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A Framework to Assess Debt Sustainability and Fiscal Risks under the Belt and Road Initiative

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Abstract

This paper provides a framework to assess the impact of infrastructure investment expected under the Belt and Road Initiative (BRI) on the debt vulnerabilities of countries that are located on BRI transport and connectivity corridors in the absence of comprehensive and consistent information on investments and financing terms. Key assumptions relate to the amount of public and publicly guaranteed (PPG) debt financing and its terms, the size and sectoral type of identified BRI investment, and the expected impact of growth in the medium and long term of that investment. BRI debt financing is expected significantly increase PPG debt in a number of countries. The paper provides estimates for both the medium and the long term. In the medium term, defined as the period 2019–2023, debt financing of BRI investment is expected to be fully disbursed while the full growth impact of BRI related infrastructure is not entirely realized. In this initial phase, around one-third of assessed BRI-recipient countries are estimated to face elevated debt vulnerabilities post- BRI, several of which have already high debt vulnerabilities. The impact of BRI on public debt would improve over the longer term under the assumption of a sustained negative interest rate-growth differential and in the absence of the materialization of BRI related fiscal risks. Still, debt to GDP ratio is expected to remain higher in one-third of countries (11 out of 30 with available data).

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A Framework to Assess Debt Sustainability and Fiscal Risks under the Belt and Road Initiative [1]

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JEL: H680, O47

Keywords: fiscal sustainability; fiscal risks; contingent liabilities; investment and growth.

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[1] This paper has been prepared by Luca Bandiera (Sr. Economist, GMTMD) and Vasileios Tsiropoulos (Young Professional, GMTMD) under the guidance of Doerte Doemeland (Practice Manager, GMTMD) and Marcello Estevão (Global Director, MTI). It is a background paper for a forthcoming World Bank report titled “Belt and Road Economics”, authored by Michele Ruta (Lead Economist, GMTRI), under the overall guidance of Caroline Freund (Director, GMTD3). It has benefited from discussions with Lea Hakim (Sr. Economist, GMTMD) and Charl Jooste (Economist, GMTMD) to define the content of the paper, from peer review comments provided by Sudarshan Gooptu (Lead Economist, GMTD4), Lars Jessen (Lead Debt Specialist, GMTMD) and Valerio Crispolti (Sr. Economist, Fiscal Affairs Department, IMF), and from comments provided by Martin Raiser (Country Director, China), Caroline Freund (Director, GMTD3) and participants to a workshop of all background papers organized in the World Bank on September 20, 2018. Inputs for the preparation of the paper were also provided by Signe Zeikate (Senior Debt Specialist, GMTMD) for Section I and from Ying Li (Consultant, GMTMD) who has provided research assistance on MAC DSAs and the cost of financing in selected BRI-recipient countries. The authors would like to thank also Evis Rucaj (Sr. Economist, DECES) and Rubena Sukaj (Economist, DECES) for kindly providing data on Chinese debt.

Introduction

The Belt and Road Initiative (BRI), announced by President Xi Jinping of China in 2013, is a China-led effort to improve connectivity and regional cooperation on a trans-continental scale through large-scale investments. By some estimates, the initiative seeks to deliver up to US$1 trillion in infrastructure investment mainly to Asia, Europe, and Africa.[2] The BRI has the potential to significantly accelerate the rate of economic integration and development of a large number of countries. But, like any large undertaking, there are significant policy and economic challenges. One important question is how the BRI affects debt sustainability in beneficiary countries.

The implementation of the BRI takes place in the context of rapidly rising public and corporate debt levels. Public debt in Emerging Markets (EMs) has been rising, reaching levels not seen since the 1980s. It has been accompanied by changes in public debt composition and by rising corporate debt in Ems, which now significantly exceeds historical levels and adds to fiscal risks and vulnerabilities. Similarly, debt risks in low-income developing countries (LIDCs) have risen substantially over recent years and the share of countries at high risk of debt distress or in debt distress has doubled since 2013 to about 40 percent (IMF and World Bank, 2018). In this context, large debt financing, especially in foreign currency and on non-concessional terms, may lead to a rapid deterioration of already heightened debt vulnerabilities over the medium term.

The analysis in the paper only covers estimated BRI investments financed through public and publicly guaranteed (PPG) debt and not total debt financing from China. Our database identifies BRI investment worth US$575 billion, including projects already executed, in implementation phase and planned. Based on this data, US$525 billion or 91 percent of total identified investments is expected to benefit IBRD or IDA-eligible countries.[3] Only US$66 billion in completed projects has been identified as of end-2016; most BRI investment is still in the construction or planning phase. The analysis largely focuses on 50 developing countries, which have been identified as lying on the original BRI transport and connectivity corridors (De Soyres et al., 2018) and for which debt and macroeconomic data are available. This approach implies that, for example, only two Sub-Saharan African countries, namely Kenya and Tanzania, are included in the database, despite significant Chinese investment in Sub-Saharan Africa, some of which has been recently rebranded as BRI related. [4]

Several countries have already scaled back on BRI investments or requested debt relief from China. In October 2018, Malaysia decided to suspend and renegotiate US$20 billion worth of projects fearing not to be able to repay such debt and Pakistan cut down the cost of a large railway project. China had to provide debt relief to several borrowing countries in recent years[5]; in some rare cases, difficulties in repaying debt has resulted in China taking possession of key infrastructure in lieu of repayment in Sri

[2] See, for example, "How Big Is China's Belt and Road?", April 3, 2018, Center of Strategic and International Studies.
[3] US$ 10 billion of financing directed to Latin American Countries was not considered in the analysis.
[4] In October 2018, the Forum on China-Africa Cooperation announced US$60 billion financing to African Countries and this financing has been re-branded as part of the BRI (see https://thediplomat.com/2018/09/focac-2018-rebranding-china-in-africa/).
[5] Hurley *et al.* (2018) provide a comprehensive list.

Lanka, Kyrgyz Republic and Zambia, raising concerns over collateralized debt obligations, debt transparency and weak governance in countries that are large recipient of financing from China.

The assessment of the impact of BRI on countries' debt sustainability outlook faces significant challenges due to lack of comprehensive and consistent information on investments and financing terms. Accurate and comprehensive debt data are important for policy makers so that they make informed borrowing decisions, thus safeguarding debt sustainability and macroeconomic stability. Yet, there is no official source of BRI investment nor systematic information of the size and terms of public and private debt financing, as well as non-debt financing related to identified BRI projects. This paper therefore relies on a variety of data sources and makes several strong assumptions, which are discussed in detail below, to establish a range of estimates for the impact of BRI on debt sustainability in 45 countries. In particular, it assumes that on average 60 percent of BRI identified investment would be financed through public or publicly guaranteed debt.[6]

The paper estimates that BRI may be associated with heightened debt dynamics in 12 out of 43 (or 28 percent) low and middle-income countries, over the medium term. Of these 12 countries, 10 have already high debt vulnerabilities before BRI. At least two additional countries would experience a severe worsening of their debt situation over the medium term, as a result of the estimated BRI financing. These estimates are bound estimates: they assume an optimistic impact of BRI investment on growth, no materialization of additional fiscal risks and no negative feedback effects from debt to growth.

Over the long-term, including the full impact of BRI investment, one-third of countries (11 out of 30 with available data) are projected to have a higher debt-to-GDP ratio as a result of BRI. In these 11 countries, the debt-to-GDP ratio resulting from BRI is projected to be higher compared to a scenario excluding BRI. However, BRI is estimated to increase the debt-to-GDP ratio only in two countries relative to at end-2016, the base-year for the simulations. In five more countries the debt ratio resulting from BRI would be higher than their levels at end-2016 if the cost of financing would increase. These findings are largely driven by the assumption of continued negative interest-growth differentials in many BRI recipient countries, which helps keeping debt dynamics under control.

The projected impact of BRI investment on public debt dynamics will worsen if fiscal risks associated with large investment projects were to be realized. Financing and implementation of large infrastructure projects could result in additional expenditure or loss of revenue depending on allocation of risks in contractual clauses. These risks are particularly relevant in case of "megaprojects" of US$ 1 billion of more as many BRI investments.

This paper is structured as follows. First, it provides an overview of the relevant literature in section I and presents the data in section II. It summarizes the debt situation of BRI-recipient countries in section III. It provides a forward-looking exercise, based on growth elasticities to investment, to project the evolution of debt-to-GDP ratios in BRI-recipient countries in section IV. It presents a metric, based on lower bound estimates of the impact of BRI on debt-to-GDP ratios, to identify countries with likely higher debt vulnerability in the medium term and provides long-term debt dynamics simulations in section V. It

[6] Authors have checked information available for Belarus, Djibouti, Kyrgyz Republic, Pakistan, Sri Lanka, Tajikistan, and Ukraine.

discusses fiscal risks in section VI. Section VII concludes, noting limitations and setting the stage for further analytical work.

I. Literature Review

The impact of large debt-financed investments on debt sustainability depends critically on how these investments affect the economic growth. A large literature studies the contribution of infrastructure capital to productivity and output. Methodologies and estimates of this impact vary widely. Using panel data, research finds that output elasticities to aggregate measures of infrastructure investment range from 0.06 to 0.18 (Calderón, Moral-Benito and Servén, 2011) in developing countries. However, there is a recognition that different types of investment have different impact on growth (Calderon, 2009) and that the efficiency of investment spending may vary across countries. For example, the impact of the observed monetary measures of public investment tend to be overstated in many low-income countries with poor institutions (Keefer and Knack 2007) due to weakness in public investment management.

To identify the impact of BRI investment on growth in recipient countries this paper applies a theoretical approach and an empirical approach. Hence, it would address the two main issues which are identified in the literature. First, countries have different elasticities of investment on growth. Second, physical indicators for the stock infrastructure are better predictors of the impact of infrastructure investment on growth.

The theoretical approach, based on Devadas and Pennings (2018), uses a constant elasticity production function to derive the marginal productivity of BRI investments. This model assumes that the impact of additional investment on growth declines as the public capital stock rises. It assumes a constant investment spending efficiency over the medium-term. This model has the advantages of being based on data that are available for most countries and providing country-specific growth estimates based on the level of capital stock and amount of investment. However, it is calibrated using a measure of capital stock derived from real public fixed capital formation, which has been shown not to be a reliable indicator of the increased capital stock.

In the empirical approach, the contribution of physical infrastructure investment to medium-term growth is estimated. Drawing on Calderon (2009) and Calderon and Serven (2014), it estimates annual elasticities of public infrastructure investment on growth by country, using a dynamic panel data growth model, with an index of infrastructure quality top measure the effective infrastructure capital stock. However, these estimates are not robust to sensitivity analysis and should be interpreted with caution. The analysis does not take into account country-specific factors, e.g. degree of economic openness, exchange rate regime, public debt levels or fiscal and monetary policies, which have been found to alter how public investment affects economic growth.

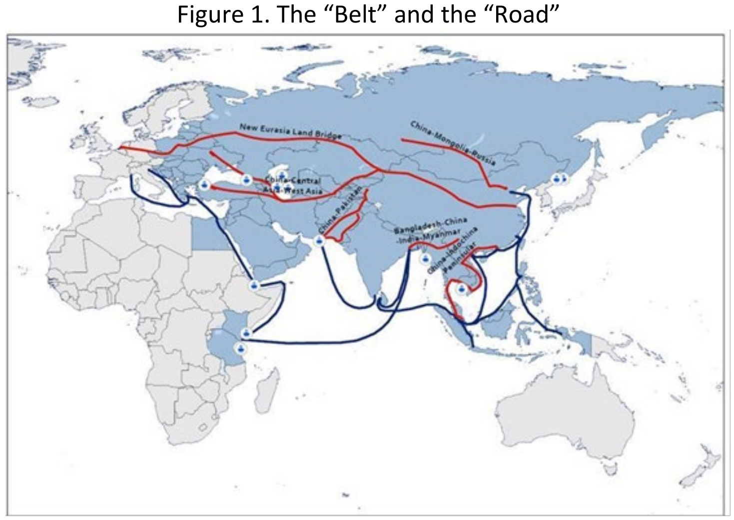
To provide long-term estimates of indebtedness due to BRI investment, the paper uses the results of a structural general equilibrium (SGE) model, based on de Soyres et al. (2019). The SGE model builds on the framework by Caliendo and Parro (2015) – a Ricardian model with sectoral linkages, trade in intermediate goods and sectoral heterogeneity – to allow for changes in trade costs due to improvements in transportation infrastructure connecting multiple countries that are financed through domestic taxation.

The model is then used to quantify the economic and growth impact of the Belt and Road Initiative for 53 countries, under several different trade policy reform scenarios.

In our knowledge, only one additional paper investigates the impact of BRI investment on debt sustainability. Hurley et al (2018) conclude that eight countries will be at risk of debt distress based on an identified pipeline of project lending associated with BRI. As in Hurley et al. (2018), this paper forecasts the impact of BRI debt financing on the indebtedness of BRI-recipient countries. However, we present a metric to assess the impact of BRI investment on debt sustainability in a cross-country context and taking into account the expected impact of BRI investment on growth in the medium and long-term.

II. Data Selection

Figure 1. The "Belt" and the "Road"



Source: De Soyres et al., 2018.
Note: Belt and Road corridor economies are colored in blue.

The analysis presented in this paper covers up to 50 countries located along BRI transport and connectivity corridors. The Government of China has not released an official list of "BRI countries" and recently a number of countries have signed up to the initiative even if geographically disconnected from major BRI routes. To define the scope of this and related BRI studies, the World Bank has limited the analysis to the Silk Road Economic Belt -the "Belt"- and the New Maritime Silk Road -the "Road" (Figure 1). The "Belt" links China to Central and South Asia and onward to Europe, while the "Road" links China to the nations of South East Asia, the Gulf Countries, East and North Africa, and on to Europe. Combined, the Belt and the Road connect 69 countries. Of these 69 countries, we consider 50 developing countries, for which debt and macroeconomic data are available. For the econometric analysis, the sample is further reduced to 43 countries, excluding seven countries for which no BRI investment planned or under construction has been identified (section IV). This approach implies that only two Sub-Saharan African countries, namely Kenya and Tanzania, are included in the database, despite significant Chinese investment in Sub-Saharan Africa, some of which has been recently rebranded as BRI related. [7]

As a result of these assumptions, the analysis focuses largely on middle-income countries. Two-thirds of the identified financing is expected to be provided to countries in East and South Asia, Europe and Central Asia, the remaining investment would benefit mainly South Asia and the Middle East, with only 2 percent to be invested in Sub-Saharan Africa (SSA). Almost all expected financing will accrue to lower and upper

[7] In October 2018, the Forum on China-Africa Cooperation announced US$60 billion financing to African Countries and this financing has been re-branded as part of the BRI (see https://thediplomat.com/2018/09/focac-2018-rebranding-china-in-africa/).

middle-income countries, only 1 percent to mainly SSA low-income countries and the reminder 3 percent to advanced economies in the Middle East and in East Asia (Figure 2).

This paper uses data from a survey of BRI-related investment that has been commissioned by the World Bank in 2018 and compiled by WIND, a Chinese consultancy firm. The WIND database covers China's construction contracts and other investment projects in non-financial sectors in 50 countries that have been identified in the news as being BRI related. For each project, the database reports their status: completed, under construction, or planned for the years 2013 to 2018. Planned projects are all officially confirmed. For the purpose of this analysis, we only include projects that are planned or under construction from 2016 to 2018. These data are complemented with investment information compiled by the World Bank's country economists for Tajikistan, Georgia and Djibouti. While the BRI has been announced in 2013, actual public and publicly guaranteed debt data used in this paper are available until 2016 and are therefore unlikely to include BRI-financing for non-completed projects identified from 2016 to 2018.

Figure 2. BRI Recipient Countries

By number

Source: WIND database.

The WIND database is the most comprehensive and up-to-date database on Chinese BRI-related outside investment. The American Enterprise Institute (AEI) compiles the China Global Investment Tracker (CGIT),[8] which tracks both overseas investment and construction contracts and identifies BRI-related projects (See Annex II for key statistics comparing the CGIT and the World Bank database). However, the AEI database includes fewer countries (38 vs 44 BRI countries with identified investment), it does not include data for

[8] http://www.aei.org/china-global-investment-tracker

BRI-recipient countries in Sub-Saharan Africa, it identifies fewer projects and much lower amounts of investment (about 300 billion, compared to about 500 billion in the Bank's database) in 2017 and 2018.

Ideally, this paper should use debt financing related to identified BRI projects, but the information is not readily available. Two publicly available large databases track lending from China. These are Aid Data from compiled by researchers at William and Mary College[9] and the China Africa Research Initiative (CARI) from John Hopkins University School of Advanced International Studies.[10] Unfortunately, both sources of lending data have severe limitations for this paper: both databases identify borrowing or commitment only up to 2014, just one year after the announcement of BRI; no loan is identified as related to BRI; and the CARI tracks lending only to Africa, which includes only a small portion of BRI-related investment, as defined in this paper.

There is very sparse information on the financing of BRI-related projects. A full debt sustainability analysis and the analysis of fiscal risks would require detailed, country-specific information on the financing structure of BRI-related projects. According to the WIND data base, about half of the BRI investment is in electricity and ¼ in transport and shipping (see Annex II). Information from Pakistan suggests that electricity investments would be conducted by Independent Power Producers (IPP). These contracts usually include public sector guarantees on loan financing and a power purchasing agreement by government entities (e.g. the Ministry of Water and Power). Infrastructure contracts in Djibouti and Pakistan are either direct lending from China to the government or to a state-owned enterprise (SOE), with explicit guarantees of the government. In both contractual structures, the BRI-recipient governments are likely to guarantee a substantial amount of the private or public financing provided. It seems therefore reasonable to assume that a large share of the BRI investment would be financed as public or publicly guaranteed debt (PPG).[11]

Country analysis suggests that PPG debt financing would amount to about 40 percent of the investment in power, electricity and mining and 80 percent in transport and other sectors. These assumptions result in PPG debt financing which amounts to around 60 percent of total BRI Investment costs, with the remainder project financing being provided as equity, grants or private non-guaranteed debt.[12] Given the structure of the investments described above, the incurred debt would be either public debt borrowed by a government ministry or debt guaranteed by the government or debt borrowed by an SOE or other government agency, with an implicit government guarantee. Consequently, we assume that all non-guaranteed SOE debt is PPG debt.[13]

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[9] https://www.aiddata.org

[10] http://www.sais-cari.org/data

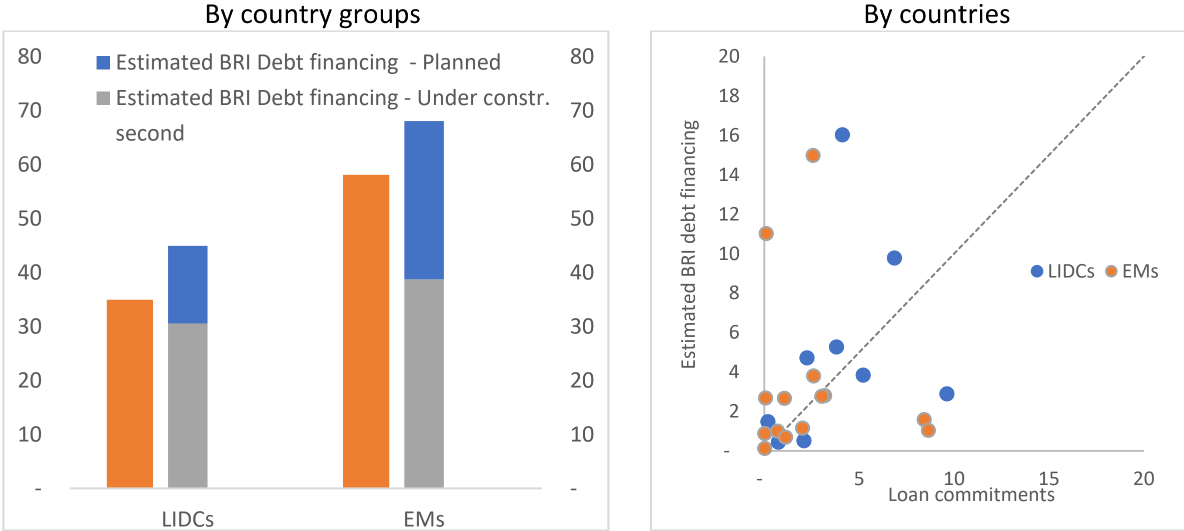
[11] Also, private non-guaranteed debt financing would also be collateralized to the underlying asset or to other assets or identified revenue and could constitute fiscal risks from lower future revenue.

[12] Costs include only the cost of construction of the infrastructure but exclude cost of maintenance, which could represent additional fiscal costs or fiscal risks.

[13] Under the joint Bank-Fund Debt Sustainability Framework for Low-income countries, debt of a public enterprise can be excluded from the coverage of PPG debt if the enterprise poses limited fiscal risk, i.e., it is able to borrow without a guarantee from the government, does not carry out uncompensated quasi-fiscal activities, and has an established track record of positive operating balances (IMF and World Bank, 2018b).

Data from the World Bank's Debtor Reporting System (DRS) has been used to assess the validity of the BRI-debt estimates and the terms of BRI-related lending used in the analysis.[14] The DRS records all loans from Chinese institutions,[15] as reported by debtors' countries. The loan information is not sufficient to identify whether a loan relates to a BRI project and, in addition, only countries which have data on both datasets are considered.[16] However, DRS data are available up to end-2017 and record all committed amounts for project loans. It is reasonable to assume that a loan contract has been signed for projects that are under construction. We therefore compare Chinese loan commitments in BRI countries with estimated BRI-debt financing derived from infrastructure projects under construction between 2013 and 2017. We find that our estimated commitments are lower than Chinese loan commitments recorded in the World Bank's Debtor Reporting System: around 4 billion less in low-income developing countries (LIDCs) and around 20 billion less in Emerging Markets (EMs). The difference may arise from the fact that governments may have already signed contracts for some projects that are still at the planning stage. As expected, the amount of estimated BRI debt financed projects planned and under construction exceeds the loan commitments during this period by about USD10 billion (Figure 2). However, discrepancies between DRS data and our estimated historical debt financing are large in some countries (Figure 3).

Figure 3. Estimated BRI PPG debt financing and China's PPG Loan Commitments, 2013-2017
(In billions of U.S. dollars)



Sources: *International Debt Statistics*, WIND database and authors' calculations.

[14] The World Bank's DRS was established in 1951. The DRS system captures detailed information at loan level for external borrowing of reporting countries using standardized set of forms. The primary objective of the DRS is to provide the Bank with reliable and timely external debt information to assess a borrowing country's foreign debt situation, creditworthiness, and economic management; and conduct its country economic work and assess regional and global indebtedness and debt servicing problems. Data submitted by countries are entered into the DRS database, from which the aggregates and country tables are produced and published annually in the International Debt Statistics publication (successor to Global Development Finance and World Debt Tables). For additional information see https://datahelpdesk.worldbank.org/knowledgebase/articles/381934-what-is-the-external-debt-reporting-system-drs.

[15] Including government agencies, Exim Bank of China, financial institutions and suppliers' credit.

[16] The comparison is limited to 9 LIDCs and 15 EMs countries compared to a total number of 43 countries with identified BRI investment either planned or under construction during the period 2013-2017.

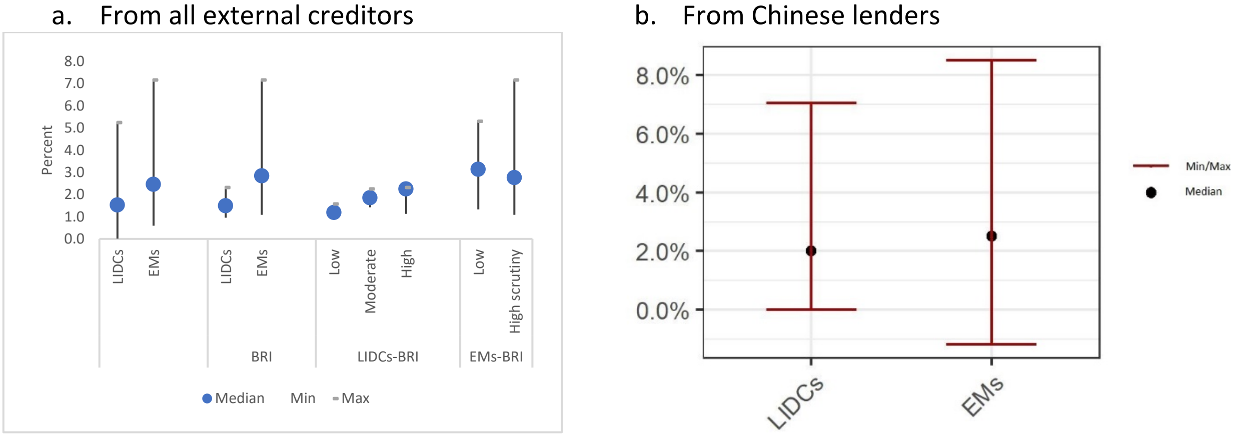
According to DRS data, most Chinese loans are concessional, but with terms that may not be the most favorable for LIDCs. Most Chinese loans to LIDCs have fixed interest rate with a median rate of 2 percent, a grace period of 6 years and a maturity of 20 years. Terms to LIDCs have been stable over time, corresponding to a median grant element of 40 percent. The median annual maturity of loans to EMs, fluctuates between 12 and 18 years and the grace period between 3 and 5 years. A growing share of loans to EMs have flexible interest rates, benchmarked to the 6-months LIBOR rate. Interest rates that Chinese lenders apply to LIDCs are on average more favorable compared to loans to EMs and meet normal concessionality requirements[17] but remain higher than those available from other creditors (Figure 4) for countries at low and moderate risk of debt distress. The median loan from China fully disburse between 2.5 and 7.5 years from the year of commitment, both in LIDCs and EMs. Characteristics of Chinese lending are discussed in Annex III.

This paper applies information on loan term from DRS. As specific information on BRI debt financing is not widely available[18], this paper uses the country-specific information included in the DRS as a proxy for the terms of BRI debt financing. Interest rates of Chinese loans are used to calculate the debt stabilizing primary balance in Section V. As median grace periods are above 5 years, the paper also assumes that no repayment on BRI debt is due ahead of 2023. In addition, consistent with a median disbursement period of 5 years, the paper also assumes that BRI debt would be fully disbursed by 2023. These assumptions are used to estimate both the growth and fiscal gaps in Section V.

Figure 4. Interest Rate on External Financing
(Median by group)

a. From all external creditors

b. From Chinese lenders



Sources: IDS, LIC DSF DSAs and MAC DSAs.

Sources: IDS, LIC DSF DSAs and MAC DSAs.
Note: Interest rates are estimated from DRS. Negative interest rates result on those loans that have LIBOR rates for the U.S. dollar as base rate.

Some authors find that a significant share of Chinese loans may be collateralized. According to Brautigam and Hwang (2016), about a third of Chinese infrastructure loans, are collateralized. The information collected through the DRS or other sources does not shed light on the amount of loans that could be collateralized. In a collateralized loan, the borrower has pledged or sold a specific asset to the lender as security against repayment of the loan. The underlying collateral can take many forms, such as the assets

[17] Defined as a grant element of at least 35 percent.
[18] Through news sources and inputs from World Bank country economists, the authors were able to identify terms of financing associated to BRI investment only in 9 countries. Loans referred only to a small number of projects. The information collected is consistent with the median terms from the DRS. Most of the identified financing originated from government institutions.

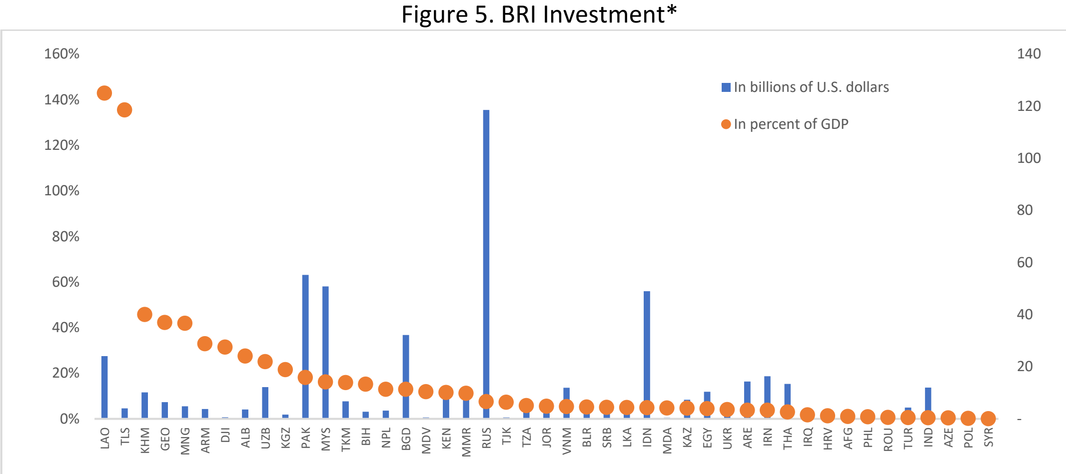
of a SOE, physical commodities destined for export markets, or a future revenue stream. Certain types of collateralized borrowing can impair a government's ability to meet or reschedule its liabilities and introduce significant macro risks. In countries with weak public investment management frameworks, the availability of funds in the immediate term may also induce borrowing countries to invest in large-scale infrastructure projects based on their ability to secure financing, rather than on the priority accorded to such projects in the government's overall development strategy.

III. Debt Vulnerabilities in BRI-Recipient Countries

Expected BRI investment is very large for a small number of countries. In our database, 66 percent of total BRI investment is expected to accrue to 7 countries, with Russia, Pakistan, Malaysia and Indonesia accounting for 50 percent of the total. Scaled by 2017 GDP, the median BRI investment amounts to under 6 percent of GDP, an amount which is not large compared to the investment needs of many countries, given that it would be disbursed over a multi-year period. Median annual BRI debt financing, could amount to slightly more than one percent of GDP if project financing would disburse over 5 years. However, in several countries the cumulative identified BRI investment surpasses 20% of 2017 GDP (Figure 5).

BRI investment takes place in countries with very different debt dynamics. Since 2012, median debt-to-GDP ratios have increased for Low Income Developing Countries (LIDCs) and Emerging Markets (EMs)[19], including BRI recipient countries (Figure 6 and Figure 7). One-third of BRI-recipient LIDCs, for which a recent debt sustainability analysis under the LIC DSF is available, are assessed to have high risk of debt distress according to the LIC DSF.[20] Nearly two-thirds of BRI-recipient EMs face elevated debt vulnerabilities, requiring high scrutiny (Figure 8 and Figure 9).[21]

Figure 5. BRI Investment*

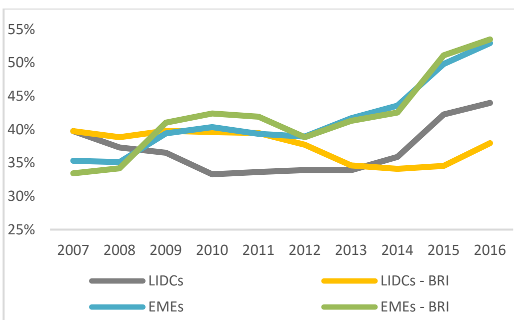


Source: WIND database and WDR.
*Note: Total identified BRI investment between 2013 to 2018.

[19] A list of countries is included in Annex I.
[20] As of end September 2018.
[21] Consistent with the definition adopted by the IMF for EM economies, high scrutiny countries are defined as those countries with (i) the public debt-to-GDP ratio equal or above 50 percent; or (ii) GFNs equal or above 10 percent of GDP; or (iii) have or are seeking exceptional access to Fund resources (IMF, 2013).

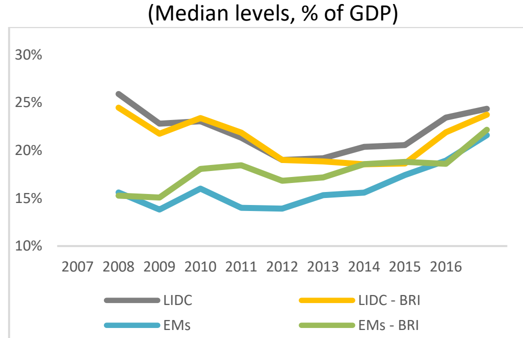
Over the past decade, BRI-recipient LIDCs, particularly those with high risk of debt distress, have increased their exposure to non-concessional debt and debt from non-traditional creditors, including China (Figure 10). Debt from multilateral and traditional bilateral creditors represented more than 70 percent of all external public debt of BRI-recipient LIDCs in 2016 (panel a). Consistent with the general trend of increased debt vulnerabilities in LIDCs (IMF, 2018 and World Bank, 2018a and 2018b),[22] the group of BRI-recipient LIDCs has over time increased reliance on private financing, including bonds and bank financing, which has doubled in the past 10 years (panel b). Non-concessional financing has increased especially in those BRI-LIDCs with moderate risk of debt distress. Exposure to non-Paris Club official creditors, including China, has also increased for the group of BRI LIDCs, reaching 22 percent of total external public debt. The largest increase of the exposure to non-traditional creditors took place in LIDCs with moderate and high risk of debt distress, with most of the increase in the latter group due to large borrowing from Laos (panel c and d).

Figure 6. General Government Gross Debt
(% of GDP)



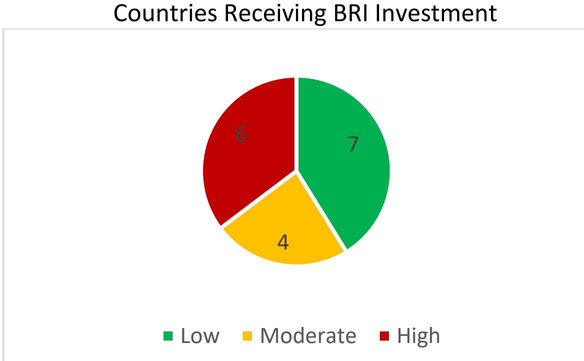
Source: International Debt Statistics.

Figure 7. Public and Publicly Guaranteed
External Debt
(Median levels, % of GDP)



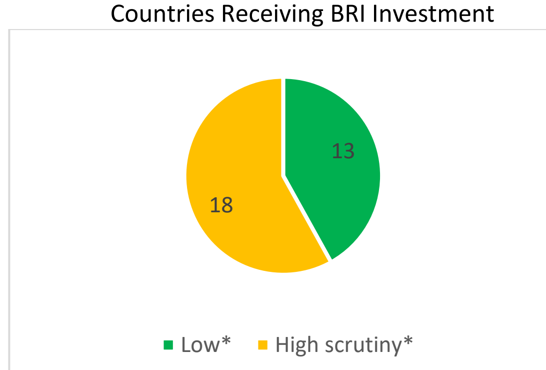
Source: World Bank and IMF debt sustainability analyses.

Figure 8. Debt vulnerabilities in Low Income Developing Countries Receiving BRI Investment



Source: World Bank and IMF debt sustainability analyses.

Figure 9. Debt vulnerabilities in Emerging Market Countries Receiving BRI Investment



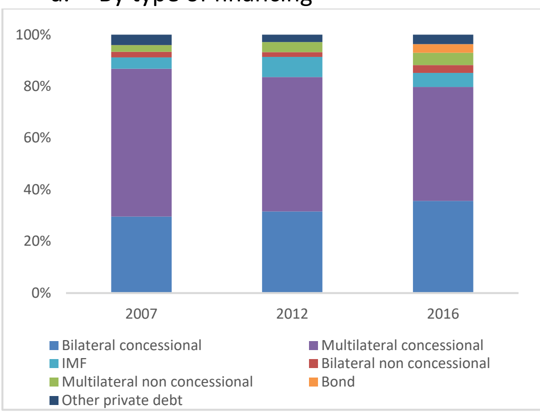
Source: World Bank and IMF debt sustainability analyses.

[22] See IMF, Macroeconomic Developments and Prospects in Low-Income Developing Countries - 2018, March 2018, which discusses the public debt situation of LIDCs in detail; IMF and World Bank. 2018a. "Rising Debt Vulnerabilities in Low-Income Developing Countries," Note to the Development Committee, April 2018; and World Bank, "Africa's Pulse", No. 17, April 2018.

Figure 10. Debt Composition of BRI-recipient LIDCs

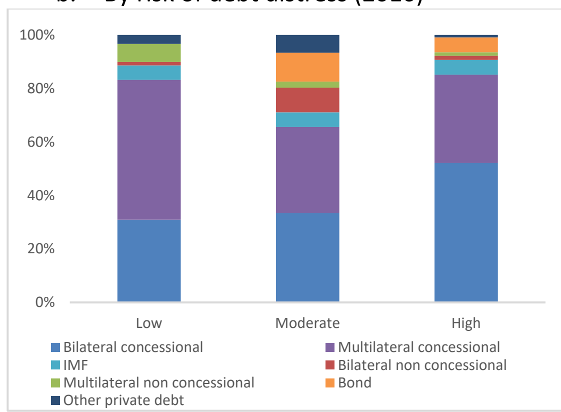
(In percent of total debt)

a. By type of financing



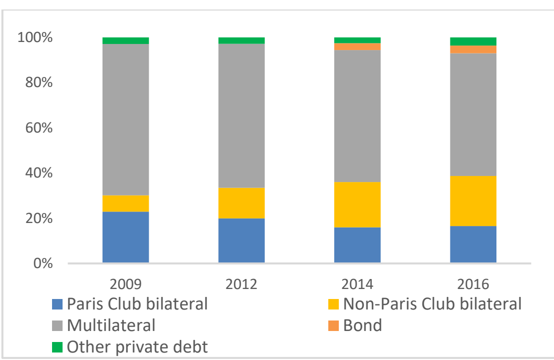
Source: International Debt Statistics.

b. By risk of debt distress (2016)



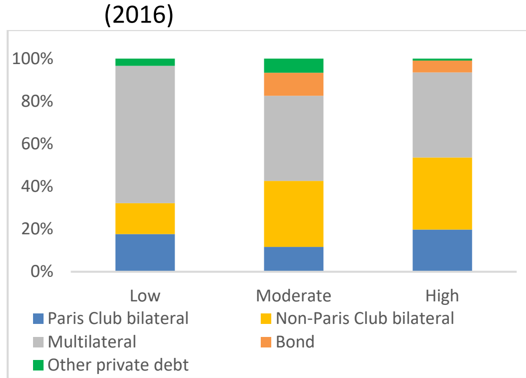
Source: International Debt Statistics.

c. By Type of creditor



Source: World Bank.

d. By type of creditor and risk of debt distress (2016)



Source: World Bank.

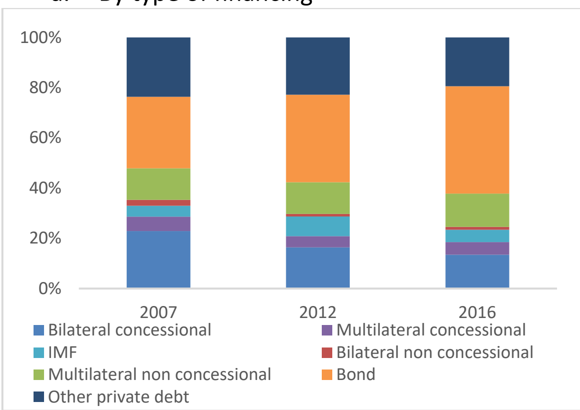
Public debt levels in terms of GDP have increased in EMs with BRI investments, but without affecting their credit ratings (Figure 11). The composition of external debt confirms an increase in the share of bond issuance, as observed in most EMs (World Bank, 2018b) (panel a); but mainly in those countries where debt vulnerability is considered lower (panel b). A growing share of BRI EMs has reached investment grade (panel c);[23] even though in few countries credit quality has deteriorated (panel d). The increased reliance on bonds could increase refinancing risks in a few countries in the medium term, but unlike other EMs there is no increasing trend in the repayment profile.

[23] Defined as a Moody's ratings of Baa3 or above.

Figure 11. Debt Composition of BRI-recipient EMs

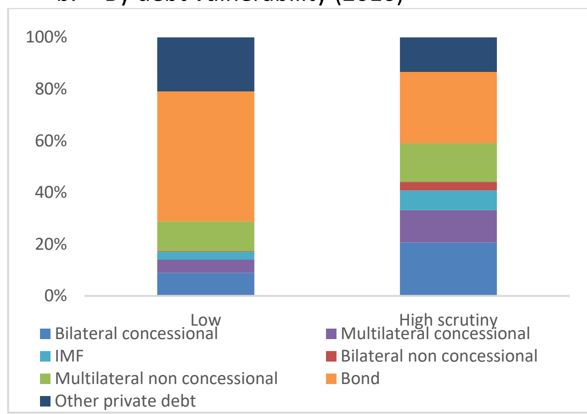
(In percent)

a. By type of financing



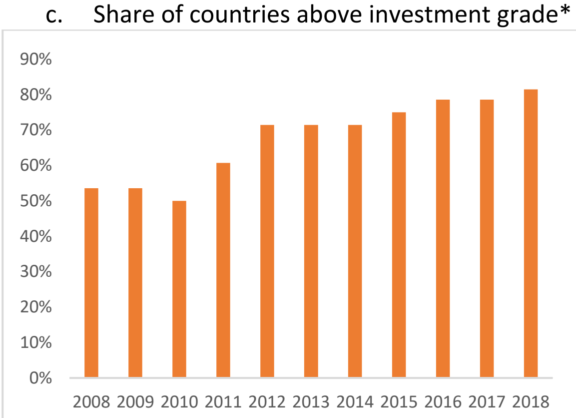
Source: International Debt Statistics.

b. By debt vulnerability (2016)



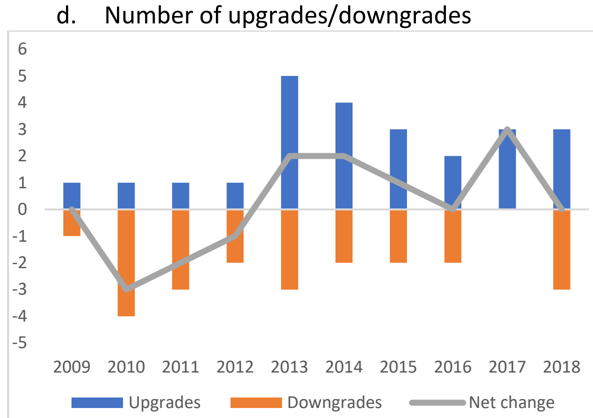
Source: International Debt Statistics.

c. Share of countries above investment grade*



Source: Dealogic.
*Moody's ratings of Baa3 or above.

d. Number of upgrades/downgrades



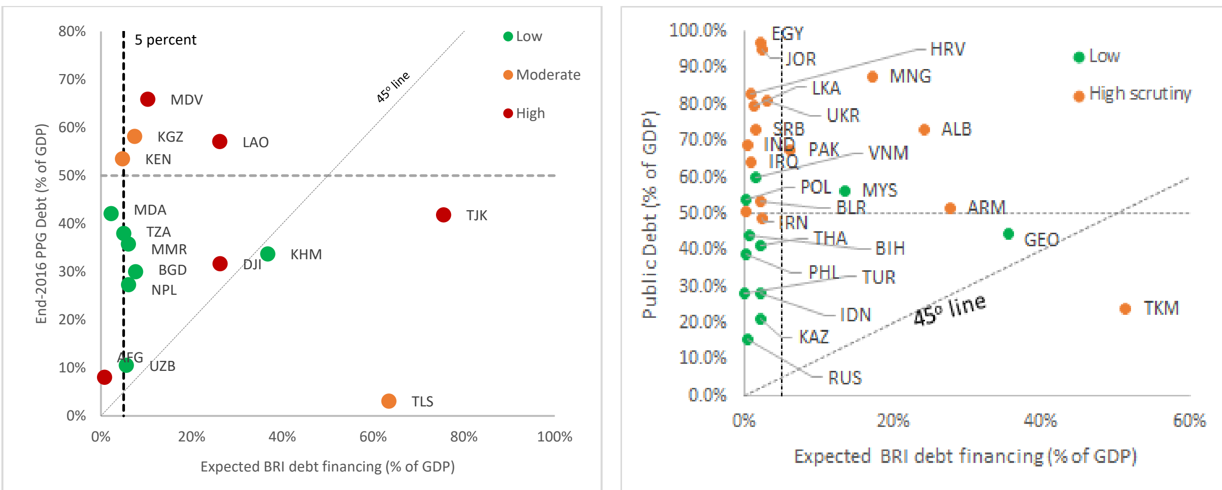
Source: Moody's ratings from Dealogic.

BRI investment financing could exacerbate existing debt vulnerabilities in a number of countries (Figure 12). Based on the assumptions defined in Section II, we consider that only BRI investment identified from 2016 to 2018 as under construction and planned would result in additional debt financing; and we apply an average 40 percent debt financing ratio for the cost of investment in the power, electricity and mining sectors and 80 percent in transport and all other sectors. Based on these assumptions estimated BRI debt financing is expected to exceed 5 percent of GDP in 4 LIDCs in high risks of debt distress and in 2 LIDCs in moderate risks of debt distress. Six more LIDCs, currently at low risk are expected to receive sizeable BRI investment. For three LIDCs (Cambodia, Tajikistan, and Timor-Leste), the amount of estimated BRI-debt financing is expected to exceed the PPG debt-to-GDP ratio as of end-2016. Five EMs in high scrutiny for potential debt vulnerabilities are also expected to receive BRI debt financing amounting to more than 5 percent of GDP and two in low scrutiny.

To assess the impact of BRI debt financing on debt sustainability, it is necessary to take the additional growth that large infrastructure investment could generate in BRI-recipient countries into account. The next section estimates the marginal impact of BRI investment on growth. Section V uses the feedback effect of investment on growth and the estimated amount of BRI-debt financing to assess if the estimated growth is expected to fully offset the expected increase in BRI debt financing and if the past fiscal stance of BRI-recipient countries is adequate to offset the increase in BRI debt financing.

Figure 12. Public Debt and BRI Expected Debt Financing
(In percent of GDP)

LIDCs EMs



Sources: WEO, WIND Database and LIC DSF DSAs.
Note: the large estimated BRI PPG debt financing for Timor-Leste could not be confirmed by World Bank internal sources, which indicate no investment planned.

Sources: WEO, WIND Database and MAC DSAs.

IV. Adding the Investment-Growth Nexus

Infrastructure investment is expected to enhance growth. In the short run, infrastructure investment can create jobs and growth in the local economy. In the longer run, (i) it enhances productivity, through increase in physical infrastructure and improved connectivity; (ii) increases private capital formation, by raising expected returns on private investments as the marginal productivity of inputs increases or transaction costs decline; and (iii) facilitates the exploitation of agglomeration economies. Because many developing countries face significant infrastructure gaps, higher investment in this area would boost long-term growth and help achieving development goals. At the same time, the demand for infrastructure services is expected to grow, as countries become richer, populations increase and the climate changes.

This paper applies two methods to estimate the impact on growth in the medium term of BRI-related physical infrastructure investments. The literature also presents two very different approaches to estimate the impact: one is theory based and the second empirical. This paper presents both approaches: *First*, it applies the marginal productivity of efficiency-adjusted public investment to estimate the impact of investment on growth in the medium term, following Devadas and Pennings (2018). *Second*, the paper estimates the impact on growth of physical infrastructure, controlling for a broad set of variables, following Calderon (2009). Growth estimates are then used to project the evolution of the public-debt-to GDP ratios and to provide a lower bound of the increase in debt vulnerabilities in BRI-recipient countries.[24]

Model-based growth projections

The effects of public capital on growth are analyzed through a production function adjusted for a measure of the level of efficiency of public capital. To analyze the effect of public capital on growth, Devadas and Pennings (2018) use a constant elasticity production function reported in Equation 1:[25]

$$Y_t = A_t(\theta_t K_t^{Gm})^{\phi}(K_t^{P})^{1-\beta-\zeta\phi}(h_t L_t)^{\beta} \tag{1}$$

Each country takes technology (TFP) A, $G=\theta_t K_t^{Gm}$ is the stock of public capital adjusted for a country-specific efficiency level θ_t, ϕ is the marginal productivity of capital, ζ a parameter that captures whether public capital becomes congested by the amount of private capital, K_t^P, and effective labor can be decomposed into h_t , human capital per worker, and L_t, the number of workers.

The stock of efficiency-adjusted public capital G (which is actually used in production) evolves based on the previous period's efficiency-adjusted undepreciated stock and efficiency-adjusted new investment $\theta^{N}{}_t$ $I^{G}{}_t$ as in Equation (2):

$$G_{t+1} = (1-\delta^G)G_t + \theta_t^N I_t^G \tag{2}$$

The level of efficiency of public capital reflects corruption and the quality of management of the infrastructure process. The model assumes that only a fraction of public capital is useful for production, with θ taking values from 0 and 1. The level of efficiency is measured by an infrastructure efficiency index which is built as a weighted average of (i) electricity transmission and distribution losses (% of output); (ii) water losses (% of provision); and (iii) paved roads (% of total roads).

The simulations assume a relatively high elasticity of output per capita to public capital. We use an elasticity of output per capita to public capital ϕ (its "usefulness") of 0.17, which corresponds to the upper bound across two meta-analysis studies.[26] This is also slightly higher than the elasticity of 0.15 percent assumed in the 2017 revision of the LIC DSF.

To estimate the growth impact of BRI investment in the medium term, we use the marginal productivity of public investment (as a share of GDP) to per capita growth, which is a function of the usefulness of the efficiency-adjusted public capital, as reported in Equation (3):[27]

$$\frac{\partial g_{y,t+1}^{PC}}{\partial I_t^G / Y_t} = \frac{\phi}{\theta_t K_t^{Gm}/Y_t}\theta_t^N \tag{3}$$

This formulation allows us to directly use the estimated level of BRI investment and to assess which countries are likely to benefit from a growth boost deriving from better efficiency, and the risks for debt

[24] Empirical estimates of the growth impact of infrastructure investment vary significantly among studies.
[25] This is equivalent to Equation 3 in Devadas and Pennings (2018).
[26] The effect of public investment on growth is most sensitive to the elasticity of output to public capital, ϕ, which is calibrated based on meta-analysis studies -- Bom and Ligthart (2014) and Nunez-Serrano and Velazquez (2016), and a recent paper by Calderon et al. (2015).

[27] This is equivalent to Equation 16A in Devadas and Pennings (2018).

sustainability if efficiency is not improved enough. Specifically, BRI investment is assumed to be fully realized during the period 2019-2023. For each BRI-recipient country, the annual level of BRI investment, assumed constant in U.S. dollar, is used to estimate annual levels of additional growth. The country specific estimates of additional growth from BRI investment are reported in Annex IV.

Empirical estimates

In addition to model-based growth projections, this paper also estimates growth based on an empirical production function approach. BRI investment is expected to significantly increase the infrastructure stock of BRI-recipient countries. Following Calderon (2009), we built an unbalanced panel for a subset of 31 countries, created an index of different infrastructure assets and dealt with endogeneity and reverse causality issues of the infrastructure stock noted in the literature. [28,29] We also depart from Calderon (2009) as we use annual data and not 5-year averages, as we are interested in medium-term effects of installed capital on growth.[30]

To measure the quantity of physical capital we built indices of infrastructure using Principal Components Analysis (PCA). This technique allows to avoid multicollinearity problems and measurement errors associated with single-infrastructure indicators. Using weights generated by PCA, we aggregate individual physical measures of infrastructure in telecommunications, electricity, and roads to compute an index of infrastructure stocks. Annex VII describes in more details the PCA analysis and data sources.

We run a regression of growth in real output per capita on a standard set of growth determinants, and on aggregate indices of infrastructure stock. Our estimation methodology is the generalized method of moments (GMM) for dynamic models of panel data (Arellano and Bond, 1991; Arellano and Bover 1995; Blundell and Bond, 1998), which is suited for dynamic panel data and accounts for some endogeneity in the explanatory variables through instrumentation. Our set of control variables comprises information on the level of trade openness, human capital (as proxied by the human capital indicator of Penn World Table), institutional quality (as proxied by the indicator of government effectiveness of the Worldwide Governance Indicators), lack of price stability, and government burden. More specifically, our dynamic panel regression equation is expressed by:

$$y_{it} - y_{it-1} = \alpha y_{it-1} + \beta X_{it-1} + \varepsilon_{it} \quad (3)$$

where y denotes the real GDP per capita (in logs), X is a set of control and stock of infrastructure measures. When estimating the above equation, we face the potential problem of endogenous regressors. This affects, in principle, both the standard determinants of matrix X given that we can argue that these variables may be jointly determined. Indeed, this may be subject to reverse causality from labor productivity.

[28] We restrict our sample to 31 countries due to data availability limitations on human capital index from Penn World Table.
[29] On these concerns, see Blanchard and Giavazzi (2003) for the case of the European Union, and Easterly and Servén (2003) for that of Latin America.
30 Calderon (2009) uses 5 years averages as the main focus of that paper is to estimate long-run growth. This paper instead focuses on the medium term, namely the period 2019-2023 and requires estimates of annual elasticity of output which are obtained using annual data.

As expected, our PCA Index of infrastructure stock has a large and positive effect on growth and all variables have the expected signs and, with the exception of human capital, are significant (Table 1). The estimates show that: (a) there is evidence of conditional convergence for real output per worker, due to the negative coefficient; (b) economic growth is enhanced by a faster accumulation of human capital and infrastructure stock as well as higher institutional quality; (c) growth is adversely affected by higher inflation and heavier government burden. The estimates do not show a robust relationship between trade openness and growth, as in Calderon (2009). [31]

We apply several tests to confirm the consistency of the GMM estimator. Similar to Calderon (2009), we rely primarily on internal instruments within the dynamic model of panel data framework. The Sargan test of overidentifying restrictions tests the overall validity of the instruments by analyzing the sample analog of the moment conditions used in the estimation process; failure to reject the null hypothesis that the conditions hold gives support to the model. The second test is the serial correlation test of the error term. In the GMM-system specification, we test whether the differenced error term (that is, the residual of the regression in differences) shows second-order serial correlation. First-order serial correlation of the differenced error term is expected, given the presence of the lagged dependent variables among the regressors. Second-order serial correlation of the differenced residual indicates that the original error term is serially correlated and follows a moving average process of order two or higher. This would render the proposed instruments invalid (and would call for higher-order lags to be used as instruments). Again, failure to reject the null lends support to the model.

Table 1. Growth: panel regression analysis - GMM

Dependent variable: Annual growth in real GDP per capita
Sample: 31 countries, 2010–2014 (unbalanced panel)
Estimation: GMM-IV system estimation

Variable	
Infrastructure Stock	*0.041****
(first principal component of stocks)	*(0.015)*
Control Variables	
GDP per capita	*-0.292****
(last period, logs)	*(0.037)*
Trade openness	*-0.094****
(trade volume as % of GDP, logs)	*(0.026)*
Human capital	*0.254*
(Penn World Table - human capital index, logs)	*(0.169)*
Institutional quality	*0.011**
(WGI for government effectiveness, logs)	*(0.006)*

[31] For example, there is a sizable heterogeneity in the extent to which growth responds to trade liberalization (Wacziarg and Welch, 2003; Chang, Kaltani, and Loayza, 2005). Greenaway et al. (1998) suggested that trade liberalization negatively affects growth in the short run. Trade share in GDP has negative impact on growth for heavily regulated economies (Bolaky and Freund, 2004). Michaely et al. (1991) and Panagariya (2004) provided case studies indicating that in an unstable macroeconomic environment and with an overvalued exchange rate, the effect of trade liberalization is likely to be reversed. Wacziarg and Welch (2003) also reported that restrictive macroeconomic policies can explain why some countries did not experience higher growth following trade liberalization. They stressed that currency overvaluation can undo trade liberalization. Finally, results may also depend on measures of trade openness (Ciccone, 2008).

Lack of price stability	*-0.090****
(inflation rate, logs)	*(0.034)*
Government burden	*-0.125****
(Government consumption as % of GDP, logs)	*(0.045)*
Constant	*3.080****
	(0.391)
No countries	*31*
No. observations	*91*
Specification test (p-value)	
(a) Sargan test	*(0.098)*
(b) Serial correlation Second-order	*(0.106)*

Robust standard errors are reported in parenthesis below the coefficient estimates.
**** implies significance at the level of 1%; ** implies significance at the level of 5%; * implies significance at the level of 10%*

To derive the marginal impact of BRI-investment on growth for the 31 countries in the estimation sample, we estimate future value of PCA infrastructure index through an efficiency adjusted index of investment, as expressed in Equation (4):

$$\Delta PCA_{it} = \beta I_{it} + \mu_i + \varepsilon_{it} \quad (4)$$

where $\boldsymbol{\Delta PCA_{it}}$ denotes the change of PCA index of infrastructure stock over the period *t* and *t-1*. $\boldsymbol{I_{it}}$ is the ratio, expressed in logs, of adjusted investment and GDP. It is constructed using the efficiency index as in Devadas and Pennings (2018). The term μ_i captures unobserved country characteristics. The estimated coefficient for adjusted investment has the expected sign and is significant (Table 2). The negative sign of the coefficient reflects the positive relationship between investment and PCA infrastructure index.[32]

Table 2. Infrastructure stock: Fixed effect analysis

Dependent variable: Infrastructure Stock
Sample: 31 countries, 1997–2014 (unbalanced panel)
Estimation: Fixed Effects Regression

Variable	
Investment	*-0.026***
(efficiency adjusted investment, logs)	*(0.018)*
No countries	*31*
No. observations	*547*

Our regression analysis includes country-specific dummy variables (not reported here but available from the authors).
Robust standard errors are reported in parenthesis below the coefficient estimates.
**** implies significance at the level of 1%; ** implies significance at the level of 5%; * implies significance at the level of 10%*

[32] $\boldsymbol{I_{it}}$ is the ratio of investment over GDP and is expressed in logs and its value is therefore negative.

We then use the coefficients from Equations (4) and (3) respectively, to estimate the new PCA infrastructure index given the additional BRI-investment and its marginal impact to growth. [33] As done with the LTGM, we add the marginal impact of growth to WEO projections. Estimates of GMM marginal impact of growth are reported in Annex V.

V. Assessing Debt Vulnerability in BRI Recipient Countries

This section uses the estimated BRI debt financing defined in Section II and the marginal growth estimates from Section IV to identify BRI-recipient countries that may not be able to maintain a stable debt-to-GDP ratio because of insufficient growth given their current fiscal policy stance. The analysis uses WEO data as published in October 2018. Given limited publicly available information around BRI financing and the comprehensive data base developed for this paper, WEO projections are likely to include some but not complete information related to BRI. The paper therefore computes debt ratios under two extreme assumptions related to the amount of financing, investment and growth that are included in the 5-year projection period 2019-2023 of the WEO:

- Assumption 1 (*A1*): under this assumption WEO projections for the period 2019-2023 fully include all information related to BRI financing in the projected PPG debt, nominal GDP and primary balance;
- Assumption 2 (*A2*): under this assumption WEO projections do not include any information related to BRI financing in the projections of PPG debt, nominal GDP and Primary Balance.

We estimate for each country a growth and a fiscal gap, under both assumptions. The *growth gap* is defined as the difference on the debt-to-GDP ratio between excluding and including the impact of BRI investment. The growth gap indicates the countries where BRI investments are projected to generate enough growth to repay themselves and the ones where this is not the case. The *fiscal gap* is defined as the difference between the average past primary balance and the primary balance needed to stabilize the PPG debt-to-GDP ratio at 2016, factoring in the additional debt and growth resulting from BRI investments. The fiscal gap assesses the amount of effort a country needs to make to keep a constant debt-to-GDP ratio when BRI investments are made. Countries with positive growth and fiscal gaps could face ever increasing debt ratios, absent higher growth or fiscal adjustment.

WEO projections are used as baseline for medium-term debt dynamics, to signal risks that countries may experience from increasing debt ratios. WEO projections are based on a consistent macroeconomic framework, which reflects current policies and outcomes of reforms on the future five years, and also assume that countries trends towards their domestic and external equilibrium.

<u>*Growth gap*</u>

The growth gap provides an estimate of whether the additional growth due to BRI investment is sufficient to offset the impact of BRI-related borrowing on the debt-to-GDP ratio. The growth gap is defined as the

[33] The PCA infrastructure index at time *t* builds-up on previous the index at time *t-1* given the additional BRI-investment without considering any depreciation. On the contrary, LTGM includes depreciation in the stock of public capital and this could result lower growth estimates than those in GMM.

difference between the PPG debt-to-GDP ratio at end of 2023 which includes the effect of BRI on debt and growth and the PPG debt-to-GDP ratio which excludes the effect of BRI. Under both *A1* and *A2*, we calculate the Debt-to-GDP ratio at end-2023 which includes and excludes BRI debt financing and the estimated impact of BRI investment on growth (Annex VIII reports the full mathematical derivation).[34] We then take the difference of these two ratios under both assumptions.

$$A1: \quad \frac{D_{2023}}{Y_{2023}^{WEO}} - \frac{D_{2023} - BRI(1+3i)}{Y_{2023}^{WEO-BRI}}$$

$$A2: \quad \frac{D_{2023} + BRI(1+3i)}{Y_{2023}^{WEO+BRI}} - \frac{D_{2023}}{Y_{2023}^{WEO}}$$

With *D* equal to the PPG debt at end-2023 as reported in WEO; *BRI* the total amount of BRI debt financing over 2019-2023; *i* the constant interest rate paid on BRI-related loans from China; *Y* the nominal GDP as reported in WEO. To be noticed that, under *A1, Y* already includes the impact of BRI investment, while under *A2* it does not.

Under *A1,* $Y_{2023}^{WEO-BRI} = Y_{2023}^{WEO} / \prod_{t=2019}^{2023}(1 + g_t^{BRI})$, is equal to the 2023 nominal GDP in WEO less the estimated marginal growth from BRI .

Under *A2,* $Y_{2023}^{WEO+BRI} = Y_{2023}^{WEO} * \prod_{t=2019}^{2023}(1 + g_t^{BRI})$ is equal to the 2023 nominal GDP in WEO, plus the estimated marginal growth from BRI.

As proved in Annex VIII, under the assumption that the marginal growth boost from BRI, g_t^{BRI}, is positive*,* the difference between the debt ratios at end-2023 under *A1* is greater than the difference under *A2,* or A1>A2*.* Furthermore, section IV reports the marginal growth estimates resulting from BRI investment and these are strictly positive. Given the relations between A1 and A2, only three cases are possible:

1) If A2>0, then A1>0. The debt-to-GDP ratio at end-2023 inclusive of BRI is greater than the debt ratio excluding BRI. Therefore, BRI-generated growth does not offset the increase in BRI debt under both A1 and A2. This is the case of countries with a <u>positive</u> growth gap, represented in quadrant I in Figure 13;
2) If A1<0, then A2<0. The debt-to-GDP ratio at end-2023 inclusive of BRI is smaller than the debt ratio without BRI and the BRI-generated growth fully offsets the increase in debt due to BRI under A1 and A2. This is the case of countries with <u>negative</u> growth gap, represented in quadrant III in Figure 13;
3) If A1>0 and A2<0 the impact on growth due to BRI is different under A1 and A2, because according to the information set in A2, growth is sufficient to outperform the increase in debt, but not under A1. This is the case of countries with <u>undefined</u> growth gap, represented in quadrant II in Figure 13.[35]

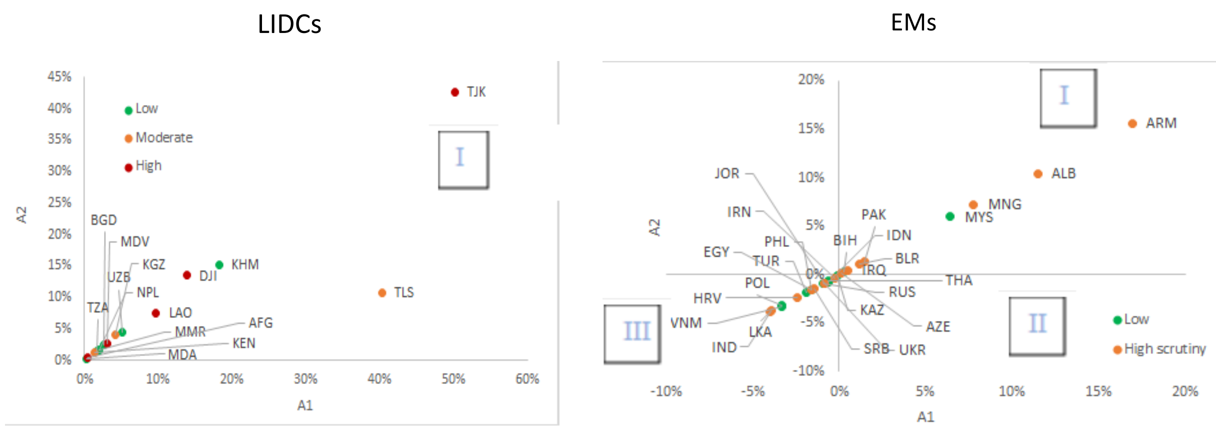
To quantify the impact of BRI we need to make a number of assumptions on economic variables. We assume that under both assumptions, there is no change in GDP deflators and exchange rates and that interest rates paid on BRI disbursements remain constant at the average country interest rate for Chinese

[34] We also assume that countries pay an additional constant annual nominal interest on the annual BRI borrowing, which increases the gross financing needs.
[35] No other combination is possible, because, as *A1>A2,* we cannot have a situation where *A1<0* and *A2>0.*

loans reported in the DRS over the period 2014-17. We assume that the marginal growth rate due to BRI investment is equal to the average of the marginal growth rates estimated through the LTGM and the GMM estimates in section IV (the comparison between the growth rates under the two estimates in reported in Annex VI).[36]While we do not make any explicit assumption related to the primary and overall fiscal deficit, the cumulative increase in the PPG debt over the 5-year projection period due to BRI-related borrowing, could be interpreted as the result of an equal increase in primary expenditure of the general government and the increase in interest payment due to the additional BRI-related borrowing.[37]

Debt financed investment is expected to help sustain or achieve higher growth, but in all 15 LIDCs and 10 EMs recipient of BRI investment the growth required to stabilize the debt ratio is higher than the estimated growth (Figure 13). Out of 43 countries, only 8 EMs are expected to increase growth, as a result of BRI, to fully compensate for the estimated increased in BRI debt financing over the period 2019-2023. Note that this result holds under both *A1* and A2, with no countries ending in the undefined area. We have also compared the growth rate needed to stabilize the PPG debt-to-GDP ratio at end-2016 assuming that the PPG debt would increase only by the BRI financing.[38] Also under this exercise, all countries with *A2>0* (*A1<0)* have a required growth rate which is greater (smaller) than the estimated average growth rate.

Figure 13. Growth Gap
(In percent of GDP, by debt vulnerability)



Sources: WEO, and LIC DSF DSAs.

Sources: WEO, and MAC DSAs.

[36] The GMM estimates are applied to only 31 countries. Therefore, the growth rates to the remaining 12 countries are equal to the LTGM estimates.
[37] However, an increase in PPG debt may not be associated to increased primary expenditure or interest payment of the general government, if guarantees are issued on debt contracted by private companies. Nevertheless, also in this case, prudent debt management would require the government to include the additional guaranteed debt in the PPG debt stock and the additional interest payment in the total PPG debt service.
[38] This can be considered as an exercise that would assume that over the period 2019-2023 the fiscal balance is always equal to 0, so that no additional borrowing is needed.

Fiscal gap

Under A1 and A2, the fiscal gap estimates the difference between the average primary balance, calculated over the period 2007-16, with the primary balance that is necessary to stabilize the PPG debt-to-GDP ratio over the period 2017-23. The fiscal gap is calculated as the difference between the historical average primary balance and the minimum of the debt-stabilizing primary balance under A1 and A2. This corresponds to the least demanding measure of fiscal adjustment. A positive fiscal gap would result in an increasing debt ratio if the fiscal stance is not modified. This is a crude measure, as countries in need of fiscal consolidation would also require the adoption of structural measures that would not undermine growth. Under *A1* (A2) WEO projections would fully (not) reflect all (any) information related to BRI in the PPG debt, nominal growth, and primary balance.

The annual average primary balance needed to stabilize the PPG debt-to-GDP ratio over the period 2017-23 is defined as:

$$\overline{pb} = d_{2016}\left(\frac{\bar{r}-\bar{g}}{1+\bar{g}}\right) \quad (4)$$

With *pb* the average primary balance; *d the* PPG debt-to-GDP ratio at end-2016, as defined in the October 2018 WEO; *r* is the country-specific average annual real interest rate; and *g* the country-specific average real growth rate over the period 2017-2023. The derivation of the debt-stabilizing primary balance is reported in Annex IX.

Under *A1* and A2, fiscal gap estimates use different assumptions for the nominal interest rate and the nominal growth rate:

A1 (WEO fully reflect BRI): r is calculated as the annual average real interest rate on PPG debt over the period 2007-16, as a proxy for the long-term rate.[39] Real growth is equivalent to the growth rate as reported in the October 2018 WEO.

A2 (WEO does not reflect BRI): r is calculated as the weighted average of the long-term rate calculated in *A1* and the average interest rate on Chinese loans recorded in the DRS, with weights equal to the share of non-BRI debt and BRI debt in total debt at end-2023. Real growth is equivalent to the real growth rate as reported in the October 2018 WEO plus the additional growth from BRI.[40]

Most LIDCs with moderate or high risk of debt distress and EMs classified as high scrutiny would have to implement a growth-friendly fiscal consolidation to avoid a deterioration in debt-to-GDP ratios (Figure 14). In many BRI-recipient countries with already high level of debt, investment supported growth would not be sufficient to reduce the level of indebtedness. In addition, the possible materialization of fiscal risks,[41] a frequent occurrence in the case of large infrastructure projects (Flyvbjerg, 2017), or related to

[39] The annual nominal interest rates *i* are calculated as the debt service on PPG debt at year *t*, divided by the stock of PPG debt at year *t-1.* The real interest rates *r* deflate the nominal rates using the annual change in the GDP deflator π, according to the formula $(1+i) = (1+r)(1+\pi)$.

[40] Defined as the average of the marginal growth rate estimated with the LTGM and the GMM regression.

[41] Beyond those represented by explicit government guarantees, which are, by definition included in PPG debt.

BRI financing that is not captured by PPG debt would require additional fiscal efforts to stabilize debt ratios.

Figure 14. Debt Stabilizing Primary Balances
(In percent of GDP, by debt vulnerability)

Sources: WEO, and LIC DSF DSAs.

Sources: WEO, and MAC DSAs.

Based on the fiscal stance and expected growth, we identify those BRI-recipient countries that are likely to face a further increase in debt vulnerabilities as a result of BRI-financing. The metric selects countries with:

- A positive growth gap, which indicates that the projected growth level, inclusive of the effect of BRI, is not expected to fully offset the increase in the stock of PPG debt due to BRI debt financing over 2019-2023 under both *A1* (WEO fully reflect the impact of BRI) and *A2* (WEO does not reflect the impact of BRI); and
- A positive fiscal gap, which signals that the primary balance required to stabilize the PPG debt-to-GDP ratio over the period 2017-2023 under *A1* and *A2* is higher than the historical average primary balance calculated over the period 2007-2016.

In addition to identifying those countries that are expected to increase the PPG debt-to-GDP ratio over the 5-year projection period, we apply two additional filters to select countries with high level of indebtedness and large expected BRI related borrowing. These countries have:

- Potential debt vulnerabilities, defined as those countries which have a PPG debt-to-GDP ratio projected under the October 2018 WEO to be at 50 percent or more[42] ; or in cased of LIDCs, countries assessed at moderate or high risk of debt distress, according to the latest available LIC DSA.
- Significant BRI financing, which is defined as an estimated BRI PPG debt financing of at least 5 percent of GDP, a level close to the median BRI debt financing of 6 percent of GDP;

As the assessment focuses only on countries with a positive growth gap, the PPG debt-to-GDP ratio at 2023 reported in WEO is, by construction, the lowest bound of possible outcomes including BRI

[42] This level is consistent with the level of debt that would trigger high scrutiny for market-access countries, MACs, classified as EMs

investment. This result follows from the assumptions made under A1 and A2 and from the fact that if the growth gap is positive the following is true (see Annex VIII):

$$A2 = \frac{D_{2023} + BRI(1+3i)}{Y_{2023}^{WEO+BRI}} - \frac{D_{2023}}{Y_{2023}^{WEO}} > 0 \qquad (5)$$

Where $\frac{D_{2023}}{Y_{2023}^{WEO}}$ is the PPG debt-to- GDP ratio including BRI under *A1* and $\frac{D_{2023} + BRI(1+3i)}{Y_{2023}^{WEO+BRI}}$ is the PPG debt-to GDP ratio including BRI under *A2* . Therefore, for countries with a positive growth gap, the PPG debt-to-GDP ratio inclusive of BRI effect on growth and debt under *A1,* equal to the debt ratio reported in WEO, is always smaller than the equivalent debt ratio under *A2.*

Out of 43 countries, 12 (7 LIDCs and 5 EMs) or 28 percent are expected to increase their level of indebtedness as a result of BRI investment (Figure 15). The selected countries include four of the five LIDCs with high risk of debt distress and two of the three LIDCs assessed at moderate risk. One low-risk LIDCs has an estimated level of indebtedness projected to exceed 50 percent. Among EMs, four are considered high-scrutiny countries, with an indebtedness ratio above 50 percent in 2018 and one a low-vulnerability country, with PPG debt expected to increase to above 50 percent of GDP by 2023.

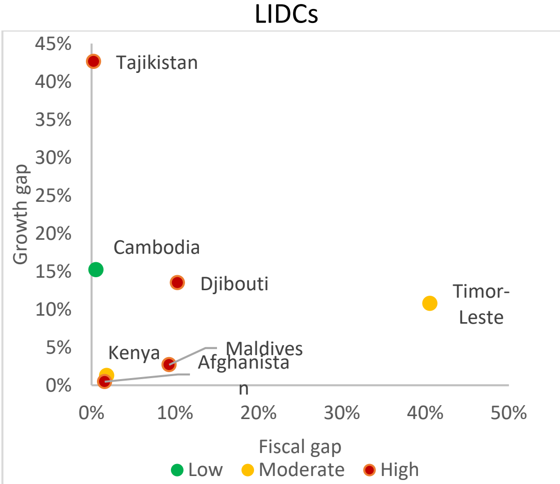
In several countries with already elevated debt vulnerabilities the PPG debt to GDP ratio is expected to increase over the period 2019-2023 as a result of BRI debt financing, despite additional positive growth (this is indicated as a positive growth gap) and given their projected fiscal policy stance. The assessment should also consider the fiscal risks, beyond those represented by explicit government debt guarantees, which could result in higher fiscal expenses. It should be noted that there are countries that despite having high level of debt vulnerability are not expected to receive a large amount of BRI-related debt financing. The debt sustainability of these countries should be monitored through the established instruments for low income and market access countries.

BRI recipient countries could be broadly classified along the following lines:

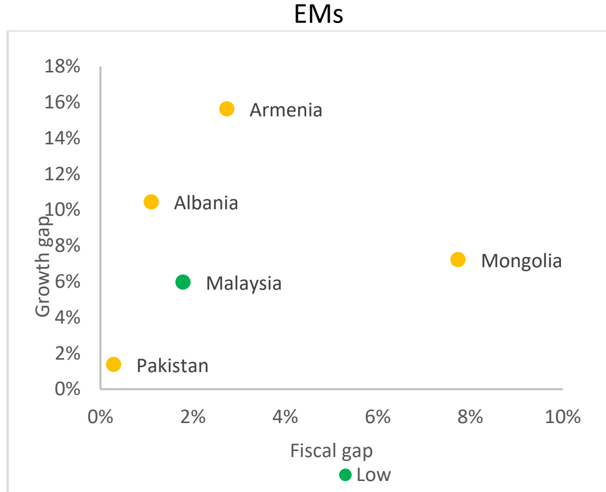
- Countries in low scrutiny or low risk of debt distress, if not substantially increasing their level of indebtedness as a result of BRI, would likely have the necessary fiscal space to increase investment. However, it is important that projects are well selected and implemented to maximize development gains and that financial terms are appropriate and transparent.
- In addition to a careful project selection and implementation, and evaluation of terms and available options of financing, countries that would increase their level of indebtedness as a result of BRI should carefully evaluate the impact of BRI on their debt sustainability outlook and fiscal risks.
- Countries with limited or no fiscal space would need to limit the number of debt-financed projects, rely on grant or highly concessional financing, favor foreign direct investment over debt financing, and, if possible, increase public savings to finance additional investments.

This simple methodology is selective enough to identify a limited number of countries, and indicate policy options, but important shortcomings need to be highlighted. The analysis and estimates are limited to the medium term, after all BRI financing has already been disbursed, but before the long-term impact of BRI investment is entirely reflected on growth. The impact of higher investment continues over time, which would be important to assess the long-term impact on debt sustainability. Growth estimates are not dependent on debt burden indicators and therefore they may be considered optimistic, especially for those countries with already high debt ratios. This metric can be further expanded, through the consideration of indicators measuring the quality of the governance and strengths of fiscal institutions and the assessment of the domestic revenue generation capacity, which would further strengthen the discussion of fiscal space and indicate further policy options.

Figure 15. Projected Status of BRI Recipient Countries in 2023
(In percent of GDP)



Sources: WEO, WIND Database and LIC DSF DSAs.



Sources: WEO, WIND Database and MAC DSAs.

Long-Term Projections of debt-to-GDP Ratios

To assess the impact of BRI financing and investment on growth and indebtedness in the long term, this section uses the results of SGE estimates from de Soyres et al. (2019). To compare the evolution of public debt-to-GDP ratio from 2016 to 2030 with and without BRI infrastructure investment, a number of assumptions, consistent with the previous sections, are made. We construct two scenarios.

- Under the *Baseline* scenario, no BRI investment and BRI-related borrowing take place. Under the baseline, the primary-balance-to-GDP ratio and the real growth rate for all countries will remain constant until 2030 and it will be equal to their average values of the period 2007-2016.
- Under the *BRI scenario*, annual growth would reflect the effect of trade-related infrastructure investment and the reduction of trade costs and policy reforms as in de Soyres et al. (2019).[43] Furthermore, the paper assumes that all the countries will have fully converged to their new equilibrium, post-BRI infrastructure, by 2030.

[43] To obtain the projected average annual real growth rate for the baseline, we estimate the average real growth over the period 2000-2016 and we project the real GDP until 2030. Then we estimate the total growth between 2030 and 2016 and divide it equally among those years. For the BRI growth, we increase the projected baseline GDP of 2030, based on the estimates of de Soyres et al. (2019). Then as in the baseline, we estimate total growth between 2030 and 2016 and divide it equally among those years. The growth estimates are reported in annex XII.

Under these scenarios (as it is proven in Annex X and XI), the debt ratio in 2030 for the *baseline* scenario is defined as:

$$d_{2030} = -\overline{pb} \cdot \frac{1-\left({}^{1+r}/_{1+\bar{g}}\right)^{14}}{1-\left({}^{1+\bar{\imath}}/_{1+\bar{g}}\right)} + \left({}^{1+\bar{r}}/_{1+\bar{g}}\right)^{14} \cdot d_{2016} \qquad (6)$$

And the debt ratio in 2030 for the *BRI scenario* is defined as:

$$d_{2030}^{BRI} = -\overline{pb} \cdot \frac{1-\left({}^{1+\bar{r}}/_{1+\bar{g}_{BRI}}\right)^{7}}{1-\left({}^{1+\bar{r}}/_{1+\bar{g}_{BRI}}\right)} + \left({}^{1+\bar{r}}/_{1+\bar{g}_{BRI}}\right)^{7} \cdot d_{2023}^{BRI} \qquad (7)$$

where $\overline{pb}$ is the average primary balance ratio, $\bar{\imath}$ is the average real annual interest rate, $\bar{g}\ and\ \bar{g}_{BRI}$ are the growth rates for the baseline and BRI respectively, and d represents the debt ratio. More specifically in the BRI scenario, d_t^{BRI} is the debt ratio which includes all the additional BRI debt financing costs. The paper assumes that the total amount of BRI financing is disbursed in five equal tranches over the period 2019-2023.

The SGE growth projections rely on a set of estimates that reduce trade time and factor in externalities from improved trade infrastructure and trade reforms. De Soyres et al. (2019) provide eight different growth estimates based on the impact of upgraded trade infrastructure, possible use of multi-modal transport modes, trade facilitation reforms and reduction in tariffs.44 The SGE fully captures the impact of externalities of lower costs of trade among all trading countries as a result of BRI trade investment and institutional and policy reforms. The authors estimate the BRI effects by performing a counterfactual analysis and compare the results to the ex-ante BRI equilibrium. For the purpose of this analysis, we focus only on the upper-bound scenario of de Soyres et al. (2019), which reflects the full impact of trade infrastructure investment, efficiency gains from use of the most efficient trade infrastructure, gains from expected trade policy reforms (including lower tariffs and faster border clearance) and positive network externalities. Annual median growth under the upper bound SGE simulations is 1.2 percentage points higher than the median historical growth used in the baseline.

Figures 16 presents the comparison between the debt ratio in 2016 and 2030, for the baseline and BRI scenarios. In Figure 16, the solid gray line is the 45-degree line. Any point above this line implies that the government will face a larger debt ratio at the end of 2030 relative to 2016. Any point below the solid gray line implies a reduction in debt ratio at the end of 2030. The dashed gray lines represent the debt ratio that is equal to 50 percent, as threshold effects for increased debt vulnerabilities. The analysis is limited to only 30 countries, which presents BRI debt financing (as for the WIND database) and the countries considered in the SGE model.

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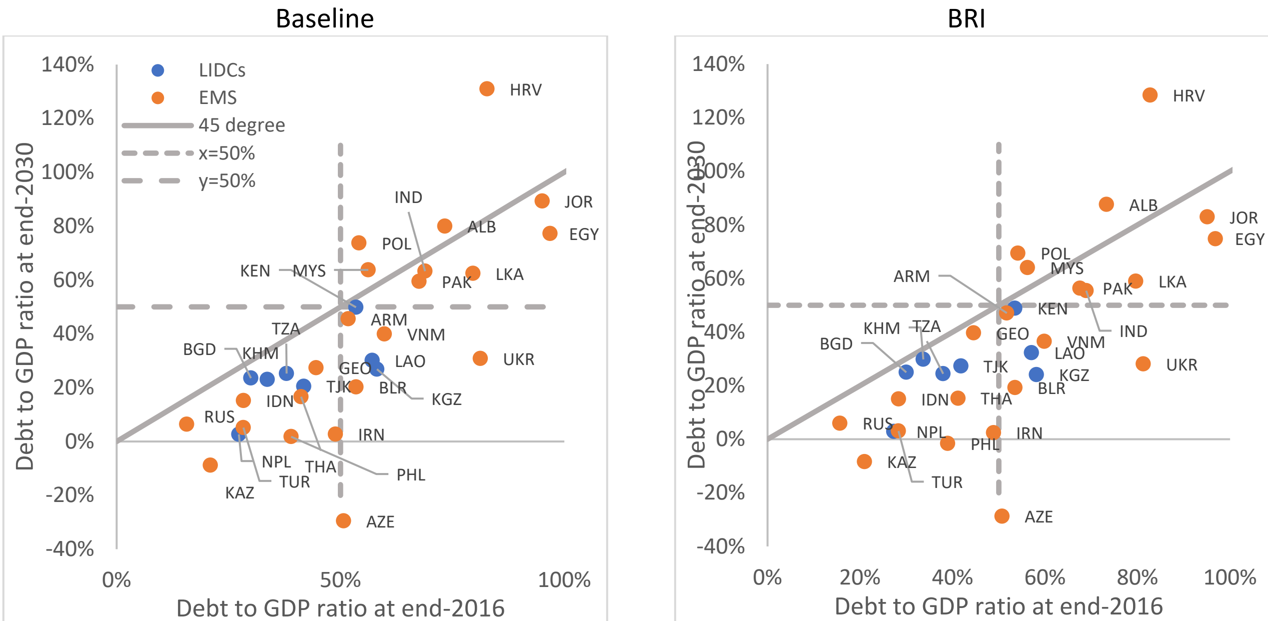
[44] de Soyres et al. (2019) provide four different growth estimates for two scenarios. The two scenarios are referred as the "lower-bound" and the "upper-bound". The "upper-bound" scenario allows for changes in transportation mode due to the new infrastructure, while the "lower-bound" scenario assumes that switching mode of transportation is difficult -allowing for modal changes lower than 5 percent with respect to the pre-BRI modes of transport. The four different growth estimates are derived by considering the: (i) additional BRI infrastructure; (ii) additional BRI infrastructure and tariff reduction; (iii) additional BRI infrastructure and additional reforms that lead to reduced boarded delays; (iv) additional BRI infrastructure, tariff reduction, and additional reforms that lead to reduced boarded delays.

Over the long-term, BRI debt financing is expected to result in higher debt-to-GDP ratios in 11 countries. Under the Baseline, (Figure 16), only 4 EMs economies are expected to have increased debt-to-GDP ratios over the period 2016-2030. The projected impact of BRI investment would not alter this result (Figure 16, BRI panel), as BRI debt financing would not result in increasing debt dynamics (that is, crossing the 45-degree line) for any additional country. In addition, no country that is expected to reduce the debt-to-GDP ratio below 50 percent by 2030 under the baseline, is projected to have a debt ratio above 50 percent of GDP with BRI. In 5 LIDCs and 6 EMs economies debt ratios under BRI are expected to be higher than under the baseline scenario[45]. For 9 of these countries, BRI-debt financing, coupled with higher growth resulting from BRI infrastructure investment would result in a smaller reduction of the debt-to-GDP ratio compared to the baseline scenario (without BRI) over the projection period. Only in two countries, Albania and Malaysia, with debt ratios above 50 percent of GDP, the debt-to-GDP ratio under the BRI scenario is expected to increase compared to the baseline.

Figure 16. Projected Debt Ratios in 2030
(In percent of GDP)



Sources: WEO, WIND Database, LIC DSF DSAs and de Soyres (2019). Sources: WEO, WIND Database, LIC DSF DSAs and de Soyres (2019).

We have conducted two sensitivity analyses to assess the vulnerability of BRI recipient countries to a change in the cost of borrowing. Projections presented in Figure 17 are based on the historical average of the real interest rates,[46] which results in a negative real interest-growth differential for all but one country in our sample. We therefore assess the sensitivity of debt sustainability to increased cost of financing

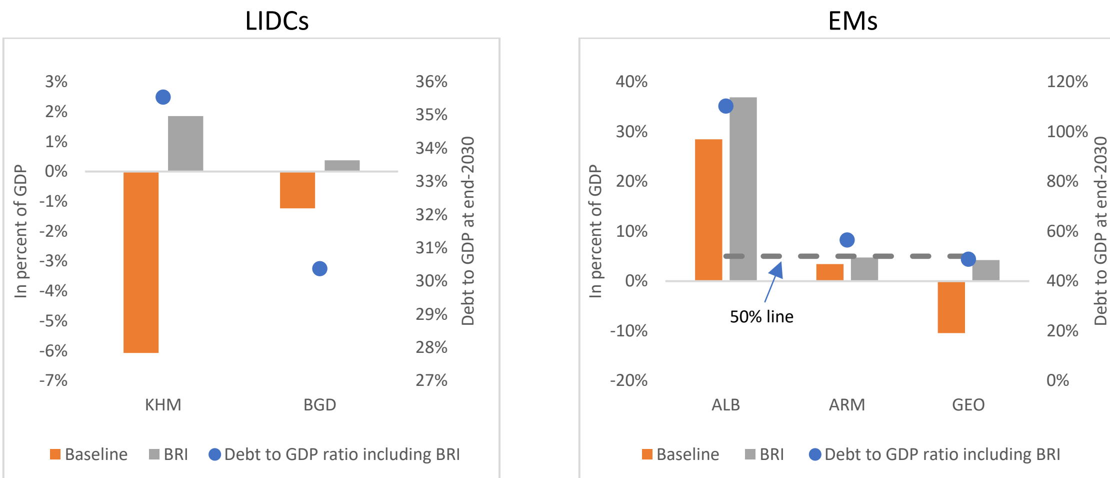
[45] The 5 LIDCs are Bangladesh, Cambodia, Laos, Nepal and Tajikistan; The 6 EMs are Albania, Armenia, Azerbaijan, Georgia, Kazakhstan and Malaysia.

[46] $\bar{\iota} = (-1) + \frac{1}{10}\sum_{t\,2007}^{2016} (1 + nominal\ interest\ rate_t) \Big/ (1 + inflation\ rate_t)$

through two stress tests, described below. These stress tests do not include any feedback effect on growth and the primary deficit. Their outcome can be considered a lower bound of possible realizations, which would be amplified by lower real growth and a higher primary balance, resulting, for example, from lower revenue.

A scenario analysis which increases the real cost of financing by two percentage points for all countries results in two countries increasing their debt-to GDP ratio above 50 percent by 2030. Figure 17 introduces an external permanent increase to the real interest rates by 2 percentage points compared to their historic average. In this scenario, all but three countries in our sample still maintain a negative real interest-growth differential. While higher interest rates would lead to a deterioration in debt dynamics in all countries, Cambodia and Bangladesh, among LDICs, and Albania, Armenia and Georgia, among EMs are projected to face an increase of public debt to GDP ratio, which would increase above 50 percent of GDP in Albania and Armenia and would remain narrowly below the 50 percent level for Georgia.

Figure 17. Scenario 1: Interest Rates are Two Percentage Points Higher
(Change in debt-to- GDP ratio, 2016-30)



Sources: WEO, WIND Database, LIC DSF DSAs and de Soyres (2019).

Sources: WEO, WIND Database, LIC DSF DSAs and de Soyres (2019).

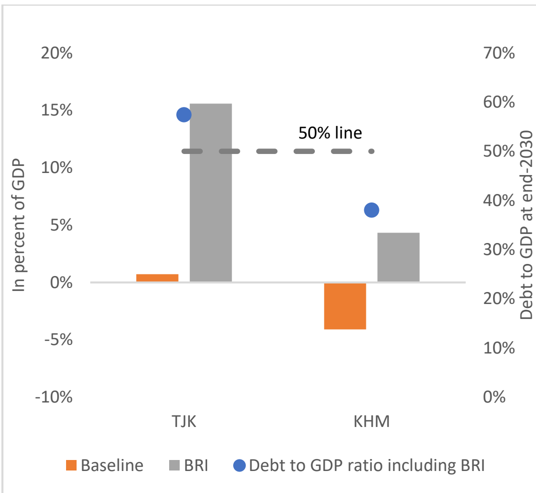
In a second scenario, we have hardened the budget constraint of some countries by setting real interest rates to be the maximum between one percent and the value under the baseline (Figure 18). Under this scenario, four countries would accumulate a debt-to-GDP ratios above 50 percent by 2030 as a result of BRI. Also in this scenario all but three countries would face a negative interest rate growth differential, but this differential would reduce from a median of -7 percent in the base case to a median of -3 percent in this scenario.[47] This increase would be consistent with a number of plausible outcomes that could be realized in the medium and long-term: (i) normalization of monetary policy in advanced economies; (ii)

[47] The authors also developed a stress test which would assume that the real interest rate would be not smaller than baseline growth, implying that all countries would face a positive interest-growth differential in a no-BRI scenario. Under this scenario a total of six countries would end up with a debt to GDP ratio that would increase above 50 percent by 2030. However, this scenario would be too extreme, as many countries would face an increase of real interest rates of more than 10 percentage points compared to the base case.

developing countries increasing access to non-concessional financing as they continue to develop; (iii) or increasingly relying on more expensive domestic debt financing, as saving increases and the domestic markets develop. Under this scenario the countries with an upward shift in debt dynamics include Cambodia, and Tajikistan, among the LIDCs, with the debt to GDP of Tajikistan reaching above 50 percent, and Albania, Georgia and Malaysia among the EMs, with all countries with a debt to GDP ratio above 50 percent.

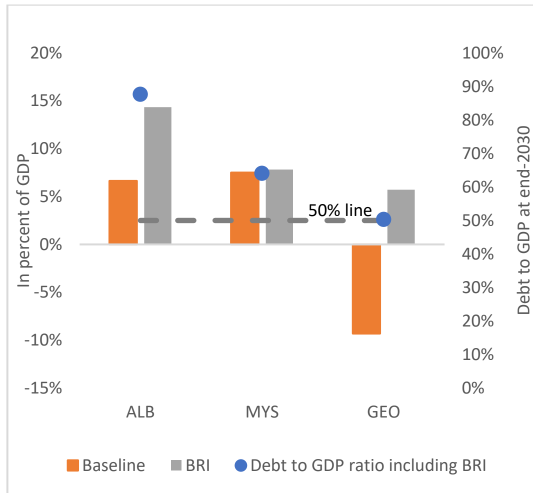
Figure 18. Scenario 2: Interest Rates at least at One Percent
(Change in debt-to- GDP ratio, 2016-30)

LIDCs



Sources: WEO, WIND Database, LIC DSF DSAs and de Soyres (2019).

EMs



Sources: WEO, WIND Database, LIC DSF DSAs and de Soyres (2019).

Debt dynamics in the medium term, during the construction phase of BRI infrastructure, signal that 12 countries (or 28 percent of the 43 countries considered) would experience heightened debt vulnerabilities. The medium-term analysis, which does not fully incorporate the impact of BRI investment on growth, concludes that 7 LIDCs and 5 EMs as a result of large BRI debt financing would quickly increase their debt-to-GDP ratio.

Debt dynamics over the long-term would worsen in 11 countries (or 37 percent of the 30 countries considered) due to BRI, but debt vulnerability would remain limited. Of the 30 countries included in the long-term debt dynamic simulations, 11 would experience a higher debt-to-GDP ratio under BRI compared to the baseline, but in only in 2 countries BRI debt financing would result in increasing debt dynamics, with the PPG debt increasing above 50 percent of GDP in 2030. Under less favorable financing conditions, 7 of these countries would experience a shift from a declining to an increasing debt-to-GDP ratio. In 5 of these 7 (1 LIDC and 4 EMs) increasing debt dynamics would result in a debt-to-GDP ratio above 50 percent.

VI. Fiscal Risks

BRI investments may also represent fiscal risks, in addition to the guarantees that may be issued by a government. As in Brixi and Schick (2002), fiscal risk is defined as the source of increased financial requirements that a government could face in the future. In BRI-recipient countries, governments are expected to contribute to the financing of BRI investment through direct borrowing or the issuance of debt guarantees (either from the central government, a government agency, an SOE or a subnational entity), as discussed in section II. A significant share of BRI investments, especially in the energy sector, would involve private sector financing and may require explicit or implicit government commitments on contractual features which do not constitute debt (or debt guarantees), but that may result in higher expenditure or lower revenue for the government.

Additional risks from BRI investments could derive from the financing of the infrastructure projects, repayment of the infrastructure, contractual clauses, and implicit additional obligations that the government may face. Depending on the contract structure and the clauses of the contracts, BRI investment is likely to increase exposure of government budgets to risks deriving from direct and contingent non-debt liabilities, availability payments, and termination clauses. Following the conceptual framework of the "Fiscal Risks Matrix" and "Fiscal Hedge Matrix" (Brixi and Schick,2002), these risks would have different sources, types and expected impact on public expenditure, debt ratios, the capacity to service public debt and the achievement of fiscal policy objectives.

Sources of risk would relate to:

- *Risks from repayment of BRI investments*. The government could guarantee a certain revenue stream to the operator through availability payments (for example the purchase of electricity from an IPP) financed from the budget or through users' fees. Fiscal risks could arise, for example, in the event of an economic downturn, which would reduce the expected revenue and trigger additional expenses for the government, while at the same time fiscal outlays could increase due to automatic stabilizers.
- *Risks from financing terms*. Large infrastructure projects are often associated with direct borrowing (often in foreign currency) or the issuance of guarantees. Refinancing, liquidity and currency risks could result in higher debt burden and debt service for the government.
- *Risk from collateralized debt financing*. In this case, default would lead to loss of asset which would further complicate fiscal management because of loss of revenue associated with the asset.
- *Risks from recurrent costs.* Contractual obligation could include maintenance costs or the need to provide inputs. Higher costs and commodity prices could result in higher fiscal expenses.
- *Contractual allocation of risks.* During project implementation there may be events triggering default or breach of contract clauses, which would require cooperation between institutions. Risks could also increase where there is a lack of a pre-agreed process for management of project disputes or default.
- *Implicit assumptions of risks*. The government may be expected to assume implicit contingent liabilities to avoid project failure, by providing additional resources, capitalizing state-owned enterprises or repaying non-guaranteed debt.
- *Asset management risks*. In addition to liabilities, risks from large projects would also derive from failure to generate revenues (e.g. user fees) or collect revenue from the private investor, because of tax incentives or inefficiency in the revenue collection systems.
- *Default risk.* Countries may also find themselves in a position where they will not be able to service the debt associated with the investment, which could trigger a takeover of strategic assets.

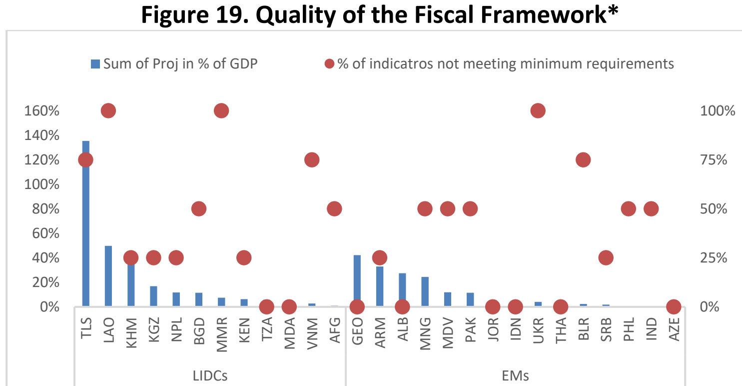
The value of government assets, future revenues and cost of government obligations could change depending on different type of risks. Different risks will change the level of government fiscal revenue, expenditure, and debt stocks and debt service payments. The main type of risks associated with PPPs are (i) refinancing risks, linked to the terms of the project financing; (ii) liquidity risks, if the government would need to liquidate asset at a loss to pay obligations; (iii) currency risks increasing the cost of debt payment and potentially triggering debt guarantees; (iv) commodity price risks, which could increase the cost of inputs; (v) political risks, for example related to protests of citizens negatively affected by an infrastructure investment (e.g. resettlements) and (vi) operational risks, related to poor project selection, non-transparent procurement practices, poor valuation, poor organizational structure, corruption and fraud.

Other operational risks are related to public investment management and procurement framework which would result in resource misallocation and overborrowing, through problems at the project selection, implementation, or management stages**.** For example, the government (or state-owned development bank) may struggle to identify viable and profitable projects, especially if non-economic considerations factor in decision making. Project implementation is likely to involve procurement-related risks, if contracts are awarded on a non-bid basis at above market prices, potentially reducing project viability. Once the infrastructure is constructed, there is a risk that recipient countries lack the capacity or financial resources to maintain the capital infrastructure. Poorly selected large-scale projects may contribute less than expected to jobs and growth. Moreover, such projects may create risk of negative economic impacts through burdening recipient countries with elevated levels of debt and debt servicing. Inefficient expenditure, investment and revenue management could result in additional future expenses for the government which would impact on debt ratios, the capacity to service public debt and the achievement of fiscal policy objectives. Fiscal risks would include also risks related to shortcomings in fiscal institutions, absorptive and implementation constraints, and potential new challenges facing revenue policies and administration (IMF, 2018b).

BRI-recipient countries need to manage also risks typical of megaprojects. While any infrastructure project financing would have an impact on fiscal sustainability and generate some fiscal risks, risks are likely to be much larger in connection to the realization of large projects. A megaproject is an infrastructure investment of US$ 1 billion or more. Of the 45 BRI-recipient countries with identified investments, 36 have investments exceeding US$1 billion. These kinds of projects are highly likely to experience large cost overruns and severe delays, which could become future large liabilities for the governments of BRI-recipient countries, potentially limiting other spending as debt service rises, and creating challenges for the implementation of fiscal policy and balance of payment (Box 1).

To manage fiscal risks, BRI recipient countries should adopt a comprehensive medium-term fiscal framework, which would regularly monitor fiscal risks. According to the Public Expenditure Performance Assessments (PEFA), the fiscal framework of BRI recipient countries is not, on average, worse than that of comparable countries. However, many countries receiving large BRI financing have significant unreported government operations, lack an adequate framework to monitor and

Figure 19. Quality of the Fiscal Framework*



Source: PEFA, 2011.

[1] Only 27 out of 43 countries with identified BRI planned and on-going investments have a PEFA assessment.

* Based on the following four indicators: P6 - Unreported gov. operations; P7 - Oversight of aggregate fiscal risk; P9 - Multi-year fiscal planning and budgeting; and P19 - Competition and controls in procurement.

manage fiscal risks, do not formulate a multi-year budget, and have non-transparent procurement practices (Figure 19).

Box 1. The Risk of Failure of Megaprojects

Infrastructure megaprojects, those that cost US$ 1 billion or more, are often considered crucial for the future of cities or countries. If done right, such investment (i) creates and sustains employment, (ii) contains a large element of domestic inputs relative to imports, (iii) improves productivity and competitiveness by lowering producer costs, (iv) benefits consumers through higher quality services, and finally, (v) improves the environment when infrastructures that are environmentally sound replace infrastructures that are not (Clegg *et al.*, 2017).

However, performance of megaprojects has been poor for the last 90 years for which comparable data are available, with a consistent history of cost overruns (see Table B.1) for both private and public sector projects. One out of 10 go over budget, with average cost overrun of 96 percent for dams and 45 percent for railways (Flyvbjerg, 2014). Only 1-2 out of 10 are delivered on schedule, and about the same achieve the expected economic and social benefits, with demand often below expectations. Successful megaprojects, typically defined as delivering the promised benefits on budget and on time are then approximately 1–8 in a thousand projects (Flyvbjerg, 2017).

Table B.1. Cost Overruns in Selected Infrastructure Megaprojects

Project	Cost overrun (%)
Suez Canal, Egypt	1,900
Troy and Greenfield Railroad, USA	900
Furka Base Tunnel, Switzerland	300
Verrazano Narrow Bridge, USA	280
Boston's Big Dig Artery/Tunnel Project, USA	220
Denver International Airport, USA	200
Panama Canal, Panama	200
Minneapolis Hiawatha Light Rail Line, USA	190
Humber Bridge, UK	180
Dublin Port Tunnel, Ireland	160
Montreal Metro Laval Extension, Canada	160
Copenhagen Metro, Denmark	150
Boston–New York–Washington Railway, USA	130
Great Belt Rail Tunnel, Denmark	120
London Limehouse Road Tunnel, UK	110
Brooklyn Bridge, USA	100
Shinkansen Joetsu High-Speed Rail Line, Japan	100
Channel Tunnel, UK, France	80
Karlsruhe–Bretten Light Rail, Germany	80
London Jubilee Line Extension, UK	80
Bangkok Metro, Thailand	70
Mexico City Metroline, Mexico	60
High-Speed Rail Line South, Netherlands	60
Great Belt East Bridge, Denmark	50

Source: Flyvbjerg, 2017.

Megaprojects are prone to "slow fail" processes, which makes it difficult to avoid higher costs. At the planning stage costs and timelines are systematically underestimated and benefits overestimated and there is no transparent and independent selection process. Megaprojects are often considered unique in their kind, with little attempt to learn from other projects.

The execution phase is plagued by weakness in organizational design and capabilities, with actors changing over time and delivery methods reacting to unforeseen problems (often due to poor planning) and stakeholders with competing interests (e.g. contractors maximize payments and political sponsors eager to minimize costs). In addition, poor planning may impact on input delivery, land acquisition or other disputes, particularly frequent in multi-country infrastructure. Despite the scale of the project one issue is likely to block the implementation of the entire project and trigger penalties. Timely monitoring is also very difficult (McKinsey, 2015).

Most BRI countries would benefit from improved PPP regulatory frameworks. PPPs are widely used to design, finance, build and operate large infrastructure projects. Proper regulatory systems and government capacity to plan, procure and implement such projects are important for efficiency gains and to limit fiscal risks associated with large investments. Since 2015, the World Bank assesses regulatory frameworks for managing PPPs in client countries.[48] The assessment is organized across three main stages of the PPP project cycle: preparation, procurement, and contract management of PPPs.[49] The 2018

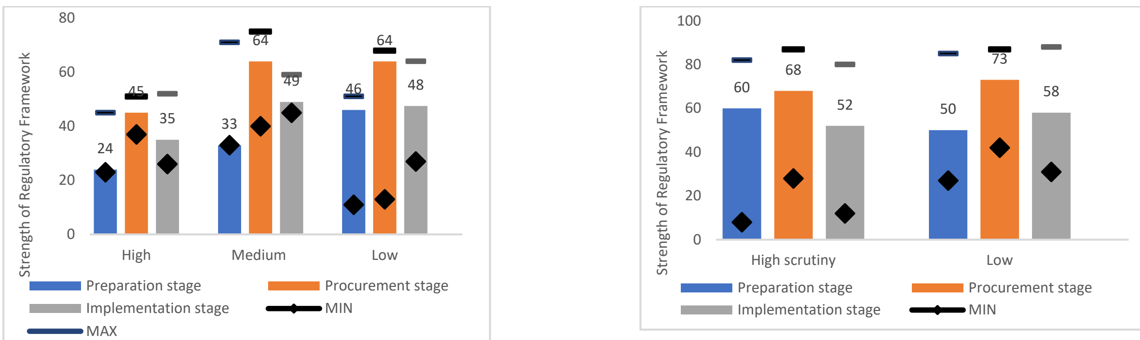
[48] The exercise was designed after the WB Doing Business methodology.

[49] Assessment of the legal and regulatory framework focuses on a highway transport project as a guiding example to ensure cross-comparability. Methodology also examines a fourth area: the management of unsolicited proposals, not considered here.

assessment summarizes national regulatory frameworks and procurement practices at the beginning of June 2017. Most BRI countries would benefit from improved PPP regulatory frameworks. Project preparation and implementation are the areas that have the most room for improvement across both groups. In these areas, LIDCs are below 50 percent of internationally recognized best practice, while EMs have higher average scores across all PPP project cycle stages. There are also significant variations within the country groups, with countries with highest vulnerability levels faring worse across all dimensions of the assessment (Figure 20).

Figure 20. Quality of PPP Regulatory Framework
(Median level of groups of countries with the same level of debt vulnerability)

LIDCs EMs



Source: The World Bank Procuring Infrastructure PPPs 2018 scores; staff estimates for LICs/MACs

Many important elements remain unknown and require a country-specific approach. Pre-existing debt vulnerabilities and recipient countries' exposure to shocks need to be carefully accounted for in designing financing strategies. Important elements of the analysis also include the countries' available type of financing, the level of public investment efficiency, the absorptive capacity, revenue mobilization and access to international and domestic borrowing.

For this reason, the paper outlines also the macroeconomic implications that would guide the assessment of the impact of large BRI project on debt sustainability and fiscal risks. Debt sustainability is a major anchor of fiscal policy, underpinning the development strategy of any economy. Fiscal risks would identify the source, type and likelihood of higher fiscal costs or lower revenue, related to BRI investment, which would require additional financing and could further complicate debt sustainability and debt management.

VII. Conclusions

This paper finds that 28 percent of BRI investment recipients (12 out of 43 countries considered) are likely to experience increased debt vulnerability as a result of BRI in the medium term. These includes 7 LIDCs and 5 EMs. Long-term debt sustainability projections find that 37 percent of countries (11, out of 30 countries, of which 5 LIDCs and 6 EMs) are likely to experience an increase in their debt-to GDP ratio as a result of BRI investment and financing, and 8 among them would be vulnerable to changes in the cost of financing. Most of the countries that have been identified through the medium-term metric and the long-term analysis have already a high level of debt vulnerability based on the most recent available IMF/World Bank debt-sustainability analysis and only 4 of them have a level of debt vulnerability currently assessed to be low.

The proposed medium-term metric is based on four elements: (1) a debt ratio projected to reach 50 percent of GDP in 2023, the year when all BRI debt financing is expected to be fully disbursed; (2) a level of BRI financing at least equal to 5 percent of GDP (close to the median BRI debt financing); (3) an estimated growth rate which is not sufficient to fully offset the increase in PPG debt due to BRI; and (4) a fiscal stance not adequate to stabilize the PPG debt-to-GDP ratio inclusive of BRI.

The results heavily depend on a number of key assumptions. First, due to lack of sufficient information on debt financing related to BRI investment projects, the paper uses information obtained from news sources and World Bank country teams to estimate BRI debt financing from the estimated cost of BRI investment, which is identified as planned or under construction from 2016 to 2018. Second, it is assumed that the terms of debt financing equal the terms of Chinese loans reported by debtor countries to the World Bank through the *Debtor Reporting System*. Third, two extreme assumptions are made with respect to projected PPG debt, GDP and primary balances as reported in the October 2018 WEO: i) that WEO projections fully incorporate the impact of BRI or ii) that WEO projections do not include any impact from BRI. Based on this three sets of assumptions the paper estimates the growth and fiscal gaps related to BRI investments.

This proposed methodology helps to identify countries that can be expected to face a rapid deterioration in debt sustainability despite very limited information on BRI investment. Estimates of growth apply the World Bank LTGM and regression techniques adequate for dynamic panels with endogeneity issues. Thanks to these estimates, the paper has estimated the marginal impact on growth that would derive from BRI infrastructure investment and used these estimates to project indebtedness ratios, assuming that BRI investment would be completed by 2023. The exercise helped identify those countries that, despite higher growth, would experience an increase in their level of indebtedness because of BRI investment. These growth estimates can be used in country-specific assessments, if there are no alternative estimates.

Turning to model-driven long-term simulations, the assumption of a negative interest-growth differential generates long-term growth projections with limited effect of BRI on debt vulnerabilities in a large number of BRI countries. Simulations have used the result of an SGE model as in de Soyres et al. (2019), to account for the full effect of trade-related infrastructure, policy reforms and externalities on growth. Simulations compared debt dynamics with respect to a scenario in which no BRI investment would take place and growth, primary balance and interest rate would be equal to their long-term historical averages. Debt dynamics are mainly driven by long-term drivers and BRI investment would generally result in lower indebtedness in most countries and would require adjustment to limit the build-up of debt vulnerabilities in only a handful of countries.

Fiscal risks associated with BRI are expected to be sizeable. Depending on the contract management structure and the clauses of the contracts, BRI investment is likely to also increase exposure of government budgets to risks deriving from direct and contingent liabilities, availability payments, and termination clauses. According to the literature, megaprojects (infrastructure projects costing US$ 1 billion or more) are very likely to go overbudget, miss deadlines, and not deliver on revenue, growth and employment expectations, thus leaving a heavy bill to be paid by governments. Among BRI-recipient countries, 36 are implementing megaprojects. Lack of adequate monitoring and management of those risks could alter future government expenditure, fiscal balances, and debt dynamics. Indicators of governance quality do not highlight particular differences between BRI-recipient and other countries. However, indicators of governance and of management of PPPs deteriorate with increased debt vulnerability, a feature warranting heightened attention for those countries identified as highly vulnerable to large BRI financing.

Further research is needed to actually assess the impact of BRI on countries' debt sustainability outlook. First, the paper uses assumptions to quantify debt financing based on the size of identified BRI projects. Further research should track the actual form of debt and non-debt financing. Availability of type and terms of financing would to prove better assessments on the projected evolution of both indebtedness and liquidity indicators and to compare the gross financing needs with the risk assessment thresholds of the LIC DSF and MAC DSA framework. Results could also be further refined through an explicit estimate of the spillover effects of BRI investment using a panel vector autoregression and impulse response analysis. Therefore, indebtedness indicators would reflect not only the estimated effect of BRI investment on growth, but also the positive externality of improved connectivity among BRI-recipient countries. Finally, it would also important to explicitly consider the impact of the level of indebtedness on growth, for example using dynamic computable general equilibrium models, to fully account for the effect of debt-financed large infrastructure investment on growth, fiscal balances, and indebtedness.

A country-specific analysis is necessary to identify the effects of BRI investment, contractual arrangements, and financing on debt sustainability and fiscal risks. The paper outlines the macroeconomic impact of large investment financing. A country-specific assessment framework could be developed using case studies. This framework would comprise (1) a revised debt sustainability analysis, which would include the debt financing of the central government or public entities, as well as additional expenses from infrastructure investment that may not be adequately included in the fiscal accounts or that would take place beyond the normal span of a medium-term fiscal framework; and (2) a fiscal risk analysis of the BRI investments, modeled under the PPP Fiscal Risk Assessment Model (PFRAM), which would estimate the possible higher fiscal outlays that the general government would face as a result of the identified risks. The application of country-specific assessments to case studies would highlight the most frequent risks and pay particular attention to infrastructure investment or megaprojects that could have higher risks of failure and larger impact on government finances.

Lack of transparency around the terms and size of Chinese financing also poses significant risks for countries and other creditors. Debt transparency is critical for borrowers and creditors to make informed decisions, ensure efficient use of available financing, and safeguard debt sustainability. It is also important for citizens to be able to hold governments accountable to their actions. In this context, it will be critical to build on past successful engagements with borrowing countries and the international creditor community, including China, while further enhancing the coordination of sustainable lending practices and debt restructuring regimes.

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Annex I - Country Classification

LIDCs are:

Afghanistan, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Cameroon, Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Republic of Congo, Côte d'Ivoire, Djibouti, Eritrea, Ethiopia, The Gambia, Ghana, Guinea, Guinea-Bissau, Haiti, Honduras, Kenya, Kiribati, Kyrgyz Republic, Lao PDR, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Moldova, Mozambique, Myanmar, Nepal, Nicaragua, Niger, Papua New Guinea, Rwanda, São Tomé and Príncipe, Senegal, Sierra Leone, Solomon Islands, Somalia, South Sudan, Sudan, Tajikistan, Tanzania, Timor-Leste, Togo, Uganda, Uzbekistan, Yemen, Rep., Zambia, Zimbabwe.

EMs are:

Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Azerbaijan, Belarus, Belize, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Cabo Verde, Chile, China, Colombia, Costa Rica, Croatia, Dominica, Dominican Republic, Ecuador, Egypt, Arab Rep., El Salvador, Equatorial Guinea, Fiji, Gabon, Georgia, Grenada, Guatemala, Guyana, India, Indonesia, Iran, Islamic Rep., Iraq, Jamaica, Jordan, Kazakhstan, Kosovo, Lebanon, Libya, Macedonia, FYR, Malaysia, Maldives, Marshall Islands, Mauritius, Mexico, Micronesia, Fed. Sts., Mongolia, Montenegro, Morocco, Namibia, Nauru, Nigeria, Pakistan, Palau, Panama, Paraguay, Peru, Philippines, Poland, Romania, Russian Federation, Samoa, Serbia, Seychelles, South Africa, Sri Lanka, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Swaziland, Syrian Arab Republic, Thailand, Tonga, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Tuvalu, Ukraine, Uruguay, Vanuatu, Venezuela, RB, Vietnam.

BRI-recipient countries are:

Afghanistan, Albania, Armenia, Azerbaijan, Bahrain, Bangladesh, Belarus, Bhutan, Bosnia and Herzegovina, Brunei Darussalam, Bulgaria, Cambodia, Croatia, Czech Republic, Djibouti, Egypt, Arab Rep., Estonia, Georgia, Greece, Hong Kong SAR, China, Hungary, India, Indonesia, Iran, Islamic Rep., Iraq, Israel, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyz Republic, Lao PDR, Latvia, Lebanon, Lithuania, Macedonia, FYR, Malaysia, Maldives, Moldova, Mongolia, Montenegro, Myanmar, Nepal, Oman, Pakistan, Philippines, Poland, Qatar, Romania, Russian Federation, Saudi Arabia, Serbia, Singapore, Slovak Republic, Slovenia, Sri Lanka, Syrian Arab Republic, Taiwan, China, Tajikistan, Tanzania, Thailand, Timor-Leste, Turkey, Turkmenistan, Ukraine, United Arab Emirates, Uzbekistan, Vietnam, West Bank and Gaza, Yemen, Rep.

Annex II – Identified BRI Investment

Table A1. Total Investment (In millions of U.S. dollars, total over the period 2013-18)

	CGIT[1]	World Bank
Afghanistan	210	205
Albania	..	3,584
Armenia	..	3,797
Azerbaijan	..	140
Bangladesh	21,090	32,153
Belarus	1,630	2,781
Bosnia and Herzegovina	2,470	2,749
Cambodia	6,970	9,880
Croatia	690	712
Djibouti	..	580
Egypt, Arab Rep.	17,160	10,395
Georgia	670	6,393
India	9,380	12,014
Indonesia	25,030	48,975
Iran, Islamic Rep.	12,970	16,365
Iraq	7,660	3,320
Jordan	3,900	2,200
Kazakhstan	8,250	7,358
Kenya	..	8,637
Kyrgyz Republic	4,340	1,631
Lao PDR	17,780	19,299
Macedonia, FYR	400	..
Malaysia	31,030	50,792
Maldives	1,700	546
Moldova	..	384
Mongolia	4,050	4,806
Montenegro	1,120	..
Myanmar	4,030	5,277
Nepal	2,660	3,161
Pakistan	39,510	54,215
Philippines	7,100	2,628
Poland	930	717
Romania	810	1,200
Russian Federation	24,300	118,525
Serbia	4,880	2,058
Sri Lanka	9,510	4,039
Syrian Arab Republic	..	43
Tajikistan	..	431
Tanzania	..	3,000
Thailand	6,940	13,434
Timor-Leste	560	4,000
Turkey	2,750	3,070
Turkmenistan	600	6,700
Ukraine	860	4,531
Uzbekistan	1,230	12,186
Vietnam	6,720	10,872
Yemen, Rep.	510	..
Grand Total	**292,400**	**499,783**

Figure A1. Annual Investment (In millions of U.S. dollars)

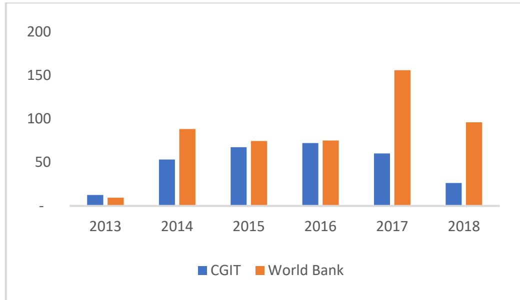


Figure A2. Regional Composition (In percent of total)

Figure A3. Income Composition (In percent of total)

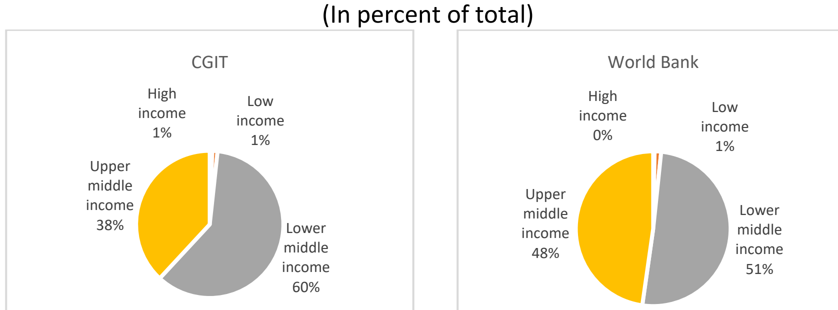
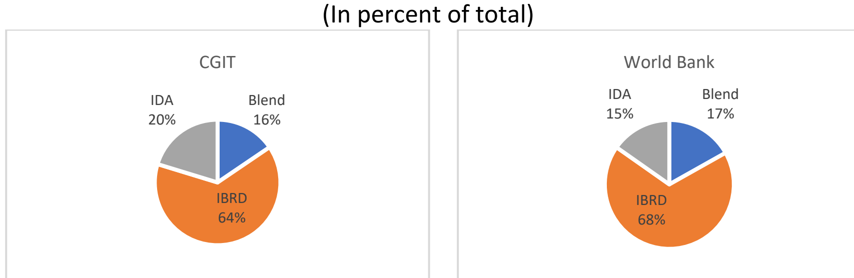
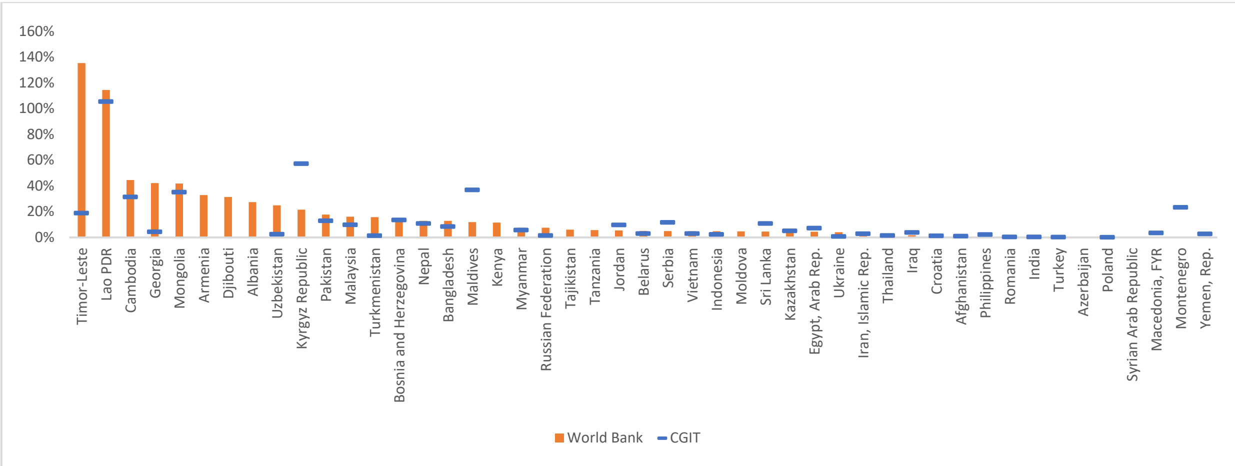


Figure A4. World Bank Lending Composition (In percent of total)



Source: AEI and The World Bank.
[1]China Global Investment Tracker.

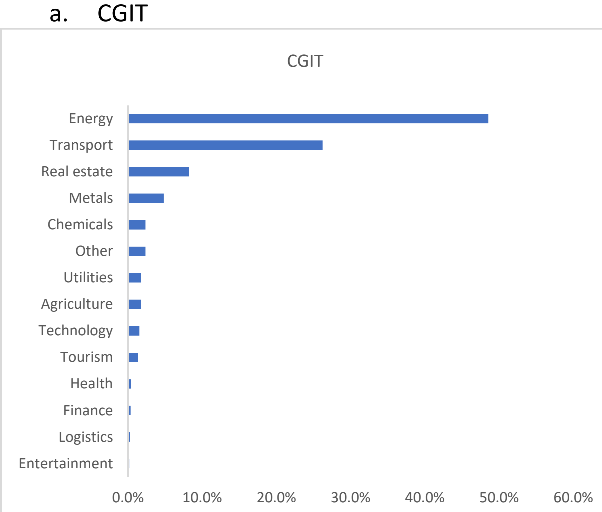
Figure A5. Total BRI Investment
(In percent of GDP)



Source: EAI, WIND database and Authors' estimates.

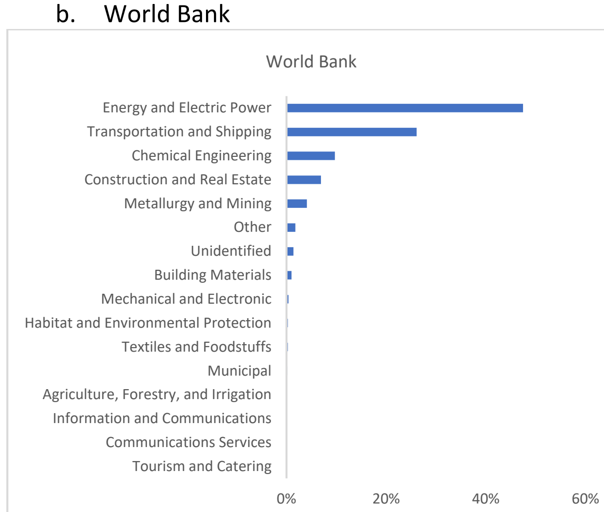
Figure A6. Sectoral Composition
(In percent of total)

a. CGIT



Source: AEI.

b. World Bank



Source: WIND and authors' estimates.

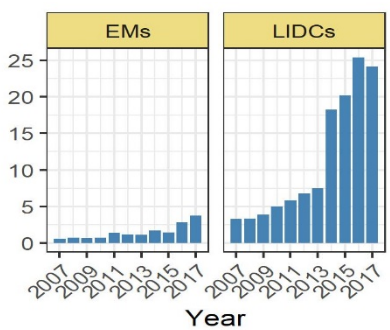
Annex III – Commitments from Chinese Lenders

This section uses loan-by-loan data collected by the Debtor Reporting System (DRS) of the World Bank.[50] Due to confidentiality requirements, data are presented in aggregated terms. Country-specific data are used to calculate fiscal gaps in the paper. This annex presents data for 36 LIDCs and EMs reporting on Chinese loans.[51]

The share of debt outstanding to Chinese institutions has increased over the period of 2007-2017 in BRI recipient countries. The median share of Chinese lending in BRI-recipient LIDCs almost tripled in a two-year period (Figure A7) from 7 per cent in 2013 to 20 per cent in 2015. For EMs, the increase is not as steep as in LIDCs, however, the trend is positive over time. The almost entirety of disbursements to BRI-recipient countries is from official sources (recorded as "bilateral lending" in the DRS). A small portion of it is held by financial institutions, export credits and supplier's credits (Figure A8). For example, financial institution in 2011 accounted for 6 per cent of total disbursement for EMs and 3 per cent on LIDCs.

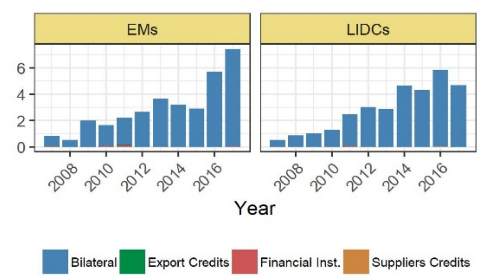
BRI recipient countries are financed with three types of interest rate (i) fixed, (ii) interest free, and (iii) variable interest rate. Loans to both EMs and LIDCs are mostly fixed rate, but with and increasing share of variable rates. A significant portion of LIDCs loans are interest free, however, the Chinese commitment for these loans is very low (Figure A9). Lending from China is generally highly concessional, with the median value of grant element for LIDCs at 53 percent over the period 2008-2017. For EMs, grant element remains large but smaller than in LIDCs and fluctuating over time (Figure A10).

Figure A7. Median of Chinese Debt to total PPG Debt (In billions of USD; median level of groups of countries across time)



Source: WDI

Figure A8. Total Disbursement by Creditor (in billions of USD)



Source: WDI

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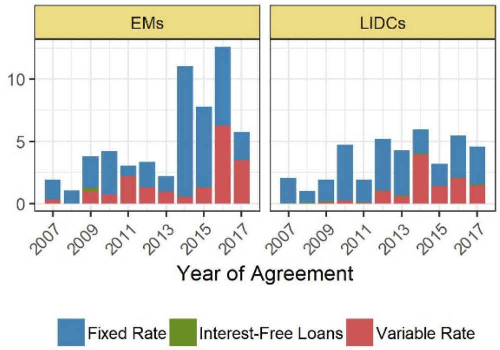
[50] The World Bank Debtor Reporting System (DRS) was established in 1951. The DRS system captures detailed information at loan level for external borrowing of reporting countries using standardized set of forms. The primary objective of the DRS is to provide the Bank with reliable and timely external debt information to assess a borrowing country's foreign debt situation, creditworthiness, and economic management; and conduct its country economic work and assess regional and global indebtedness and debt servicing problems. Data submitted by countries are entered into the DRS database, from which the aggregates and country tables are produced and published annually in the International Debt Statistics publication (successor to Global Development Finance and World Debt Tables). For additional information see https://datahelpdesk.worldbank.org/knowledgebase/articles/381934-what-is-the-external-debt-reporting-system-drs.

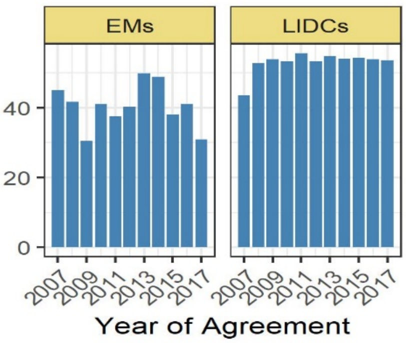
[51] Albania, Armenia, Bangladesh, Belarus, Cambodia, Djibouti, Egypt, Georgia, India, Indonesia, Iran, Jordan, Kazakhstan, Kenya, Kyrgyz Republic, Laos., Lebanon, Macedonia, Maldives, Moldova, Mongolia, Montenegro, Myanmar, Nepal, Pakistan, Philippines, Serbia, Sri Lanka, Syria, Tajikistan, Tanzania, Turkey, Turkmenistan, Uzbekistan, Vietnam, and Yemen.

Figure A9. Chinese Commitment by Type of Interest Rate
(in billions USD)



Source: WDI.

Figure A10. Grant Element
(Median level of groups of countries across time, in percent)

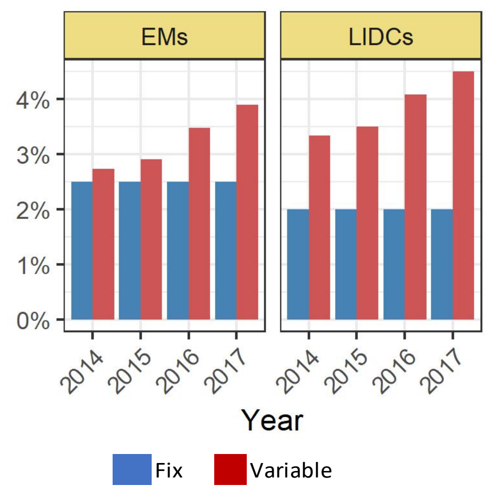


Source: WDI

Variable interest rates are higher than fixed rates both for EMs and LIDCs (Figure A11). The median value and the distribution of the fixed interest rate remained stable over the reported period for EMs and LIDCs. The median value of the variable rates is rising due to a constant increase on the 6-Month LIBOR Deposit rate between 2014 and 2017.[52]

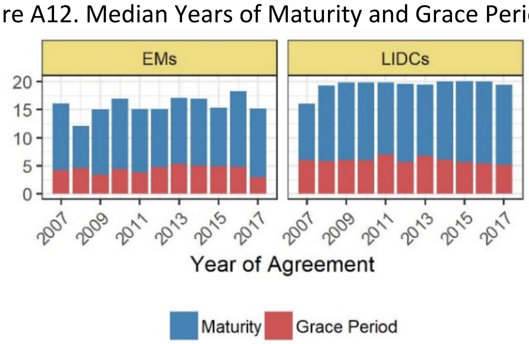
LIDCs have longer maturity and grace periods than EMs (Figure A12). For LIDCs, the median value of maturity was constant over the reported period, approximately 20 years of maturity with 6 years of grace period. In EMs maturity fluctuated between 12 and 18 years and grace period between 3 and 5 years.

Figure A11. Median Interest Rate by Type of Interest Rate
(In percent)



Source: WDI

Figure A12. Median Years of Maturity and Grace Period

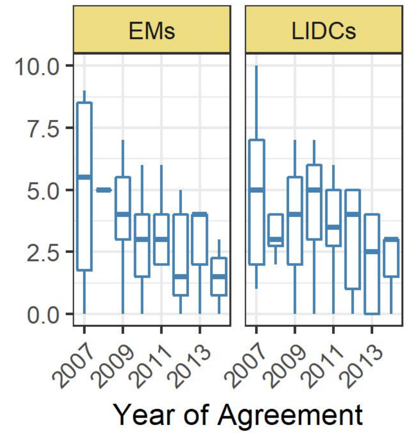


[52] The 91 per cent of the loans with variable rate are attached to 6-Month LIBOR Deposit rate.

Source: WDI

Most loans from China fully disburse between 2.5 and 7.5 years from the year of commitment, both in LIDCs and EMs. Considering loans committed in 2008 and 2009 (two years with the highest percentage of fully disbursed loans), the median number of years to full disbursement is about 5 years (Figure A13).

Figure A13. Distribution of Years until Full Disbursement



Source: WDI

Note: It visualizes five summary statistics (the median, two hinges and two whiskers). The lower and upper hinges correspond to the first and third quartiles (the 25th and 75th percentiles). The upper/lower whiskers extend from the hinge to the largest/smallest value of the index respectively

Annex IV - Additional growth from BRI investment from the Long-Term Growth Model

						Extra BRI Investment (% of GDP)					Extra Growth Relative to Baseline				
CountryName	Kg/K[1] (1)	K/Y[2] (2)	Kg/Y (3)=1/2	ϕ	MPKg[3]	2019	2020	2021	2022	2023	2020	2021	2022	2023	2024
Afghanistan	0.44	2.21	0.97	0.17	0.18	0.19%	0.18%	0.17%	0.16%	0.15%	0.03%	0.03%	0.03%	0.03%	0.03%
Albania	0.29	4.05	1.18		0.14	4.48%	4.18%	3.90%	3.63%	3.40%	0.65%	0.60%	0.56%	0.52%	0.49%
Armenia	0.27	2.70	0.73		0.23	5.78%	5.44%	5.09%	4.74%	4.41%	1.35%	1.27%	1.19%	1.11%	1.03%
Azerbaijan, Rep. (	0.45	1.73	0.77		0.22	0.06%	0.06%	0.05%	0.05%	0.05%	0.01%	0.01%	0.01%	0.01%	0.01%
Bangladesh	0.33	2.78	0.92		0.18	1.84%	1.69%	1.55%	1.42%	1.30%	0.34%	0.31%	0.28%	0.26%	0.24%
Belarus	0.16	2.77	0.43		0.40	0.42%	0.41%	0.39%	0.38%	0.36%	0.17%	0.16%	0.16%	0.15%	0.14%
Bosnia & Herzego	0.47	2.32	1.10		0.16	0.21%	0.20%	0.19%	0.18%	0.17%	0.03%	0.03%	0.03%	0.03%	0.03%
Cambodia	0.47	2.07	0.97		0.18	7.44%	6.83%	6.28%	5.79%	5.34%	1.31%	1.20%	1.10%	1.02%	0.94%
Croatia	0.34	3.91	1.35		0.13	0.22%	0.21%	0.20%	0.19%	0.19%	0.03%	0.03%	0.03%	0.02%	0.02%
Djibouti	0.74	3.38	2.51		0.07	4.85%	4.46%	4.11%	3.78%	3.48%	0.33%	0.30%	0.28%	0.26%	0.24%
Egypt	0.32	1.65	0.53		0.32	0.52%	0.44%	0.39%	0.34%	0.30%	0.17%	0.14%	0.12%	0.11%	0.10%
Georgia	0.37	2.86	1.07		0.16	7.29%	6.75%	6.22%	5.74%	5.29%	1.16%	1.07%	0.99%	0.91%	0.84%
India	0.33	2.19	0.73		0.23	0.08%	0.07%	0.06%	0.06%	0.05%	0.02%	0.02%	0.01%	0.01%	0.01%
Indonesia	0.16	2.93	0.47		0.36	0.76%	0.70%	0.66%	0.61%	0.57%	0.28%	0.26%	0.24%	0.22%	0.21%
Iran, I.R. of	0.73	2.60	1.91		0.09	0.50%	0.48%	0.44%	0.42%	0.39%	0.04%	0.04%	0.04%	0.04%	0.04%
Iraq	0.73	1.60	1.17		0.15	0.26%	0.25%	0.24%	0.23%	0.22%	0.04%	0.04%	0.03%	0.03%	0.03%
Jordan	0.35	4.17	1.45		0.12	1.00%	0.95%	0.90%	0.85%	0.81%	0.12%	0.11%	0.11%	0.10%	0.10%
Kazakhstan	0.24	3.19	0.77		0.22	0.51%	0.48%	0.45%	0.41%	0.38%	0.11%	0.11%	0.10%	0.09%	0.08%
Kenya	0.33	1.69	0.57		0.30	0.97%	0.90%	0.83%	0.76%	0.70%	0.29%	0.27%	0.25%	0.23%	0.21%
Kyrgyz Republic	0.39	2.03	0.79		0.21	3.04%	2.85%	2.69%	2.53%	2.43%	0.65%	0.61%	0.58%	0.54%	0.52%
Lao People's Dem	0.39	3.26	1.27		0.13	8.41%	7.68%	7.05%	6.48%	5.96%	1.12%	1.03%	0.94%	0.86%	0.79%
Malaysia	0.51	3.08	1.56		0.11	2.60%	2.37%	2.17%	1.99%	1.83%	0.28%	0.26%	0.24%	0.22%	0.20%
Maldives	0.47	2.27	1.08		0.16	2.12%	1.96%	1.82%	1.68%	1.56%	0.34%	0.31%	0.29%	0.27%	0.25%
Moldova	0.33	3.78	1.25		0.14	0.66%	0.62%	0.59%	0.57%	0.55%	0.09%	0.08%	0.08%	0.08%	0.07%
Mongolia	0.55	4.77	2.62		0.06	3.96%	3.59%	3.24%	2.90%	2.60%	0.26%	0.23%	0.21%	0.19%	0.17%
Myanmar	0.47	2.52	1.18		0.14	1.39%	1.26%	1.15%	1.05%	0.95%	0.20%	0.18%	0.17%	0.15%	0.14%
Nepal	0.25	3.48	0.86		0.20	1.91%	1.81%	1.68%	1.56%	1.45%	0.38%	0.36%	0.33%	0.31%	0.29%
Pakistan	0.35	2.24	0.79		0.21	1.93%	1.77%	1.64%	1.51%	1.40%	0.41%	0.38%	0.35%	0.32%	0.30%
Philippines	0.21	2.76	0.59		0.29	0.10%	0.09%	0.08%	0.07%	0.07%	0.03%	0.03%	0.02%	0.02%	0.02%
Poland	0.35	2.67	0.94		0.18	0.02%	0.02%	0.02%	0.02%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%
Russia	0.28	3.48	0.98		0.17	0.09%	0.09%	0.09%	0.08%	0.08%	0.02%	0.02%	0.02%	0.01%	0.01%
Serbia, Republic (	0.18	3.69	0.66		0.26	0.29%	0.27%	0.25%	0.24%	0.22%	0.08%	0.07%	0.07%	0.06%	0.06%
Sri Lanka	0.27	2.23	0.61		0.28	0.28%	0.27%	0.25%	0.23%	0.22%	0.08%	0.07%	0.07%	0.06%	0.06%
Syrian Arab Repul	0.62	2.81	1.75		0.10	..	..	..	..	..					
Tanzania	0.26	2.21	0.57		0.30	0.99%	0.91%	0.84%	0.78%	0.72%	0.29%	0.27%	0.25%	0.23%	0.21%
Thailand	0.36	3.45	1.24		0.14	0.42%	0.40%	0.38%	0.36%	0.34%	0.06%	0.05%	0.05%	0.05%	0.05%
Timor-Leste	0.36	2.52	0.91		0.19	23.45%	22.30%	22.04%	21.39%	23.73%	4.37%	4.15%	4.11%	3.98%	4.42%
Turkey	0.32	1.85	0.60		0.28	0.04%	0.03%	0.03%	0.03%	0.03%	0.01%	0.01%	0.01%	0.01%	0.01%
Ukraine	0.27	4.83	1.31		0.13	0.70%	0.64%	0.59%	0.54%	0.50%	0.09%	0.08%	0.08%	0.07%	0.06%
Uzbekistan	0.26	1.44	0.37		0.46	3.63%	3.27%	3.01%	2.82%	2.66%	1.65%	1.49%	1.37%	1.28%	1.21%
Vietnam	0.38	3.75	1.43		0.12	0.48%	0.43%	0.40%	0.37%	0.34%	0.06%	0.05%	0.05%	0.04%	0.04%

[1] Ratio of public capital to total capital, from IMF.

[2] Ratio of total capital to GDP, from Penn World Tables (PWT8.1)

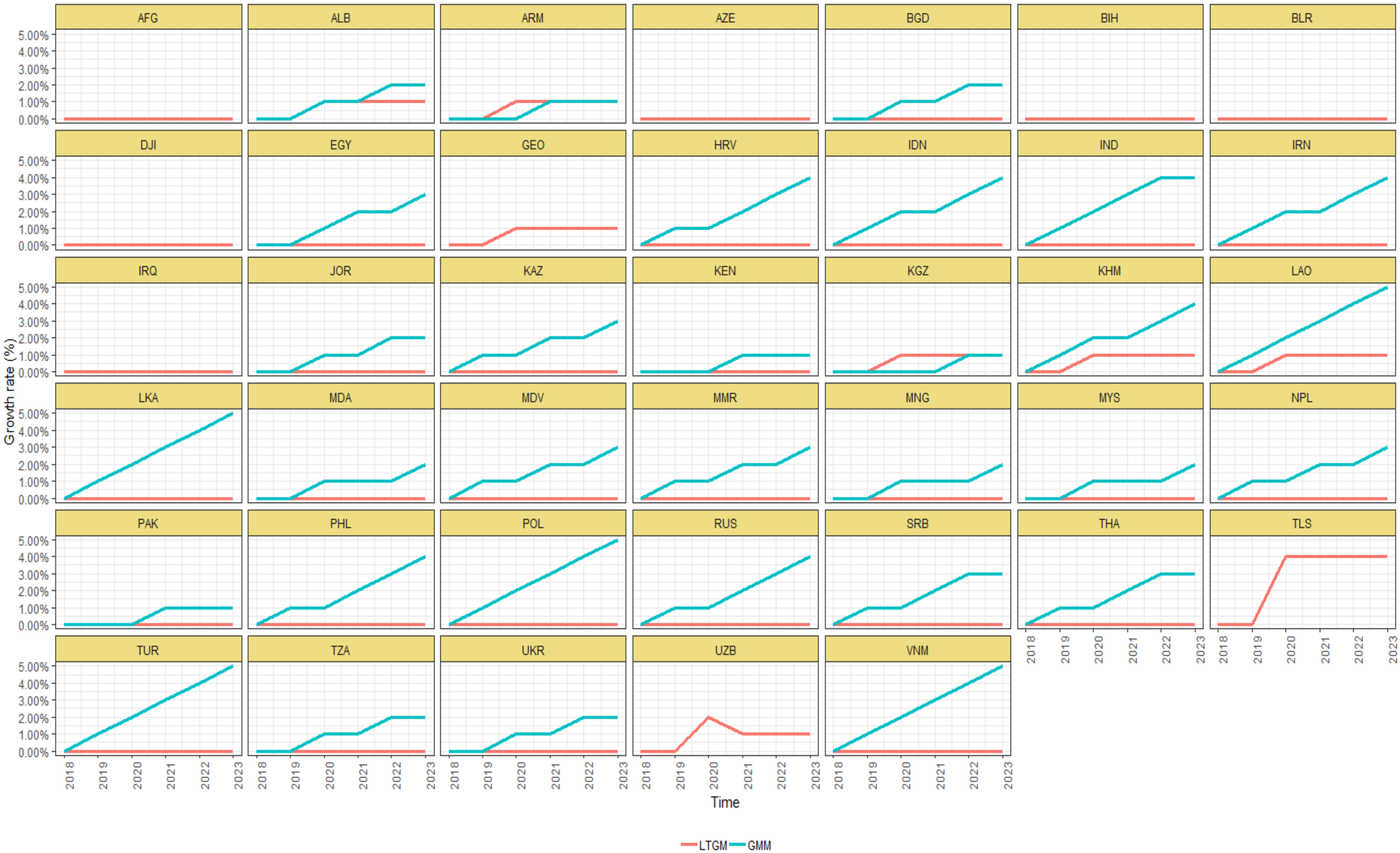
[3] Marginal productivity of public capital.

Annex V - Additional growth from BRI investment from the GMM Model

Country	2019	2020	2021	2022	2023
Albania	0.42%	0.84%	1.28%	1.72%	2.18%
Armenia	0.17%	0.36%	0.55%	0.75%	0.96%
Bulgaria	0.45%	0.91%	1.38%	1.86%	2.36%
Egypt	0.48%	0.99%	1.51%	2.05%	2.61%
Croatia	0.68%	1.37%	2.07%	2.79%	3.51%
Indonesia	0.76%	1.53%	2.31%	3.11%	3.93%
India	0.86%	1.73%	2.62%	3.53%	4.47%
Iran	0.81%	1.64%	2.48%	3.34%	4.21%
Jordan	0.39%	0.79%	1.19%	1.60%	2.03%
Kazakhstan	0.59%	1.19%	1.80%	2.42%	3.06%
Kenya	0.24%	0.48%	0.74%	1.00%	1.28%
Kyrgyz Republic	0.13%	0.26%	0.41%	0.56%	0.71%
Cambodia	0.76%	1.54%	2.33%	3.14%	3.96%
Lao RPD	0.93%	1.88%	2.85%	3.84%	4.85%
Sri Lanka	0.93%	1.88%	2.84%	3.82%	4.82%
Moldova	0.32%	0.65%	0.98%	1.32%	1.67%
MDV	0.53%	1.07%	1.62%	2.19%	2.77%
Myanmar	0.53%	1.07%	1.62%	2.19%	2.77%
MNG	0.35%	0.71%	1.09%	1.48%	1.89%
Malaysia	0.35%	0.71%	1.08%	1.47%	1.86%
Nepal	0.55%	1.12%	1.69%	2.28%	2.88%
Pakistan	0.23%	0.47%	0.72%	0.98%	1.25%
Philippines	0.67%	1.36%	2.06%	2.77%	3.51%
Poland	0.97%	1.95%	2.95%	3.97%	5.00%
Russian Federation	0.74%	1.50%	2.26%	3.03%	3.82%
Serbia	0.61%	1.24%	1.88%	2.53%	3.20%
Thailand	0.63%	1.26%	1.91%	2.57%	3.24%
Turkey	0.89%	1.79%	2.72%	3.66%	4.62%
Tajikistan	0.36%	0.73%	1.11%	1.50%	1.90%
Ukraine	0.43%	0.88%	1.34%	1.82%	2.30%
Vietnam	0.92%	1.85%	2.81%	3.78%	4.77%

Note: To derive the extra growth relative to baseline, we estimate the difference of growth in real GDP per capita before and after the additional BRI adjusted investment.

Annex VI - Marginal BRI Real Growth Impact



Annex VII – Measuring the quantity of infrastructure

Following Calderon (2009) and the empirical literature on infrastructure and economic performance, our synthetic indices of infrastructure stock are constructed using the PCA method. This takes *n* specific indicators and yields new indices (principal components) that capture information on the different dimensions of the data and that are mutually uncorrelated.

Our aggregate index of infrastructure is the first principal component of the vector of three physical indicators of infrastructure stocks, telecommunications, electricity, and roads. In the telecommunications sector, our stock measure the number of main telephone lines per 100 people. The data for telecommunications sector were retrieved from the World Development Indicators of the World Bank. In the electricity sector, the proxy for our stock is measured in electricity-generating capacity (megawatts per 1,000 people). The data for the electricity-generating capacity were collected from UNdata. The size of the infrastructure stock in roads is captured by the length of the total road network (in kilometers) normalized by the surface area in the country.[53] The data for the road network and the surface area were retrieved from the World Factbook of the CIA. All variables are expressed in logs:

$$\text{PCA} = 0.69 * log\left(\frac{Z_1}{L}\right) + 0.68 * log\left(\frac{Z_2}{L}\right) + 0.22 * log\left(\frac{Z_3}{A}\right)$$

where PCA is the synthetic index of infrastructure stock, (Z_1/L) is the number of main telephone lines, (Z_2/L) is the electricity-generating capacity, and (Z_3/A) represents the total road length normalized by the surface area. As expected, the infrastructure index is highly correlated with each individual measure considered. More specifically, the correlation between the infrastructure index and main telephone lines is 0.96, its correlation with electricity-generating capacity is 0.95, and 0.30 with the length of the road network.

[53] The road network includes the length of the paved and unpaved roads.

Annex VIII - Marginal impact of BRI financing on GDP growth under two assumptions

In this annex we consider two assumptions to compare the marginal impact of BRI financing on debt-to-GDP ratio. In both assumptions, we assume that the same growth is generated by BRI financing and the growth is always positive. Assumption 1 (A1) assumes that WEO projections for the period 2019-2023 fully include all information related to BRI financing in the projected PPG debt, *D*, and in nominal GDP, *Y*. Assumption 2 (A2) assumes that WEO projections do not include any information related to BRI financing in the projections of PPG debt and nominal GDP.

Under both assumptions, we also assume that BRI-recipient countries would borrow BRI debt over 5 years at the constant nominal amount (BRI/5) in local currency and pay a constant nominal annual interest *i* over the borrowing amounts. This additional interest rate would increase the annual gross financing needs and results in additional debt. The total interest rate paid on BRI debt financing is defined as

$$\sum_{t=1}^{5} i * \frac{t}{5}\mathrm{BRI} = 3 * i * BRI$$

Assumption 1: WEO projections includes BRI financing

Based on this hypothesis the WEO projections of GDP (Y_t^{WEO}) include the growth rate that derives from BRI investment (g_t^{BRI}) and other contributing factors (g_t^{WEO}). Therefore, GDP projections should follow the sequence of equations below:

$$Y_{2019}^{WEO} = Y_{2018}^{WEO} * \left(1 + g_{2019}^{WEO}\right) * (1 + g_{2019}^{BRI})$$

$$Y_{2020}^{WEO} = Y_{2019}^{WEO} * \left(1 + g_{2020}^{WEO}\right) * (1 + g_{2020}^{BRI})$$

$$\vdots$$

$$Y_{2023}^{WEO} = Y_{2022}^{WEO} * \left(1 + g_{2023}^{WEO}\right) * (1 + g_{2023}^{BRI})$$

Consequently, $Y_{2023}^{WEO-BRI}$ is the GDP in 2023 that excludes the growth which derives from BRI financing and should be equal to:

$$Y_{2023}^{WEO-BRI} = {Y_{2023}^{WEO}} \Big/ {\prod_{t=2019}^{2023}(1 + g_t^{BRI})}$$

Under A1, to estimate the marginal impact of BRI financing on debt-to-GDP ratio, we need to derive the difference between the debt-to-GDP ratio that includes BRI financing and the debt-to-GDP ratio that does not. Hence, we have:

$$\frac{D_{2023}}{Y_{2023}^{WEO}} - \frac{D_{2023} - BRI\ (1+3i)}{Y_{2023}^{WEO-BRI}} = \cdots$$

$$= \frac{D_{2023} * (1 - \prod_{t=2019}^{2023}(1+g_t^{BRI})) + BRI(1+3i) * \prod_{t=2019}^{2023}(1+g_t^{BRI})}{Y_{2023}^{WEO}} \quad (A1)$$

where D_{2023} is the stock of debt in 2023 that is reported in WEO and BRI is the stock of BRI debt financing for the period at end-2023. Assuming that $g_t^{BRI} > 0$ for every period t, then $D_{2023} * (1 - \prod_{t=2019}^{2023}(1+g_t^{BRI})) < 0$ and $BRI * \prod_{t=2019}^{2023}(1+g_t^{BRI}) > 0$. If equation A1 is greater than 0, then the effect on growth generated by BRI financing is not sufficient to outperform the increase on debt and vice versa.

Assumption 2: WEO projection excludes BRI financing

Based on this hypothesis the WEO projections of GDP (Y_t^{WEO}) include the growth rate that derives from other contributing factors (g_t^{WEO}) and not from BRI financing (g_t^{BRI}). Therefore, GDP projections should follow the sequence of equations below:

$$Y_{2019}^{WEO} = Y_{2018}^{WEO} * \left(1 + g_{2019}^{WEO}\right)$$

$$Y_{2020}^{WEO} = Y_{2019}^{WEO} * \left(1 + g_{2020}^{WEO}\right)$$

$$\vdots$$

$$Y_{2023}^{WEO} = Y_{2022}^{WEO} * \left(1 + g_{2023}^{WEO}\right)$$

Consequently, $Y_{2023}^{WEO+BRI}$ is the GDP that includes BRI investment and other contributing factors and should be equal to:

$$Y_{2023}^{WEO+BRI} = Y_{2023}^{WEO} * \prod_{t=2019}^{2023}(1+g_t^{BRI})$$

As in A1, to estimate the marginal impact of BRI financing on debt to GDP ratio, we need to derive the difference between the debt-to-GDP ratio that includes BRI debt and the debt-to-GDP ratio that does not. Hence, we have:

$$\frac{D_{2023} + BRI(1+3i)}{Y_{2023}^{WEO+BRI}} - \frac{D_{2023}}{Y_{2023}^{WEO}} = \cdots$$

$$= \frac{D_{2023} * (1 - \prod_{t=2019}^{2023}(1+g_t^{BRI})) + BRI(1+3i)}{Y_{2023}^{WEO+BRI}} \quad (A2)$$

where D_{2023} is the stock of debt in 2023 that is reported in WEO and BRI is the stock of BRI debt at end-2023.

Assuming that $g_t^{BRI} > 0$ for every period, then $D_{2023} * (1 - \prod_{t=2019}^{2023}(1 + g_t^{BRI})) < 0$ and $\mathrm{B}RI > 0$. Equation A2 has similar intuition as in equation A1. If equation A2 is greater than 0, then the effect on growth generated by BRI financing is not sufficient to outperform the increase on debt and vice versa.

<u>Comparing *A1* and *A2*</u>

For $g_t^{BRI} \geq 0, \forall t, A2 \leq A1$. The marginal impact of BRI financing is always smaller in A2 than in A1, where WEO projections exclude and include BRI financing respectively. The difference of the marginal impact between *A1* and *A2* is defined by $\mathrm{A2} - \mathrm{A1} = \Delta = -\mathrm{BRI} * (\prod_{t=2019}^{2023}(1 + g_t^{BRI}) - 1) / Y_{2023}^{WEO+BRI} \leq 0$. More specifically, the numerator in equation A1 is never smaller than the numerator in equation A2 and the denominator is the same for both A1 and A2. The denominator is the same in A1 and A2 since *A1* assumes that WEO projections include BRI financing, while *A2* adds on the additional BRI-growth to WEO projections which excludes the impact of BRI.

The relationship between *A1 and A2* yields 3 possible outcomes of BRI financing:

1) If A2>0, then A1>0. Under this circumstance, the debt to GDP ratio inclusive of BRI is greater than the debt ratio without BRI. Therefore, BRI-generated growth does not offset the increase in debt under A1 and A2.
2) If A1<0, then A2<0. Under this circumstance, the debt to GDP ratio inclusive of BRI is smaller than the debt ratio without BRI and the BRI-generated growth fully offsets the increase in debt due to BRI under A1 and A2.
3) If A1>0, A2<0 if 0>A2>Δ. In this circumstance, the impact on growth due to BRI is different under A1 and A2, because according to the information set in A2, growth is sufficient to outperform the increase in debt, but not under A1.

Hence, the analysis in the main text identifies countries in case 1) above as those ones with a growth gap, that is where growth is not expected to offset the increase in debt due to BRI under both *A1 and A2.*

Annex IX – Definition of the Fiscal Gap

The fiscal gap is estimated by comparing the average primary deficit, calculated over the period 2007-2016 with the primary deficit that would stabilize the public debt-to-GDP ratio at end-2023 at the same level of end-2016. The paper estimates the impact of debt financing for identified BRI projects planned or under construction starting in 2016 and it assumes that all disbursements take place by end-2023, consistent with information on disbursements of project loans financed by Chinese institutions compiled in the DRS. By construction, the period 2007-2016 excludes any additional planned and on-going BRI financing, while the period 2017-2023 includes all additional BRI debt financing. The comparison between historical primary balance and the debt-stabilizing primary balance, which includes all BRI financing and growth, determines the fiscal effort required to avoid BRI adds to a country's debt burden. This effort is particularly significant for those countries where the effect of BRI investment on growth is not expected to fully offset the estimated increase in debt due to BRI. This is the situation of countries with positive growth gap, as defined in Annex VII.

As in the case of the estimation of the growth gap, we make two radical and opposite assumptions. Under Assumption 1 (*A1*) WEO projections are assumed to include full BRI information on debt, growth and fiscal balances. Under Assumption 2 (*A2*) WEO projections do not include any BRI information. Hence, the debt-to-GDP ratio at end 2023 is then defined as:

A1) $\frac{D_{2023}^{WEO}}{Y_{2023}^{WEO}} = d_{2023}^{WEO}$, with *D* equals to the public debt projected by WEO expressed in national currency and *Y* the nominal GDP in national currency projected by WEO. In this hypothesis, both public debt and nominal GDP include full BRI information.

A2) $\frac{D_{2023}^{WEO}+BRI(1+3i)}{Y_{2023}^{WEO+BRI}} = d_{2023}^{WEO+BRI}$, where D is the public debt projected by WEO expressed in national currency with BRI the estimated stock of debt financing of BRI. $Y_{2023}^{WEO+BRI} = Y_{2023}^{WEO} * \prod_{t=2019}^{2023}(1 + g_t^{BRI})$, as defined in Annex VII, with g_t^{BRI} equal to the marginal growth burst from BRI investment.

Under both hypothesis, we define:

$$D_{t+1} = -PB_{t+1} + (1 + i_{t+1})D_t \quad (B1)$$

With PB defined as the primary balance and i the average annual nominal interest rate. Dividing equation (B1) by nominal GDP at time *t+1* we obtain:

$$d_{t+1} = -pb_{t+1} + \frac{(1 + r_{t+1})}{(1 + g_{t+1})} d_t \quad (B2)$$

With *g the* real growth rate and *r* the real interest rate. We define $\frac{(1+i_{t+1})}{(1+g_{t+1})} = k_{t+1}$. Rearranging (B2), we obtain:

$$d_t = \frac{pb_{t+1}}{k_{t+1}} + \frac{d_{t+1}}{k_{t+1}} \quad (B3)$$

Both for $H1$ *or* $H2$, we assume that $r_t = \bar{r}$ and remains constant at its long-term annual average, while $g_t = \bar{g}$ is the annual average projected nominal growth over the period 2017-2023. Hence, we have $\bar{k} = \frac{(1+\bar{r})}{(1+\bar{g})}$ to be a constant term and we can express d_t as the discounted sum of all future primary balances from 2017 to 2023 and the discounted value of *d* at end-2023:

$$d_t = \sum_{j=1}^{n} \frac{pb_{t+j}}{\bar{k}^j} + \frac{d_{t+n}}{\bar{k}^n} \quad (B4)$$

Under the assumption that $d_t = d_{t+n}$, $t = 2016$ and $t + n = 2023$, the average level of the primary balance $\overline{pb}$ that stabilizes the public debt-to-GDP ratio between 2017 and 2023 is defined as:

$$d_t - \frac{d_{t+n}}{\bar{k}^n} = \sum_{j=1}^{n} \frac{1}{\bar{r}^j} \overline{pb} \;\; (B5)$$

Assuming $\bar{\imath} \neq \bar{g} \Leftrightarrow \bar{k} \neq 1$, we can obtain, $\sum_{j=1}^{n} \frac{1}{\bar{k}^j} = \frac{1}{\bar{k}} . \frac{(1-\frac{1}{\bar{k}^n})}{(1-\frac{1}{\bar{k}})} = \frac{\bar{k}^n - 1}{\bar{k}^n(\bar{k}-1)}$.[54] Rearranging (*B5),* we obtain:

$$d_t - \frac{d_{t+n}}{\bar{k}^n} = \frac{\bar{k}^n - 1}{\bar{k}^n(\bar{k} - 1)} \cdot \overline{pb} \quad (B5)$$

$$\vdots$$

$$\overline{pb} = d_t \cdot \frac{(\bar{k}^n - 1)}{\bar{k}^n} \cdot \frac{k^n(\bar{k} - 1)}{\bar{k}^n - 1} = d_t \cdot (\bar{k} - 1) \quad (B6)$$

With $\bar{r} = \frac{(1+\bar{\imath})}{(1+\bar{g})}$, we obtain that the average primary balance which stabilizes the debt-to-GDP ratio between 2017-2023 is equal to:

$$\overline{pb} = d_{2016}\left(\frac{(1+\bar{r})}{(1+\bar{g})} - 1\right) = d_{2016}\left(\frac{\bar{r} - \bar{g}}{1 + \bar{g}}\right) \quad (B7)$$

[54] For any geometric sequence with common ratio $\frac{1}{\bar{r}} = k \neq 1$, we can obtain the sum of powers: $k + k^2 + k^3 + \cdots$ $\ldots + k^n = k(1 + k + k^2 + \cdots + k^{n-1}) = k\frac{1-k^n}{1-k}$.

Annex X – Evolution of Debt Ratio

Under the assumption that the values of primary balance, real interest rate, and real growth rate remain constant over the projected time. The evolution of debt ratio is given by the equation below:

$$d_{2030} = -\overline{pb} + \frac{(1+\bar{r})}{(1+\bar{g})} d_{2029}$$

$$d_{2029} = -\overline{pb} + \frac{(1+\bar{r})}{(1+\bar{g})} d_{2028}$$

$$\vdots$$

$$d_{2030-n+1} = -\overline{pb} + \frac{(1+\bar{r})}{(1+\bar{g})} d_{2030-n}$$

where, d is the debt ratio, $\overline{pb}$ is the primary balance-to-GDP ratio, $\bar{\imath}$ is the average real interest rate and $\bar{g}$ is the average real growth rate. We can rewrite the equation as:

$$d_{2030} = -\overline{pb} \cdot \left(1 + {}^{(1+\bar{r})}\!/_{(1+\bar{g})} + \cdots + \left({}^{(1+\bar{r})}\!/_{(1+\bar{g})}\right)^{n-1}\right) + \cdots$$

$$\left({}^{(1+\bar{r})}\!/_{(1+\bar{g})}\right)^{n} \cdot d_{2030-n}$$

which can be summarized by:

$$d_{2030} = -\overline{pb} \cdot \left(\frac{1-\left({}^{(1+\bar{r})}\!/_{(1+\bar{g})}\right)^{n}}{1-\left({}^{(1+\bar{r})}\!/_{(1+\bar{g})}\right)}\right) + \left({}^{(1+\bar{r})}\!/_{(1+\bar{g})}\right)^{n} \cdot d_{2030-n}$$

Defining as in Annex IX $\bar{k} = \frac{(1+\bar{r})}{(1+\bar{g})}$, we can express the formula above as:

$$d_{2030} = -\overline{pb} \cdot \left(\frac{1-\bar{k}^{n}}{1-\bar{k}}\right) + \bar{k}^{n} \cdot d_{2030-n}$$

Annex XI –BRI Debt Ratio 2024

We assume that the values of primary balance, real interest rate, and real growth rate remain constant over the projected time as in Annex X. Another main assumption is that countries will borrow in full and in five equal tranches in constant 2016 U.S. dollars the BRI PPG debt financing cost over the period 2019-2024. Under these assumptions, the evolution of the debt ratio is given by the equations below:

$$d_{2023}^{BRI} = -\overline{pb} + \frac{1/5 \cdot BRI}{(1+\bar{g})^7} + \frac{(1+\bar{r})}{(1+\bar{g})} d_{2022}^{BRI}$$

$$\vdots$$

$$d_{2020}^{BRI} = -\overline{pb} + \frac{1/5 \cdot BRI}{(1+\bar{g})^4} + \frac{(1+\bar{r})}{(1+\bar{g})} d_{2019}^{BRI}$$

$$d_{2019}^{BRI} = -\overline{pb} + \frac{1/5 \cdot BRI}{(1+\bar{g})^3} + \frac{(1+\bar{r})}{(1+\bar{g})} d_{2018}$$

$$d_{2018} = -\overline{pb} + \frac{(1+\bar{r})}{(1+\bar{g})} d_{2017}$$

$$d_{2017} = -\overline{pb} + \frac{(1+\bar{r})}{(1+\bar{g})} d_{2016}$$

where, d before BRI borrowing, d_t^{BRI} is the debt ratio from 2019 top 2013, which includes borrowing from BRI, $\overline{pb}$ is the primary balance-to-GDP ratio, $\bar{r}$ is the average real interest rate, BRI is the ratio of total BRI financing cost, in constant 2016 U.S. dollars to GDP in 2016, and $\bar{g}$ is the average real growth rate, which factors in the BRI impact on growth. We can rewrite the series of equations as:

$$\begin{aligned} d_{2023}^{BRI} = & -\overline{pb} \cdot \left(1 + {}^{(1+\bar{\imath})}\!/_{(1+\bar{g})} + \cdots + \left({}^{(1+\bar{\imath})}\!/_{(1+\bar{g})}\right)^6\right) + \frac{1/5 \cdot BRI}{(1+\bar{g})^7} + \cdots \\ & + \left({}^{(1+\bar{\imath})}\!/_{(1+\bar{g})}\right) \cdot \frac{1/5 \cdot BRI}{(1+\bar{g})^7} + \left({}^{(1+\bar{\imath})}\!/_{(1+\bar{g})}\right)^2 \cdot \frac{1/5 \cdot BRI}{(1+\bar{g})^6} + \cdots \\ & + \left({}^{(1+\bar{\imath})}\!/_{(1+\bar{g})}\right)^5 \cdot \frac{1/5 \cdot BRI}{(1+\bar{g})^3} + \left({}^{(1+\bar{\imath})}\!/_{(1+\bar{g})}\right)^7 \cdot d_{2016} \end{aligned}$$

Defining as in Annex IX $\bar{k} = \frac{(1+\bar{r})}{(1+\bar{g})}$, we can express the formula above as:

$$d_{2023}^{BRI} = -\overline{pb} \cdot \frac{1-\bar{k}^7}{1-\bar{k}} + \frac{1}{5} BRI \sum_{i=0}^{4} \bar{k}^i \frac{1}{(1+\bar{g})^{7-i}} + \bar{k}^7 \cdot d_{2016}$$

Or equivalently, using the result of Annex X as the sum of the debt excluding BRI at 2024 and the BRI component:

$$d_{2023}^{BRI} = d_{2023} + \tfrac{1}{5} BRI \textstyle\sum_{i=0}^{4} \bar{k}^i \frac{1}{(1+\bar{g})^{7-i}}$$

Annex XII – LT Growth by de Soyres et al (2019)

Average annual real growth rates (2016-2030)		
Economy	Baseline	BRI
ALB	0.034758	0.03755
AZE	0.054609	0.062509
BGD	0.132273	0.134642
BLR	0.209049	0.215746
GEO	0.007436	0.009155
HRV	0.05284	0.054144
IDN	0.053043	0.054926
IND	0.042736	0.04524
IRN	0.060068	0.06853
JOR	0.108152	0.112183
KAZ	0.043582	0.051383
KGZ	0.019271	0.027965
KHM	0.068203	0.078373
LAO	0.067271	0.086285
LKA	0.136531	0.139705
MYS	0.041279	0.046765
NPL	0.053521	0.056865
PAK	0.003344	0.008505
PHL	0.228623	0.239524
POL	0.145591	0.150257
RUS	0.040842	0.044235
TJK	0.048198	0.054416
TUR	0.018154	0.022449
TZA	0.075799	0.081078
UKR	0.024701	0.027946
VNM	0.043203	0.051033