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Growth in the shadow of debt[☆]

Jamus Jerome Lim[a,b]

[a] Associate Professor, ESSEC Business School, Singapore
[b] Research Affiliate, Center for Analytical Finance, Santa Cruz, California, United States

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ABSTRACT

This paper revisits the relationship between debt and growth from a vantage point that considers the totality of private and public debt. We exploit quarter-long timing lags inherent in the response of borrowing to innovations in output to identify the effects of debt on growth in a panel vector autoregressive model. We verify that debt accumulation is negatively related to output growth, with a one standard deviation innovation in the former leading to a 0.2 percentage-point contraction in the latter. This result is robust to the inclusion of exogenous variables in the system, alternative measures of the endogenous variables, and varying temporal treatments. We also find variations depending on the type of debt accumulated, the specific subset of countries considered, and the channels along which debt expansion operates.

He that goes a-borrowing, goes a-sorrowing.
Benjamin Franklin (1706–1790)

1. Introduction

The assumption of debt, from an economic perspective, can be both a blessing and a curse. Leverage is often necessary for financing profitable investment opportunities, and rapid economic growth is often accompanied by deepening financial markets that render the debt burden sustainable. Yet rapid borrowing can result in misallocated resources and heightened inefficiencies, and an excessive debt overhang can be corrosive to economic confidence and growth prospects. This fundamental tension—the question of whether debt accumulation leads to or follows from aggregate growth—underlies all studies that seek to understand the relationship between debt burdens and economic performance.

Given this essential tradeoff, it is natural to couch any relationship between debt and economic outcomes in terms of the full extent to which leverage is deployed; that is, *total* economy-wide debt—rather than debt of either a public or private nature—is what should be relevant. Even setting aside arguments about Ricardian equivalence (Barro, 1974)—where, at the limit, higher public debt financed by more taxation would simply be offset by greater private saving or, equivalently, reduction in private debt—it is straightforward to recognize that any marginal gain or loss to economic growth as a result of credit extension should depend only on increments in the total debt stock, regardless of source. Yet most of the literature has focused on either private or public debt independently, leaving the macroeconomic effects of total debt underexplored.

The objective of this paper is to contribute to the understanding of the linkages between total debt and economic outcomes, especially output growth. In particular, we seek to establish a causal link from the sum of public and private debt to growth, which we do by exploiting the temporal lag between shocks to output and the rational responses by borrowers, within a panel vector autoregressive (VAR) framework. The decision to treat debt as a totality—rather than in isolation—allows us to account for the full effect of debt on growth, and is the main contribution of our paper.

Our identification assumption is premised on the fact that neither private action nor public policy responds contemporaneously to innovations in aggregate economic activity, but do so after a quarter. This is plausible for movements in slower-adjusting real variables—such as changes in debt—since reacting to growth shocks typically requires redesigning policies, restructuring plans, renegotiating terms, and amending contracts, all of which require time.

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E-mail address: jamus@essec.edu

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Moreover, our panel VAR setting offers several additional advantages. VARs permit insight into short-run dynamics—by accounting for interdependencies between debt and growth—while the panel setting allows abstraction from (time-invariant) unobserved heterogeneity that is secondary to the question at hand. At the same time, panel VARs accommodate general inferences that may not be available to causal analyses reliant on country-level natural experiments, due to external validity concerns.

Existing studies of debt and growth rely, virtually unanimously, on data gathered at the annual frequency. While this is not generally problematic for empirical analyses whose central objective is to simply document the coevolution of the two variables of interest, annual data typically disqualifies the use of standard (Blanchard and Perotti, 2002)-type timing assumptions necessary for causal identification. Such arguments are generally only plausible when working with quarterly data, since it is much harder to argue the case that innovations to macroeconomic variables do not fully propagate within the economy—and hence garner behavioral responses from agents—over the course of a full year.

Using this timing-based identification strategy, we verify that debt accumulation leads to a contraction in output growth: a one standard deviation innovation results in a decline in GDP of around 0.2 percentage points. This relatively modest cumulative effect is mostly realized by the first year following the shock, although in a more fully-specified model that includes open-economy variables, changes in the current account and real exchange rate serve to largely offset this drag, nullifying any relationship in the long run. This absence of a lasting long-run effect (and the presence of a negative short-run one) is corroborated by regressions using panel error-correction models. Variance decompositions further indicate that, over the course of two-and-a-half years following the shock, debt shocks account for between 0.3 to 1% of variance in growth.

In addition to these baseline results obtained, our analysis also reveals additional nuances. A decomposition of debt indicates that, on average, public debt expansions are responsible for growth contractions; to the extent that private debt accumulation matters, it operates more along corporate, rather than household, leverage. This has implications, in particular, for China, which has seen significant growth in total debt, especially corporate debt. Simple simulations suggest that the effects of this debt accumulation could lead to a reduction in the projected 10-year average growth rate of as much as 0.4%. An analogous exercise decomposing the channels by which debt contractions are transmitted to subcomponents of output suggests that the shock appears to reduce investment, rather than government consumption.

We also find evidence of variations in outcomes based on different subsamples of the data. The need to take into account interdependencies between the issuance of public and bank debt appear to be important for the Euro Area—echoing concerns about a toxic bank-sovereign doom loop—but such linkages appear to be absent from broader samples of either developed economies, or all countries. Finally, we compare the relative influence of trade versus capital flows in mitigating the debt effect. We establish that while both real and financial channels are operative, the effects of capital flows appears to be more persistent, and this is especially the case after the global crisis, with the magnitude of responses around double that when compared to the full historical sample.

There is a small cottage industry of empirical papers exploring the relationship between debt and growth. However, much of this work is focused on the debt burden of the public sector alone. Eberhardt and Presbitero (2015), Lof and Malinen (2014), and Panizza and Presbitero (2014) all identify negative public debt-growth relationships, although the last finds that this effect disappears once they account for endogeneity, a negative result that (De Vita et al., 2018) also demonstrate is the case for the longer run. While interesting in their own right, the focus of these papers on public debt leads us to regard these results as an incomplete representation of the full effects of debt on growth in the macroeconomy.[1]

Several papers have touched on a broader conception of debt. The voluminous literature on financial development and growth (Arcand et al., 2015; Levine, 2005; Rajan and Zingales, 1998) has typically relied on domestic credit provided to the private sector as a proxy for the maturity of the financial sector. Yet even when we set aside definitional distinctions,[2] this branch of the literature is typically more interested in the longer-term relationship between growth and private credit availability, rather than the total debt burden. More crucially, such findings are often due to between-country variations in financial depth, rather than the sort of within-country dynamics that give rise to our results. And while several other papers (Denis and Mihov, 2003; Drehmann and Juselius, 2014; Schularick, 2014) are also concerned with total debt, their focus is on other issues (such as financial stability or instrument choice), rather than broader macroeconomic performance.

The papers that are closest in spirit to our own are Bernardini and Forni (2017), Jordà et al. (2013), and Mian et al. (2017). The first two examine how changes in total debt can affect macroeconomic outcomes, and find that debt buildups are indeed associated with longer-lasting and more severe recessions. However, the reliance of these papers on local projection methods imposes distinct identification assumptions that abstract from causal interpretation, in contrast our timing approach.[3] Like us, the final paper details the distinct effects of household, corporate, and public debt, and how these may differentially affect macroeconomic outcomes of interest. But unlike us, the emphasis is on distinguishing between the growth effects of household and corporate debt; we instead stress the importance of total debt, and remain agnostic with regard to the contribution of any given subcomponent that comprises this aggregate. Finally, it is worth noting that all these papers rely on data gathered annually, which can obscure important shorter-term dynamics in favor of long-run equilibrium relationships.

The rest of the paper is organized as follows. In the following section, we review the relevant theory on the relationship between debt and growth, together with the case for treating public and private debt in tandem. Section 3 describes our empirical approach and identification strategy, while Section 4 documents our main results, including robustness. A penultimate section discusses a number of secondary findings, applied to specific cases. A final section concludes with some brief remarks on future research directions.

2. Theoretical background

2.1. Debt accumulation and economic growth

In theory, the relationship between debt and growth is indeterminate. The efficiency-enhancing transfer of risk between savers and investors necessarily requires the extension of credit; consequently, it is natural for debt to increase as an economy develops. To the extent that leverage raises the intensity of efficient capital usage, the economy will grow faster than otherwise; this increased growth can then reduce the ratio of total debt to output, even in

[1] A small literature, as exemplified by Chudik et al. (2017), narrows down this question to whether the effect of debt on growth is subject to a threshold. By and large, most papers have struggled to conclusively demonstrate the existence of such a tipping point.

[2] Domestic credit generally refers to financial resources that may include financing items, such as trade credit, which are generally excluded from "core" definitions of debt.

[3] As a robustness check, however, we also estimate our primary specification using local projections.

the absence of explicit fiscal consolidation/deleveraging, excess inflation/monetization, or default. In this instance, both the growth of debt and output move in tandem.

However, if borrowing becomes excessive, there is a risk that financial resources are misallocated. This will result in inefficiencies that lower the performance of the economy below potential. The debt burden becomes increasingly unsustainable: the overhang of debt erodes economic confidence, lowering investment; this in turn heightens uncertainly over future prospects, which further reduces investment in a negative feedback loop. Such an outcome would then imply a negative relationship between debt accumulation and growth outcomes.

Th fundamental issue, then, is whether taking on more debt stimulates growth or retards it. Given the indeterminacy of the debt-growth relationship—especially the heterogeneity of conditions under which accelerated debt buildup may alter the growth trajectory—a deeper understanding of the phenomenon ultimately calls for an empirical resolution, which is the objective of this paper.

2.2. Total debt and growth dynamics

Economic theory has long implied that properly accounting for the effects of debt on growth entails working with changes in the aggregate debt stock, rather than either the public or private debt burden alone. At the most basic level, Ricardian equivalence-type arguments (Barro, 1974) would imply substitutability between public debt and the future tax burden, which detracts from saving available for allocation into private assets. If such government debt financing is subsequently directed toward expenditure, one would expect a concomitant reduction in capital formation, and hence growth (Modigliani, 1961).[4]

More articulated models make analogous points. While canonical Ramsey-Cass-Koopman-style models typically introduce debt as a single state variable, relatively straightforward extensions that explicitly model government reconcile the distinct public and private components under a single intertemporal national resource constraint (see Blanchard and Fischer, 1989, chap. 2). Both forms of debt enter into the first-order conditions that define optimal growth, and in cases where taxation is distortionary, the balanced growth path as well. Substitution effects may themselves be dominated by income effects. If more debt is incurred as a result of a more developed financial system, the reduced risk associated with improved financial arrangements can lower saving, which in turn retards economic growth by lowering capital accumulation when externalities are present (Levhari and Srinivasan, 1969). Moreover, the effects of debt need not operate only on the supply side: if agents face debt constraints, debt accumulation can give rise to changes in aggregate demand as well, whether in overlapping-generations (Blanchard, 1985; Diamond, 1965) or New-Keynesian (Eggertsson and Krugman, 2012) settings.[5]

The conditioning effects of debt are not limited to first-generation models of growth. Second-generation endogenous growth models that incorporate leverage elements generally identify a negative growth drag due to debt (Bianchi et al., 2019; Bräuninger, 2005; Saint-Paul, 1992). In contrast to exogenous growth settings, however, an enlarged debt stock in such models may diminish real growth through mechanisms beyond efficient capital allocation via the interest rate;[6] such factors include the nonneutral effects of monetary expansions (van der Ploeg and Alogoskoufis, 1994) or congestion in the provision of public goods (Turnovsky, 1996). More generally, any of an assortment of market frictions hold the potential to alter resource allocation decisions and, in turn, economic growth (Levine, 2005).

Another theoretical argument in favor of a complete treatment of debt stems from more recent work on government-bank debt interdependence (Brunnermeier et al., 2016; Cheng et al., 2017; Farhi and Tirole, 2018; Gennaiola et al., 2014).[7] This literature traces the manner by which bank indebtedness—which in turn reflects borrowing from the nonfinancial private sector—can amplify credit stresses experienced by the sovereign, in a mutually-reinforcing “doom loops.” On the other side of the coin, banks—due to either risk-shifting (Crosignani, 2017) or credit discrimination (Broner et al., 2014) motivations—may persist in holding (and may even expand) government debt even in bad times, effectively supporting the sovereign. Because such feedback loops effectively link public and private debt, buildups in either class will have implications for the overall quality of the country’s aggregate debt portfolio, as well as for the nation’s financial stability and economic performance.

The discussion above hints at one possible approach to reconciling the indeterminacy in the debt-growth relationship: by simultaneously incorporating both public and private debt into the same empirical model, offsetting effects from specific subcomponents of debt working in different directions will be fully accounted for. Moreover, these subcomponents can then be independently analyzed to discern the relative importance (and direction) of each of these elements of debt on output growth. This results in a more holistic treatment of debt dynamics that is glossed over by other studies of debt on growth that do not emphasize the importance of total debt.

3. Empirical approach

3.1. Data sources and definitions

The baseline sample is an unbalanced panel beginning in 1952Q1 and ending 2016Q3, with coverage of up to 41 advanced and emerging economies. The debt data are from the Bank for International Settlements’ (BIS) *Total Credit Statistics*. For our baseline, these are matched with standardized national accounts data for real GDP from Datastream—which in turn relies on national statistical organizations—and supplemented with real effective exchange rate (REER) data from the *Effective Exchange Rate Indices* of the BIS, and balance-of-payments data from the International Monetary Fund’s (IMF) *International Financial Statistics*. Beyond our baseline, we draw further on a variety of sources, including (but not limited to) national accounts data from the Organisation for Economic Cooperation’s (OECD) *Main Economic Indicators*, effective exchange rate estimates from J.P. Morgan, and political risk data from the Political Risk Services’ *International Country Risk Guide*.

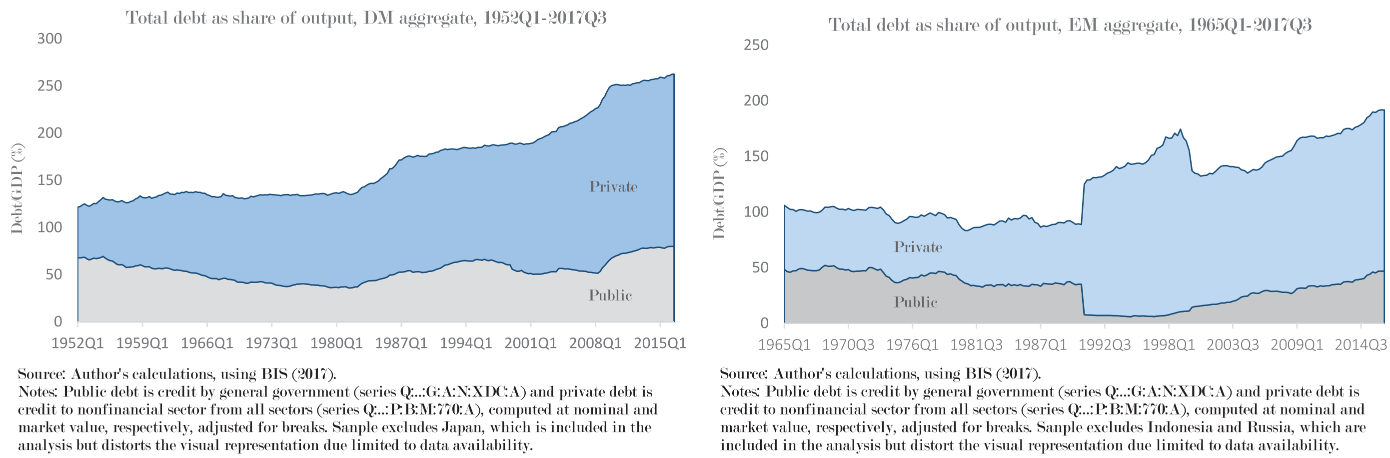
Since the debt data are central to our study, it is worth describing the series in some additional detail. The database includes coverage of both bank and nonbank credit extended to either the private nonfinancial sector and government sector. Private nonfinan-

[4] At the extreme, Pritchett (2000) goes as far as to argue that government investment results in little useful productive capital, in which case inefficient public borrowing would fully crowd out private debt.

[5] In the appendix, we develop a sketch of a number of these theoretical arguments in formal detail.

[6] Indeed, Lin (2000) demonstrates that in an endogenous growth model with overlapping generations, changes to debt may have an ambiguous effect on the real interest rate and, in turn, growth.

[7] This concurrent occurrence of different types of financial distress has long been recognized in the empirical twin-crises literature, of course. Hutchison and Noy (2005) is an early example that links currency with banking crises; while (Reinhart and Rogoff, 2011) document the relationship for debt and banking crises empirically, and Bindseil and Winkler (2013) propose a theoretical explanation based on a closed system of financial accounts.



(a) Developed markets (b) Emerging markets

Fig. 1. Total debt as share of output, decomposed into public and private shares, for developed (left panel) and emerging (right panel) market economies. Growth in the debt stock, especially for private sector debt, has been steadily rising since the 1990s, with increases among EMs around financial crisis-led recessions in Asia and Latin America, and among DMs around the subprime- and Euro Area-crises. The discrete jumps in the DM and EM charts at 1997Q4, 1990Q4, and 2010Q1 are mainly artifacts of the data, representing the inclusion of Japan, Russia, and Indonesia into the respective aggregates.

cial credit can be further subdivided into corporate and household borrowing, via either loans or debt securities. Government credit comprises only core debt instruments (currency & deposits, loans, and debt securities), and all liabilities are consolidated across different levels of government (central, state, and local), such that cross-holdings between different public entities are netted out. For all the analyses to follow, total debt (or its subcomponent) is always measured as a share of GDP.

The overall trend of increases in the global debt stock, especially from the 1990s onward, is well-recognized. This fact is captured in Fig. 1, which charts the decomposition of total debt for our unbalanced panel, by developmental aggregate.[8] Although the pattern of rising total debt is evident in both groups, the increase appears to be greater for public debt among developed market (DM) economies, while the rise in private debt is more pronounced among emerging market (EM) economies.

All variables were deseasonalized (where necessary), and the baseline computes either quarter-on-quarter (QoQ) first differences or deviations from the linear-quadratic trend of natural logarithms of the variables (except when ratios are involved).[9] The full list of data sources, and their accompanying definitions, is provided in the appendix.

3.2. Econometric methodology

Our baseline model is an m-variate homogeneous panel VAR, of order k and comprised of $i = 1, \dots, N$ economies over $t = 1, \dots, T$ periods. This is represented as

$$\mathbf{X}_{it} = \sum_{j=1}^{k} \mathbf{X}'_{i,t-j}\boldsymbol{\beta}_j + \mathbf{Z}'_{it}\boldsymbol{\zeta} + \boldsymbol{\alpha}_i + \boldsymbol{\epsilon}_{it}, \tag{1}$$

where $\mathbf{X}$ is a $(1 \times m)$ vector of interdependent system variables, $\mathbf{Z}$ is a $(1 \times l)$ vector of exogenous covariates, and $\boldsymbol{\alpha}$ is a $(1 \times m)$ vector of time-invariant fixed effects specific to each system variable. $\boldsymbol{\epsilon} \sim \text{IID}(\mathbf{0}, \boldsymbol{\Sigma})$ is the vector of idiosyncratic innovations, and the $(m \times m)$ matrices $\boldsymbol{\beta}_1, \dots, \boldsymbol{\beta}_k$ and $(l \times m)$ matrix $\boldsymbol{\zeta}$ are the coefficients to be estimated.

To reduce dimensionality, our solution approach follows (Holtz-Eakin et al., 1988) in assuming that every ith cross-sectional unit shares the same data-generating process, and hence the reduced-form coefficient estimates $\boldsymbol{\beta}_1, \dots, \boldsymbol{\beta}_k$, and $\boldsymbol{\zeta}$ are common among all N economies.[10]

For what follows, we let the two-variable vector of debt (D) and output (Y), represented by $\mathbf{X}^p = [D \;\; Y]$, be our *parsimonious* specification. We populate our *comprehensive* version with the addition of the balance of payments (B) and real exchange rate (Q), so that $\mathbf{X}^c = [D \;\; Y \;\; B \;\; Q]$.[11]

3.3. Estimation and identification strategy

Our empirical analysis begins with a number of preliminaries, which we summarize in Section 4.1. These involve assessing variable transformations and checks to ensure stationarity, and absence of longer-run cointegrating or cross-sectionally dependent relationships between the variables. We then proceed with the estimation of the panel VAR using generalized method of moments (GMM), which yields consistent estimates of (1) in the presence of Nickell (1981) bias, so long as $\frac{T}{N} \to c$, $\forall c \leq 2$ (as is the case in our application).[12] To minimize data loss given the unbalanced nature of our panel, panel-specific fixed effects α_i are removed using forward orthogonal deviations rather than first differences. All standard errors are computed such that they are robust to misspecification due to heteroskedasticity.

Our identification of the relationship between output and public debt is an expanded version of the argument first forwarded by Blanchard and Perotti (2002). Discretionary adjustments made to fiscal policy in response to unexpected events require at least a

[8] Note that, in constructing the charts, we have chosen to introduce countries into the sample as data become available, which may account for discrete jumps in the aggregate representations shown. Such anomalies do not affect our formal analyses, however, since we allow for country-specific fixed effects.

[9] Taking QoQ changes is most consistent with the timing assumptions implied by our Cholesky-type identification strategy. In robustness checks, we also consider transformations of the data by taking year-on-year (YoY) or deviations from trend.

[10] This stands in contrast to the random-coefficient approach, the other commonly-applied estimation methodology for panel VARs, which estimates slope parameters using either classical or Bayesian distributions.

[11] As we discuss in Section 4.1, these variables are subsequently transformed to ensure stationarity. Thus debt and output actually enter in first-differenced form, while the current account and exchange rate enter as trend deviations.

[12] Since differencing introduces serial correlation into the model, our internal instrument list comprises lags of at least one or deeper (for trend deviations), and two or deeper (for first differences), through to four periods.

quarter or more before policymakers are able to learn about, decide on fiscal responses, pass relevant legislature, and implement measures, which only then become reflected in aggregate output. Government expenditure or tax revenue (or more simply, the primary balance) is then directly reflected as changes in debt, net of interest payments on past debt—which we assume to be orthogonal to unexpected changes in debt, and hence exogenous.[13] Consequently, unexpected changes in output do not prompt any *immediate* feedback response from the stock of outstanding public debt.

The identification of private sector debt responses follow a similar logic of delayed response. Unanticipated economic activity does not affect contemporaneous accrual of private debt. Here, we appeal to financing frictions faced by firms endured during capital raising (Gilchrist et al., 2014; Gomes, 2001), along with standard time-to-build delays incurred when implementing new production plans (Kydland and Prescott, 1982; Salomon and Martin, 2008). Consequently, changes to a firm's debt liabilities require at least a quarter before it is captured in aggregate output fluctuations.[14] Thus, analogously to public debt, unanticipated output shocks yield no systematic responses from private debt.

Taken together, output is effectively more endogenous than total debt, and treated as such in the innovation variance-covariance matrix $\boldsymbol{\Sigma}$ used for our estimation of the orthogonalized impulse response functions (IRFs). More formally, innovations in our parsimonious setup follow the structure

$$D_{it} = \psi Y_{it} + \varepsilon_{it}^{D}, \tag{2a}$$

$$Y_{it} = \delta D_{it} + \varepsilon_{it}^{Y}, \tag{2b}$$

where ε^D and ε^Y are mutually uncorrelated structural shocks to be recovered. Given the identification assumptions discussed above, $\psi = 0$, but $\delta \neq 0$; equivalently, this implies that we adopt a recursive identification scheme with a lower-triangular impact matrix. As stressed by Blanchard and Perotti (2002), our identification strategy depends crucially on the fact that the higher-frequency quarterly data effectively eliminates the channel where agents, whether public or private, are able to respond to unanticipated movements in output within the period.

Identification for the remaining two variables in the comprehensive specification is straightforward. We rely on the conventional Cholesky ordering common in the open-economy literature—such as that employed in Ilzetzki et al. (2013)—that treats the external account as less endogenous than the real exchange rate. Thus, whereas the current account (along with debt and output) affect the exchange rate both contemporaneously as well as with a lag, the exchange rate only affects these variables with a lag. In our robustness checks, we also investigate alternative orderings of these secondary variables.

4. Results

4.1. Preliminaries

We begin by examining a number of temporally-relevant panel properties of the data. In particular, we wish to ascertain that the form of the variables we include in the panel VAR are not only stationary, but also do not exhibit any cointegrating or spatially-dependent relationship among themselves, since imposing a VAR structure in that case would amount to misspecification. In the interest of space, we relegate the details of these preliminary tests to the appendix. Here, we summarize the main findings.

Table 1
Baseline estimates for panel VAR, parsimonious and comprehensive models, 1970Q1–2016Q3 (unbalanced)[a].

Response of	*Response to* D_{t-1}	Y_{t-1}	B_{t-1}	Q_{t-1}
Parsimonious				
D_t	0.304	−0.230		
	(0.04)***	(0.05)***		
Y_t	−0.030	0.259		
	(0.01)**	(0.03)***		
Obs	3,174			
Ctry (Periods)	41 (77)			
Comprehensive				
D_t	0.286	−0.147	−0.070	0.029
	(0.04)***	(0.06)***	(0.02)***	(0.01)***
Y_t	−0.015	0.339	0.010	−0.006
	(0.02)	(0.04)***	(0.02)	(0.00)*
B_t	−0.044	−0.185	0.779	−0.009
	(0.02)**	(0.04)***	(0.02)***	(0.00)***
Q_t	−0.258	−0.031	0.077	0.934
	(0.05)***	(0.06)	(0.03)**	(0.01)***
Obs	2,559			
Ctry (Periods)	41 (62)			

[a] Panel VAR estimated via GMM, with fixed effects removed via forward orthogonal deviations. Coefficients correspond to the regression of variables in each row on the lagged variables in each column. Reported periods are averages, since the panel is unbalanced. Heteroskedasticity-robust standard errors are given in parentheses, where * indicates significance at the 10% level, ** significance at the 5% level, and *** significance at the 1% level.

Insofar as stationarity is concerned, the panel unit root tests we run suggest that stationarity tends to be an issue for total debt and real output when entered as either levels or trend deviations. Accordingly, these take on a first-differenced form in our baseline.[15] However, since the current account and exchange rate are stationary in trend deviation form, we adopt this alternative transformation for these latter two variables instead.[16]

In terms of cointegration, while test statistics from a small handful of panel cointegration checks hint at the possibility of cointegration, the bulk of the evidence favors its absence. Tests for cross-sectional dependence, in contrast, suggest the presence of possible spatial interdependencies, which could give rise to inconsistent estimates. We proceed on the notion that cointegration is not a concern for our application, but spatial dependency may be, which we address in our robustness checks.

Our optimal model and moment selection tests used for lag length selection do not yield a perfectly unambiguous result. However, most information criteria support the selection of the first-order panel VAR. Accordingly, we treat this as our baseline, and consider deeper-order panel VARs in our robustness checks.

4.2. Baseline results

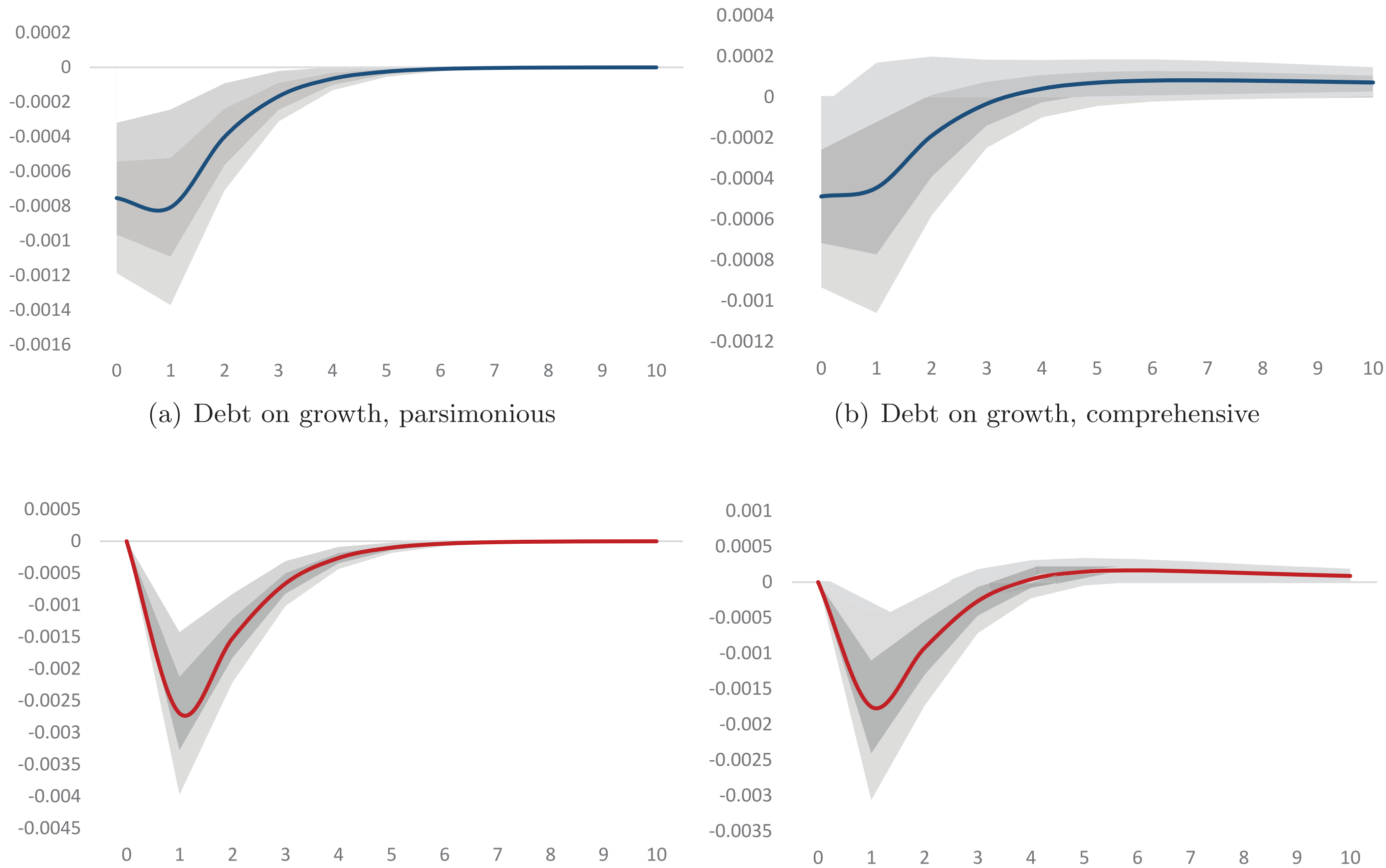
Table 1 reports the baseline results for both the parsimonious (top panel) and comprehensive (bottom panel) specifications of the model. As is convention, in the absence of imposing additional structure, we refrain from excess interpretation of the coefficients. However, we do note that the coefficient of the response of growth

[13] Importantly, this assumption does *not* imply that interest rates are therefore exogenous; rather, the schedule of interest payments on debt *already incurred* is exogenous.

[14] This serves as a pure private sector-induced delay in responding to changes in macroeconomic conditions, and is a related (but distinct) mechanism from the assumption that the private sector does not respond to monetary policy changes contemporaneously, à la Bernanke and Mihov (1998).

[15] Incidentally, this treatment of debt and output as changes, instead of levels, is entirely consistent with their representation in the transition dynamics of standard growth models.

[16] Our decision to consider trend deviations is to minimize the effects of overdifferencing for the purposes of attaining stationarity, since doing so can degrade the quality of the forward projections.



(a) Debt on growth, parsimonious

(b) Debt on growth, comprehensive

(c) Growth on debt, parsimonious

(d) Growth on debt, comprehensive

Fig. 2. Orthogonalized impulse response functions for debt on growth (top panel) and growth on debt (bottom panel), for a one standard-deviation innovation in debt and growth, respectively, for 10 quarters after the shock. The dark (light) gray areas indicate the 68 (95)% confidence intervals generated using Gaussian approximation of 200 Monte Carlo draws from a fitted panel VAR. It is evident that in both cases, increases in either debt or growth give rise to a negative response from the other. In both instances, the effect fades after around a year, with peaks in the first quarter after impact.

to (lagged) debt accumulation is negative, although statistically insignificant in the comprehensive model.

We now turn to examining the impulse response functions.[17] These are provided in Fig. 2, for a unit standard deviation innovation of D_t on Y_t, and *vice versa* (responses of the variable to its own impulse are omitted).

Our results indicate that the effect of debt on growth is negative: an increase in debt is followed on impact by a decline in growth, which attains a maximum after a quarter, before gradually fading over the course of around a year.[18] This effect is less precisely estimated for the comprehensive model—the error bands larger—and the magnitude of effects smaller. The converse effect of growth on debt, which is also negative, lends further nuance to this result. Clearly, there are two-way effects: more rapid GDP growth also decelerates the buildup of debt. In a sense, this result is less surprising, given its somewhat mechanical nature: *ceteris paribus*, rapid growth tends to lower growth in the debt/GDP ratio, by dint of changes to the denominator. But the result underscores the importance of modeling these mutual feedback effects via a VAR structure.

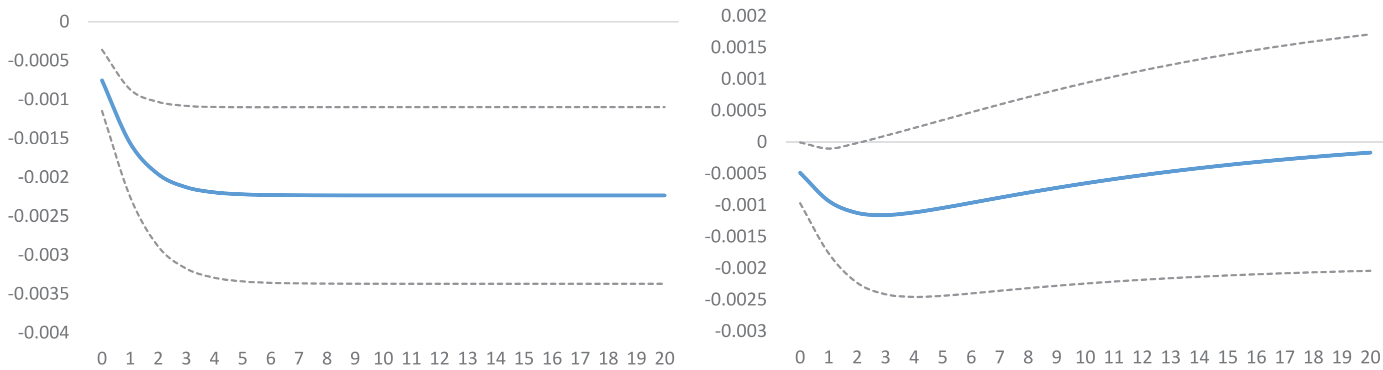
To place these results in context, consider a one-standard deviation positive innovation to debt accumulation in our parsimonious model. In this case, a country that sees a one-off increase in debt accumulation—of 2.2 percentage points faster than the average quarterly growth rate of 0.4%—is also liable to see an accompanying decline in its GDP growth rate, amounting to a total of around 0.2%, most of which will be realized within a year. Since the mean annualized real growth rate of our sample is 2.9%, this amounts to a growth deceleration of around 7%.

These findings are broadly consistent with the existing empirical literature, which finds that increases in the debt stock give rise to a growth slowdown (Chudik et al., 2017; Eberhardt and Presbitero, 2015; Jordà et al., 2013; Mian et al., 2017), although these papers typically focus on the effects of either public or private debt alone. The results also suggest that first-generation theoretical models (e.g. Blanchard, 1985) that posit a positive short-run effect of higher fiscal deficits (and debt) do not appear to be validated, in contrast to later models where—in the absence of rigidities—public debt gives rise to a reduction in labor supply, investment, and hence growth (Greiner, 2011). However, in stands contrast to the predictions of endogenous growth models where a negative private debt shock ends up decreasing investment and GDP growth (Bianchi et al., 2019) (although the effect horizons are comparable).

Since the total effect of any given shock is best understood in terms of its full impact, Fig. 3 shows the cumulative orthogonalized impulse responses for each model. What is most striking here is how, once we allow for the additional feedback effects from the

[17] The moduli of eigenvalues of both fitted models are strictly less than unity, thereby satisfying the stability condition for the invertibility of the respective characteristic polynomials; IRFs therefore admit their standard interpretations. These results are available on request.

[18] This reversion is also consistent with standard theoretical predictions that imply no steady-state relationship between changes in debt and output along the balanced growth path.



(a) Debt on growth (cumulative), parsimonious

(b) Debt on growth (cumulative), comprehensive

Fig. 3. Cumulative orthogonalized impulse response functions for debt on growth for the parsimonious (left panel) and comprehensive (right panel) models, for a one standard-deviation innovation in debt, for 20 quarters after the shock. The gray dark dashed lines indicate the 95% confidence intervals generated using Gaussian approximation of 200 Monte Carlo draws from a fitted panel VAR. The cumulative effects appear to fade away for the full model, in contrast to the parsimonious specification.

current account and exchange rate, the cumulative effects eventually fade away; this results from the incrementally *positive* effects of debt on growth in the comprehensive model, which are evident on closer inspection of Fig. 2(b) (the net cumulative effect remains negative, however, even after 20 quarters).

We interpret this diminished effect of debt on growth in the comprehensive model as reflective of the importance of open-economy factors in conditioning the ultimate persistence of any given debt shock. More specifically, an economy that undergoes an acceleration in its total debt burden will experience a persistent effect on its growth performance only if it is not mitigated by adjustments in its external account. This can be verified by examining the response of the exchange rate and current account in the full impulse response matrix (included in the appendix). After impact, the exchange rate gradually depreciates, reaching a peak after 2 quarters. In the short run, the current account also deteriorates—in line with the J-curve effect—but this reverses as the effects of depreciation begin to operate, and this positive contribution of a balance of payments surplus, which follows after 7 quarters, offsets the growth drag that results from the debt increase.[19]

But taking into account the conditioning effect of the balance of payments goes beyond expressing the effects of a trade-related adjustment mechanism in an open economy. The flip side of the current account is the financial account, and so an alternative interpretation of this result is that the cumulative detrimental effect of debt accumulation on growth can be offset if an economy runs a substantial excess of national saving over investment. This is essentially the story of high-surplus export-oriented economies, as exemplified by the newly-industrialized economies in East Asia (and most recently, China).

The modest effects of debt on growth is further corroborated by variance decompositions, which are shown in Table 2. The 10-period-ahead response of growth to innovations in debt is just shy of 1% (in the parsimonious model) and as low as 0.3% (in the comprehensive one). By and large, the significant majority of the dynamics displayed by each macro variable continues to be explained by its own autoregressive contribution. In addition, the meaningful amount of variation in debt explained by changes in the exchange rate—around 2%—likewise points to the moderating effects of the external sector, as mentioned previously.[20] In sum, the effects of an increase in debt accumulation on output growth are nontrivial, but relatively limited, and tend to be eroded over time.

Table 2
Variance decompositions for the baseline panel VAR, parsimonious and comprehensive models, 1970Q1–2016Q3 (unbalanced)[a].

Response of	*Response to*					
	Parsimonious		Comprehensive			
	D_t	Y_t	D_t	Y_t	B_t	Q_t
Y_{t+10}	0.009	0.991	0.003	0.993	0.001	0.003
D_{t+10}	0.979	0.021	0.960	0.008	0.011	0.021
B_{t+10}			0.004	0.030	0.959	0.007
Q_{t+10}			0.115	0.004	0.006	0.875

[a] Share of forecast error variance for predicted variables 10 periods ahead in each row explained by innovations of variables in each column.

4.3. Subcomponents of debt and output

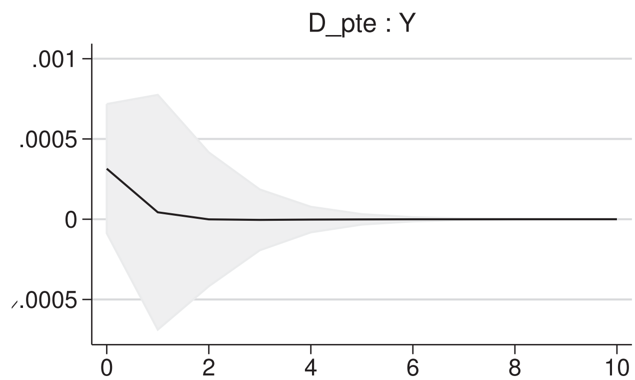
Since we have available independent series for private and public debt, we are able to go further and probe into whether the *nature* of debt matters. To this effect, the top row of Fig. 4 produces the IRFs for each type of debt on growth, while the bottom row further decomposes private debt into household and corporate components. On the basis of this set of IRFs, it is clear that the negative effect of debt on growth is driven by public debt accumulation, consistent with theoretical arguments where a greater debt burden can be corrosive for growth, either due to dynamic inefficiency (Saint-Paul, 1992) or multiple equilibria (Bräuninger, 2005), or by increasing uncertainty about the possibility of future financial repression (Cochrane, 2011). This result also runs against claims that public debt may turn out to be self-financing (Eggertsson and Krugman, 2012).[21] Private debt impulses actually generate a positive—albeit insignificant—growth outcome. This positive growth effect of private debt is attributable to household debt, however, while corporate debt accumulation remains detrimental.

[19] This diminishing effect of debt and growth in the longer run may explain why authors working with annual data, such as Panizza and Presbitero (2014), find that the growth effects of debt disappear after accounting for endogeneity.

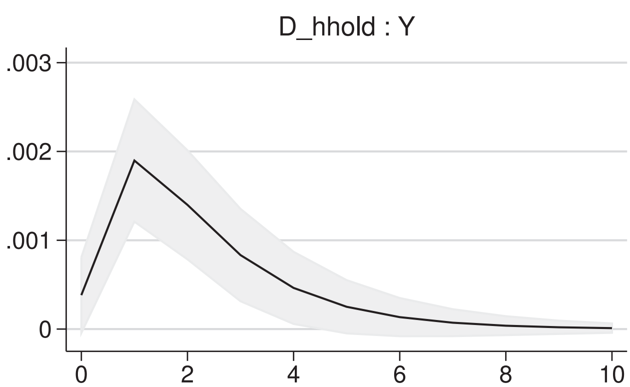
[20] Variations in the exchange rate attributable to debt are even larger, close to 12%.

[21] The important caveat here is that the specific setting considered in Eggertsson and Krugman (2012) corresponds to a liquidity trap (more formally, when the real interest rate $r < \dot{Y}$), which is not the case in our baseline. More generally, most economists that call for deficit-financed stimulus do so in a setting where the increase in debt is one-shot (rather than continuous, as we examine here), and we there is spare capacity (as in a recession, as opposed to our study across all conditions).

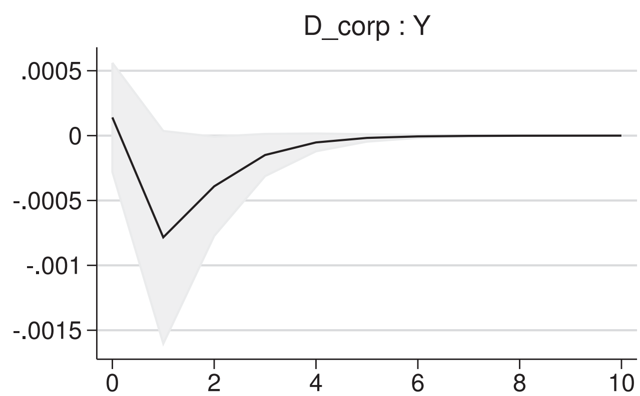
(a) Public debt on growth



(b) Private debt on growth



(c) Household debt on growth



(d) Corporate debt on growth

Fig. 4. Orthogonalized impulse response functions for various subcomponents of debt on growth for the parsimonious model, for a one standard-deviation innovation in debt, for 10 quarters after the shock. The light gray areas indicate the 95% confidence intervals generated using Gaussian approximation of 200 Monte Carlo draws from a fitted panel VAR. The negative effect of debt on growth is driven by public debt accumulation, whereas private debt impulses generate a positive (but insignificant) growth outcome. The positive effect of private debt on growth is attributable to household debt, with corporate debt accumulation remaining detrimental.

Does this contradict the results by others, such as Jordà et al. (2013) and Schularick and Taylor (2012), that private debt overhang gives rise to slower growth? Not necessarily. The slower post-recession growth demonstrated in these papers are *relative* to a no-crisis counterfactual; this could well hold in our data as well. Instead, our claim here is simply that *absolute* output growth is little threatened by private debt accumulation. More importantly, Jordà et al. (2013) also find that when treated in tandem, public debt conditions the post-recession path of output, and economies with large holdings of public debt do grow more slowly.[22] In this regard, their results actually underscore the conditioning role of public debt on growth, just as we do.

Accounting for subcomponents of output is a little trickier. Recall from our identification assumptions in Section 3.3 that the lagged effects of public deficits and private borrowing respond, with a slight lag, to observed innovations in *aggregate* output. Such legislative delays and time-to-build arguments are harder to sustain for any single component of income, which can undermine the Cholesky ordering. This is further exacerbated by data limitations.[23] For these reasons, while we recognize that examining different dimensions of the output response may be of interest, we caution against placing too much stock in the results that immediately follow.

We focus on government consumption and domestic investment (which includes public and private components). The IRFs are shown in Fig. 5. The negative effect of debt accumulation appear to operate on investment, peaking after a quarter, before reverting fairly quickly. Government consumption, in contrast, actually *increases* slightly after a positive debt innovation, although this effect is imprecisely estimated and insignificant even for a tighter 68% confidence interval.[24]

4.4. Robustness of the baseline

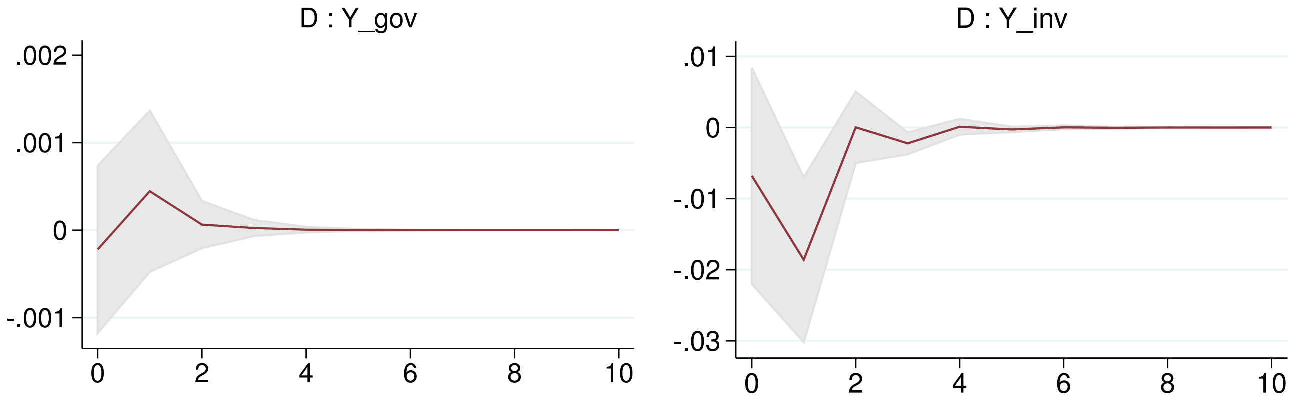
We are now in a position to examine the overall robustness of the baseline result. We focus here on only our main relationship of interest—the effect of a debt accumulation impulse on growth—and mention alternative results only where relevant.[25] Unless not applicable, we include both IRFs from the parsimonious and com-

[22] Jordà et al. (2013) also find that the counterfactuals they find are mostly applicable to post-financial crisis recessions, and their various output paths for regular contractions are largely indistinguishable.

[23] Many subcomponents of output are not typically available at the quarterly frequency, especially in emerging economies (since GDP is not always calculated via the expenditure method). Consequently, the panel VAR estimates are typically obtained from a smaller subsample relative to the baseline (significantly so for investment).

[24] Had this result been statistically significant, it may have lent some credence to the Eggertsson and Krugman (2012) argument that deficit-financed government spending can expand output.

[25] For completeness (and because they are potentially of independent interest), we include the full matrix of IRFs for higher-order panel VARs in the appendix. The IRF matrices for the remainder of the robustness checks discussed in this subsection are available on request.



(a) Total debt on government consumption (b) Total debt on domestic investment

Fig. 5. Orthogonalized impulse response functions for total debt on growth of government consumption and domestic investment for the parsimonious model, for a one standard-deviation innovation in debt, for 10 quarters after the shock. The light gray areas indicate the 95% confidence intervals generated using Gaussian approximation of 200 Monte Carlo draws from a fitted panel VAR. The negative effect of debt on growth operates through reductions in domestic investment, while government spending increases (albeit this effect is insignificant).

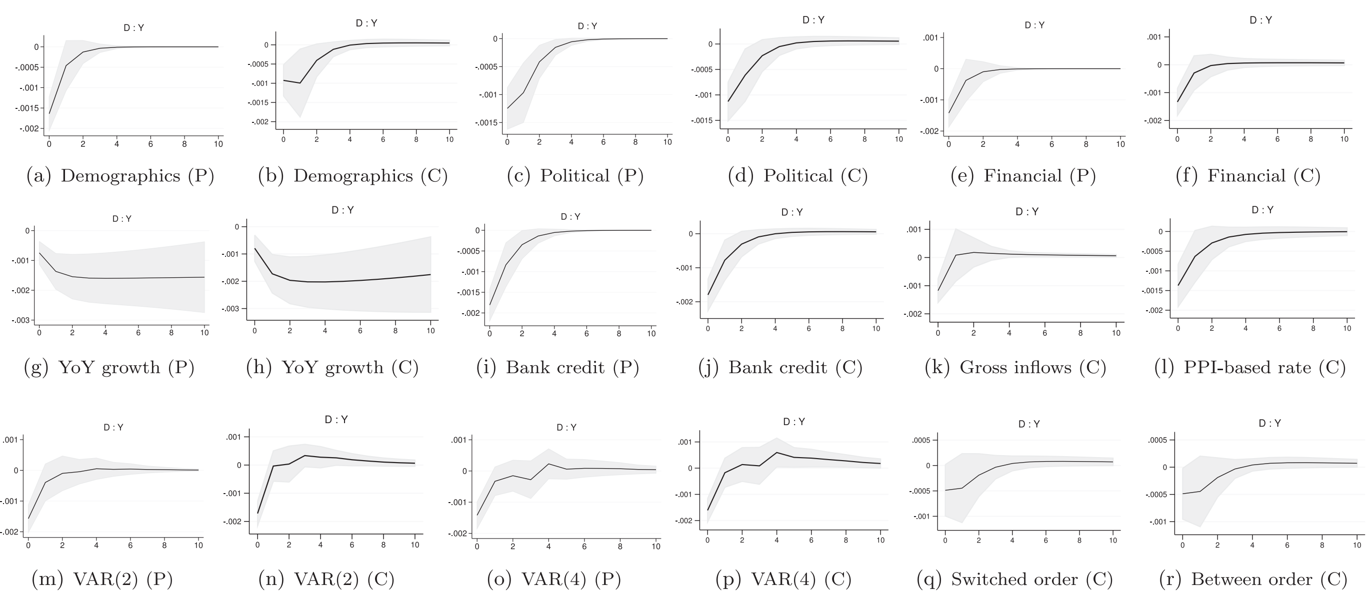


Fig. 6. Orthogonalized impulse response functions for debt on growth for the parsimonious (P) and comprehensive (C) models with the inclusion of exogenous variables (top row), alternative variable choices (middle row), and different temporal assumptions (bottom row), for a one standard-deviation innovation in debt, for 10 quarters after the shock. The light gray areas indicate the 95% confidence intervals generated using Gaussian approximation of 200 Monte Carlo draws from a fitted panel VAR. The overall dynamics of growth in response to a debt shock are similar to those in the baseline, although the dynamics in a few instances differ.

prehensive models. We proceed with three classes of checks: (a) the inclusion of exogenous variables for the vector **Z** into the baseline models; (b) the use of alternative measures for our endogenous variables; and (c) changes to the temporal treatment of the models. We also summarize a number of additional checks based on subsamples of the data.

Impulse responses for first set of checks are presented in the top row of Fig. 6. These further condition the panel VAR with the exogenous effects of demographics, political risk, and financial development (which we distinguish from debt, *per se*).[26,27] On balance, including exogenous controls does not substantially alter the effects of debt on growth. If anything, even while the overall dynamics of output in response to a debt shock remain very close to the baseline, the magnitudes of the contractions are larger in virtually all cases. This result also suggests that the theoretical claim—that exogenous improvements in the efficiency of resource allocation arising from financial development would lower risk and the interest rate, discouraging saving used to finance capital accumulation and thereby slowing growth (Levine, 2005)—is not a first-order concern.

We next consider a range of alternative measures for our endogenous variables. Given the relative importance of debt, we introduce two different variations: debt calculated as the year-on-year change in total debt, and debt with the private component computed as credit extended by banks alone (rather than across

[26] We capture demographics with the dependency ratio (of young and aged to the working-age population), political risk with a weighted, subjective index of political-economic risk ratings based on factors such as government stability, corruption, ethno-religious tensions, and law and order, and financial development with the equity market capitalization of listed corporations (as a share of output).

[27] Our measure of financial market development does *not* rely on domestic credit to the private sector (a more commonly-employed proxy for financial depth) because of its close relationship to private debt. Our choice of stock market capitalization is motivated by the fact that the correlation between capitalization and either total debt or private debt is very low ($\rho = 0.21$ and 0.26, respectively).

all financial sectors).[28] We next substitute the balance of payments with gross financial (portfolio and FDI) inflows, which offers an external account measure that better approximates the effects of capital flows. For the real exchange rate, we replace the baseline REER, which is deflated with the consumer price index (CPI), with a version deflated by the producer price index (PPI).[29] Finally, we impose different transformations: trend deviations for GDP and total debt, and first differences for the balance of payments and real exchange rate.[30] The results are summarized in second row of Fig. 6.

The main takeaway from these changes is that changes in debt retain their negative relationship with growth. In all instances, positive debt impulses are followed by declines in output. In most cases, the decline is greatest on impact or within the first quarter, as it was in the baseline, with the effects fading within the year. Notably, however, this effect does *not* dissipate when debt is measured in a YoY fashion, nor in the case when debt and growth are measured as trend deviations. For technical reasons alluded to earlier,[31] however, we are cautious about overinterpreting this result, and simply note that the overall negative relationship remains robust to this suite of alternative measures.

The first of our final set of tests increases the lag count to higher-order VAR(2) and VAR(4) systems.[32] Next, we alter the ordering of the secondary variables, but in a manner that does not affect the timing inherent in our identification strategy: we either switch the real exchange rate and allow it to be more exogenous than the current account, or we place the real exchange rate between debt and growth.

We summarize the responses of these temporal sensitivity tests in the bottom row of Fig. 6. While our main qualitative results are unchanged, we offer two additional remarks concerning the effects of a different VAR order. First, the *cumulative* effects of debt on growth tend to weaken as the number of lags increases; this is especially the case for the comprehensive model, as evidenced by Fig. 6(p), which shows the growth response remaining positive for a substantial time from the fourth quarter onward. Second, the corresponding dynamics in a panel VAR(4) specification are also less smooth; indeed, there is a sharp kink in either model in the third quarter following the shock, which actually goes some way toward offsetting the initial negative impulse.

We now consider a number of alternative estimators. We consider estimators that allow us to relax the assumptions of no cointegration or spatial dependency,[33] and a nonparametric estimator that is more robust to misspecification. First, we estimate a variety of dynamic heterogeneous panel models that cater for the possibility of cointegrating and spatially-dependent relationships, which we summarize in Table 3. Second, we report impulse responses generated from local projections (Jordà, 2005).

We accommodate the possibility of a long-run cointegrating relationship between debt and growth by considering panel error-correction models (ECMs) of the form

$$\Delta Y_{it} = \sum_{j=1}^{k} \delta_{ij} \Delta Y_{i,t-j} + \sum_{j=1}^{k} \Delta \mathbf{X}'_{i,t-j} \boldsymbol{\beta}_j + \phi_i \left(Y_{i,t-1} - \tilde{\mathbf{X}}'_{it} \boldsymbol{\theta}_i \right) + \alpha_i + \epsilon_{it}, \tag{3}$$

where Y is output, and $\tilde{\mathbf{X}}$ is the $(1 \times (n-1))$ vector of endogenous variables *excluding* output. $\phi \geq 0$, commonly known as the error-correction parameter, captures the speed of adjustment to the long-run relationship, α is a country fixed effect, and δ, $\boldsymbol{\beta}$, and $\boldsymbol{\theta}$ are additional coefficients to be estimated. ϵ is an error term that, in the first instance, we assume to be spatially independent. $\tilde{\mathbf{X}}^p = [D]$ then mimics our parsimonious specification, and $\tilde{\mathbf{X}}^c = [D \;\; B \;\; Q]$ is analogous to the comprehensive specification. For consistency with our baseline, we maintain just one lag, $k = 1$.

We report two alternative panel ECM specifications: a dynamic fixed effect model with Nickell (1981) bias-corrected estimators—which imposes the most restrictions on parameters—and a mean group model (Pesaran and Smith, 1995), which imposes the least.[34] In each case, we consider both parsimonious and comprehensive versions; the results are given in the first four columns of the table.

The next two sets of specifications relaxes the spatial independence assumption for the error term by allowing $\mathrm{cov}(\epsilon_{it}, \epsilon_{jt}) \neq 0$ for some $i \neq j$ and t. We first impose an error-correction structure on fixed-effect estimates corrected for spatial correlation (Driscoll and Kraay, 1998),[35] before running models with dynamic common correlated effects (Chudik and Pesaran, 2015), which addresses spatial dependency within a very heterogeneous error structure (and is the most general among the estimators we consider here). These results constitute the final four columns. Across all these specifications, we verify the negative short-run effect of debt on growth, along with the absence of statistically-significant evidence of any persistent long-run influence.

For local projections, we estimate a specification homologous to (1), although for simplicity we exclude any additional exogenous covariates given by $\mathbf{Z}$, such that the estimating equation is given by

$$\mathbf{X}_{it} = \sum_{j=1}^{k} \mathbf{X}'_{i,t-j} \boldsymbol{\mu}_j + \boldsymbol{\alpha}_i + \boldsymbol{\epsilon}_{it}, \tag{4}$$

where, as before, $\mathbf{X}$ represents the vector of interdependent system variables, $\boldsymbol{\alpha}$ that of fixed effects, and $\boldsymbol{\epsilon}$ an upper-triangular matrix of innovations. The distinction here is that the parameter matrices $\boldsymbol{\beta}_1, \ldots, \boldsymbol{\mu}_k$ are now obtained via fixed effects estimation. (4) is estimated one equation at a time, with standard errors robust to within-cluster error correlations.[36]

The IRFs corresponding to D_t on Y_t, estimated via local projections, for the parsimonious and comprehensive models, are shown in Fig. 7. As is common with local projections, the responses are less smooth relative to those estimated via a panel VAR system.

[28] The difference between credit from all sectors and from banks is credit by the nonbank financial sector, commonly referred to as shadow bank lending.

[29] Arguably, a PPI-based REER measure is more sensitive to changes in the exchange rate, since the CPI basket is more likely to include less-tradable goods and services, such as owners' equivalent rent.

[30] For economy, we report the IRFs corresponding to these final two modifications in the appendix.

[31] In particular, the YoY measure is not well-suited to our identification strategy premised on quarter-to-quarter changes in debt in response to output. The ambiguous stationarity properties of the trend deviations for debt and output are also potentially problematic for a VAR setting, although if the objective is to understand interrelationships between variables rather than obtain parameter estimates, variable nonstationarity may be less of a concern than overdifferencing (Sims et al., 1990).

[32] Other than the majority of the tests—which favor the VAR(1)—the other lag specifications identified are the VAR(2) and VAR(4) for the parsimonious model (by R^2 and AIC, respectively) and VAR(3) for the comprehensive model (by AIC). We chose to report the VAR(2) because the IRFs for the VAR(3) appear to be averages of the VAR(2) and VAR(4) outcomes; the greater contrast offered by the VAR(2) therefore favors its inclusion here.

[33] Recall, our baseline is premised on the fact that tests for cointegration are statistically inconsequential, although cross-sectional dependence could be an issue. The models estimated here may therefore run the risk of misspecification, although they are still potentially useful robustness checks.

[34] Specifically, the former pools all time-series data for each country, allowing only the intercepts to differ, while the latter allows intercepts, slope coefficients, and error variances to vary. We also obtained intermediate pooled mean group (Pesaran et al., 1999) estimates, which yielded very similar results; these are available on request.

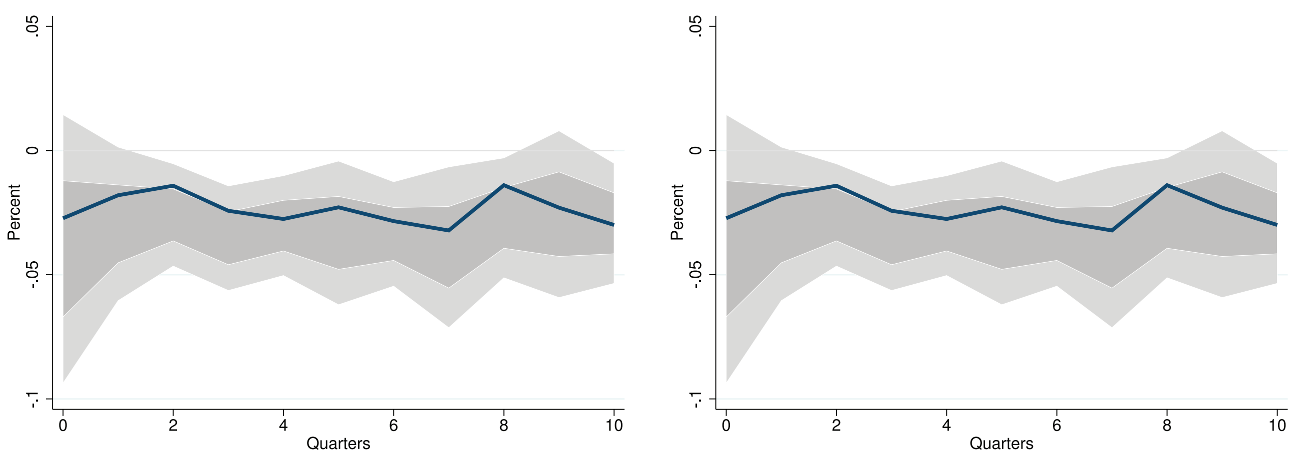
[35] By including the lagged dependent variable into the specification, we introduce the possibility that the estimated coefficients suffer from Nickell (1981) bias. That said, any such bias is likely to be limited since our temporal dimension is relatively long, and the estimator is consistent as $T \to \infty$.

[36] Additional details on the estimation are provided in the appendix.

Table 3
Robustness results for dynamic heterogeneous panels, parsimonious and comprehensive models, 1970Q1–2016Q3 (unbalanced)[a].

	Potential cointegration				*Potential spatial dependency*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Short-run								
ΔY_{t-1}	0.171	0.172	−0.020	−0.038	0.163	0.160		
	(0.02)***	(0.02)***	(0.01)***	(0.01)***	(0.06)***	(0.07)**		
ΔD_t	−0.049	−0.024	−0.121	−0.100	−0.049	−0.026	−0.044	−0.038
	(0.08)	(0.07)	(0.02)***	(0.02)***	(0.04)	(0.04)	(0.01)***	(0.02)**
ΔB_t		0.022		−0.055		−0.022		0.001
		(0.08)		(0.04)		(0.05)		(0.03)
ΔQ_t		0.029		−0.027		0.028		−0.024
		(0.04)		(0.02)		(0.01)		(0.02)
Long-run								
Y_{t-1}	0.000	−0.004		−0.038	−0.003	−0.008	−0.006	−0.015
	(0.01)	(0.01)		(0.01)***	(0.00)*	(0.00)**	(0.00)	(0.01)**
D_t	−0.004	−0.005	4.660	4.188	−0.004	−0.005	0.522	2.469
	(0.01)	(0.01)	(5.44)	(2.11)**	(0.00)	(0.00)	(1.79)	(3.68)
B_t		0.024		−0.890		0.025		−26.706
		(0.04)		(7.13)		(0.01)**		(28.66)
Q_t		0.003		9.751		0.003		−86.580
		(0.01)		(7.55)		(0.01)***		(83.11)
Estimator	DFE-C	DFE-C	MG	MG	SCC	SCC	DCCE	DCCE
Model	Pars.	Comp.	Pars.	Comp.	Pars.	Comp.	Pars.	Comp.
R^2	0.03	0.04			0.03	0.06	0.25	0.33
Obs	3244	2618	3256	2625	3244	2618	3256	2625
Ctry (Periods)	41 (79)	41 (63)	41 (79)	41 (64)	41 (79)	41 (63)	41 (79)	41 (64)

[a] The dependent variable is the GDP growth rate. Dynamic heterogeneous panel methods reported in the first row of the lower panel, corresponding to biased-corrected dynamic fixed effects (DFE-C), mean group (MG), spatial correlation-consistent (SCC), and dynamic common correlated (DCCE) estimators. DFE-C estimates are initialized with the Anderson-Hsiao estimator and corrected to $O(1/NT)$. Within goodness of fit (adjusted R^2) reported where available. Reported periods are averages, since the panel is unbalanced. A homogeneous constant was included in all specifications, but not reported. Standard errors are given in parentheses, and are bootstrapped over 200 simulations (DFE-C), Driscoll-Kraay spatial dependency, heteroskedasticity, and autocorrelation-corrected standard errors (SCC). * indicates significance at the 10% level, ** significance at the 5% level, and *** significance at the 1% level.



(a) Debt on growth, parsimonious (b) Debt on growth, comprehensive

Fig. 7. Orthogonalized impulse response functions for total debt on growth for the parsimonious (left) and comprehensive (right) model, for one standard-deviation innovations, 10 quarters after the shock. The gray areas indicate the 95% (68%) confidence intervals generated using the moving average of local cluster-robust standard errors. The onset of the negative effect is delayed relative to estimates obtained via panel VARs, and is relatively more persistent.

But our main result—a significant, negative response of debt on growth—remains, although in this case the effect is slightly delayed, while remaining significant at least through about two years.

Before closing this subsection, we summarize a number of additional checks based on different subsamples of the data.[37] Overall, the negative relationship between debt accumulation and output growth survives various slices of the data, whether by overall debt level, region, income group, or time period. However, the persistence and magnitude of the negative response varies; for example,

[37] While we are guarded in any interpretations based on such regressions—the panel specification would already take into account systematic differences between countries, so analyzing subsamples entails throwing away information—it is worth probing the overall robustness of the main result. The IRFs, along with additional commentary, are available in the appendix.

Table 4
Panel Granger causality tests, parsimonious and comprehensive models[a].

	$Y_{t-1} \rightarrow D_t$	$\tilde{X}_{t-1} \rightarrow D_t$	$D_{t-1} \rightarrow Y_t$	$\tilde{X}_{t-1} \rightarrow Y_t$
First differences				
Parsimonious	16.107***		3.944**	
Complete	7.595***	20.744***	0.855	4.663
Trend deviations				
Parsimonious	25.953***		1.827	
Complete	27.545***	32.739***	3.627*	5.469
Log levels				
Parsimonious	26.610***		0.600	
Complete	5.190		2.990	

[a] The null hypothesis is that the excluded variable(s) (on the left) does not Granger-cause the dependent variable (on the right). $\tilde{\mathbf{X}}_t$ represents all other endogenous variables in the complete specification. The Granger causality test reports the Wald χ^2 statistic for the coefficients of all lags of non-excluded variables jointly being zero, with the exception of the log levels, where only the first 3 lags are considered. * indicates significance at 10% level, ** indicates significance at 5% level, and *** indicates significance at 1% level.

the effect is twice as large and four times as persistent for EMs relative to DMs.[38]

A few takeaways are in order. Across all the specifications considered, the shorter-run effects of debt are systematically negative, albeit not always statistically significant (they are in half the specifications). The longer-run effects of debt are also mixed; although by and large, the coefficients—while sometimes much larger in magnitude—are insignificant. Overall, even after accounting for the possibility of cointegrating relationships and spatial dependency, the message of a negative effect of debt accumulation on output growth remains, along with the tendency for these effects to dissipate in the longer run.

4.5. Identification concerns

To gain additional perspective into the (temporally) causal nature of our results, we report panel Granger (non)causality tests for each model for growth on debt, and *vice versa*, in Table 4. The top and middle panels report standard Granger tests for panel VARs with variables in the first differenced and trend deviation forms, respectively. The bottom panel reports tests for variables in levels, following the Toda and Yamamoto (1995) procedure, which yields results robust to the presence of nonstationarity.

As can be seen, the results almost uniformly indicate that lagged effects of growth (Granger)-causes debt accumulation in either model, while the lagged effects of changes in debt—as well as the totality of the other endogenous variables in the comprehensive model—has no Granger-causal effect on growth, with the exception of the parsimonious model in first-differenced form.[39] This implies that growth shocks induce contemporaneous shifts in debt stocks, whereas changes in debt will only affect future changes in output: a result that indirectly supports the error structure we impose on (2), and our implied causal ordering that places output before debt.

While the presence of a (Granger) influence of debt on output (in the parsimonious model) may lead one to question the credibility of our identification strategy, it is useful to keep in mind two mitigating factors. Most importantly, Granger causality from debt changes to growth fails to hold in all other specifications, at least at conventional levels of significance. Furthermore, it is useful to recall that the simple presence of a lagged effect is neither necessary nor sufficient to claim genuine causality. This is because our identification argument relies on responses to *unplanned* innovations in output; in contrast, the Granger (non)causality tests only establish whether lagged changes in the debt stock—which includes both anticipated (interest payments, planned spending) and unanticipated (true fiscal and investment innovations) components—help predict growth outcomes (beyond lagged growth alone). Overall, however, the results essentially corroborate the theoretical arguments made concerning the exclusion restriction.

5. Discussion

5.1. China's debt experience

It is instructive to consider our findings in the context of China. In the two decades between 1996 and 2016, the total debt stock in the economy more than doubled, rising from around 107% of GDP to in excess of 250%. Perhaps more alarming, the rate of debt accumulation also doubled, from an average rate of 0.6 to 1.5% (QoQ). The rapid growth of Chinese debt has evoked much consternation among observers, who rightly note that such a debt burden is unprecedented in the country's modern history.

In light of our baseline results, such rapid debt buildup certainly invites caution. The focus of most observers has been on the rapid acceleration in private debt (see, for example, Coulton et al., 2018; IMF, 2017). Our discussion in Section 4.2 indicates that private debt, as a whole, is not associated with any growth slowdown; but a further decomposition also underscores how this is due to a positive relationship between household debt accumulation and growth, while corporate debt retains an unambiguously negative (albeit only marginally significant) relationship with growth.

In China's case, much of recent debt growth has indeed been attributable to the private sector, with public debt remaining significantly below shares routinely observed in developed markets (the public-to-private debt ratio for China in 2016 was 82—versus 18% across all DMs—and public debt only amounted to 46% of GDP in 2016). If it is public and not private debt booms that induce growth slowdowns, defenders of China's recent debt trajectory may point to this fact as a mitigating factor.

But this claim appears premature. In contrast to other economies, the pattern of total debt growth in China has historically been much more reflective of private credit growth (Fig. 8); to the extent that it is total debt that matters, China's rapid private debt expansion may well still prejudice its growth prospects. Moreover, it is corporate debt that underlies China's private debt expansion, and since the growth of firm debt is negative for growth, continued expansion in this component of the private debt will further subtract from GDP performance.[40] Finally, it is worth keeping in mind that Japanese government debt, up till the eve of its crisis in 1991, remained very manageable (around 68% of GDP), and only increased to its current levels following a lost decade of economic growth.

5.2. Europe's toxic bank-sovereign debt loop

The tight relationship between public and private debt is by no means limited to China. Indeed, analysts following the European

[38] One anomalous result occurs when the sample is restricted to only the brief period after the Great Recession, when an increase in debt accumulation prompts a *positive* growth response. We attribute this outcome to sample size limitations, and leave this matter for future research.

[39] This ambiguity in a two-equation setting could be the reason behind why others, such as Lof and Malinen (2014), have struggled to establish any robust effects of debt on growth.

[40] In the appendix, we apply our model to explore, via simulations, how different debt accumulation paths may potentially affect China's future growth rate.

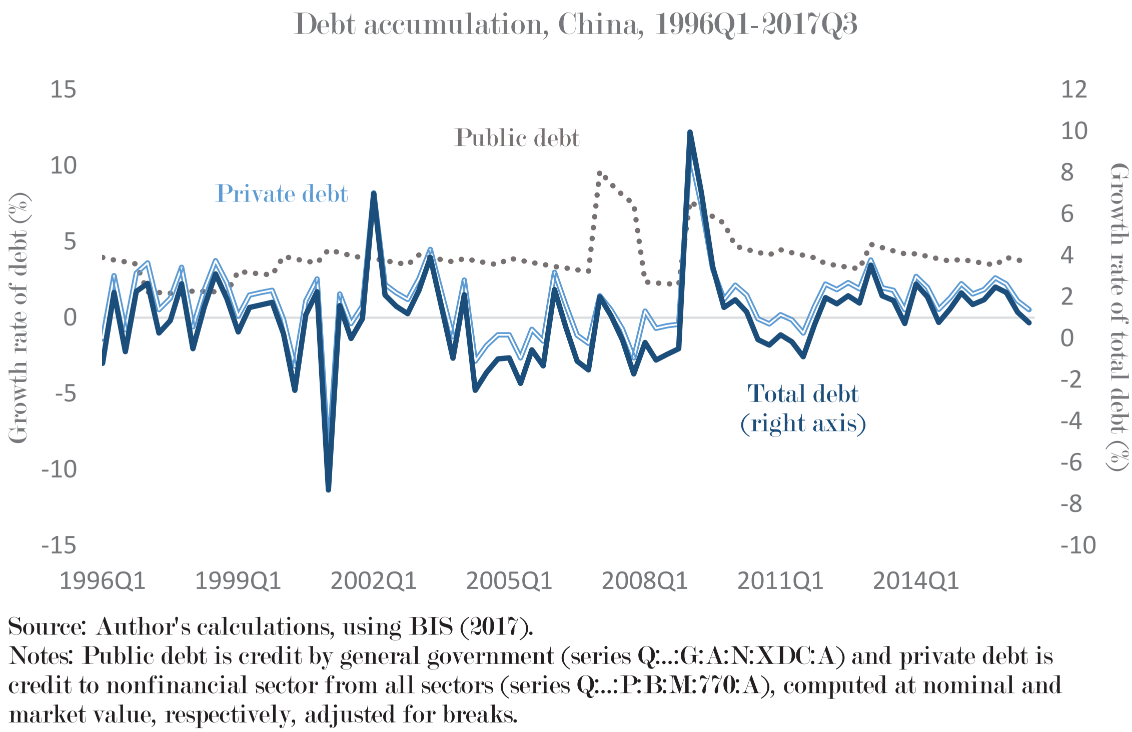


Fig. 8. Chinese debt accumulation dynamics, decomposed into public and private rates. The growth rate of total debt for the period 1996Q1–2006Q4 averaged 0.6% QoQ, compared to 1.5% between 2007Q1–2016Q3. In contrast to other economies, total debt growth in the economy has historically reflected changes in private rather than public sector debt.

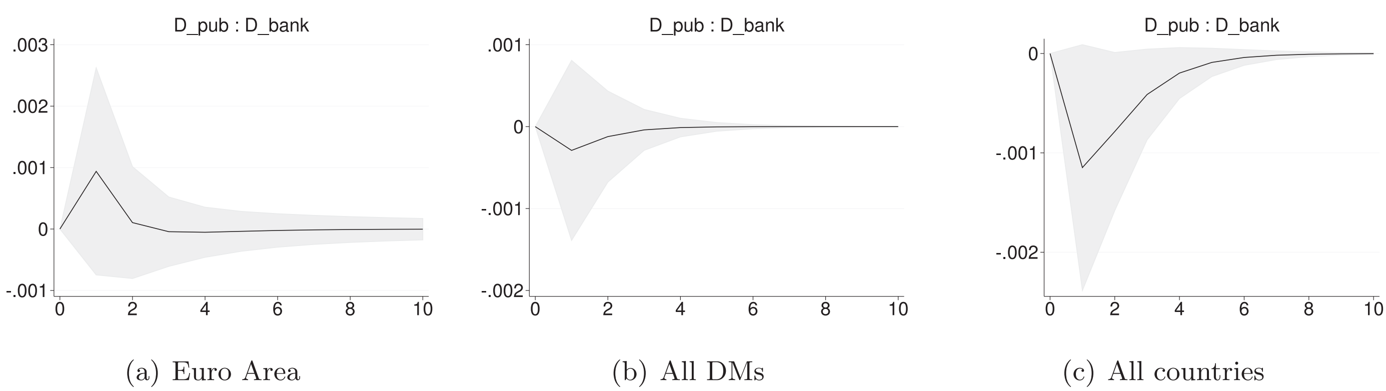
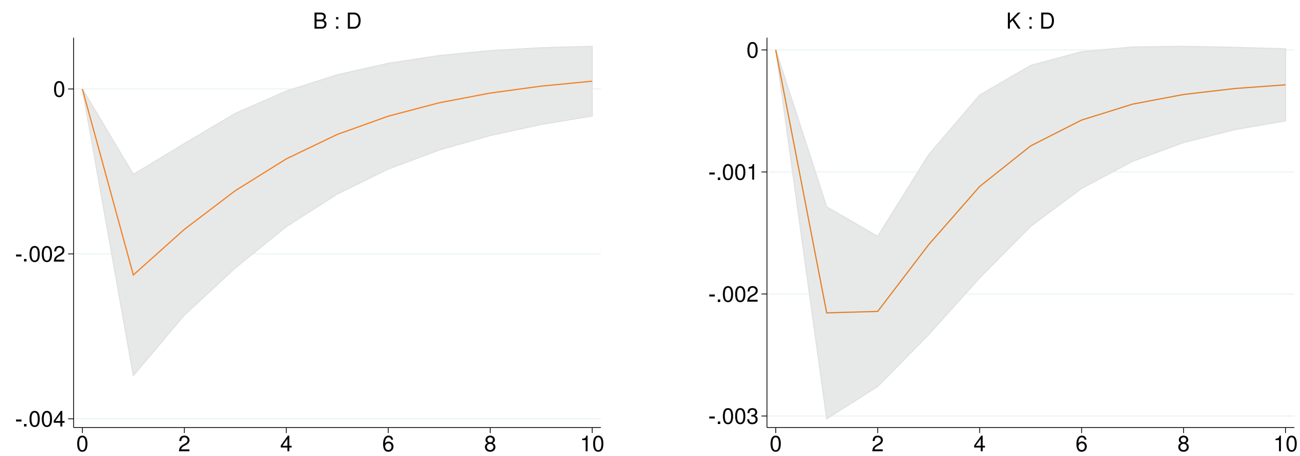


Fig. 9. Orthogonalized impulse response functions for public debt on private bank debt for the parsimonious model, for a one standard-deviation innovation in debt, for 10 quarters after the shock. The light gray areas indicate the 95% confidence intervals generated using Gaussian approximation of 200 Monte Carlo draws from a fitted panel VAR. An increase in the rate of public debt issuance gives rise to faster accumulation of bank debt in the Euro Area, a result that does not hold either in the broader subsample of all DMs, or the full sample of all countries (where the effects tend in the opposite direction).

debt crisis of 2009 have remarked on how debt interdependence between banks and their sovereigns played a central role in perpetuating the crisis (Brunnermeier et al., 2016; Farhi and Tirole, 2018; Lane, 2012). While empirical papers examining this phenomenon are beginning to emerge (Acharya and Steffen, 2015; Altavilla et al., 2017; Bocola, 2016; Gennaiola et al., 2014; Popov and Horen, 2015), the overall evidence base remains small. We offer some additional insight into this issue by taking advantage of our VAR setup, which inherently captures the effects of cross-variable feedback. Our analysis begins by separating out the total debt stock into public and private bank-financed components, followed by examining the IRFs for a public debt impulse on private debt issued by banks. The results are shown in Fig. 9.[41]

For the Euro Area, we find evidence in favor of the doom loop hypothesis. Fig. 9(a) shows that an increase in public debt issuance is, among Euro Area economies, accompanied by a concomitant increase in private bank debt (although this shock is not statistically significant at 95% confidence, it is at the 68% level). Akin to our other debt shocks, this effect is short-lived, and fades within the year. What is remarkable about this result is that it neither holds for the broader sample of all DMs (Fig. 9(b)), nor for the full sample of all countries (Fig. 9(c)); in fact, the evidence for the latter is that the effects of public debt expansion tend to give rise to the *opposite* outcome (a crowding out of bank debt). This suggests that the sovereign-bank doom loops are essentially a European phenomenon, which are probably best understood in the context of

[41] We report the parsimonious model with bank debt ordered before public debt. Alternative specifications, either with the comprehensive model or with the alternative ordering of the debt variables, do not generate very different results, and are detailed in the annex.



(a) Real (trade balance)

(b) Financial (gross inflows)

Fig. 10. Orthogonalized impulse response functions for the external account on debt for the comprehensive model when using the trade balance (left) or financial inflows (right) during 2008Q1–2016Q3, for a one standard-deviation innovation in debt, for 10 quarters after the shock. The light gray areas indicate the 95% confidence intervals generated using Gaussian approximation of 200 Monte Carlo draws from a fitted panel VAR.

the region's unique institutional features, such as the Fiscal Compact and Target2 settlement system.[42]

5.3. Debt transmission channels after the global crisis

One important feature of the post-2008 global financial landscape has been the persistence of leverage, even in the wake of a massive leverage-driven crisis (Dobbs et al., 2015). This is evident in Fig. 1: after 2008, total debt continues to accumulate, with an acceleration in public (private) debt growth among DMs (EMs). The specific transmission channels by which debt has expanded, however, remain unclear; while some have suggested that capital flows into emerging markets—led by the adoption of unconventional monetary policies by G4 central banks—may be responsible (Ahmed and Zlate, 2014; Lim and Mohapatra, 2016), others have sought to pose debt uptake as a function of responses to the post-crisis collapse in international trade (Aizenman and Jinjarak, 2012; Baldwin and Evenett, 2009). Which transmission channel came to be more relevant, however, remains uncertain.

We dig a little deeper into this issue by comparing the IRFs for the comprehensive model when we utilize different proxies for the external account. As discussed in Section 4.2, the external account plays an important role in mitigating the permanence of a debt shock on growth. By substituting gross capital inflows—which we regard as more consistent with a financial-side transmission channel—for the trade balance (which instead primarily captures real-side effects due to trade flows), we can examine how total debt responds to impulses in either of these measures, and determine whether one channel might be more operative (or not). To ensure relevance for the post-crisis period, we restrict the sample to data from 2008 onward.

The outcome of this exercise is given in Fig. 10. In both cases, either a positive real (a trade surplus) or financial (increased capital inflows) shock leads to a reduction in total debt growth. The magnitudes of the declines are also comparable, consistent with the fact that both a constrained according to the balance of payments identity. The fact that both channels matter in conditioning the effect of debt on growth is consistent with theoretical models (for example, Blackburn and Hung (1998)) where either trade or financial liberalization can accelerate credit intermediation, thereby affecting growth.

That said, the effects of changes in capital flows appears to be more persistent. After attaining troughs over two quarters, it never fully dissipates, unlike the case of trade flows. This result is not exactly replicated in our full sample (reported in the appendix); instead, the magnitudes of both the responses are smaller (by about half), and the response of debt to the financial channel is also more volatile and less persistent. Taken together, this set of results suggests that capital flows played a more important role in debt accumulation after the crisis, as might be expected from a major financial shock.

6. Conclusion

In this paper, we establish a negative relationship between the rate of total debt accumulation and economic growth. In particular, we find that debt impulses generate a small but negative growth effect, which tends to dissipate over time, especially in an open-economy setting. Beyond academic interest, our findings are also relevant to current debates over China's debt trajectory, the Euro Area sovereign-bank doom loop, and the limited deleveraging of economies in the post-crisis period.

As is standard for VAR analyses, the results we obtain may be sensitive to misspecification concerns. We have shown in Section 4.4 that our results survive a very rich set of perturbations, but one aspect in particular may warrant further attention: the need to examine the stability of long-run effects of leverage extension on economic performance. While we have taken a meaningful stab at the question in the results reported in Table 3, we believe that a dedicated analysis—which carefully distinguishes between sustainable financial development and unsustainable debt buildups—would be valuable. So would studies that better differentiate between domestic and external creditors. On the theory side, models that incorporate the growth-retarding implications of public and private (especially firm) debt, would represent a step forward. We leave such an endeavors to future research.

[42] The role of these institutional elements in driving bank-sovereign diabolical loops has been discussed elsewhere at length; see, *inter alia*, Campos and Sturm (2018).

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jbankfin.2019.04.002.

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