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Benchmarking Dynamically Stable Public Debt Trajectories for Low-Income Countries

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ABSTRACT: In this paper, we develop two complementary approaches for benchmarking the public debt trajectories of Low-Income Countries (LICs) to assess their dynamic stability. We compare the evolution of the overall public debt-to-GDP ratios of reference LICs with the historical experiences of other countries with similar characteristics, which are now further down the path of economic development and have not experienced public debt stress events. We rely on both direct comparison and a novel application of the synthetic control method (SCM). These public debt trajectories that are dynamically stable from a historical perspective can provide insights into debt sustainability analyses for LICs.

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WORKING PAPERS

Benchmarking Dynamically Stable Public Debt Trajectories for Low-Income Countries

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Contents

Glossary

ADL	Autoregressive Distributed Lag
CPI	Consumer Price Index
CPIA	Country Policy and Institutional Assessment
DGE	Dynamic General Equilibrium
DSF	Debt Sustainability Framework
FFR	Federal Funds Rate
FRED	Federal Reserve Economic Data
FV	Face Value
GDP	Gross Domestic Product
GGEI	General Government Expense, Interest
H-P	Hodrick–Prescott
HIPC	Heavily Indebted Poor Countries
IDA	International Development Association
IDS	International Debt Statistics
IFS	International Financial Statistics
IMF	International Monetary Fund
LCU	Local Currency Unit
LIC	Low-Income Country
LIC DSF	Debt Sustainability Framework for Low-Income Countries
MAC	Market Access Country
MAC SRDSF	Sovereign Risk and Debt Sustainability Framework for Market Access Countries
MDRI	Multilateral Debt Relief Initiative
ODA	Official Development Assistance
PASS	The Pontifical Academy of Social Sciences
PPP	Purchasing Power Parity
PPG	Public and Publicly Guaranteed
REER	Real Effective Exchange Rate
SCM	Synthetic Control Method
SCU	Synthetic Control Unit
WB	World Bank
WDI	World Development Indicators
WEO	World Economic Outlook
WGI	World Governance Indicators

Executive Summary

In this paper, we develop two complementary approaches for benchmarking the public debt trajectories of LICs to assess their dynamic stability. Our operational definition of dynamically stable public debt trajectories focuses on comparing the evolution of LICs' public debt-to-GDP ratios over the past 20 years with the historical experiences of other countries with similar characteristics, which are now further down the path of economic development and have not yet experienced public debt stress events. Our novel technique involves aligning the historical data for a comparison group of present-day MACs to that of each reference LIC – namely the *25th, 75th, and median reference LICs* – in such a way that these MACs' per capita PPP GDP is similar to that of the reference LIC in 2005.

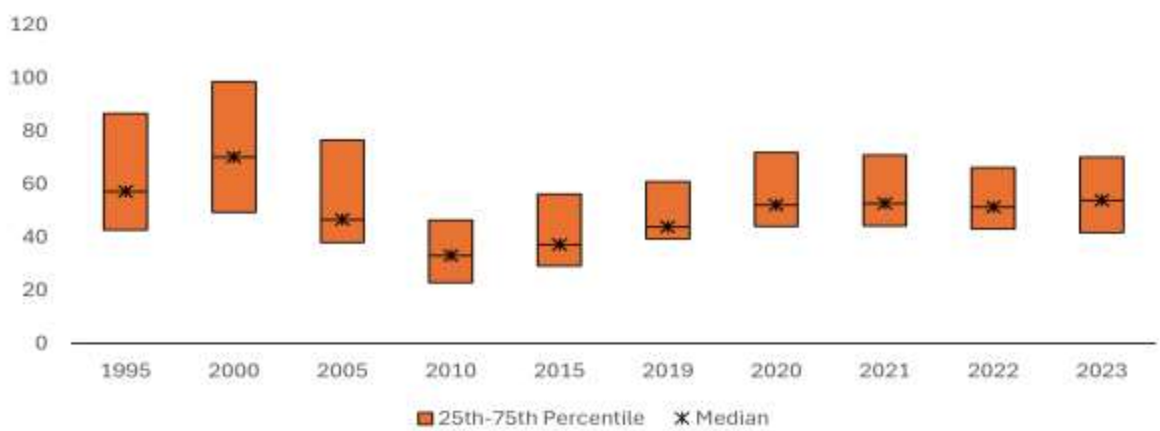
The comparison of LICs' public debt trajectories with those of historically similar peers that have, thus far, avoided public debt stress offers a probabilistic view of the conformity of LICs' public debt trajectories with one of two operational conditions, depending on whether their public debt-to-GDP ratios are above or below their optimal values in the medium-to-long term (i.e., in the five-to-ten year horizon), as determined in the Jiang, Sargent, Wang, Yang (2022) model. If a LIC's public debt-to-GDP ratio is above its optimal value, the first condition calls for meeting the Bohn test, which would ensure that the public debt-to-GDP ratio will eventually converge from above to its optimal value. Whereas, in the Jiang et. al. (2022) model public debt trajectories cannot generally be downward-sloping in a continuous manner – if public debt-to-GDP ratio exceeds the maximum sustainable level, it is optimal for the government to default – in practice this can occur for various reasons, including due to binding credit constraints for the government or temporary periods of negative interest rate-income growth differentials. If instead, the LIC's public debt-to-GDP ratio is below its optimal value, the second condition requires that the observed upward trend in the ratio be in line with the experiences of other countries with similar characteristics, which are ahead in this convergence process and have not yet experienced a public debt stress event. This would imply that the observed upward trend is consistent with convergence from below to the LIC's optimal value.

Results from the direct comparison of the experiences of LICs with those of present-day MACs in the development time dimension, and from the application of the synthetic control method (SCM) suggest that the experiences of the *25th percentile, the median, and the legacy 75th percentile LICs* are broadly in line with those of the majority of MACs at a similar level of economic development, which have avoided public debt stress. This serves as empirical evidence to indicate that these LICs' public debt trajectories have been dynamically stable over the last 20 years. The public debt trajectory of the *recent 75th percentile LIC*, on the other hand, has diverged from the confidence band around its dynamically stable benchmark under both approaches. This provides an additional signal from our cross-country comparison that can be incorporated in a detailed, country-specific analysis of debt sustainability, but which is beyond the remit of the current paper.

Overview

Over the past thirty years, the public debt trajectories of LICs[1] were shaped by high debt burdens in the mid-1990s that were subsequently reduced by debt relief and strong economic growth through the 2000s, only to rebound again from the mid-2010s on the back of a massive infrastructure drive, and the financing in response to the COVID-19 pandemic (Figure 1; UN, 2024). While public debt-to-GDP ratios appear to have recently stabilized in many LICs, they remain elevated (Figure 1). The notable rebound in public debt-to-GDP ratios since 2010 has raised questions about the ability of LICs to honor their debt obligations and still be able to achieve their social and development goals (PAAS, 2025). While academic research has demonstrated that the situation today is quite different from what it was at the cusp of HIPC, the post-2010 rapid debt accumulation has proven unsustainable in the cases of Chad, Ethiopia, Ghana, and Zambia (Global Sovereign Debt Roundtable, 2025) and has increased debt vulnerabilities in a number of other LICs (IMF, 2025).

Figure 1. LICs: Overall Public Debt, 1995-2023
(Percent of GDP)



Source: IMF October 2024 WEO database and authors' calculations.
Note: In box plots, boxes and horizontal lines indicate the interquartile range and the median, respectively.

Beneath the common patterns described above, there is considerable heterogeneity across individual countries' public debt trajectories. This can be seen in Figure 1, focusing on the evolution of the 25th, 50th, and 75th percentiles across LICs over time. The post-2010 rapid increase of public debt-to-GDP ratios has been more pronounced at the higher end of the interquartile range – with the 75th percentile increasing from 46 to 72 percent of GDP, a 26-percentage point increase – than for the median and 25th percentile LICs, for which the increase has been around 20 percentage points. Hence, the analysis of the evolution of the public debt trajectories of LICs needs to differentiate between the experiences of countries that appear in the first and fourth quartiles of the distribution from those of LICs in the middle two quartiles.

In the rest of the paper, we carry out the analysis on country experiences that most closely mirror the intertemporal pattern of the 25th, 50th, and 75th percentiles across LICs at different points of time (e.g., 1995,

[1] In this paper, we define LICs as the 60 countries eligible to receive IMF and World Bank concessional financing as of end-2024, for which we have sufficient data for the analysis (Appendix Table 1).

2000, …, 2023). We refer to these different country experiences as those of reference LICs, i.e., the 25th, 75th, and median reference LICs. Specifically, we benchmark public debt trajectories of reference LICs over the past twenty years against those of comparable peers that have historically avoided public debt stress, to analyze whether the debt trajectories of reference LICs are consistent with dynamic stability. We define a dynamically stable debt trajectory as one that is consistent with the last public debt-to-GDP outturn being sustainable. Debrun, Ostry, Willems, and Wyplosz (2019) present the theoretical definition of sustainability[2] and discuss the difficulties in its operationalization, stemming from the need to project macroeconomic aggregates over an infinite time horizon, and in case the public debt-to-GDP ratio does not stabilize under the baseline projections, to determine the political and social feasibility of the policy adjustments necessary to do so.

In individual country cases, debt sustainability analysis is carried out using highly specialized toolkits that take as inputs detailed, internally consistent forecasts for different sectors of the economy. In applied policy analyses, the standard workhorses are the Sovereign Risk and Debt Sustainability Framework (MAC SRDSF; IMF, 2022), developed by the IMF for use in market access countries (MACs), and the joint IMF-World Bank Debt Sustainability Framework for Low Income Countries (LIC-DSF; IMF and WB, 2018). The empirical literature on debt sustainability focuses instead on empirical tests of the validity of specific operational conditions that need to be met for a country to be on a dynamically stable debt trajectory.

Early empirical studies on debt sustainability focused on testing the intertemporal budget constraint based on the cointegration properties of fiscal data. Trehan and Walsh (1988) show that if real revenues, real spending, and real debt have unit roots, then a stationary overall deficit is sufficient for *ad hoc* sustainability. Trehan and Walsh (1991) generalize this result further. One weakness of the empirical tests of *ad hoc* sustainability is that they do not require a stationary public debt-to-GDP ratio. To address this weakness, Bohn (1998) proposes a model-based sustainability approach to account for the general equilibrium conditions linking fiscal policy to the rest of the economy. Based on assumptions about the determinants of the primary balance from Barro (1979), Bohn finds that the intertemporal budget constraint is satisfied if the primary fiscal balance as a share of GDP exhibits a statistically significant positive response to the public debt-to-GDP ratio. The latter implies a mean reversion of the public debt-to-GDP ratio and has become known as the Bohn test. Bohn (1998, 2005) test this condition for the United States; Lee et al. (2018) implement a similar test in a cross-country setting for European economies; Beqiraj et al. (2018) extend the analysis to OECD countries; and Mendoza and Ostry (2008) apply it to a wide cross-section of LICs. Willems and Zettelmeyer (2022) provide a survey of the debt sustainability literature. Bulíř and Chauhan (2025) have, more recently, shown that empirical analyses of the Bohn test can be volatile in their assessment of debt sustainability. Cao, Yongquan, Jiang, Lam, and Wang (2025) take a different approach by parametrizing the Jiang, Sargent, Wang, Yang (2022) model – which offers a closed-form solution for the maximum sustainable level of public debt (that is also optimal) as a function of macroeconomic variables and deeper model parameters – to obtain estimates of the maximum sustainable public debt-to-GDP ratios for 170 countries.

Our operational definition of dynamically stable public debt trajectories focuses on comparing the evolution of LICs' public debt-to-GDP ratios over the past 20 years with the historical experiences of other countries with similar characteristics, which are now further down the path of economic development and are yet to experience

[2] The formal assessment of debt sustainability hinges on the plausibility of the requirement that the outstanding stock of debt can be repaid by future primary surpluses (i.e., its value is at least equal to the sum of future primary surpluses discounted to the present). This condition rules out rational Ponzi schemes – a strategy of continuous rollover of the debt principal and interest – which O'Connell and Zeldes (1988) demonstrate can only exist in a dynamically Pareto inefficient equilibrium, in which the interest rate-growth differential remains negative for an infinite period of time.

public debt stress events. Our novel technique involves aligning the data for a comparison group of MACs to that of each reference LIC in such a way that their per capita PPP GDP are similar to that of the reference LIC in 2005.

The comparison of LICs' public debt trajectories with those of peers with similar country characteristics that have, thus far, avoided public debt stress offers a probabilistic view of the conformity of LICs' public debt trajectories with one of two operational conditions, depending on whether their public debt-to-GDP ratios are above or below their optimal values in the medium-to-long term (i.e., in the five-to-ten year horizon), as determined in the Jiang et. al. (2022) model. If a LIC public debt-to-GDP ratio is above its optimal value, the first condition calls for meeting the Bohn test, which would ensure that the public debt-to-GDP ratio would eventually converge from above to its optimal value. Whereas, in the Jiang et. al. (2022) model public debt trajectories cannot generally be downward-sloping in a continuous manner – if public debt-to-GDP ratio exceeds the maximum sustainable level, it is optimal for the government to default – in practice this can occur for various reasons, including due to binding credit constraints for the government or temporary periods of negative interest rate-income growth differentials. If instead, the LIC's public debt-to-GDP ratio is below its optimal value, the second condition requires that the observed upward trend in the ratio be in line with the experiences of other countries with similar characteristics, which are further ahead in the convergence process and have not yet experienced a public debt stress event. This would imply that the observed upward trend is consistent with convergence from below to the optimal value.

Our novel approach of benchmarking LICs' public debt trajectories to dynamically stable ones of comparable peers overcomes the difficulties of direct empirical evaluation of the two operational conditions for countries that lack long and reliable time series of macroeconomic indicators, and which experience large structural breaks. In our analysis, we focus instead on identifying a set of comparator MACs with similar characteristics that are deeper in the development process and have not experienced public debt stress. The identification of relevant macroeconomic characteristics, on which to align countries, is theoretically grounded in the Jiang et al. (2022) model of the maximum sustainable level of public debt. A starting point in the analysis is comparing LICs' public debt trajectories to those of MACs, controlling for the degree of economic development. The degree of economic development is used as a proxy for a number of institutional and fiscal policy characteristics, which have been shown to correlate highly with per capita incomes (Rodrik, Subramanian, & Trebbi, 2004). We then refine the comparison by using a rendition of the SCM to construct a single comparison unit that closely resembles each reference LIC in the pre-2005 training period, implicitly controlling for empirically relevant public finance, macro, and debt-related country characteristics that determine the maximum sustainable public debt level and the likelihood and speed of convergence to it. The empirical relevance of different country characteristics is determined based on their economic and statistical significance in a cross-country regression analysis under an augmented Bohn test.

Our first contribution to the empirical literature is the application of historical comparisons and the SCM in assessing the dynamic stability of LICs' public debt trajectories in a novel "development time" setting. Our approach builds upon existing literature, which has applied the concept of a synthetic LIC in the regular, calendar-year time setting to assess, for example, the impact of debt relief initiatives on the creditor composition for new financing to LICs, and to compare debt vulnerabilities of LICs over time. Chuku et al. (2023) develop a synthetic LIC, *albeit* not using the SCM, to assess the evolution of debt vulnerabilities across LICs from the HIPC Initiative to the COVID-19 pandemic. More recently, Cordella et al. (2025) apply the SCM to construct a synthetic non-HIPC LIC to compare with LICs treated under the HIPC initiative in order to assess how the creditor composition has changed for the two types of countries over time. Our novel implementation of the SCM in the "development time" setting allows us to significantly expand the universe of potential candidate countries for inclusion in the synthetic control unit (SCU), by tapping historical data for MACs. Recognizing the reliance of the traditional SCM on similar underlying conditions, we control for key global variables to mitigate the impact of shifting from calendar years to development years.

Our second contribution to the empirical literature is the consideration of a broader range of country characteristics related to the dynamic stability of public debt in the SCM application. The empirical Bohn test literature identifies such features mainly for advanced and emerging economies, which are further down the path of economic development than LICs, and as such could plausibly be considered to have reached steady state. Our approach is in line with recent work (IMF, 2023). We expand the search by considering a number of additional indicators relevant in the LIC context, such as institutional quality, revenue mobilization, real growth, resource dependence, access to development aid, reliance on short-term debt, and reserve coverage. Importantly, our regression specification also addresses issues of non-stationarity of relevant time series.

The rest of the paper is organized as follows: Section II presents the analytical underpinning of our analysis. Section III identifies alternative controls for constructing benchmarks of dynamically stable public debt trajectories and constructs such benchmarks with confidence intervals for four reference LICs. Section IV concludes.

Conceptual Framework

The starting point of the analysis of public debt dynamics is the stylized government budget constraint:[3]

$$G_t + (1 + r_t)D_{t-1} = T_t + D_t \tag{II.1}$$

$$D_t = (1 + r_t)D_{t-1} - PB_t$$

T_t – Total tax revenue

G_t – Non-interest government expenditure

$PB_t \equiv T_t - G_t$ – Primary fiscal balance

D_t – Overall public debt stock

r_t – Nominal interest rate

Normalizing both sides of the equation by nominal GDP and using lower case letters to denote variables expressed as ratios to GDP returns the well-known, stylized, public debt accumulation equation (Debrun et al., 2019):

$$d_t = \left(\frac{1+r_t}{1+g_t}\right) d_{t-1} - pb_t \tag{II.2}$$

g_t – Nominal GDP growth

The public debt trajectory is then determined by the change over time of the public debt-to-GDP ratio (Δd_t):

[3] The presentation closely follows the expose of debt sustainability concepts in Debrun et al. (2019).

$$\Delta d_t \equiv d_t - d_{t-1} = \frac{r_t - g_t}{1+g_t} d_{t-1} - pb_t \tag{II.3}$$

Equation (II.3) makes it clear that a sufficient condition for avoiding putting public debt on an explosive path relative to GDP ($\Delta d_t > 0$) is for the primary fiscal balance to be positively related to the accumulated stock of public debt ($pb_t = \rho d_{t-1}$, where $\rho > 0$). In the limit case ($\Delta d_t = 0$), the debt-stabilizing primary fiscal balance (pb_t^0) is then given by:

$$pb_t^0 = \frac{r_t - g_t}{1+g_t} d_{t-1} \tag{II.4}$$

In the long run, the public debt-to-GDP ratio stabilizes at a level $\bar{d}$ given by the steady-state values of the primary fiscal balance and the interest rate-income growth differential (identified below by dropping the time subscript):

$$\bar{d} \approx \frac{pb}{r-g} \tag{II.5}$$

Jiang et al. (2022) present a dynamic general equilibrium (DGE) model with unhedgeable output shocks that results in debt surges, in which the government chooses optimally the tax burden, so that in steady state, the ratio of defaultable public debt-to-GDP ratio ($\bar{d}$) is equal to the closed-form solution for its maximum sustainable level ($\bar{b}$):

$$\bar{d} = \bar{b} = \frac{\tau(\bar{b}) - \gamma}{\underline{r} + \tilde{\zeta} - \delta + \lambda - g} \tag{II.6}$$

In equation (II.6), ($\bar{b}$) and hence ($\bar{d}$) are pinned down by: (1) a *public finance channel* that includes the exogenous expenditure-to-GDP ratio (γ), and the optimal revenue-to-GDP ratio (τ), which is determined endogenously in the face of the distortionary effect of taxation and is capped by countries' tax capacity ($\bar{\tau}$) (Jiang et al., 2024); (2) a *macro channel* composed of the exogenous stochastic process for the nominal risk-free rate ($\underline{r}$) and nominal GDP growth (g); and (3) a *debt channel* that captures different aspects of the interest rate mark-up over the risk-free rate ($\underline{r}$), including the debt-surge probability ($\tilde{\zeta}$), risk premium on sovereign debt (λ), and convenience yield on debt (δ).[4]

Comparison of equations (II.5) and (II.6) reveals that the latter is a specific parametrization of the former, in which the steady states of the endogenously determined pb and r are pinned down by the model parameters:

$$pb \equiv \tau(\bar{b}) - \gamma$$

$$r \equiv \underline{r} + \tilde{\zeta} - \delta + \lambda$$

In the Jiang et al. (2022) model, if the public debt-to-GDP ratio is below its maximum sustainable level, it gradually converges to ($\bar{b}$) along a dynamically stable trajectory. If the public debt-to-GDP ratio exceeds $\bar{b}$, it is optimal for the government to default. The model offers important insights into the economic channels that determine countries' maximum sustainable public debt-to-GDP ratios, and which impact the dynamically stable trajectories to reach them. In the next section, we leverage these insights to select proxies for economic indicators that capture the observable and unobservable (structural) features of the model.

[4] For LICs, which do not benefit from safe-haven status, convenience yields are less important.

Empirical Analysis

A. Data Description

In carrying out the analysis, we leverage a comprehensive, in-house dataset of 60 LICs and 85 MACs over 1970-2023. The dataset combines information from: 1) IMF databases, including the World Economic Outlook (WEO), Global Debt Database, Historical Public Debt Database, and data from different vintages of the debt sustainability analyses carried out by IMF and World Bank staff; 2) World Bank's World Development Indicators (WDI) and World Governance Indicators (WGI) databases; and 3) UN Data and Penn World Table. Appendix I provides a description of the variables used for the analysis.

We align the data for a comparison group of MACs to that of each reference LIC, in such a way that the MACs' per capita PPP GDP is similar to that of the LIC under analysis in the base year of the analysis. The general approach is to align the data for the reference LIC and comparator MACs by switching the time dimension of the sample from calendar to "developmental year," so that in period *t=0* the per capita PPP GDP of suitable MACs in the comparison group is similar to that of the analyzed LIC in 2005.[5] We then construct different databases for each reference LIC, as the developmental year is normalized relative to its per capita PPP GDP in 2005. We choose 2005 as the base year to: 1) Be able to analyze the reference LIC's public debt trajectories over the long-run (i.e., 2005-2023); and 2) Capture the time period following the completion of the majority of debt relief coordinated by the IMF and the WB under the Heavily Indebted Poor Countries (HIPC) Initiative and the Multilateral Debt Relief Initiative (MDRI).

The analysis is carried out with long-term series of per capita PPP GDP, constructed by back-splicing data on per capita GDP on purchasing power parity (PPP) basis (in constant 2021 international dollars) from the World Bank WDI database for 1990-2023, with data for 1970-1990 on "Expenditure-side real GDP at chained PPPs (in millions of 2017 US dollars)," converted in per capita terms, from the Penn World Table 10.01 (Feenstra, Inklaar, and Timmer, 2015).[6] Only MACs that have not experienced public debt stress in the near 20-year "development time horizon" are used in the comparison.[7] We identify the incidence of public debt stress, using an updated version of the database of fiscal crises episodes compiled by Badia, Arbelaez, and Xiang (2022).[8]

Benchmarking the experiences of LICs to those of MACs that are further down the path of economic development and have not yet experienced public debt stress events necessarily comes with some caveats. On the one hand, LICs typically depend to a greater extent on external financing and are hence, both more exposed to external shocks and less able to respond to them, given the generally weaker substitutability between domestic and external financing. On the other hand, MACs are more exposed than LICs to shifts in investor sentiment that can result in a liquidity squeeze leading to debt defaults. These effects work in opposite directions, largely mitigating any biases stemming from the benchmarking exercise.

[5] For each reference LIC and every MAC_j, we find the year t^{MAC_j}, in which the level of per capita PPP GDP of the MAC was most similar to that of the LIC in 2005: $t^{MAC_j} = \arg\min_t |y_{2005}^{LIC} - y_t^{MAC_j}|$.

[6] The series are back-spliced using the growth rate of the Penn World Table data.

[7] The 20-year "development time horizon" for individual MACs corresponds to the time period 2005-2023 for each reference LIC.

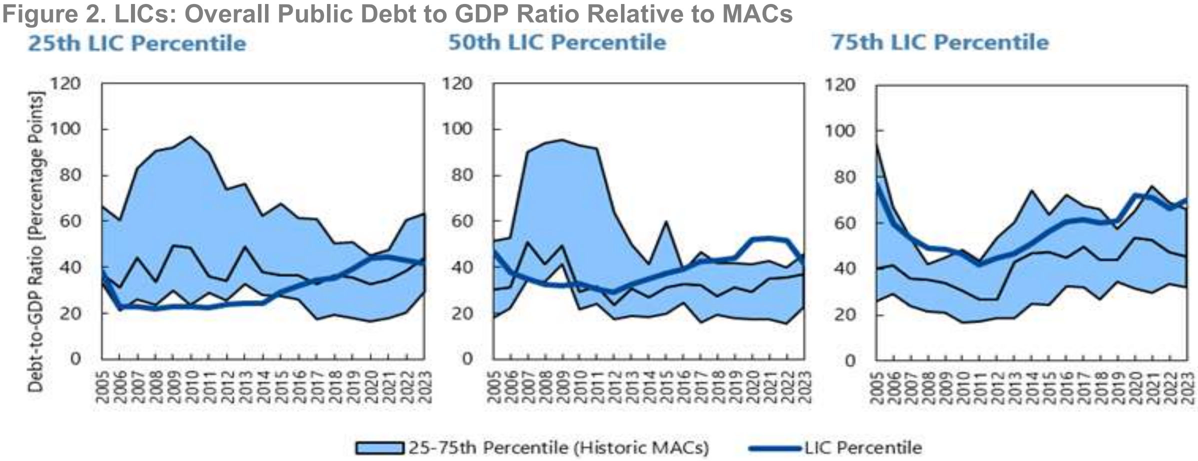
[8] The criteria for identifying fiscal crises include the materialization of one or more of the following: credit events, exceptionally large official financing, implicit domestic public debt default, or loss of market confidence (Badia, Arbelaez, and Xiang, 2022).

B. Historical Comparison

As a first pass, we compare directly the intertemporal values (debt trajectories) of the 25th, 50th, and 75th percentiles of the overall public debt-to-GDP ratio across LICs with the trajectories of present-day MACs that have not experienced public debt stress, starting from when these MACs were at a similar stage of economic development as the reference LIC in 2005. As countries do not typically stay in the respective quartiles of the distribution of the overall public debt-to-GDP ratio across LICs throughout the entire time period considered (2005-2023), we proxy the stage of economic development of countries that can typically be found in the 25th percentile of the distribution of LICs' overall public debt-to-GDP ratio by the median per capita PPP GDP in 2005 of LICs that are ranked in the bottom quartile of the distribution in at least half of the time period covered by the analysis. Similarly, we proxy the stage of economic development of LICs in the two middle and the top quartiles by the median per capita PPP GDP in 2005 of LICs that are ranked in these ranges of the distribution in at least half of the time period. The stage of economic development is used as a proxy for a number of institutional and fiscal policy characteristics, which have been shown to be highly correlated with per capita incomes (Rodrik, Subramanian, and Trebbi, 2004).

In Figure 2, the intertemporal values of the 25th, 50th, and 75th percentiles across LICs are juxtaposed against the interquartile range of percentile-specific comparator MACs, which provide a natural confidence interval. Appendix Table 2 outlines the set of MACs that comprise the interquartile range and to what year they were shifted to, respectively. Results suggest that the experiences of the *25th percentile, median, and 75th percentile LICs* over the last twenty years are broadly in line with those of the majority of MACs at similar levels of economic development, which have avoided public debt stress. However, in all three cases, the post-2010 rapid accumulation of public debt places these reference LICs near the top of the MAC interquartile range, at times exceeding it such as for the *median and 75th percentile LICs*, signaling a build-up of debt vulnerabilities. This provides an additional signal from a cross-country comparison that can be incorporated in a detailed, country-specific analysis of debt sustainability that is beyond the remit of the current paper.

Figure 2. LICs: Overall Public Debt to GDP Ratio Relative to MACs



Source: Authors' estimates.

Anchoring the analysis exclusively on per capita PPP GDP in the base year does not fully control for cross-country differences in the broader range of country characteristics related to the dynamic stability of public debt. Moreover, the historical comparison cannot control for differences in the macroeconomic environment in the different calendar-year time periods mapped to the "development year" timeline. We address these issues by improving the resemblance between reference LICs and comparator MACs with the help of the SCM.

C. Synthetic Control Method

Traditionally, the SCM has been used to derive causal treatment effects in a setting where one unit is exposed to an event or an intervention by comparing the trajectory of the treated unit (in this case, a country) to an SCU. The SCU is formed by assigning weights to the data for a comparator group of countries on the outcome variable and key predictor variables, in such a way that pre-treatment, the treatment unit and the SCU closely resemble each other.[9]

However, instead of using the SCM to derive treatment effects around some intervention, we take advantage of the fact that the SCU is constructed to closely resemble the reference LIC across a broad set of macroeconomic characteristics over a pre-defined training period. Combined with the novel application of "development time" and the exclusion from the pool of potential donor MACs of countries that have experienced public debt stress, this allows us to compare the public debt trajectories of the reference LICs ("treatment units") with that of the SCU, which is dynamically stable by construction.

The SCM analysis can only be carried out with country-specific data. We use the closest neighbor matching technique to identify countries whose public debt trajectories most closely resemble the intertemporal pattern of the actual 25th, 50th (median), and 75th percentiles across LICs at different points of time (e.g., 1995, 2000, …, 2023). The closest neighbor matching technique seeks to minimize the absolute mean deviation between the respective percentile values and particular LICs' debt ratios.[10] It allows us to select countries that can be used as stand-ins for the median and 25th percentile LICs over the entire time period (*closest neighbors to the 25th percentile and median LICs*). However, finding a particular LIC whose public debt-to-GDP ratio remains consistently close to the 75th percentile of the entire distribution of LICs across time proves difficult. This comes as no surprise, given the early warning indicator properties of the public debt-to-GDP ratio for debt defaults and subsequent restructurings (IMF and WB, 2017). As a result, in addition to our pick for the *closest neighbor to the 75th percentile across LICs over the full sample* – which remains in the top quartile of the distribution across LICs only until 2019, hence, termed "*legacy" 75th percentile LIC* – we also consider the closest neighbor over the last 20 years (*recent closest neighbor to 75th percentile across LICs* or *"recent" 75th percentile LIC).*

We use the first 11 years after 2005, which is the base year for the analysis, as a training sample and compare the experiences of the reference LICs with those of their respective SCUs in our development time setting.[11] The dependent variable in the analysis is the face value of overall public debt as a ratio to GDP.
The choice of predictor variables is informed by the debt burden indicators and variables that capture different aspects of LICs' debt carrying capacity in the joint IMF-World Bank LIC-DSF (IMF and WB, 2018), as well as the results from augmented Bohn test regression estimates. In Appendix II, we estimate Autoregressive Distributed Lag (ADL) regressions that add different indicators (one at a time) to our basic Bohn test specification, capturing

[9] Appendix III summarizes the technical details of the SCM.

[10] In the analysis, we give twice as much weight to deviations in 2010-2023 to ensure that the experiences of the selected countries are representative over the post-2010 debt build-up, a key consideration. The selection of reference LICs is robust to the use of different time windows, and, in the case of countries selected as closest neighbors to the 25th and 50th percentiles over time, to the use of uniform weights over 1995-2023. The closest neighbor selection is robust to different time windows, such as 2000-2023.

[11] The timeframe is chosen to allow for a sufficiently long pre-benchmark period to accurately derive a comparable benchmark unit, while still allowing for a comparative analysis over the medium-to-long term (over five or more years). Results are robust to the selection of slightly shorter or longer benchmark periods based on the selected cutoff year.

the economic channels that determine countries' maximum sustainable public debt-to-GDP ratios and that impact the dynamically stable trajectories needed to reach them in Jiang et al. (2022). The regressions are estimated with panel data for 53 LICs, for which a sufficient number of observations is available, over the period 1970-2023.

Results suggest that a number of economic indicators are empirically relevant in determining the shape of LICs' public debt trajectories (Appendix Table 3). We find evidence that revenue mobilization as proxied by the revenue-GDP share, real GDP growth, the global risk-free rate as proxied by the average US Federal Funds Rate (FFR), changes in the real effective exchange rate (REER), and the level of resource dependence are all associated with a change in the reactiveness of the primary balance to lagged public debt levels.

Table 1. Selected Controls based on the ADL Bohn Regressions

Channels	Selected Predictors
Public Finance	PPG external debt (% overall debt) PPG external debt service (% Exports) PPG external debt (% Revenues) Public revenue (% GDP)
Macroeconomics	Real GDP growth Exports (% GDP) REER depreciation Natural resource rents (% GDP) Average US FFR World GDP growth PPP GDP per capita (log $)
Finance	Per capita net ODA (log $) FX reserves (months of imports) ST debt (% FX reserves)

Source: Authors' estimates.

The final set of predictor variables (Table 1) spans the different economic channels that determine countries' maximum sustainable public debt-to-GDP ratios and impacts the dynamically stable public debt trajectories to reach them. These include proxies for:

- Public finance channel: (i) the share of PPG external debt in overall public debt (measured in face value), (ii) the ratio of PPG external public debt service to exports of goods and services, (iii) the ratio of PPG external public debt service to revenues (excluding grants), and (iv) the ratio of public revenue to GDP.

- Macro channel: (i) real GDP growth, (ii) the ratio of exports to GDP, (iii) REER depreciation, (iv) total natural resource rents as a share of GDP (to proxy for resource dependency), (v) the average US FFR; (vi) world GDP growth rate, and (vii) PPP GDP per capita.

- Financial characteristics: (i) per capita, net official development assistance (ODA) in current US dollars (log), (ii) international FX reserves in months of imports (log), and (iii) short-term debt as a share of international FX reserves. While we do not directly consider institutional indicators due to the lack of sufficiently long series,[12] we ensure a base level of institutional comparability, by imposing the constraint that MACs in the donor pool are at a similar stage of economic development over the training sample.[13]

We construct SCUs for the reference LICs by drawing from our donor pool of MACs to ensure the closest possible alignment between the values of the overall public debt-to-GDP ratio and its predictors over the training period in calendar year time for LICs with those of the SCUs, which are constructed by weighting the values in "development time" for MACs. Summary statistics of the predictor variables over the training sample for both the reference LICs, the MACs used in the construction of the SCUs, and all MACs are presented in Appendix Table 4. Overall, we find that the countries included in the construction of the SCUs resemble the reference LICs significantly better than the average MAC in the entire donor pool (Appendix Table 4). The goodness-of-fit for different predictor variables varies across countries, depending on how much weight the SCM assigns to each variable according to its explanatory power for the public debt-to-GDP ratio.[14]

In addition to the standard SCM output of a public debt trajectory for the SCU, we can construct a confidence interval around this trajectory, taking into account the standard deviation of the differences between the public debt-to-GDP ratios of the reference LICs and their SCUs over the training period:[15]

$$SD_{LIC} \equiv sd\left(\hat{d}_{LIC,t^{start}} - d_{LIC,t^{start}}, \ldots, \hat{d}_{LIC,t^{0}} - d_{LIC,t^{0}}\right) \quad \text{(III.1)}$$

$d_{LIC,t}$ – public debt-to-GDP ratio of the reference LIC

$\hat{d}_{LIC,t}$ – public debt-to-GDP ratio of the SCU for a reference LIC

This allows us to construct confidence bands of +/- $1.96 \cdot SD_{LIC}$ around the public debt trajectory of the SCU. Intuitively, the confidence band would be smaller if the synthetic benchmark tracks more closely the public debt trajectory of the reference LIC over the training period.

Figure 3 presents the results from the comparison of the public debt trajectories of reference LICs with those of their SCUs, which are dynamically stable by construction, expressed in percentage point differences in the levels of the overall public debt-to-GDP ratio, together with confidence bands. The experiences of the reference *25th percentile, the median, and the legacy 75th percentile LICs* closely track those of their SCUs, which are constructed from dynamically stable debt trajectories. While the reference median LIC diverges for some time,

[12] Data is generally available from 1996 onwards, after alignment across countries in terms of economic development and restricting to the debt stress-free nature of historical MACs.

[13] Given the strong links in the literature between economic development and institutional quality.

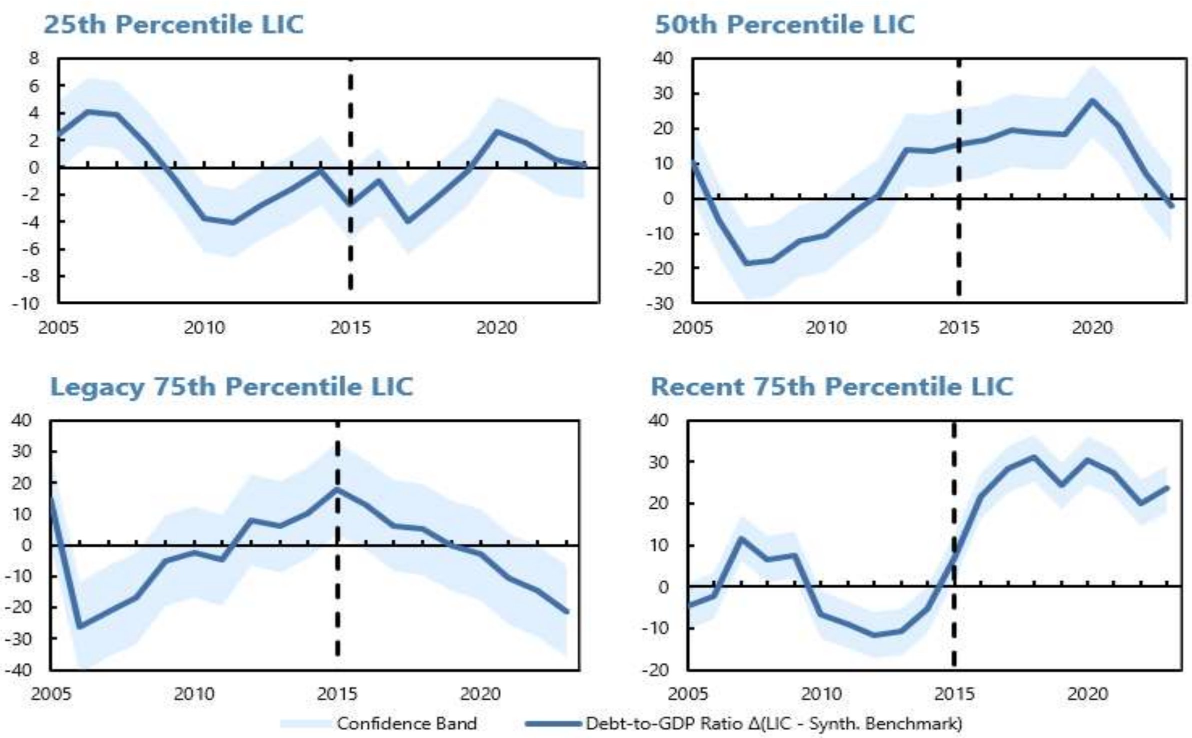
[14] Goodness-of-fit is also determined by the number of MACs in the donor pool, which are those debt stress-free MACs that exhibit complete data over their respective development times. Applications of this methodology that choose a later start year for the benchmarking period would be expected to draw from a larger donor pool due to high data coverage in recent years, which would allow for an even better fit across the predictor variables, but would leave a shorter post-training time period for the comparison.

[15] There is a limited body of literature on inference analysis for SCM estimates. Abadie, Diamond, and Hainmueller (2012) propose inference for the SCM that is based on permutation methods. They estimate the effect of an intervention separately for all untreated units in the sample and obtain a permutation distribution by using the dispersion of these effects as a benchmark for the effect on the treated unit. This approach, however, does not lend itself easily to our setup, as we do not estimate a specific treatment effect, but rather create a benchmark in the absence of a specific treatment. An alternative approach for inference has recently been introduced by Cattaneo, Feng, Palomba, and Titiunik (2025), but their approach can only be applied in a simple synthetic control setup where all predictors receive uniform weighting.

towards the end of the benchmark period it realigns with its dynamically stable benchmark. The public debt trajectory of the reference *recent 75th percentile LIC* on the other hand, has diverged from the confidence band around its dynamically stable benchmark. In all cases, the SCUs trace the evolution of the overall public debt-to-GDP ratios of the reference LICs reasonably well over the training period.

The results from the SCM analysis confirm the insights from the historical comparison presented in the preceding section for most LICs. An important benefit from the SCM analysis – which better matches the reference LICs with peer MACs on a broad range of country characteristics related to the dynamic stability of public debt – is the narrowing of the confidence band around the dynamically stable benchmarks. This helps uncover the divergent dynamic of the public debt trajectory of the reference *recent 75th percentile LIC*.

Figure 3. Differences between Overall Public-Debt-to-GDP Ratios of Reference LICs and their Synthetic Benchmarks



Source: Authors' estimates.

Conclusion

In this paper, we develop two complementary approaches for benchmarking the public debt trajectories of LICs to assess their dynamic stability. Our operational definition of dynamically stable public debt trajectories focuses on comparing the evolution of LICs' public debt-to-GDP ratios over the past 20 years with the historical experiences of other countries with similar characteristics, which are further along the path of economic development and have not yet experienced public debt stress events. Our novel technique involves aligning the data for a comparison group of MACs to that of each reference LIC in such a way that their per capita PPP GDP is similar to that of the reference LIC in 2005.

The comparison of LICs' public debt trajectories with those of peers with similar country characteristics that have, thus far, avoided public debt stress offers a probabilistic view of the conformity of LICs' public debt trajectories with one of two operational conditions, depending on whether their public debt-to-GDP ratios are above or below their optimal values in the medium to long term. If above their optimal values, then meeting the Bohn test would ensure that the public debt-to-GDP ratio will eventually converge from above to its optimal value. If below, then the observed upward trend in the ratio needs to be aligned with the experiences of other countries with similar characteristics, which are more advanced at present in their economic development journey, implying the observed upward trend to be consistent with convergence from below to the optimal value.

Our first contribution to the empirical literature is the application of historical comparisons and the SCM in assessing the dynamic stability of LICs' public debt trajectories in a novel development time setting. Instead of developing a synthetic LIC in the regular, calendar-year time setting as is done in the existing literature, our novel implementation of the historical comparison and SCM in the development time setting allows us to significantly expand the universe of potential candidate countries for inclusion in the SCU, by tapping historical data for MACs.

Our second contribution to the literature is the consideration of a broader range of country characteristics related to the dynamic stability of public debt in the SCM application. While the Bohn test literature identifies such features mainly for advanced and emerging economies that could plausibly already be at their steady state, we expand the search by considering a number of additional indicators relevant in the LIC context. Concomitantly, our ADL regression specification also addresses issues of non-stationarity of time series, a previous concern in this literature.

Results from the direct comparison of the experiences of reference LICs with those of present-day MACs in development time dimension and from the application of the SCM suggest that the experiences of most LICs are broadly in line with those of the majority of MACs at similar levels of economic development and that have avoided public debt stress. This provides empirical evidence that their public debt trajectories have broadly been dynamically stable over the last 20 years. The public debt trajectory of the *recent 75th percentile LIC*, on the other hand, has diverged from the confidence band around its dynamically stable benchmark. These findings provide additional signals from a cross-country comparison that can be incorporated in a detailed, country-specific analysis of debt sustainability. Future research could consider the relationship between the maximum reduction in public debt for synthetic controls as a potential measure for the maximum level of average debt reduction in debt restructurings. Comparing the synthetic controls to countries in the sample period could also shed light on the performance of non-debt stress LICs in the contemporary time period.

Appendix I. Data Dictionary

Data Sample

Appendix I Table 1. Sample of Low-Income Countries Used in the Analysis

Count	Country	ISO3 Code
1	Afghanistan	AFG
2	Bangladesh	BGD
3	Benin	BEN
4	Bhutan	BTN
5	Burkina Faso	BFA
6	Burundi	BDI
7	Cabo Verde	CPV
8	Cambodia	KHM
9	Cameroon	CMR
10	Central African Republic	CAF
11	Chad	TCD
12	Comoros	COM
13	Congo, Republic of	COG
14	Djibouti	DJI
15	Dominica	DMA
16	Eritrea	ERI
17	Ethiopia	ETH
18	Ghana	GHA
19	Grenada	GRD
20	Guinea	GIN
21	Guinea-Bissau	GNB
22	Haiti	HTI
23	Honduras	HND
24	Kenya	KEN
25	Kiribati	KIR
26	Kyrgyz Republic	KGZ
27	Lesotho	LSO
28	Liberia	LBR
29	Madagascar	MDG
30	Malawi	MWI
31	Maldives	MDV
32	Mali	MLI
33	Mauritania	MRT
34	Moldova	MDA
35	Mozambique	MOZ
36	Myanmar	MMR
37	Nepal	NPL
38	Nicaragua	NIC
39	Niger	NER
40	Papua New Guinea	PNG
41	Rwanda	RWA
42	Samoa	WSM
43	Senegal	SEN
44	Sierra Leone	SLE
45	Solomon Islands	SLB
46	Somalia	SOM
47	St. Lucia	LCA
48	St. Vincent and the Grenadines	VCT
49	Sudan	SDN
50	Tajikistan	TJK

(continued)

Appendix I Table 1. Sample of Low-Income Countries Used in the Analysis (concluded)

Count	Country	ISO3 Code
51	Tanzania	TZA
52	Timor-Leste	TLS
53	Togo	TGO
54	Tonga	TON
55	Uganda	UGA
56	Uzbekistan	UZB
57	Vanuatu	VUT
58	Yemen	YEM
59	Zambia	ZMB
60	Zimbabwe	ZWE

Appendix I Table 2. Sample of Market Access Countries Used as Peers for Reference Percentile LICs

LIC percentiles					
25th Percentile		50th Percentile		75th Percentile	
MACs	Base year	MACs	Base year	MACs	Base year
Albania*	1992	Albania*	1992	Albania*	2001
Angola*	1994	Angola*	1994	Angola*	2003
Armenia*	1993	Armenia*	1993	Armenia*	2003
Azerbaijan*	1996	Azerbaijan*	1996	Azerbaijan*	2002
Belize	1983	Belize	1983	Belarus	1995
Bosnia and Herzegovina	1994	Botswana	1973	Belize	1988
Botswana	1977	China	1993	Bosnia and Herzegovina	1998
China	1996	El Salvador	1982	Botswana	1986
El Salvador	1982	Equatorial Guinea	1995	Bulgaria	1973
Equatorial Guinea	1995	Georgia*	1994	Chile	1976
Georgia*	1994	Guyana	1990	Dominican Republic	1979
Guyana	1990	Indonesia	1975	Egypt	1987
India*	1998	Iraq	1992	El Salvador	1994
Indonesia	1979	Lebanon	1977	Equatorial Guinea	1997
Iraq	1992	Nigeria*	1998	Fiji	1987
Jordan	1974	Sri Lanka*	1980	Georgia*	2002
Lebanon	1977	Turkmenistan	1997	Guatemala	1973
Mongolia*	1977	Vietnam*	1987	Guyana	1979
Morocco	1980			Indonesia	2004
Nigeria*	1998			Iran	1988
Pakistan*	1985			Iraq	1996
Sri Lanka*	1980			Jamaica	1985
Turkmenistan	1997			Jordan	1977
Vietnam*	1993			Lebanon	1988
				Malaysia	1974
				Malta	1974
				Mauritius	1986
				Mongolia*	2004
				Namibia	1995
				Paraguay	1976
				Peru	1972
				Serbia	1994
				Sri Lanka*	2003
				St. Kitts and Nevis	1977
				Thailand	1986
				Tunisia	1991
				Ukraine	1998

Note: Countries with a * indicate LIC graduates (i.e., former LICs that are classified as MACs at present). The base year refers to the year in which the MACs' PPP GDP per capita was closest to the PPP GDP per capita of the respective reference LIC percentile. The average PPP GDP per capita values in 2005 for LICs in the 25th, 50th, and 75th percentiles of the public debt-to-GDP ratio distribution are US$2,935, US$2,275, and US$6,851, respectively.

Indicator Definition and Data Sources

Debt Burden Indicators

Face value (FV) of overall (domestic and external) public debt in US$. This is constructed using data from the IDS series on PPG external public debt stocks, augmented with use of IMF credit, and domestic debt from WEO. PPG external debt comprises public external debt (an external obligation of a public debtor, such as the general government or agency, the central bank, a political subdivision or agency, or an autonomous public body) and publicly guaranteed external debt (an external obligation of a private debtor that is guaranteed for repayment by a public entity).

Nominal GDP in US$ and nominal GDP in LCU. The primary source for the data is the 2024 October WEO. Data is back-casted using growth rates for the periods not covered by WEO derived from data from WDI, UNdata, and growth rates in the 2017 database.

Public Debt Stress

Public debt event dummy variable. We identify the incidence of public debt stress using an updated version of the database of fiscal crises episodes compiled by Badia, Arbelaez, and Xiang (2022).

Public Finance Indicators

Face value (FV) of external public debt in US$. This is constructed using data from the IDS series on PPG external debt stocks, augmented with use of IMF credit.

Debt service on PPG external debt in US$. Data from the World Bank's IDS database, which is sourced from the World Bank's Debt Reporting System (DRS). The data is augmented with information about debt service to the IMF (IMF repurchases and charges) from IDS.

Exports of goods and services in US$. We use the October 2024 vintage of WEO as the primary source, with missing values imputed based on data from WDI and UNdata.

Revenue in US$. Derived by multiplying revenue in LCU with period-average exchange rates. Revenue in LCU is obtained as follows: 1) Revenue as percent of GDP is multiplied by nominal GDP in LCU, with both series coming from the October 2024 WEO; 2) Missing values are filled by backward imputation based on LCU revenue derived by multiplying revenue-to-GDP ratios from the 2017 database with nominal GDP in LCU sourced from the October 2024 WEO. Revenues exclude grants.

Macroeconomic Indicators

PPP GDP per capita in constant US$. Data on GDP per capita, PPP (constant 2021 international dollars) is sourced from WDI for the period 1990-2022. The series is then back-casted to 1970 using the growth rate of the "expenditure-side real GDP at chained PPPs (in millions of 2017 US$)," converted to per capita terms sourced from the Penn World Table, version 10.01 (Feenstra, Inklaar, and Timmer, 2015).

Real GDP growth is sourced from the October 2024 vintage of WEO. Missing values are imputed with growth rates obtained from WDI and UNdata.

Real effective exchange rate (REER). Series are sourced from IMF's INS database, with missing values imputed based on estimates of real exchange rates against the US dollar.

Total natural resource rents as a share of GDP. Series are sourced from the World Bank's WDI database.

Average US Federal Funds Rate. Sourced from Federal Reserve Economic Data (FRED).

The world real GDP growth rate. Series is sourced from the WEO database

Financial Characteristics Indicators

Net Official Development Aid (ODA) received per capita in current US$. Series are sourced from the WDI database.

International reserves in US$ are obtained from the October 2024 WEO, with missing values imputed based on data from WDI and IFS.

Imports of goods and services in US$ are obtained from the October 2024 WEO, with missing values imputed based on data from WDI and UNdata.

Short-term debt as a share of total reserves. Short-term debt includes all debt having an original maturity of one year or less, and interest in arrears on long-term debt. Total reserves include gold. Data is sourced from the WDI database.

Other Indicators

Overall public debt interest payments in US$. Data on General Government Expense, Interest (GGEI) series from 2024 October WEO. The data has better coverage than the one on total debt service.

Country Policy and Institutional Assessment (CPIA) index comes from World Bank's CPIA database (the precise name of the indicator is "IDA resource allocation index (1=low to 6=high)"). Missing CPIA data in the early 1970s is fitted with a regression model of the CPIA. The annual CPIA score is explained by three covariates: country real GDP growth rate relative to the sample average; annual inflation rate relative to the sample average; and the lead value of the annual CPIA score. Short spells of missing values in subsequent periods are filled based on linear interpolation. Longer periods of missing values are left unfilled.

Inflation is the CPI-based period-average inflation rate. Missing values are filled with inflation derived from the GDP deflator. Both series come from 2024 October WEO.

Appendix II. Augmented Bohn Test

A. Overview

Bohn (1998, 2005) propose a model-based sustainability approach based on estimating the responsiveness of the primary fiscal balance (ρ) in a single-equation regression (AIII.1) that also includes as controls the temporary variations in government expenditure ($\tilde{g}_t$) and output ($\tilde{y}_t$) from their steady states, as informed by Barro's (1979) tax-smoothing DGE model:

$$pb_t = \beta_0 + \beta_1\tilde{g}_t + \beta_2\tilde{y}_t + \rho d_{t-1} + \varepsilon_t \quad \text{(AIII.1)}$$

Bohn showed that a positive conditional response of the primary balance to public debt (i.e., $\rho > 0$) is sufficient to satisfy the solvency condition in a general equilibrium model under reasonable assumptions (Abbas et al., 2019). The resultant Bohn test has been widely applied in the empirical literature, including for the United States (Bohn,1998), European countries (Lee et al., 2018), and OECD members (Begiraj et al., 2018). In this literature, the temporary variations in government expenditure and output are typically obtained by detrending the underlying series using the Hodrick–Prescott (H-P) filter (Mendoza and Ostry, 2008).

The regression specification (AIII.1) is generally well-specified only for advanced countries that are close to their dynamic steady-state paths, along which the interest rate-income growth differential is generally positive and deviations from the H-P filter are good proxies for government expenditure and output dynamics.

The application of the Bohn test for LICs would need to account for the fact that these countries are generally on paths of convergence from below to the levels of economic and macro-financial development, as well as government spending and taxation typical of advanced economies. Along these convergence paths, the interest rate-income growth differential may be negative for a prolonged period of time and there may be other structural reasons for the primary fiscal balance not to be as responsive to the existing public debt stock as in their more developed peers.

In this paper, we leverage insights from Jiang et al. (2022) to estimate a novel extension of the Bohn test that is better suited for LICs. We augment the regression specification (AIII.1) to account for the public finance, macro, and debt channels that help determine the maximum sustainable public debt-to-GDP ratio and the dynamically stable debt trajectories to reach them:

$$pb_t = \beta_0 + \beta_1\tilde{g}_t + \beta_2\tilde{y}_t + \rho d_{t-1} + \gamma I_{t-1} + \delta d_{t-1}\, I_{t-1} + \varepsilon_t \quad \text{(AIII.2)}$$

I_{t-1} – economic indicators that determine the maximum sustainable public debt-to-GDP ratio and dynamically stable debt trajectories

In regression (AIII.2), economic indicators that proxy observable and unobservable (structural) features of the Jiang et al. (2022) model are included both in levels and as interaction terms with the accumulated stock of public debt-to-GDP ratio. In the augmented Bohn test, the responsiveness of the primary fiscal balance to the lagged public debt-to-GDP ratio is captured not only by ρ but by the term $\rho + \delta I_{i,t-1}$. A positive, statistically significant estimate of δ would imply that a given economic indicator I is associated with a higher responsiveness of the primary fiscal balance to last year's public debt-to-GDP ratio. Irrespective of their sign, statistically significant estimates of δ provide evidence of the empirical relevance of the economic indicators, initially selected on conceptual considerations, for LICs' public debt trajectories.

Direct estimation of regression (AIII.2) for each LIC is not feasible due to the limited number of country observations with complete data across variables, ranging from 8 to 24 years. Instead, we estimate the regression with panel data for 53 LICs, for which a sufficient number of observations is available over the period 1970-2023. We follow Mendoza and Ostry (2008) in calculating the output gap $\tilde{y}_{i,t}$ and the government expenditure gap $\tilde{g}_{i,t}$ as the cyclical components of those variables obtained by detrending the data using a Hodrick-Prescott filter, with a smoothing parameter of 100.

Given the persistence of many economic time series, the residual in regression (AIII.2) is likely to exhibit serial correlation that would affect the reliability of the coefficients' point estimates. Preliminary results from applying the Breusch-Godfrey test for serial correlation in the error term to the panel estimation of regression (AIII.2) reject the null hypothesis of no serial correlation at the 5 percent confidence level. To account for such serial correlation, we estimate the regression in its Autoregressive Distributed Lag (ADL) specification:

$$pb_t = \sum_{k=1}^{2} \zeta_k pb_{t-k} + \sum_{k=0}^{2} \alpha_k \tilde{g}_{t-k} + \sum_{k=0}^{2} \beta_k \tilde{y}_{t-k} + \sum_{k=1}^{2} \rho_k d_{t-k} + \sum_{k=1}^{2} \gamma_k I_{t-k} + \delta d_{t-1} I_{t-1} + \varepsilon_t \qquad \text{(AIII.3)}$$

Rerunning the Breusch-Godfrey test on the regression (AIII.3) with two lags of the dependent and explanatory variables, we establish that the null hypothesis of no serial correlation cannot be rejected. Thus, the generalization of regression (AIII.2) to an ADL model (AIII.3) helps address the problem of serial correlation commonly encountered in the literature and allows us to capture richer dynamics in the interactions between the dependent and explanatory variables.

We proceed to estimate regression (AIII.3) by including one economic indicator at a time (in levels and interacted with the lagged public debt-to-GDP ratio) to the basic Bohn test specification with country-level fixed effects (Appendix Table 3). For each indicator *I*, the regression sample varies with data availability. In order to make the effects of different indicators comparable, we standardize all indicators by dividing their values by their standard deviation. Appendix Table 3 reports the statistical significance of the long-run effect of an increase by one standard deviation in *I* on the steady-state reactiveness of the primary balance as a share of GDP to the public debt-to-GDP ratio. Standard errors are heteroskedasticity-robust and are clustered at the country level. The long-term coefficients of the other explanatory variables and the coefficients of short-term dynamics are not shown in the table for parsimony.

Results suggest that a number of economic indicators are empirically relevant in determining the shape of LICs' public debt trajectories (Appendix Table 3). We find evidence that revenue mobilization as proxied by the revenue-GDP share, real GDP growth, the global risk-free rate as proxied by the average US FFR, changes in the REER, and the level of resource dependence are all associated with a change in the reactiveness of the primary balance to lagged public debt levels. This makes them suitable candidates for serving as controls in the construction of synthetic benchmarks for LICs.

We confirm the importance of the public finance channel, as revenue mobilization (proxied by the revenue-GDP share) is statistically significantly associated with the reactiveness of the primary balance to the lagged public debt-to-GDP ratio. We also find evidence of the importance of the macro channel. Growth is positively related to the reactiveness of the primary balance to lagged debt levels, while increases in the US FFR and appreciation of the REER appear to dampen this reactiveness. Lastly, we find that a higher reliance on natural resource rents also suppresses such reactiveness. Most of the proxies for institutional quality are not statistically significant, with the exception of the control of corruption variable, which tends to lower the reactiveness of the primary balance to lagged debt levels.

Appendix II Table 1. Effect of Institutional Features on Debt Sustainability

	ADL Specification	
	$\hat{\delta}$	Country-year Observations
Public Finance		
Exports-to-GDP Ratio	-0.007	1,217
	(0.005)	
Revenue-to-GDP Ratio	0.039***	1,351
	(0.004)	
PPG External Debt Servicing (Share of Revenue)	0.002	1,348
	(0.003)	
PPG External Debt Servicing (Share of Exports)	-0.009	1,348
	(0.005)	
PPG External Debt (Share of Total Debt)	0.000	1,345
	(0.003)	
Macro Indicators		
Real GDP Growth	0.007***	1,351
	(0.001)	
Risk-Free Rate (US Federal Funds Rate)	-0.018	1,351
	(0.006)	
Real Effective Exchange Rate Depreciation	-0.406***	1,351
	(0.069)	
Financial Characteristics		
Natural Resource Rents-to-GDP Ratio	-0.021**	1,254
	(0.005)	
Net ODA Received Per Capita (Log of Current US$)	0.002	1,315
	(0.009)	
Reserves in Months of Imports	-0.033	1,084
	(0.028)	
Short-Term Debt-to-Reserves Ratio	0.057	1,084
	(0.021)	
Institutional Characteristics		
Control of Corruption	-0.02***	962
	(0.003)	
Political Stability & Absence of Violence	0.008	967
	(0.005)	
Government Effectiveness	-0.012	960
	(0.004)	
Regulatory Quality	-0.006	960
	(0.005)	
Rule of Law	-0.006	968
	(0.006)	
Voice and Accountability	-0.011	968
	(0.006)	

Note: Standard errors are heteroskedasticity-robust and clustered at the country level. Statistical significance is indicated by ***, **, and * at the 1%, 5%, and 10% confidence levels, respectively.

Appendix III. Synthetic Control Method

A. Overview

Consider a reference LIC for which we want to derive a benchmark. We define a year t^0 around which we consider T years of data from t^{start} to t^{end}, composed of T^0 pre-benchmark periods (that is the T^0 periods before t^0) as well as T^1 benchmark periods. For all MACs, we find t_j as the year in which the MAC exhibited the PPP GDP per capita level closest to the benchmarked LIC's level in year t^{start} such that:

$$t_j = \arg\min_t \left| y_t^j - y_{t^{start}}^{LIC} \right|$$

We consider the respective subsequent T periods of equivalent development time for the respective MACs. For each MAC in the donor pool, we observe the outcome of interest (the debt-ratio $d_{i,t}$), as well as a set of k predictors of the outcome, which consist of a set of variables that affect the maximum sustainable debt path and that we identify in the next two subsections. We denote this by the $(k+1) \times 1$ vectors, $X_{i,t}$. Now suppose that we have complete data across the outcome and predictor variables for J historical MACs in the donor pool over all T periods.

To derive a suitable benchmark over the benchmark period, we construct a synthetic benchmark of the debt ratio from our sample of J historical MACs:

$$\hat{d}_{LIC,t} = \sum_{j=1}^{J} \omega_j \, d_{j,t}$$

Where $\hat{d}_{LIC,t}$ is the synthetic benchmark value for our LIC in year t, $d_{j,t}$ is the debt-to-GDP ratio in MAC j in development time year t, and ω_j is a set of time-invariant weights that achieves a combination of MACs that is most alike our LIC over the pre-benchmark period. We follow Abadie and Gardeazabal (2003) and Abadie, Diamond, and Hainmueller (2012) in choosing ω_j such that the resulting synthetic control benchmark best resembles the pre-benchmark values for the predictors and debt-to-GDP ratios exhibited by the LIC. Concretely, we find weights ω_j by:

$$\omega = \arg\min_{\omega} \left(\sum_{h=1}^{k} \nu_h \left(\boldsymbol{X}_{h,LIC} - \omega_1 \boldsymbol{X}_{h,MAC_1} - \cdots - \omega_J \boldsymbol{X}_{h,MAC_J} \right)^2 \right)^{\frac{1}{2}}$$

We follow the standard literature and choose ν such that it minimizes the mean squared prediction error of the synthetic control benchmark with respect to the outcome of interest, which is the public debt-to-GDP ratio. This procedure allows us to sidestep direct estimation of dynamically stable public debt levels. Noisy data can make conventional direct estimations volatile in the context of LICs. We compare LICs' debt trajectories or projections to the observed experience of similar MACs, which did not face public debt stress events over a similar duration of time.

B. Implementation Details

Applying the SCM, we construct a synthetic MAC that best reproduces the values of the predictors of the public debt-to-GDP ratio over the pre-benchmark period. Appendix Table 4 compares the pre-benchmark characteristics of the analyzed LIC with those of the respective synthetic benchmark, as well as to the average in the sample of shifted MACs from which the benchmark is constructed. Predictors are sorted by the weight that the SCM assigns to them in descending order for the 25th percentile LIC. The ordering for other reference LICs differs, and the ordering of predictors is unrelated to the predictor weights for the 50th and 75th percentiles.

Overall, we find that the synthetic benchmark typically provides a better fit in our predictor variables than the average of the sample MACs. LIC-specific synthetic benchmarks are very similar to the LICs over the pre-benchmark period in terms of debt-to-GDP, as well as various other key predictor variables that have predictive power over public debt-to-GDP. The goodness-of-fit for different predictor variables varies across LICs, depending on how much weight the SCM assigns to them according to their explanatory power for the public debt-to-GDP ratio.

Appendix III Table 1. Differences in Means of Overall Public Debt-to-GDP Ratios and Its Predictors, between Reference LICs and Synthetic Units Over Pre-Benchmark Period

(Percent unless otherwise noted)

Predictors	25th Percentile LIC		50th Percentile LIC		75th Percentile LIC		Recent 75th Percentile LIC	
	Δ(LIC - Synth. Unit)	Δ(LIC - All MACs[1/])	Δ(LIC - Synth. Unit)	Δ(LIC - All MACs[1/])	Δ(LIC - Synth. Unit)	Δ(LIC - All MACs[1/])	Δ(LIC - Synth. Unit)	Δ(LIC - All MACs[1/])
Overall Public Debt (% GDP)	-0.4	-9.2	0.1	-9.7	-0.5	13.4	0.4	1.5
Revenue (% GDP)	-9.3	-11.4	-3.0	0.6	-6.6	-9.7	10.4	6.5
Net ODA per Capita (log USD)	0.4	0.3	0.9	1.2	0.9	1.0	2.6	2.3
Natural Resource Rents (% GDP)	-7.9	-11.7	-18.6	-8.3	13.4	4.3	-2.4	-10.2
International Reserve Coverage (months of imports)	-0.8	-0.5	-0.3	-0.8	-1.4	-1.2	-2.4	-1.9
External Debt Servicing (% Exports)	1.6	-2.3	-3.3	-5.1	2.1	5.7	-6.1	-5.5
US Federal Funds Rate (percentage points)	-2.3	-2.0	-1.2	-0.8	-0.7	-0.9	-2.7	-2.6
Short-Term Debt (% International Reserves)	8.7	-5.8	-3.1	-4.0	246.9	245.8	34.8	37.7
Share of External in Overall Public Debt	39.7	17.1	35.5	47.8	68.3	62.9	61.7	43
Real GDP growth (percentage points)	-3.4	-1.8	-6.6	-4.6	-2.1	-4.5	-3.4	-3.3
PPP GDP Per Capita	-0.2	-0.1	-0.4	-0.3	-0.2	-0.4	-0.1	-0.2
Exports (% GDP)	-14.2	-12.2	5.9	14.4	7.5	-0.4	143.7	138.5
External Debt Servicing (% Revenues excluding Grants)	3.9	1.8	-4.7	-6.6	10.3	14.4	1.1	2.8
REER Depreciation (+ = Appreciation)	2.3	1.1	0.0	0.5	1.1	-0.5	-1.5	-0.7
World Growth	-0.3	-0.2	-0.2	-0.2	-0.1	-0.1	-0.2	-0.3

Notes: Predictors are sorted in descending order of the weight ω_h assigned to them in the SCM for the 25th percentile LIC. The ordering is not necessarily the same for the 50th and 75th percentile LICs.

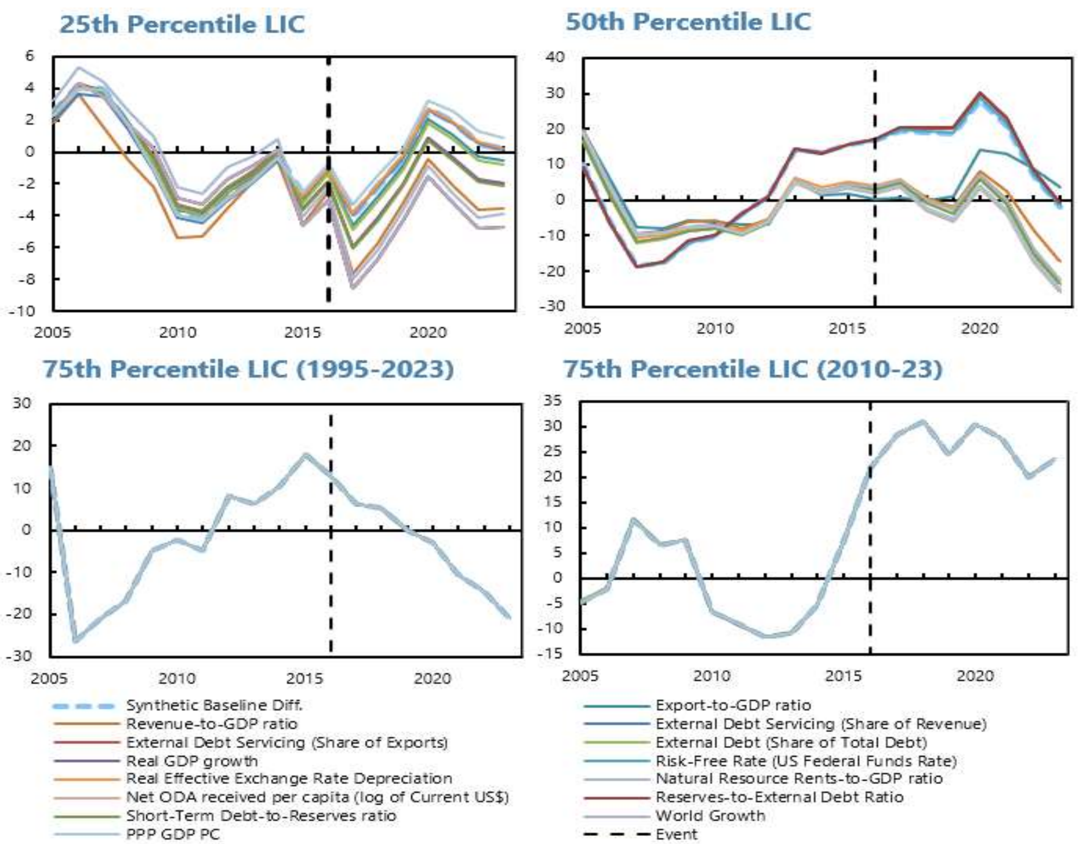
[1/] Universe of MACs with per capita PPP GDP similar to that of the reference LIC in 2005.

C. Robustness Checks

We investigate whether our results are sensitive to a change in the benchmarking starting year t^0. We rerun the analysis for the reference LICs by changing t^0 up to one year before and after 2015 ($t^0 \in \{2014, 2016\}$). Our results confirm that alternative choices of a starting point of the analysis do not qualitatively change the findings.

In addition, we repeat the analysis by dropping predictor variables one-at-a-time. Results suggest that the synthetic benchmarks are broadly robust to dropping single predictor variables, with some variation noted when dropping REER depreciation (Appendix Figure 1).

Appendix III Figure 1. SCM Robustness: Differences between Overall Public Debt-to-GDP Ratios of Reference LICs and Alternative Synthetic Benchmarks



Source: Authors' estimates.

Notes: The panels show the difference between public debt-to-GDP trajectories of the reference LICs and their synthetic benchmarks from Figure 3, alongside differences to alternative synthetic benchmarks, constructed by dropping one of the predictor variables (as shown in the legend). All panels contain all series though some are not visible due to overlaps with other series.

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PUBLICATIONS

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