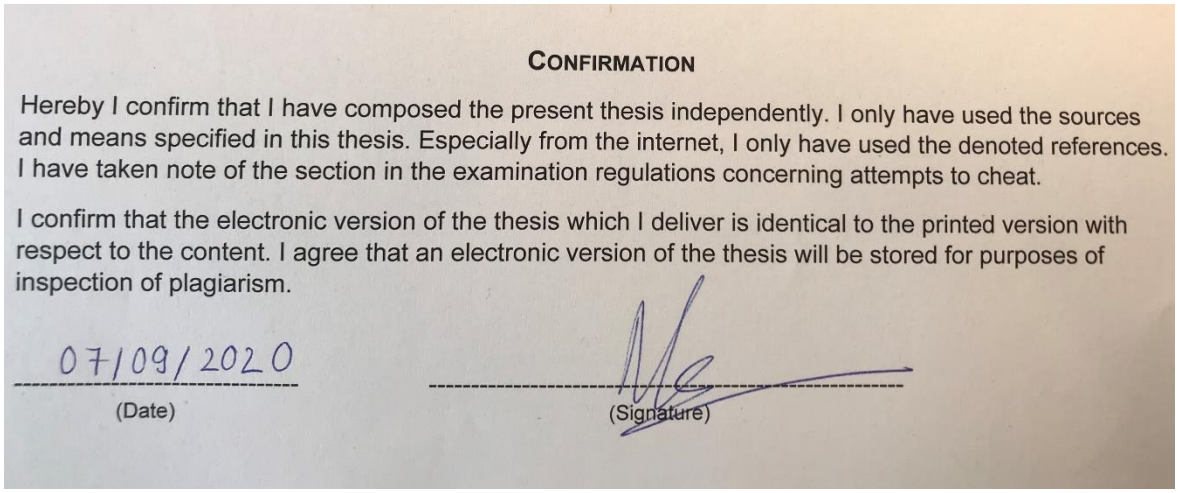
(Date)	(Signature)



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