The Relationship between Debt and Output

Yun Jung Kim and Jing Zhang

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Yun Jung Kim

Sogang University

Jing Zhang

Federal Reserve Bank of Chicago[†]

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Abstract

In this paper we empirically explore the relationship between debt and output in a panel of 72 countries over the period 1970–2014 using a vector autoregression (VAR). We document two puzzling empirical findings that contrast with what is predicted by a standard small open economy model by Aguiar and Gopinath (2007), where debt and output endogenously respond to total factor productivity (TFP) shocks. First, developing countries' debt falls after a positive output shock, while the model predicts a debt expansion. Second, output declines in developed and developing countries after a debt shock, while the model predicts higher output. The relationship between debt and output depends on the sector taking on debt (households, firms, or governments) and the source of financing (domestic versus external) and differs across countries with varying degrees of economic development or different exchange rate regimes.

JEL Classifications: E44, F32, F34, F41

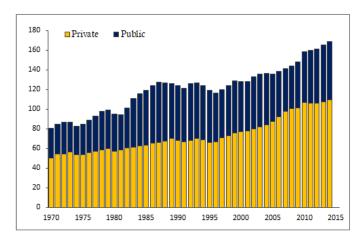*Keywords*: public debt, household debt, firm debt, foreign debt

1   Introduction

The world has experienced a large increase in indebtedness. Figure 1 shows that the ratio of total debt to gross domestic product (GDP) rose from 84.8 percent in 1970 to 168.6 percent in 2014. Overall, the global debt-to-GDP ratio reached an all-time high in 2018, generating many concerns among both academic researchers and policymakers about what the ramifications for global growth might be. Debt might be beneficial for smoothing consumption, accelerating capital accumulation, and increasing output, but increased debt services might also leave countries vulnerable to financial risks and lower GDP in the medium run. To shed more light on the discussion and provide support to policy analysis, we investigate empirically the dynamic relationship between debt and output. Understanding this relationship is critical for investigating the mechanisms underlying the linkages between indebtedness and economic growth.

Figure 1: Global Debt to GDP, Percent

Note: The figure shows the average ratios of private and public debt to one-year lagged GDP for 72 sample countries. Data comes from the IMF's Global Debt Database and the Historical Public Debt Database.

Not all debt is the same, nor is the relationship between debt and output the same across countries. Debt expansions have different correlations with output dynamics depending on the sector taking it on (households, firms, or governments). The relationship also depends on the source of financing (domestic versus external). Importantly, the patterns of the relationship differ across countries with varying degrees of economic development or different exchange rate regimes. In this paper, we investigate the relationship between debt changes and output dynamics along all these dimensions of the data.

The dynamics of output and debt are endogenous outcomes of underlying shocks and economic frictions in the data. To interpret the empirical findings, we generate simulated series of debt and output using a standard small open economy model by Aguiar and Gopinath (2007), in which debt and output endogenously respond to stochastic total factor productivity (TFP)

shocks with no fundamental real or nominal frictions. To explore the dynamic relationship between output and debt, we conduct a vector autoregression (VAR) analysis on output and debt in model-simulated data and actual data for developed and developing countries. The model has only one form of debt—that is total debt. However, there are many relevant debt statistics in the actual data, which allow us to investigate debt taken on by various economic sectors and financed from different sources.

We document two puzzling empirical findings that contrast with what is predicted by the baseline model. First, developing countries' total debt falls below the initial level for several years after a positive output shock, while the model predicts a debt expansion. Second, output declines for several years in both developed and developing countries after a debt shock, while the model predicts sustained higher output.

When dissecting the data further, we find that (i) an output shock decreases public debt, but increases private debt—household and firm debt, in both groups of countries; (ii) a shock to private debt suppresses future output, with a shock to firm debt lowering future output and with a shock to household debt leading to a short-term boom followed by a medium-term slump, particularly in developing countries; (iii) a shock to public debt decreases (increases) future output in developed (developing) countries, although the relationship is not significant; (iv) a shock to foreign debt suppresses future output more than a shock to domestic debt in both groups of countries; and (v) the negative impact on output from a shock to household, firm or foreign debt is more pronounced in countries with a fixed exchange rate regime than in those with a floating exchange rate regime.

To guide the empirical investigation, we start by analyzing the dynamic relationship between debt and output in an international business cycles model built by Aguiar and Gopinath (2007). Their model features stochastic shocks that are primarily permanent on TFP trends in emerging markets, but largely transitory on TFP levels in developed countries. We study the endogenous dynamics of debt and output driven by estimated TFP shocks in this model with no other fundamental frictions. The model provides two key implications. One is that a positive output shock today reduces subsequent debt-to-output ratios in developed countries, but it increases subsequent debt-to-output ratios in developing countries. The other is that an increase in debt today is associated with higher subsequent output in both groups of countries.

The intuition for these model-implied relations is straightforward. Output growth in developed countries is driven mainly by transitory shocks, which induce savings to smooth consumption over a temporary windfall and thus reduce debt. In contrast, output growth in developing countries is driven primarily by permanent trend shocks, which boost borrowing against a higher permanent income and thus expand debt. In developed countries, debt growth is likely to be driven by a negative transitory TFP shock, which implies higher subsequent output due to the

3

mean reversion of the transitory shock. In developing countries, debt growth is driven by a positive trend shock, which leads to higher subsequent output. The model-implied relationship between debt and output provides a useful benchmark for the empirical findings.

We next study empirically the relationship between debt and output in a panel of 72 countries over the period 1970–2014, using a panel VAR on output and the debt-to-lagged-output ratios. We dissect total debt data by indebted economic sectors (households, firms, and governments) and by sources of financing (domestic and external). To shed light on the mechanisms of the results, we examine countries with varying degrees of economic development (developed and developing economies) and different exchange rate regimes (fixed and flexible). We also investigate the impact of credit booms on the dynamics of consumption and investment.

We find strikingly different relations between debt and output in the data from those in the baseline model. In the data, in response to a positive output shock, total debt declines in the beginning for two years and then rises gradually, but it remains below the pre-shock level for six years in both developed and developing countries. The absence of debt expansion after an output shock in developing countries is particularly puzzling when considered relative to what is predicted by the baseline model. In response to a debt shock, output declines persistently in both groups, and the decline is much larger in developed countries than in developing countries. For a one-percentage-point increase in the ratio of total debt and output, the peak magnitude of the output reduction is 0.16 percent in developed countries and 0.05 percent in developing countries. This empirical pattern is the opposite of what is expected according to the baseline model, where the debt shock is associated with subsequent output growth.

We then examine relations between output and debt taken on by various economic sectors and find that the relations differ substantially by sector. In response to a positive output shock, public debt declines, while private debt rises, persistently in both developed and developing countries, although the responses are weak in developing countries. For a one-percent output shock, the ratio of private debt and output rises by 2.8 percentage points in developed countries, but by only 0.6 percentage points in developing countries, and the ratio of public debt and output decreases by 2.5 percentage points in developed countries, but only by 1.2 percentage points in developing countries. Household debt and firm debt—two forms of private debt—rise in response to an output shock in both groups of countries. The magnitude of the increase is larger in developed countries.

How a debt shock is associated with subsequent output also differs greatly across these economic sectors and across country groups. A shock to private debt suppresses future output in both groups of countries. With respect to specific types of private debt, a shock to firm debt lowers subsequent output and a shock to household debt leads to an output boom followed by an output slump in both groups. The negative impact of a firm debt shock on output is larger

4

in developing countries. Also, the output boom due to a shock to household debt is much smaller and short-lived in developing countries, followed by a much larger output decline for many years. By the tenth year after the household debt shock, output in developing countries remains 0.7 percent below the pre-shock level, and the decline is statistically significant at the 95 percent level. Overall, output declines by more in response to a shock to private debt in developing countries than in developed countries.

On the other hand, a shock to public debt tends to decrease (increase) future output persistently in developed (developing) countries, although the coefficients are not significant. This difference in the output responses to a public-debt shock between developed and developing countries explains why a shock to total debt has a weaker negative association with future output, although a shock to private debt—either firm or household debt— has a stronger negative association with future output in developing countries than in developed countries. The empirical findings across economic sectors highlight the importance of modeling both private and public debt concurrently in a quantitative model, which is absent in the baseline model.

Furthermore, we find that the impact of household debt and firm debt on subsequent output differs substantially across different exchange rate regimes. In countries with a floating exchange rate regime, the negative impact of household and firm debt on output is small and insignificant. In countries with a fixed exchange rate regime, however, the negative impact on the medium-term output is large and persistent. By the eighth year after the debt shocks, output remains 0.6 percent below the initial level in response to a one-percentage-point increase in the firm debt to output ratio, and it remains 0.9 percent below the initial level in response to an increase in household debt of the same size. These results suggest that nominal rigidities or constraints on monetary policy might be important for understanding the linkage between expansions of household or firm debt and declines in future output.

Turning to the source of debt financing, we find that a shock to foreign debt tends to suppress future output more than a shock to domestic debt in both groups of countries. Since foreign debt often is denominated in foreign currency, the exchange rate regime matters to a large extent for the implication of holding foreign debt. In countries with a floating exchange rate regime, a shock to either domestic or foreign debt has limited impacts on future output, just as a shock to household or firm debt. However, in countries with a fixed exchange rate regime, a shock to foreign debt significantly lowers future output for a sustained period of time. By the tenth year after the shock, output remains 0.22 percent below trend, in response to a one-percentage-point increase in the foreign-debt-to-output ratio.

Lastly, we investigate the impact of credit booms to the subsequent consumption and investment. In both groups of countries, a shock to household debt is the driving force behind the dynamics of consumption and investment: after the household debt shock, both consump-

tion and investment experience an initial boom followed by a sustained slump. Quantitatively, the booms are small, short-lived, and insignificant, but the subsequent declines are large and significant in developing countries. By contrast, the initial booms are large and persistent, and the subsequent slumps are small in developed countries. Shocks to either firm debt or public debt tend to have only a small, insignificantly negative impact on future consumption and investment in developed countries. Developing countries share similar patterns with one exception. A shock to firm debt reduces subsequent investment substantially: in response to a one-percentage-point increase in the ratio of firm debt and output, the decline in investment is 1.1 percent in the fourth year and remains significantly negative.

There is a large empirical literature on the role of debt in macroeconomic stability and continued growth. These studies have focused on either private sector debt, public sector debt, or external debt, of particular sample groups. We build on this literature by examining a large set of countries with a comprehensive set of debt statistics. Reinhart and Rogoff (2009) illustrate the history of debt, crisis, and growth, and they document that when debt ratios are beyond a certain level, financial crises become more likely and severe. There is a large set of recent studies analyzing the empirical relationship between government debt and economic performance. Reinhart and Rogoff (2010) find that countries with public debt over 90% of GDP experience notably slower growth.[1] Several papers (Cecchetti et al. 2011; Cecherita-Westphal and Rother 2012; Baum et al. 2013; Panizza and Presbitero 2014; Kumar and Woo 2015) have estimated versions of the dynamic growth model to alleviate omitted variable bias and concerns of reverse causality and find mixed evidence of the threshold effect.

Concerns with the growth of private sector debt have emerged more recently. Using the historical data constructed by Schularick and Taylor (2012) for advanced economies, Jorda et al. (2013) show a systematic link between private sector credit booms, financial crises, and slow growth. While household debt booms and busts in advanced economies have attracted much attention since the Great Recession, the buildup of corporate debt in emerging markets, notably China, is now raising concerns. Cecchetti et al. (2011) study 18 OECD countries from 1980 and 2010 and find that beyond a certain level, corporate debt is a significant drag on growth, while the estimates for household debt are insignificant. In contrast, the recent work by Mian et al. (2017) shows that an increase in the household-debt-to-GDP ratio predicts lower GDP growth in the medium run for an unbalanced panel of 30 countries over the period 1960–2012. In their

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[1]This finding inspired extensive follow-up studies that provide mixed results. Cecchetti et al. (2011), Padoan et al. (2012), Cecherita-Westphal and Rother (2012), and Baum et al. (2013) confirmed this finding for similar sets of countries. Nevertheless, Caner et al. (2010), Elmeskov and Sutherland (2012), Baglan and Yoldas (2016), Eberhardt and Presbitero (2015), Herndon et al. (2013), Pescatori et al. (2014), and Egert (2015) showed that finding a negative non-linear relationship is extremely difficult and sensitive to modeling choices and data coverage.

study, the growth in corporate debt does not imply a slower rate of output. Park et al. (2018) extend Mian et al. (2017) to include emerging market countries. Bernardini and Forni (2017) study a sample of emerging economies and find that both private debt buildup and public debt buildup exacerbate the duration and intensity of recessions.

A related literature has focused on the role of external debt in growth, particularly among developing countries. The Asian financial crisis in 1997–98 and sovereign debt crisis of Latin American countries in the 1980s have attracted a large deal of attention to the potentially adverse implications of external debt. Patillo et al. (2002) show that for a country with average indebtedness, doubling the external debt ratio would lower annual growth by between 0.5 and 1 percentage point. Similarly, Chowdhury (2001) finds that the negative relationship between external debt and growth holds for both heavily indebted poor countries (HIPC) and non-HIPC. Several other studies find mixed results. Lin and Sosin (2001) find a strongly negative relationship between external debt and growth in African countries, but no statistically significant relationship in Latin American and Asian countries. Changyong et al. (2012) find that the impact of foreign debt on economic growth depends on the degree that debt is transformed into investment. Using Pakistan as a case study, Ramzan and Ahmad (2014) find that external debt has a negative impact on economic growth, but this negative effect can be reduced, or even reversed, in the presence of sound macroeconomic policy.

The remainder of the paper is organized as follows. In Section 2, we lay out the baseline model and present key model mechanisms. In Section 3, we describe data sources and summarize the key features of the data. In Section 4, we discuss the findings from the empirical analysis we conducted to study the dynamic relationship between debt and output. Finally, we present our conclusions in Section 5.

2 Baseline Model

We need to organize our empirical investigation of the relationship between debt and output. To do so, we first analyze this relationship as implied by a standard international business cycles model. Specifically, we select the model framework in Aguiar and Gopinath (2007) for two main reasons. First, the model is a workhorse small open economy model, featuring stochastic TFP shocks as the driving force for both output and debt dynamics. Second, the model is successful in replicating distinct features of business cycles in developed and developing countries with estimated TFP shock differences across these two groups. Specifically, shocks are primarily permanent on TFP trends in emerging markets, but largely transitory on TFP levels in developed countries. Thus, this model offers us an opportunity to study the endogenous dynamics of debt and output growth under empirically relevant TFP shocks without other

fundamental frictions. The model-implied relationship between debt and output will provide a useful guide when we examine and interpret the empirical findings.

We now lay out the key ingredients of the model. The production function is Cobb-Douglas in capital K_t and labor L_t:

$$Y_t = e^{z_t} K_t^{1-\alpha} \left(\Gamma_t L_t\right)^{\alpha},$$

where α is labor's share of output Y_t. There are two productivity processes—z_t and Γ_t—with different stochastic properties. The transitory shock z_t follows a first order autoregressive, or AR(1), process

$$z_t = \rho_z z_{t-1} + \epsilon_t^z,$$

where ρ_z is the persistence parameter, and ϵ_t^z is independently and identically drawn from a normal distribution with mean zero and standard deviation σ_z. Γ_t is the cumulative product of the growth rate shocks: $\Gamma_t = e^{g_t} \Gamma_{t-1} = \Pi_{s=0}^t e^{g_s}$, and g_t follows an AR(1) process

$$g_t = (1 - \rho_g)\mu_g + \rho_g g_{t-1} + \epsilon_t^g,$$

where ρ_g is the persistence parameter, μ_g is the unconditional mean, and ϵ_t^g is independently and identically drawn from a normal distribution with mean zero and standard deviation σ_g. We normalize nonstationary variables X_t by Γ_{t-1}, and denote detrended variables by $x_t = \frac{X_t}{\Gamma_{t-1}}$.

In detrended form, the representative agent's problem can be written recursively as follows:

$$V(k, b, z, g) = \max_{c, L, k', b'} \left\{ \frac{\left(c^{\gamma}(1 - L)^{1-\gamma}\right)^{1-\sigma}}{1 - \sigma} + \beta e^{e\gamma(1-\sigma)} EV(k', b', z', g') \right\},$$

subject to

$$c + e^g k' = e^{z+g\alpha} k^{1-\alpha} L^{\alpha} + (1 - \delta)k - \frac{\phi}{2}\left(\frac{e^g k'}{k} - e^{\mu_g}\right)^2 k - b + q e^g b'.$$

Consumption is denoted by c, and the level of outstanding debt is given by b. β is the discount factor, σ is the risk aversion parameter, γ is the consumption exponent in utility, and q is the price of debt.[2] Capital depreciates at the rate δ, and adjustments incur a quadratic cost given by the third term on the right-hand side of the constraint, where ϕ is the cost parameter.

We use the parameter values estimated by Aguiar and Gopinath (2007). Table 1 summarizes

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[2]The price of debt takes the form used in Schmitt-Grohe and Uribe (2003):

$$1/q = 1 + r^{\star} + \psi \left[\exp\left(b' - b\right) - 1\right],$$

where $r^{\star}$ is the world interest rate, b is the steady-state level of debt, and ψ captures the elasticity of the interest rate to changes in debt levels. In choosing b', the representative agent does not internalize the upward-sloping supply schedule. This feature is introduced to make assets in the linearized model stationary. Quantitatively ψ is set close to zero so that the short-run responses are unaffected by this schedule.

the parameter values at the quarterly frequency. The non-productivity parameters are standard in the literature and common across developed and developing countries. For the productivity process, the baseline estimation sets μ_g, ρ_g, and ρ_z to be the same across the two groups and estimates σ_g and σ_z using generalized method of moments (GMM). The estimated σ_g is higher in developing countries than in developed countries: 2.81 versus 0.88. The estimated σ_z is higher in developed countries than in developing countries: 0.78 versus 0.48. Thus, shocks to trend growth are the primary source of fluctuations in emerging markets, while both transitory and trend fluctuations characterize developed countries.
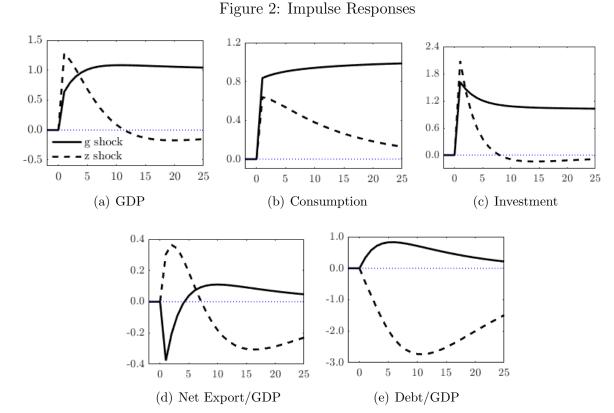
Table 1: Parameter Values

Common non-TFP parameter			TFP parameter	Developed	Developing
Discount factor	β	0.98	μ_g	1.006	1.006
Risk aversion	σ	2.00	ρ_g	0.01	0.01
Consumption exponent	γ	0.36	ρ_z	0.95	0.95
Labor exponent	α	0.68	σ_g	0.88	2.81
Depreciation rate	δ	0.05	σ_z	0.78	0.48
Capital adjustment cost	ϕ	4.00			
Interest premium coefficient	ψ	0.001			

Note: The steady-state debt-GDP ratio b is set at 0.1, which does not affect the results.

The main contribution of Aguiar and Gopinath (2007) is to demonstrate that the differences in the TFP shock process between developed and developing countries can account for two distinct features of business cycles across these two groups of countries. One is that the trade balance is more countercyclical in emerging markets than in developed countries. The other is that consumption is more volatile than output in emerging markets while consumption is slightly less volatile than output in developed countries. The intuition of these results can be illustrated by Figure 2, which contrasts the impulse responses of key model variables following a one percent growth shock (solid lines) with those following a one percent transitory shock (dashed lines) in the first quarter. We plot the impulse responses at the annual frequency by aggregating across four quarters, to be consistent with subsequent empirical work in which data on debt statistics are available only annually.

Panel (a) of Figure 2 shows that the representative agent expects a boost to current output and an even larger boost to future output following a growth shock, but she expects only a temporary boost to output following a transitory shock. The permanent income hypothesis implies that consumption jumps up substantially on impact and continues to rise to the new steady state in response to a growth shock, but it rises moderately on impact and then gradually declines back to the initial steady state in response to a transitory shock, which is shown in panel (b). Investment responds more in the short run to a transitory shock than to a growth shock, as shown in panel (c). As shown in panel (d), following a growth shock, the trade

Figure 2: Impulse Responses

(a) GDP (b) Consumption (c) Investment

(d) Net Export/GDP (e) Debt/GDP

Note: The figure shows the impulse response of output, consumption, investment, net export to GDP, and debt to GDP in response to a one percent shock to ϵ^g (solid line) and ϵ_z (dashed line). The values plotted are deviations from the steady state.
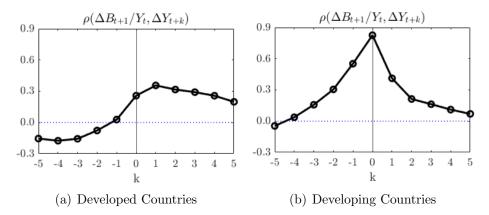
balance turns negative (i.e., there is a trade deficit) to accommodate the boost in consumption and investment in the short run. In contrast, a transitory shock generates a trade surplus in the short run as the country is smoothing the transitory income shock. Hence, in response to a growth shock, the trade balance is strongly countercyclical on impact, and consumption responds more than output in the short run, implying a larger consumption volatility than that of output. The opposite is true in the case of a transitory shock: consumption is less volatile than output, and the trade balance is procyclical. Given that the growth shock is more (less) important in developing (developed) countries, the model successfully replicates the distinct features of business cycles in the two groups.

Our focus is on the joint dynamics of debt and growth, so we extend their analysis to debt dynamics across the two groups of countries. Panel (e) of Figure 2 plots the impulse responses of the debt-to-output ratio $\frac{B_{t+1}}{Y_t}$ in terms of percentage differences from the initial steady state. In response to a growth shock, the debt-to-output ratio rises as the country borrows and the trade balance quickly deteriorates, resulting in a trade deficit in the first five years, and then the debt-to-output ratio gradually declines as the trade balance improves, resulting in a trade surplus. In contrast, in response to a transitory shock, the debt-to-output ratio declines substantially

10

in the short run as the country saves and the trade balance improves dramatically, resulting in a trade surplus in the first eight years, and then the debt-to-output ratio rises as the trade balance deteriorates, resulting in a trade deficit. The striking difference in debt dynamics in response to the growth and transitory shocks drives the different patterns of the joint dynamics of debt and output between developed and developing countries, which we turn to next.

Figure 3 presents the cross-correlation between changes in the debt-to-output ratio and output growth in the model simulations. Panel (a) illustrates the patterns for developed countries, and panel (b) illustrates those for developing countries. The correlations between changes in the debt-to-output ratio $\Delta \frac{B_{t+1}}{Y_t}$ and output growth $\Delta \ln Y_{t+k}$ are plotted for different $k = -5, -4, ..., 4, 5$. When $k = 0$, both groups display a positive contemporaneous correlation, but the correlation is much larger in developing countries than in developed countries. That is, when the output growth rate is high, the debt-to-output ratio increases in both groups. Moreover, the debt-to-output ratio rises by substantially more in developing countries because they are more likely to experience a growth shock, which implies larger trade deficits.

Figure 3: Cross-Correlations between Debt and Growth

(a) Developed Countries (b) Developing Countries

Note: The figure shows the cross-correlation between changes in the debt-to-output ratio $(\Delta \frac{B_{t+1}}{Y_t})$ and output growth $(\Delta \ln Y_{t+k})$ for different $k = -5, -4, ..., 4, 5$, computed from the model simulations.

When $k < 0$, the cross-correlation tells how past output growth relates to the current debt-to-output ratio. In developed countries, these correlations are negative up to $k = -1$. That is, developed countries that experienced faster growth three years ago are likely to have a lower debt-to-output ratio today. In developing countries, these correlations are generally positive, implying that such countries that experienced faster growth three years ago are likely to have a higher debt-to-output ratio today. This is consistent with the impulse responses of output and debt in Figure 2. Output growth in developed countries is driven mainly by positive, transitory shocks, which lead to declines in subsequent debt-to-output ratios for several years. In contrast, output growth in developing countries is driven primarily by positive growth shocks,

11

which generates higher debt-to-output ratios in the next five years.

When $k > 0$, the cross-correlation tells how an increase in the debt-to-output ratio today relates to subsequent future output growth. In developed countries, the correlations peak after one year and then decline afterwards, but they remain positive. That is, countries that experienced an increase in debt are likely to have faster growth in the coming several years. A similar pattern shows up for developing countries, although their correlations peak at $k = 0$. This is consistent with the impulse responses of output and debt in Figure 2. In developed countries, a high debt-to-output ratio today is likely the result of a recent negative transitory TFP shock, which leads to borrowing to smooth consumption. The mean reversion of the transitory shock implies that growth is likely to pick up in the following years. In developing countries, a high debt-to-output ratio today is likely to be the result of a recent high growth rate shock, which induces borrowing and a trade deficit. On the one hand, because output continues to grow in response to a positive growth shock for several periods, output growth is likely to be high in subsequent periods, implying a positive correlation. On the other hand, the growth shock has low persistence, so the correlation drops quickly, compared with the case for developed countries.

We conclude this section by summarizing the key implications of the quantitative small open economy model by Aguiar and Gopinath (2007) for the joint dynamics of output and debt in developed and developing countries. Contemporaneously, the debt-to-output ratio and output growth are positively correlated in both groups of countries, and the correlation is larger in developing countries than in developed ones. If they experienced faster output growth several years ago, developed countries are likely to have a lower debt-to-output ratio today, while developing countries are likely to have a higher debt-to-output ratio today. If they experience an increase in debt today, both developed and developing countries are likely to have faster growth over the coming years. These theoretical predictions informed and helped guide our empirical investigation on the relationship between debt and output.

3   Data

This section describes the data for the empirical investigation of the relationship between debt and output. The baseline model is stylized with only one form of debt for the economy. In the actual data, however, there are many relevant debt statistics, in addition to total debt of the economy. For instance, we have debt statistics according to the sector taking on the debt—namely, private debt and public debt, which are debt issued by the private sector and the public sector, respectively. Within the private debt category, the data are further classified as debt taken on by households and firms separately. There are also debt statistics according

to the source of financing—that is, domestic debt and foreign debt, which are debt financed from domestic creditors and external creditors.

We study all these forms of debt in the empirical investigation for two reasons. First, it is important to understand whether these types of debt relate to output growth in similar ways. For example, does private debt respond to an output shock similarly as public debt, and does future output respond to a private debt shock similarly as a public debt shock? Second, it is useful to test whether the model captures the behavior of a certain type of debt in the data. Is it household debt or firm debt that responds to an output shock and impacts future output in a way consistent with the model?

To examine the empirical relationship between debt and output, we collected a large panel data set of 72 countries over the period 1970-2014. Specifically, we have 21 developed countries and 51 developing countries.[3] For macroeconomic variables, we collect data on real GDP and its components from the *World Development Indicators* database by the World Bank. For debt statistics, we retrieve series of total debt, private debt, and public debt from the IMF's *Global Debt Database* and *Historical Public Debt Database*. Total debt is the sum of private debt and public debt. Private debt is the total stock of loans and debt securities issued by households and non-financial corporations. Public debt is gross debt issued by the public sector. For a smaller sample of 56 countries, we have household debt and firm debt separately, but the coverage is unbalanced over time. Most developed countries have full coverage, while most developing countries start in the mid-1990s. We also collect data on foreign debt, which is defined as net debt financed by foreigners using the 2016 update of the *External Wealth of Nations Mark II* database by Lane and Milesi-Ferretti (2007). The difference between total debt and foreign debt gives us a proxy for the debt financed by domestic agents, which we refer to as domestic debt.

We report the summary of debt statistics as a percentage of lagged GDP in the left panel of Table 2 for the samples of the developed and developing countries. The developed countries on average have double the total debt of the developing countries: the total-debt-to-GDP ratio is 188 percent in the developed countries and only 91 percent in the developing countries. The private sector borrows substantially more in the developed countries (with a private-debt-to-GDP ratio of 130 percent) than in the developing countries (47 percent). A similar pattern shows up for both households and firms. The household-debt-to-GDP ratio is on average 56 percent in the developed countries, but only 22 percent in the developing countries. The firm-debt-to-GDP ratio is 83 percent in the developed countries, but only 48 percent in the developing countries. This is not surprising given that the degree of financial development—often measured by the ratio of private debt and GDP—is highly correlated with income. The ratio of public

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[3]The list of countries is described in the Appendix, Table A1.

Table 2: Summary of GDP and Debt/GDP, Percent

	level			one-year change		
	mean	median	std.	mean	median	std.
Developed Countries						
GDP				1.84	1.97	2.47
Total Debt/GDP	187.95	183.50	64.32	3.78	3.51	8.01
Public Debt/GDP	57.47	51.41	34.10	1.31	0.72	4.92
Private Debt/GDP	129.94	123.29	50.29	2.39	2.04	6.33
Household Debt/GDP	56.13	52.97	26.67	1.30	1.17	2.74
Firm Debt/GDP	83.43	81.38	30.40	1.25	0.81	5.36
Domestic Debt/GDP	178.11	162.73	79.88	3.57	3.41	11.60
Foreign Debt/GDP	9.84	11.08	41.05	0.27	0.08	8.88
Developing Countries						
GDP				2.34	2.78	5.17
Total Debt/GDP	91.02	82.30	46.03	1.87	1.56	10.12
Public Debt/GDP	44.12	39.03	29.41	0.45	0.05	8.20
Private Debt/GDP	47.07	34.63	36.50	1.36	1.06	6.11
Household Debt/GDP	21.79	16.73	17.67	1.02	0.72	2.73
Firm Debt/GDP	48.16	41.68	27.96	1.18	1.05	5.06
Domestic Debt/GDP	78.00	60.51	67.15	1.75	1.26	13.12
Foreign Debt/GDP	13.01	20.96	53.98	0.07	0.05	10.89

debt and GDP for developed countries (57 percent) is larger than that for developing countries (44 percent), but this difference is much smaller than the difference between their the private-debt-to-GDP ratios. Thus, the public sector accounts for a disproportionately larger share of total debt in the developing countries than in the developed countries.

With respect to the credit statistics, our data show that domestic debt is much larger in the developed countries than in the developing countries, while the foreign-debt-to-GDP ratio is higher in the developing countries than in the developed countries. Given their smaller magnitude of total debt to GDP, the developing countries disproportionately finance their total debt using external resources relative to the developed countries.

The right panel of Table 2 reports the summary statistics for annual GDP growth and changes in debt-to-output ratios.[4] The mean and median annual GDP growth rates are 1.84% and 1.97%, respectively, for the developed countries. The mean and median annual growth rates for the developing countries are higher at 2.34% and 2.78%, respectively. The standard deviation in GDP growth is also much larger in the developing countries than in the developed countries: 5.17 versus 2.47.

In the developed countries, household, firm, and public debt as a share of GDP have been rising at a similar rate of 1.3 percentage points per year on average. The average one-year

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[4]GDP growth is measured by the percent change in log real GDP. Changes in debt ratios are measured by the percentage-point difference in debt/GDP ratios.

changes for household and firm debt as a share of GDP are slightly lower in the developing countries than in the developed countries. The public-debt-to-GDP ratio increases much more slowly in the developing countries than in the developed countries: on average 0.5 versus 1.3 percentage points. Thus, total debt as a share of GDP has been growing much faster in developed countries than in the developing countries: on average 3.78 versus 1.87 percentage points. The average one-year change in the foreign-debt-to-GDP ratio is low (0.3 percentage points in the developed countries and 0.1 percentage points in the developing countries). As for the volatility of debt changes, the public-debt-to-GDP ratio in the developing countries is more volatile than that in the developed countries: 8.20 versus 4.92 standard deviations. The standard deviations are similar across the two groups for private debt and its components (household and firm debt).

4 Empirical Findings

In this section, we discuss the findings from our empirical investigation on the relationship between debt and output in developed and developing countries using a vector autoregression analysis. To be upfront, the analysis is not intended to identify causal patterns. The VAR is commonly used to uncover the full dynamic relations between multiple time series in the empirical literature. Specifically, we estimate a VAR in log real GDP and the debt-to-GDP ratios.

For debt statistics, we focus on not only total debt, but also debt taken on by different sectors (households, firms, and governments) and financed from different sources (domestic and foreign creditors). Debt statistics are normalized by one-year lagged GDP instead of current GDP to avoid capturing innovations to GDP in the debt equations. The structural shocks are identified through a Cholesky decomposition, with log real GDP ordered first. The lag orders are set to be five.[5] We run a panel VAR with country fixed effects for developed and developing countries separately. Following Mian et al. (2017), we employ an iterative bootstrap procedure to correct for potential Nickell bias from the inclusion of country fixed effects. To construct confidence intervals, we use bootstrap methods using resampling based on the bias-corrected estimates.

We also conduct the same analysis on model-simulated data and contrast model-implied relations with empirical relations between debt and output. To be specific, we generate two sets of simulated series of log output and the debt-to-output ratio at the annual frequency using the calibrations for developed countries and for developing countries. Then we estimate a VAR model with $(\log(Y_t), B_t/Y_{t-1})$ on each set of simulated data. The comparisons between the
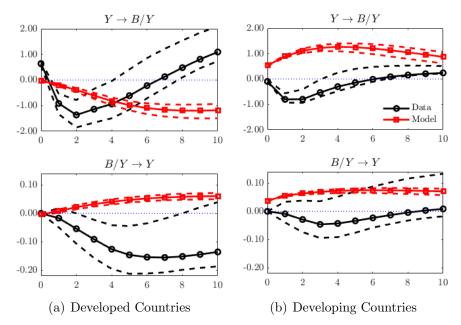
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[5]The results are not sensitive to the choice of the lag order or to the ordering of the variables.

model-implied and empirical relations offer insights on mechanisms underlying the empirical relations.

4.1 Total Debt and Output

Our aim is to study the relationship between total debt and output. Figure 4 presents the impulse responses from the VAR model with output and the total-debt-to-GDP ratio. Dashed lines around the impulse responses are 95% confidence intervals computed with the bias-corrected bootstrap. Both panels on the left are for developed countries, and both panels on the right are for developing countries. In each panel, the red lines with squares are for the model simulations, and the black lines with circles are for the data. The panels in the top row plot the impulse responses of the total-debt-to-output ratio (in percentage points) to a one-percent positive shock to output, and the panels in the bottom row plot the impulse responses of output (in percent) to a positive shock to the total-debt-to-output ratio by one percentage point.

Figure 4: Impulse Responses: Total Debt and Output

(a) Developed Countries   (b) Developing Countries

Notes: The figure presents impulse responses from a two-variable VAR in log real GDP and the ratio of total debt and GDP, estimated in the data and in the model. The solid lines are the responses to a one-percent shock in each variable, and the dashed lines are 95% confidence intervals computed with the bias-corrected bootstrap.

Let's first look at the responses of total debt to a positive output shock. In the baseline model, total debt persistently declines for many years in developed countries, while it rises above the initial level for many years in developing countries. These patterns are the result of the model mechanisms. A positive transitory shock that boosts output induces saving to smooth consumption and reduces total debt for many years in the simulated developed countries. In

16

contrast, a positive growth rate shock that boosts output leads to an increase in debt on impact and in subsequent years in the simulated developing countries. In the data, total debt declines briefly for two years and then rises above the initial level in five years after the income shock in both groups of countries. The peak reduction in the debt-to-output ratio is larger in developed countries than in developing countries: 1.4 versus 0.9 percentage points.

We next look at the output responses to a positive shock to the total-debt-to-output ratio. The baseline model implies that in response to a debt shock, output rises by a similar magnitude for many years in developing and developed countries, as shown by the red lines with squares. This is consistent with the positive cross-correlations between $\frac{B_{t+1}}{Y_t}$ and ΔY_{t+k} when k is positive, shown in section 2. The data presents different patterns from those of the baseline model. In both groups of countries, an increase in the debt-to-output ratio leads to a persistent decline in output. However, the persistence and the magnitude of the decline are much greater in developed countries than in developing countries. At the peak, the decline in output is 0.16 percent in developed countries and only 0.05 percent in developing countries. By the tenth year after the debt shock, output is still below trend by about 0.14 percent in developed countries, but it returns to the level before the debt shock in developing countries. Although the 95% confidence bands are relatively wide, the negative impact of an increase in debt on output is statistically significant between the second year to eighth year in developed countries.

In sum, the empirical relations between debt and output present two striking patterns that are different from the predictions by the baseline model. The first difference is that after an increase in debt in both groups of countries, the model implies a persistent increase in output, while the data shows a persistent decline in output, particularly in developed countries. The other difference is that after a positive income shock in developing countries, the model predicts a persistent rise in the debt-to-output ratio, but the data shows a persistent reduction of debt. These discrepancies between the empirical findings and the predictions made by a frictionless model illustrate the importance of frictions in the real world absent in the baseline model.

4.2 Public Debt, Private Debt, and Output

Total economy-wide debt is the sum of debt in the private sector and in the public, or government, sector. To understand the behavior of total debt, we examine the behavior of its components. Specifically, we explore the relations between output, public debt, and private debt in a three-variable VAR regression. The impulse responses of private and public debt to a positive output shock are plotted in the top row panels of Figure 5. The impulse responses of output to a positive shock to either private or public debt are plotted in the bottom panels of Figure 5.

In response to an income shock, both groups of countries experience a persistent increase
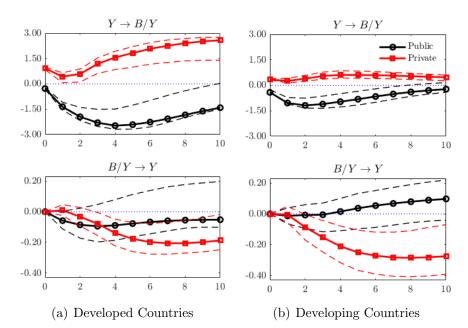
Figure 5: Impulse Responses: Public Debt, Private Debt, and Output

(a) Developed Countries   (b) Developing Countries

Notes: The figure presents impulse responses from a three-variable VAR in log real GDP, the public-debt-to-GDP ratio, and the private-debt-to-GDP ratio. The solid lines are the responses to a one-percent shock in each variable, and the dashed lines are 95% confidence intervals computed with the bias-corrected bootstrap.

in private debt and a persistent decline in public debt. The magnitudes of the debt responses, however, are much larger in developed countries than in developing countries for both private and public debt. In response to a one percent output shock, the ratio of private debt to output rises as much as about 2.8 percentage points in developed countries, but it rises only about 0.6 percentage points in developing countries. The public-debt-to-output ratio declines by 2.5 percentage points in developed countries, but by only 1.2 percentage points in developing countries. As shown in the previous section, private debt accounts for a larger share of total debt than public debt in developed countries, while in developing countries private and public debt are of a similar magnitude. This composition difference, together with the dynamics of each type of debt, accounts for the responses of total debt to an output shock.

In response to a private debt shock, output declines substantially in both groups of countries. The declines in the third year following the shock are statistically significant, and the magnitude of the declines is substantial, particularly in developing countries. Output is down by 0.27 percent in developing countries and by 0.20 percent in developed countries in the sixth year after the shock. In response to a public debt shock, output declines in developed countries, but it rises in developing countries. That said, the confidence bands of output's responses to the public debt shock are wide and the responses are not statistically significant. This difference in the output responses to a public-debt shock between developed and developing

18

countries explains why a shock to total debt has a weaker negative association with future output, although a shock to private debteither firm or household debt has a stronger negative association with future output in developing countries than in developed countries.

These findings illustrate two striking differences between private debt and public debt. First, in response to an output shock, public debt declines while private debt increases in both groups of countries. Second, an increase in private debt substantially decreases future output in both groups, while an increase in public debt tends to increase future output in developing countries. Thus, it is important to differentiate the source of a debt shock: it is a shock to private debt, not public debt, that significantly and negatively impacts the medium-term output in both groups of countries.

The empirical findings across economic sectors highlight the importance of modeling both private and public debt concurrently in a quantitative model, which is absent in the baseline model. The systematic interactions between public and private debt across the two groups of countries are the key to understanding the dynamics of total debt. Most existing theories in the literature focus on either type of debt or total debt. Kim and Zhang (2020) make some progress by documenting and rationalizing the patterns of capital inflows to private and public sectors in developed and developing countries.

4.3   Household Debt, Firm Debt, and Output

We further explore the two primary subcategories of private debt: household debt and firm debt. We run a three-variable VAR regression of output, firm debt, and household debt for developed and developing countries, and plot the impulse responses in Figure 6. In response to an output shock, firm and household debt rise in both groups of countries. Firm debt has a larger response to the output shock than household debt in developed countries, and both forms of debt respond similarly in developing countries. In response to a firm debt shock, output tends to be persistently below the initial level in developing countries. The negative impact of firm debt on output is relatively small in developed countries. In response to a household debt shock, output rises for several years and then falls below the initial level after five years in developed countries. The impact of a household debt shock on output is mainly negative in developing countries. The magnitude of output declines is larger and more significant in developing countries than in developed countries.

Theories that link credit booms to lower subsequent growth rely on frictions, such as financial frictions, nominal rigidities, or constraints on monetary policy. Examples include Curdia and Woodford (2010), Eggertsson and Krugman (2012), Martin and Philippon (2017), Farhi and Werning (2016), Korinek and Simsek (2016), Schmitt-Grohé and Uribe (2016), and Guerrieri and Lorenzoni (2017). In these works, constraints, frictions, or rigidities exacerbate negative
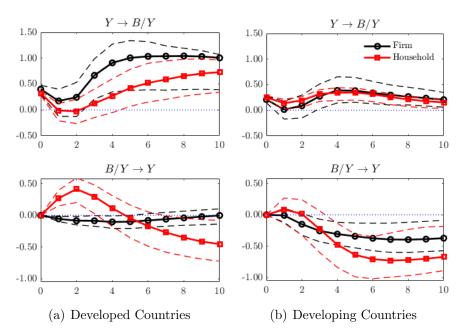
19

Figure 6: Impulse Responses: Household Debt, Firm Debt, and Output

(a) Developed Countries   (b) Developing Countries

Notes: The figure presents impulse responses from a three-variable VAR in log real GDP, the ratio of firm debt to GDP, and the ratio of household debt to GDP. The solid lines are the responses to a one-percent shock in each variable, and the dashed lines are 95% confidence intervals computed with the bias-corrected bootstrap.

shocks and lead to adverse outcomes in economic growth, when debt expansions or credit booms stall. To shed light on these mechanisms, we study the relations of household and firm debt with output across exchange rate regimes of different rigidities, which broadly captures the macroeconomic rigidities across countries.

We look at countries with a fixed exchange rate regime versus a floating exchange rate regime. We divide the sample into fixed and floating exchange rate regimes based on the *de facto* exchange rate regime from Reinhart and Rogoff (2004), which was updated in Ilzetzki et al. (2017). "Fixed regimes" are regimes with no separate legal tender, currency boards, pegs, and narrowly defined horizontal bands (coarse ERA code 1 from Ilzetzki et al., 2017). "Floating regimes" are regimes with widely defined horizontal bands, crawling pegs, crawling bands, moving bands, managed floats, and freely floating regimes (coarse ERA codes 2 to 4). We classify countries in the fixed or floating exchange regime according to their average ERA codes. We conduct the VAR analysis for these two samples by exchange rate regime.

Figure 7 reports the impulse responses by exchange rate regime for the VAR with output, household debt and firm debt. View the results for the countries with floating exchange rate regimes in the panels on the left. A positive output shock reduces both the household-debt-to-output ratio and the firm-debt-to-output ratio—significantly so for up to four years. An increase in firm debt barely changes future output, and an increase in household debt leads to
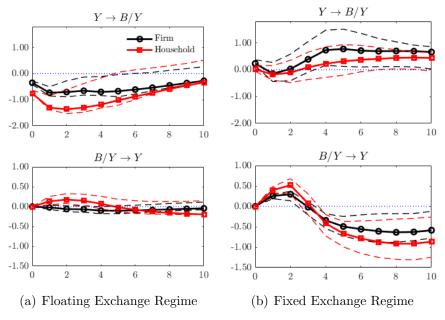
Figure 7: Impulse Responses across Exchange Rate Regimes:
Household Debt, Firm Debt, and Output

(a) Floating Exchange Regime (b) Fixed Exchange Regime

Notes: The figure presents impulse responses from a three-variable VAR in log real GDP, the ratio of firm debt to GDP, and the ratio of household debt to GDP. The solid lines are the responses to a one-percent shock in each variable, and the dashed lines are 95% confidence intervals computed with the bias-corrected bootstrap.

a small increase in output up to four to five years. The patterns are strikingly different for the countries with fixed exchange rate regimes, whose results are plotted in the panels on the right. An increase in output tends to increase household and firm debt. An increase in household and firm debt leads to a short-term boom in output for two to three years, but sustained lower output in the medium term from the fourth year on. The fluctuations in output are especially larger in response to an increase in household debt than to an increase in firm debt.
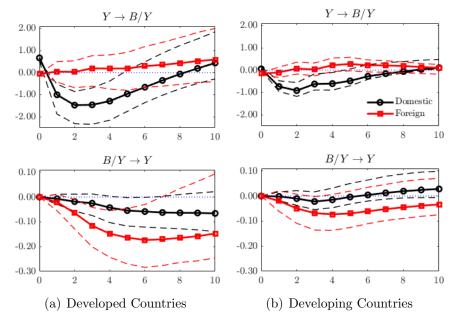
It is interesting to see that the exchange rate regime affects the dynamic relationship between debt and output. Both household debt and firm debt decline in the floating exchange rate countries, but rise in the fixed exchange rate countries, in response to an output shock. In the floating exchange rate countries, we do not observe a significantly negative implication for output from a shock to either household debt or firm debt. By contrast, in the fixed exchange rate countries, a shock to either household debt or firm debt generates large fluctuations in output: output rises in the short term, but declines substantially in the medium term. The short-run output booms and the medium-run output slumps are both statistically significant.

Thus, nominal rigidities captured by fixed exchange rates appear to be an important friction which drives the negative relationship between a shock to either household or firm debt and future output in the data. In contrast, the baseline model, which does not have nominal rigidities or frictions, predicts a positive relationship between a debt shock and future output.

4.4 Foreign Debt and Output

We next investigate whether the source of financing—domestic or external—matters for the dynamic relationship between debt and output. To be more specific, we run the VAR regression with output, domestic debt, and foreign debt. The results are plotted in Figure 8. As shown in the two upper panels, a positive output shock barely changes the foreign-debt-to-output ratio over time in both developed and developing countries. By contrast, a positive output shock lowers the-domestic debt-to-output ratio in both groups in the short and medium run. The magnitude of the decline in the domestic-debt-to-output ratio is substantially larger in developed countries than in developing countries: 1.5 versus 0.9 percentage points.

Figure 8: Impulse Responses: Domestic Debt, Foreign Debt, and Output

(a) Developed Countries (b) Developing Countries

Notes: The figure presents impulse responses from a three-variable VAR in log real GDP, the ratio of domestic debt to GDP, and the ratio of foreign debt to GDP. The solid lines are the responses to a one-percent shock in each variable, and the dashed lines are 95% confidence intervals computed with the bias-corrected bootstrap.

Turning to the two lower panels of Figure 8, we observe that a shock to foreign debt tends to depress subsequent output for many years in both groups of countries. It might not be surprising that a shock to foreign debt is associated with lower future output in developing countries. What is surprising is that output is depressed more substantially in response to a foreign debt shock in the developed countries. The magnitude in the developed countries is more than twice of that in the developing countries: 0.17 versus 0.07 percent.

External debt is often denominated in a foreign currency, which makes the exchange rate regime matter for the implications of debt overhang. High levels of foreign debt in countries with a fixed exchange rate regime exposes those countries to currency crises and severe real

contractions. In general, high levels of domestic debt in fixed exchange rate countries are not associated with these risks. The Asian financial crisis in 1997–1998 is largely the consequence of the private sector's high exposure to foreign debt. The Latin American sovereign debt crisis in the 1980s is an example of the consequence of high external indebtedness in the public sector. We thus explore the relationship between foreign debt and GDP across different exchange rate regimes. The results are plotted in Figure 9.
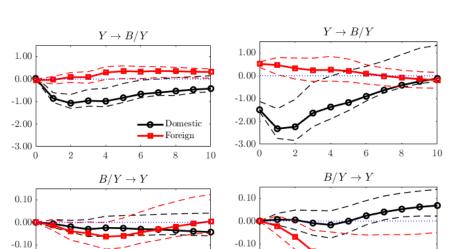
Figure 9: Impulse Responses across Exchange Rate Regimes:
Domestic Debt, Foreign Debt, and Output

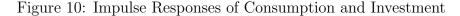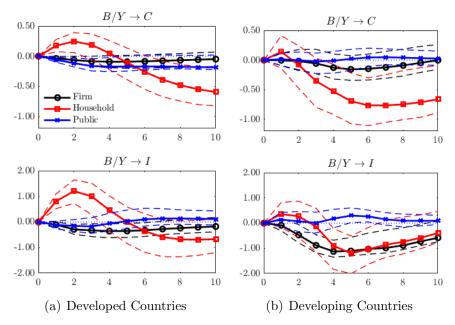(a) Floating Exchange Regime   (b) Fixed Exchange Regime

Note: The figure presents impulse responses from a three-variable VAR in log real GDP, domestic debt to lagged GDP, and net foreign debt to lagged GDP. The solid lines are the responses to one percent shock in each variable, and the dotted lines are 95% confidence interval by the bias-corrected bootstrap.

In response to a positive output shock, domestic debt decreases and foreign debt increases in both the fixed and floating exchange rate (see the two upper panels of Figure 9). The decline in domestic debt is much larger in countries with a fixed exchange rate regime. In the floating exchange rate countries, a shock to either domestic debt or foreign debt has limited impacts on future output, just as a shock to household and firm debt. However, in the fixed exchange rate countries, a shock to foreign debt significantly lowers future output for a sustained period of time. By the tenth year after the shock, output is 0.22 percent lower than the initial level. These different implications of holding foreign and domestic debt across exchange rate regimes show the importance of nominal rigidities or frictions in understanding the negative relationship between a shock to foreign debt and future output.

23

4.5 Further Empirical Analysis

Consumption and investment are two major components of output. In theory, the impact of a debt shock on output works through either the investment channel or the consumption channel.[6] We examine the implications of debt shocks on consumption and investment dynamics and compare the patterns across the developed and developing countries. Specifically, we estimate a VAR in log real consumption (or investment), public debt, firm debt, and household debt. Figure 10 presents the behavior of consumption and investment in response to positive debt shocks.

Figure 10: Impulse Responses of Consumption and Investment

(a) Developed Countries (b) Developing Countries

Notes: The top (bottom) panels present impulse responses from a four-variable VAR in log real consumption (investment), the ratio of public debt to GDP, the ratio of firm debt to GDP, and the ratio of household debt to GDP. The solid lines are the responses to a one-percent shock in each variable, and the dashed lines are 95% confidence intervals computed with the bias-corrected bootstrap.

Let's first look at the responses of developed countries in the panels on the left of Figure 10. A shock to either firm debt or public debt lowers future consumption and investment, but the negative impact tends to be small and statistically insignificant. What moves future consumption and investment is a shock to household debt: countries initially experience consumption and investment booms, and then consumption and investment fall below the trend. The initial consumption and investment booms are significant and persistent for four years. The subsequent consumption declines are also significant, while investment declines are not

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[6]Examples of research on the investment channel include Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Caballero and Krishnamurthy (2003), Lorenzoni (2008), and Brunnermeier and Sannikov (2014). Mian et al. (2013) provide empirical support for this channel for the United States during the Great Recession.

significant.

Let's now switch to the impulse responses of the developing countries in the panels on the right of Figure 10. A public debt shock does not appear to have a negative effect on consumption or investment. Consumption is not significantly affected by a firm debt shock either. Investment, however, declines substantially in response to a firm debt shock. The decline in investment by the fourth year is 1.1 percent and remains significantly negative until the ninth year. The response patterns of consumption and investment in developing countries to a household debt shock are qualitatively similar to those in developed countries: initial booms followed by large declines. Quantitatively, the initial booms are small and not significant, but the subsequent declines are large and significant. The magnitudes of the declines in consumption and investment are substantially larger in developing countries than in developed countries. By the sixth year, consumption drops by 0.77 percent and investment drops by 1.0 percent.

Finally, we conduct robustness analysis on the main empirical findings. First, we check whether our results, particularly for the developed countries, are driven by the Great Recession. Specifically, we limit the sample periods up to 2006 and redo the VAR analysis. While we generally observe qualitatively similar results for developed countries, the estimated coefficients of the VAR models using substantially shorter time-series observations have wider confidence intervals. Second, given the large heterogeneity across the developing countries, we separate the developing sample further into two groups: emerging markets and other developing countries. We find that the impulse responses are similar across emerging markets and other developing countries (see the appendix for further details of our analysis).

5   Conclusion

The global economy is at a record high level of indebtedness. The phenomenon of increasing debt exposure occurs in every economic sector (households, firms, and governments) across the globe. Often the bust of a debt expansion is associated with severe and enduring real contractions, where output growth is depressed for many years. Academic researchers and policymakers are increasingly concerned about the ramifications of the current outstanding debt levels. That said, not all types of debt are created equal. Different types of debt differ in their implications for subsequent output growth, which is thoroughly investigated and documented in this paper for a panel of 72 countries over the period 1970–2014 using VAR analysis. The empirical findings are useful for further academic research and policy studies.

We document two puzzling findings that run counter to predictions made by the baseline model by Aguiar and Gopinath (2007). In their model, debt and output endogenously respond to stochastic TFP shocks without fundamental real or nominal frictions. The first puzzle is that

in developing countries total debt falls below the initial level for several years after a positive output shock, while the model predicts a debt expansion. The other is that output declines persistently in both developed and developing countries after a debt shock, while the model predicts sustained higher output. This negative relationship is stronger for developing countries (than developed countries) and for countries with a fixed exchange regime (than countries with a floating exchange regime). When probing deeply into different categories of total debt, we find systematic differences in the relational patterns between debt and output across economic sectors and financing sources.

These empirical results are broadly consistent with stories of either financial frictions or nominal rigidities in the literature, which are absent in the baseline model. Particularly, these frictions are more pronounced in developing countries or countries with a fixed exchange rate regime. Given the systematic patterns in the relations of output with private and public debt documented in this paper, it is critical to incorporate both public and private debt in a quantitative model in the future analysis of this topic.

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Appendix

A1. Country Coverage

Table A1: List of Sample Countries

	Developed Countries (21)	
Australia	Germany	Norway
Austria	Greece*	Portugal
Belgium	Ireland	Spain
Canada	Italy	Sweden
Denmark	Japan	Switzerland
Finland	Netherlands	United Kingdom
France	New Zealand	United States

	Developing Countries (51)	
Algeria	Guatemala	Philippines*
Argentina*	Hungary*	Poland*
Bahrain	India*	Russian Federation*
Bangladesh	Indonesia*	Saudi Arabia*
Bhutan	Iran	Singapore
Botswana	Israel	Slovak Republic
Brazil*	Kazakhstan	Slovenia
Cambodia	Kenya	South Africa*
Chile*	Korea*	Sri Lanka
China, Mainland	Latvia	St. Lucia
Croatia	Lithuania	Thailand
Czech Republic*	Malaysia*	Turkey*
Dominican Republic	Mexico*	United Arab Emirates*
Ecuador	Morocco	Ukraine
Egypt*	Nepal	Uruguay
El Salvador	Oman	Vanuatu
Estonia	Pakistan*	Venezuela

*: Emerging market countries from the Morgan Stanley Capital International (MSCI) Emerging Markets Index.

The sample countries are selected by the following procedure. Among the countries with debt data available, we exclude the top and bottom 1% outliers based on the annual changes in debt to GDP ratios. Then we remove countries with the coverage of private and public debt data less than ten consecutive years within our sample period 1970-2014. This leaves us 72 sample countries. We include 21 advanced OECD countries in the developed sample. The rest are included in the developing sample. Among the OECD countries, Chile, Czech Republic, Estonia, Hungary, Israel, Korea, Latvia, Lithuania, Poland, Slovak Republic, Slovenia, and Turkey are kept in the developing sample to be consistent with the developing countries used

in the literature. Table A1 shows the list of the sample countries.

A2. Data Sources

National Accounts National accounts data comes from the World Bank's World Development Indicators. For output, we use annual data in constant 2010 U.S. dollars for GDP. For consumption and investment, we use household and NIPSH final consumption expenditure, and gross fixed capital formation, respectively.

Exchange Rate Regime Information about the *de facto* exchange rate regime comes from Reinhart and Rogoff (2004), wich was updated in Ilzetzki et al. (2017). "Fixed regimes" are regimes with no separate legal tender, currency boards, pegs, and narrowly defined horizontal bands (coarse ERA code 1 from Ilzetzki et al., 2017). "Floating regimes" are regimes with widely defined horizontal bands, crawling pegs, crawling bands, moving bands, managed floats, and freely floating regimes (coarse ERA codes 2 to 4).

Private Debt Private debt data comes from the Private Debt, Loans and Securities series in the IMF's Global Debt Database. It is defined as total stock of loans and debt securities issued by households and nonfinancial corporations as a share of lagged GDP.
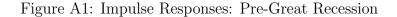
Public Debt Public debt data comes from the IMF's Historical Public Debt Database. Public debt is gross government debt as a share of lagged GDP.
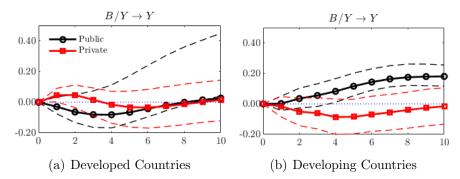
Foreign Debt Foreign debt data comes from the 2016 update of the External Wealth of Nations Mark II database of Lane and Milesi-Ferretti (2007). Net foreign debt is defined as total external liabilities minus total external assets as a share of lagged GDP.

A.3 Robustness Checks

This appendix reports the results for robustness checks. First, we check whether our results are driven by the Great Recession. Specifically, we limit the sample periods up to 2006 and redo the VAR analysis. The results in the pre-global recession sample are similar to those in the baseline full sample, even though the responses often become statistically not significant because of wide confidence bands in the reduced sample. Figure A1 displays the response of output to positive shocks in private debt and public debt as an illustration.[7] In the full sample, private debt negatively impacts output in both developed and developing countries. In the pre-global recession sample, the negative impact of private debt is much weaker and statistically not significant. The result for public debt we observe in the full sample still remains in the pre-global recession sample as well. A positive public debt shock reduces output in developed countries and raises output in developing countries.

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[7]The other impulse responses are similar to the full sample case, and thus not reported.

Figure A1: Impulse Responses: Pre-Great Recession

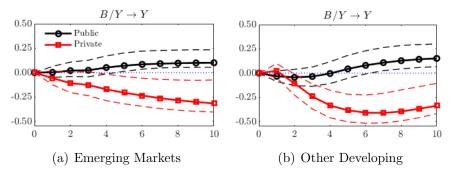

(a) Developed Countries　　　　　(b) Developing Countries

Notes: The figure presents impulse responses from a three-variable VAR in log real GDP, the ratio of public debt to GDP, and the ratio of private debt to GDP. The solid lines are the responses to a one-percent shock in each variable, and the dashed lines are 95% confidence intervals computed with the bias-corrected bootstrap.

Second, given the large heterogeneity across the developing countries, we separate the developing sample further into two groups: emerging markets and other developing countries. The 20 emerging market countries are listed with asterisks within Table A1. Figure A2 compares the response of output to a positive private and public debt shocks for emerging market countries and for other developing countries.[8] In both groups of countries, output declines in response to a private debt shock and rises in response to a public debt shock.

Figure A2: Impulse Responses: Emerging Markets versus Other Developing Countries

(a) Emerging Markets　　　　　(b) Other Developing

Notes: The figure presents impulse responses from a three-variable VAR in log real GDP, the ratio of public debt to GDP, and the ratio of private debt to GDP. The solid lines are the responses to a one-percent shock in each variable, and the dashed lines are 95% confidence intervals computed with the bias-corrected bootstrap.

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[8]The debt responses to a positive output shock and output responses to the other debt expansions are similar across emerging markets and other developing countries, and thus not reported.