Public debt and growth in Asian developing economies: evidence of non-linearity and geographical heterogeneity

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Abstract

This paper examines the non-linear effects of public debt on economic growth in Asian developing economies using panel Generalized Method of Moments (GMM) regressions and panel vector autoregression (VAR) models. We find a statistically significant non-linear effect of public debt (as a percent of GDP) on GDP per capita growth, with a turning point at 52 percent and 50 percent of GDP for all Asian developing and Asian coastal developing economies, respectively. It is found that asymmetric mutual feedback effects exist between the growth and the public debt depending on the public debt level. The two-way effects are statistically significant and more evident when the public debt exceeds its threshold level. Our results also show evidence of geographical (cross-country) heterogeneity in the mutual feedback effects. These findings have important policy implications, including the need to use geographic (or region)-specific debt threshold levels and asymmetric response coefficients in public debt policy analysis.

Keywords: Public debt, economic growth, Asian developing countries, sustainability of debt, non-linearity, geographical heterogeneity

JEL classification: C23, E62, F34, H63, O11, R11

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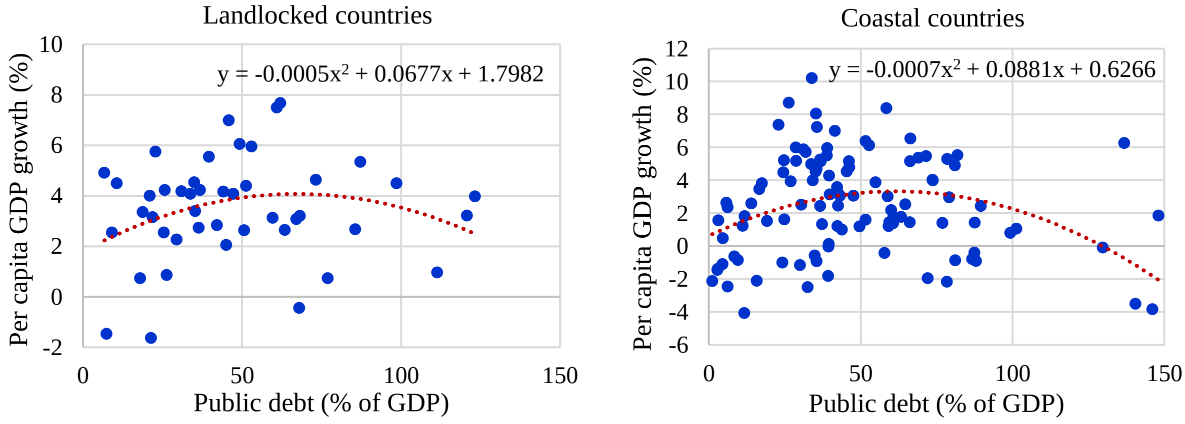
1. Introduction

In the last 15 years, significant global events such as the 2007-2008 global financial crisis (GFC) and COVID-19-induced global recession have led to an unprecedented surge in global public debt. By the end of 2020, global government debt stood at a five-decade record of 97 percent of GDP and, in emerging market and developing economies (EMDEs), at a three-decade record of 63 percent (Rogoff et al. 2021). Some economists (i.e., Estevão and Essl 2022) argue that today, 58 percent of the world's poorest countries are in debt distress or at high risk, and the danger is spreading to some middle-income countries. This situation has raised serious concerns about fiscal sustainability and the high public debt's economic and financial market effects. The existing studies (i.e., Reinhart and Rogoff 2010) covering advanced and emerging market economies suggest that high public debt levels harm economic growth. Some papers (i.e., Baum et al. 2013, Mercinger et al. 2014, Eberhardt and Presbitero 2015, and Gómez-Puig and Sosvilla-Rivero 2017) have shown a non-linear relationship and a high degree of heterogeneity in the impact of public debt levels on economic growth across countries. Instead, other studies (i.e., Égert 2015) find that the negative non-linear relationship between public debt and economic growth cannot be taken for granted, and non-linearity can change across different samples and specifications. Cross-sectional raw data from the World Economic Outlook (WEO) database supports the non-linear relationship in Asian landlocked and coastal countries (Figure 1). However, very few papers (i.e., Thao 2018 and Lau et al. 2022) have explicitly addressed the public debt and growth nexus in Asian developing countries. In particular, the existing papers have not explicitly studied the non-linear impact of debt on growth with a turning point (a threshold level) in Asian landlocked and coastal developing economies.

Figure 1. Public debt-to-GDP ratio and economic growth, 5-year average, 1995-2020



Source: The World Economic Outlook (WEO) database, International Monetary Fund.

In this context, the present paper empirically examines the non-linear effects of public debt on economic growth in Asian developing economies. In particular, we analyze geographical (cross-country) heterogeneity in the non-linear effects by separating the samples for coastal and landlocked economies. The empirical analysis is applied to 36 developing Asia economies, of which 24 are coastal and 12 are landlocked economies.

This paper extends the literature in two distinct ways. First, it is one of the first attempts to empirically examine non-linearity and geographical (cross-country) heterogeneity in the public debt-growth relationship for developing Asia economies. Hence evidence from the exercise would be crucial to setting public debt management policy and ensuring debt sustainability in debt-burdened developing economies. Second, we adopt panel VAR specifications which allow for endogeneity, non-linearity, and geographical heterogeneity in the public debt-growth relationship, thus reflecting theoretical and empirical arguments. The methodological approach will enable us to analyze mutual feedback effects and asymmetric responses depending on the debt level for different geographical regions.

The literature suggests that the findings can be divided into four main groups. First, numerous papers (i.e., Woodford 1990, Fincke and Greiner 2015 for selected emerging market economies, and Thao 2018 for ASEAN countries) find a significant positive relationship between public debt and GDP growth rate. Second, many studies have found adverse effects of public debt on growth. For example, Krugman (1988) raises the debt overhang problem, which harms growth. Using large datasets, some papers (i.e., Calderón and Fuentes 2013, Zouhaier and Fatma 2014, Siddique et al. 2016, and Lim 2019) find robust negative relationships between public debt and economic growth. Third, several studies (i.e., Caner et al. 2010, Cecchetti et al. 2011, Checherita-Westphal and Rother 2012, Afonso and Jalles 2013, Woo and Kumar 2015, and Swamy 2020) support a non-linear relationship (i.e., an inverted U-shaped curve, the threshold or non-linear effect theory), suggesting that high levels of public debt have a negative impact on growth. For the papers reviewed by Salmon (2021), the estimated debt threshold levels vary among the sample countries, ranging from 59 percent to 94 percent of GDP. He finds that mean threshold levels for advanced and developing countries are 78 percent and 61 percent of GDP, respectively. According to the non-linear effect theory, at low debt levels, increases in the debt ratio provide positive economic stimulus in line with conventional Keynesian multipliers. Once the debt ratio reaches heightened levels (non-linear threshold), further increases in the debt level (as a percent of GDP) negatively impact growth. The neoclassical theory also supports the non-linear relationship as the distortionary impact of future tax increases to achieve debt sustainability will likely lower the potential economic output (Salmon 2021). Boskin (2020) highlights that a significant rise in the debt-to-GDP ratio could lead to much higher taxes, lower future incomes, and intergenerational inequity. The non-linear threshold effect is also in line with the debt overhang hypothesis. Fourth, several studies (i.e., Eberhardt and Presbitero 2015, Gómez-Puig et al. 2022) find some evidence for heterogeneity in the debt-growth relationship across countries.

The literature suggests various channels through which high and growing public debt levels negatively affect economic growth: i) the crowding out of private investment as government borrowing competes for funds in the nation’s capital markets (Elmendorf and Mankiw 1999), ii) higher long-term interest rates caused by an excess supply of government bond and greater credit risk premia (Von Hagen et al. 2011), and iii) higher distortionary taxes to fund future liabilities and rising debt repayments (Dotsey 1994), iv) an increase in the rate of inflation (Cochrane 2011, Reinhart and Rogoff 2010), and v) as countries hit debt tolerance ceilings, the market interest rate can begin to rise quite suddenly, forcing painful adjustment (Reinhart and Rogoff 2010, and Baldacci and Kumar 2010). In addition, Salmon (2021) hypothesizes that lower-quality institutions likely reduce the threshold levels at which debt adversely affects growth in low-income economies.

Regarding the economic models adopted, the existing studies employ two main approaches. First, many studies have adopted a single regression approach, including ordinary least squares (OLS) (i.e., Afonso and Alves 2015, Bökemeier and Greiner 2015, Eberhardt and Presbitero 2015, Snieška and Burksaitiene 2018), autoregressive distributed lag (ARDL) (i.e., Siddique et al. 2016, Asteriou et al. 2021), and two-stage GMM estimator with instrumental variables (i.e., Kourtellos et al. 2013, Mercinger et al. 2015, Swamy 2020). Second, recent studies (i.e., Lim 2019, Pegkas et al. 2020) also use a panel vector autoregression (VAR) approach. Our paper employs the GMM estimator with instrumental variables and the panel VAR framework.

The rest of this paper is structured as follows. Section 2 provides an empirical approach including non-linear panel regression and panel VAR models. Section 3 desribes the data and reports empirical results. Section 4 shows robustness checks of the main findings. Finally, section 5 concludes the paper and discusses policy implications.

2. Empirical approach

2.1 A non-linear panel regression model

In line with the existing literature (i.e., Checherita-Westphal and Rother 2012, Baum et al. 2013, Woo and Kumar 2015), we estimate the following panel regression to examine the non-linear impact of public debt-to-GDP ratio on the per capita GDP growth:

$$g_{i,t} = \beta_0 + \beta_1 \log\left(gdppc_{i,t-1}\right) + \beta_2 debt_{i,t-1} + \beta_3 debt_{i,t-1}^2 + \mathbf{X}_{i,t-1}\beta + u_{i,t} \qquad (1)$$

where t denotes the end of a period; i denotes the country; g is the real per capita GDP (annual) growth; $\ln(gdppc)$ is the logarithm of the initial level of real per capita GDP; $debt_{i,t-1}$ is the initial public debt-to-GDP ratio; $debt_{i,t-1}^2$ is the quadratic term of the initial public debt-to-GDP ratio; **X** is a vector of control variables, including the initial fiscal balance-to-GDP ratio ($fisbal_{i,t-1}$), initial gross fixed capital formation (investment)-to-GDP ratio ($cap_{i,t-1}$), initial annual population growth ($popg_{i,t-1}$), initial foreign direct investment-to-GDP ratio (fdi_{t-1}), initial inflation ($inf_{i,t-1}$), initial real interest rate ($r_{i,t-1}$); $u_{i,t}$is the error term, having independent and identically distributed with mean zero and finite variance.

The empirical growth model (1) is based on a conditional convergence equation that relates the GDP per capita growth rate to the initial level of income per capita ($\ln(gdppc)$), the investment-to-GDP ratio (*cap*), and the population growth rate (*popg*). According to the model, the sign of β_1 is expected to be negative as the catching-up process exists. The model is augmented to include the level of initial public debt (as a share of GDP, $debt$). Since we are interested in checking whether there exists a non-linear impact of government debt on growth, we use a quadratic equation in debt ($debt^2$). According to the model, the expected sign of the coefficient on *cap* is positive since capital (or investment) is an essential input of the production, and the expected sign of coefficient on pop is negative as described in the

Solow growth model (i.e., Kourtellos et al. 2013, Butkus et al. 2021). If we assume a non-linear relationship between debt and growth, the expected signs of coefficients on $debt$ and $debt^2$ are positive and negative, respectively.

In line with Checherita and Rother (2010), other control variables in **X** include: i) fiscal balance ($fisbal$) to allow more extensively for the possibility of fiscal policy affecting economic growth, and the expected sign of coefficient on the variable is positive in line with the Keynesian multiplier model[2]; (ii) inflation measured by CPI inflation (inf) to capture its adverse effect on growth (the inflation channel of public debt); (iii) foreign direct investment (fdi) to capture the impact of efficiency of investment and absorbing ideas from the rest of the world, and the expected sign of coefficient on the variable is positive; (iv) real interest rate (r) to include the interest rate channel of high public debt.

We follow Mencinger et al. (2014)'s computation of the debt threshold value (dtv) for the selected countries (debt to GDP turning point) as $dtv = -\beta_2/2\beta_3$.

Given the strong potential for the endogeneity of the debt variable, particularly reverse causation (low or negative growth rates of per-capita GDP are likely to induce higher debt burdens), we use various instrumental variable estimation techniques in estimating the model (1). In a panel context, many studies on growth regressions have used the instrumental variable (IV) approach to deal with the issue of simultaneity bias. The estimators used in our paper are the Generalized Method of Moments (GMM). With the GMM estimator, we use Two-Stages Least Squares (2SLS) for GMM weights and cross-section weights for Generalized Least Squares (GLS) weights. We instrument lagged terms of all regressors, including $debt$ and $debt^2$as instruments, which is a relatively common practice with macroeconomic data.

2.2 A panel VAR model

An alternative way to handle the endogeneity and the reverse causation issues among variables is to estimate a vector autoregression (VAR). To examine the relationship between public debt and per capita GDP, we also estimate a m-variate homogenous panel VAR of order k and comprised of $i = 1, \dots, N$ economies over $t = 1, \dots, T$ periods. This is represented as

$$\mathbf{X}_{i,t} = \sum_{j=1}^{k} \mathbf{X}_{i,t-1}\boldsymbol{\beta}_j + \mathbf{Z}'_{i,t}\boldsymbol{\zeta} + \boldsymbol{\epsilon}_{i,t} \quad (2)$$

where $\mathbf{X}$ is a $(\mathbf{1} \times m)$ vector of interdependent system variables, $\mathbf{Z}$ is a $(\mathbf{1} \times l)$ vector of exogenous covariates, and $\boldsymbol{\alpha}$ is a $(\mathbf{1} \times m)$ vector of time-invariant fixed effects specific to each system variable. $\boldsymbol{\epsilon}\sim$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. The reduced-form coefficient estimates, $\boldsymbol{\beta}_1, \dots, \boldsymbol{\beta}_k$, and $\boldsymbol{\zeta}$, are common among all N economies.

To test the non-linear relationship public debt-to-GDP ratio and the per capita GDP growth, we use two dummy variables such as i) $dum_{(+)i,t} = 1$ if $debt_{i,t} \leq debt^*$ and $dum_+ = 0$

[2] Asian developing countries mainly were in budgetary deficits because of the priority of government spending on socio-economic investment projects to intensify long-term growth (Thao 2018).

otherwise, and ii) $dum_{(-)i,t} = 1$ if $debt_{i,t} > debt^*$ and $dum_{(-)} = 0$ otherwise, where $debt^*$ is the threshold value. In this paper, we obtain the specific threshold value ($debt^*$) from the non-linear relationship between g and $debt$ from the model (1). Using the dummies, we construct two debt variables such as $dum_{(+)i,t} \times debt_{i,t}$ for the case of $debt_{i,t} \leq debt^*$ and $dum_{(-)i,t} \times debt_{i,t}$ for the case of $debt_{i,t} > debt^*$.

The VAR approach also allows us to examine the channels of public debt passing through inflation and interest rates. Hence, we include the following endogenous and exogenous variables into the panel VAR model: $\mathbf{X}_{i,t} = \left[dum_{(+)i,t} \times debt_{i,t}, dum_{(-)i,t} \times debt_{i,t}, g_{i,t}, inf_{i,t}, r_{i,t}\right]$, and $\mathbf{Z}_{i,t} = [\ln\left(gdppc_{i,t-1}\right), fisbal_{i,t-1}, fdi_{i,t-1}, cap_{i,t-1}, pop_{i,t-1}]$.

As $dum_{(+)i,t} \times debt_{i,t}$ and $dum_{(-)i,t} \times debt_{i,t}$ are included in the VAR system, we do not use a recursive identification scheme for the baseline results. Instead, we calculate the generalized impulse response functions and the generalized forecast error variance decomposition. Unlike the Cholesky decomposition, the generalized approach proposed by Pesaran and Shin (1998) constructs an orthogonal set of shocks, which does not depend on the VAR ordering. In the robustness checks section, we also consider a recursive identification scheme for separate VARs, such as $\mathbf{X}_{(+)i,t} = \left[dum_{(+)i,t} \times debt_{i,t}, g_{i,t}, inf_{i,t}, r_{i,t}\right]$ and $\mathbf{X}_{(-)i,t} = \left[dum_{(-)i,t} \times debt_{i,t}, g_{i,t}, inf_{i,t}, r_{i,t}\right]$, which is in line with Lim (2019).

3. Data and empirical results

3.1 Data

Our baseline panel VARs are estimated for three data sets covering the period of 1995 to 2020: i) Asian developing economies, ii) Asian coastal developing economies, and iii) Asian landlocked developing economies[3].

The real GDP per capita growth (g), gross general government debt (a proxy for public debt) to GDP ratio ($debt$), real GDP per capita in US dollar ($gdppc$), and fiscal balance as percent of GDP ($fisbal$) variables are observed from the World Economic Outlook (WEO) database of the IMF. Gross fixed capital formation as a percent of GDP (cap), population growth ($popg$), net foreign direct investment (fdi), inflation (inf), and real lending rate (r, difference between nominal lending rate and inflation) variables are obtained from the World Development Indicators (WDI) database of the World Bank. In the analysis, the logarithm is taken from real GDP per capita ($gdppc$), and all other variables are in percent.

[3] *Asian coastal developing economies* include 24 countries such as Bahrain, Bangladesh, Brunei, Myanmar, Cambodia, Georgia, India, Indonesia, Iran, Jordan, Kuwait, Lebanon, Maldives, Oman, Pakistan, People's Republic of China, Philippines, Qatar, Saudi Arabia, Sri Lanka, Thailand, United Arab Emirates, Vietnam, and Yemen. *Asian landlocked developing economies* include 12 countries such as Afghanistan, Armenia, Azerbaijan, Bhutan, Laos, Kazakhstan, Kyrgyzstan, Mongolia, Nepal, Tajikistan, Turkmenistan, and Uzbekistan. *Asian developing economies* include all 36 Asian developing countries.

The descriptive statistics of the observed variables for 36 Asian developing economies, 24 Asian coastal developing economies, and 12 Asian landlocked developing economies are shown in Table 1.

Table 1. Descriptive statistics of observed variables

Variables	**Mean**	**Median**	**Maximum**	**Minimum**	**Std. Dev.**
Asian developing economies (whole sample)					
g	2.80	3.31	28.37	-40.20	5.51
$gdppc$	7488.46	2246.84	101933.10	100.45	12985.76
$pubdebt$	47.35	39.36	345.98	0.60	37.47
$fisbal$	-1.29	-2.20	43.30	-28.70	7.89
cap	27.24	26.21	69.67	4.03	9.11
$popg$	1.97	1.53	17.51	-3.76	2.06
fdi	3.96	2.50	55.07	-37.17	5.48
inf	7.25	4.93	90.14	-8.53	9.70
r	6.64	5.91	56.18	-42.10	7.29
Asian coastal developing economies					
g	2.21	2.77	21.44	-40.20	5.52
$gdppc$	10048.07	3446.70	101933.10	116.22	15105.99
$pubdebt$	49.54	41.41	252.78	0.60	35.92
$fisbal$	-1.82	-2.85	43.30	-28.70	8.59
cap	26.33	25.78	49.49	4.03	7.84
$popg$	2.25	1.62	17.51	-3.76	2.36
fdi	3.38	2.22	33.57	-5.11	3.92
inf	5.87	3.98	84.86	-19.79	8.10
r	5.38	5.28	35.42	-27.42	5.60
Asian landlocked developing economies					
g	4.02	4.31	28.37	-14.92	5.29
$gdppc$	2276.94	1059.21	13789.17	100.45	2660.65
$pubdebt$	42.61	35.43	345.98	1.41	40.29
$fisbal$	-0.20	-1.10	25.70	-15.30	6.10
cap	29.11	27.22	69.67	9.14	11.08
$popg$	1.39	1.47	5.88	-2.06	1.00
fdi	5.17	3.41	55.07	-37.17	7.63
inf	10.05	7.18	90.14	-8.53	12.03
r	10.41	9.21	56.18	-42.10	9.99

The average and median annual real GDP per capita growth for the whole sample are 2.8 and 3.3 percent, respectively. The average public debt to GDP ratio in the sample is about 47.4 percent from 1995 to 2020. The growth rate, inflation, real interest rate, Gross fixed capital formation as a percent of GDP, and net FDI as a percent of GDP are higher in landlocked than in coastal developing economies. It is in line with the following fact: landlocked economies incur higher trade costs due to their geographical remoteness, inadequate transport infrastructure, and poor trade logistics, and therefore, face with a lack of financial liquidity.

However, GDP per capita, public debt to GDP ratio, and population growth are much higher in the coastal economies.

3.2 Non-linear regression analysis

Before estimating regression models, we perform various unit root tests (i.e., Augmented Dickey-Fuller, ADF, and Phillips-Perron, PP, tests) in panel datasets to assess the time-series properties of the variables. The results of the tests are summarized in Table A.1 of the Appendix. The results show that only $\log(gdppc)$ variable has unit root (i.e., I(1)) and other level variables have no unit root (i.e., I(0)). However, for both statistical[4] and economic reasons (to estimate a conditional convergence equation and compare the results with existing papers' findings), we have decided to estimate the growth model with the explanatory variables in levels.

To examine the non-linear effects of public debt on real GDP per capita growth, we conduct panel data analyses using the GMM estimator with 2SLS for GMM weights and cross-section weights for GLS weights. The main results for Asian developing economies, Asian Coastal developing economies, and Asian Landlocked developing economies are presented in Table 3. The consistency of the GMM estimator depends on the validity of the instruments. The validity of the instrumental variables is tested using Sargan-Hansen J-test of over-identifying restrictions, which tests the overall validity of the instruments[5]. The test results indicate that we cannot reject the null hypothesis that the complete set of orthogonality conditions are valid (p-value=0.02 for the sample of Asian developing economies, p-value=0.03 for the sample of Asian coastal developing economies, and p-value=0.01 for the sample of Asian landlocked developing economies).

Column 1 of Table 2 shows the coefficients of initial public debt and square of initial public debt for Asian developing economies are positive and negative and are significant at the 10 percent level and 5 percent level, respectively. Hence, the results support an inverted U-shaped relationship between public debt and economic growth, implying that low levels of public debt positively impact growth, and beyond a certain debt turning point, there is a negative effect on growth.

[4] These tests have notoriously poor power and they do not handle the possible breaks and cross-sectional dependences (Gómez-Puig et al. 2022).

[5] The null hypothesis of the test is that the instrumental variables are correlated with residuals.

Table 2. Non-linear regression results

Dependent variable: Real GDP per capita growth

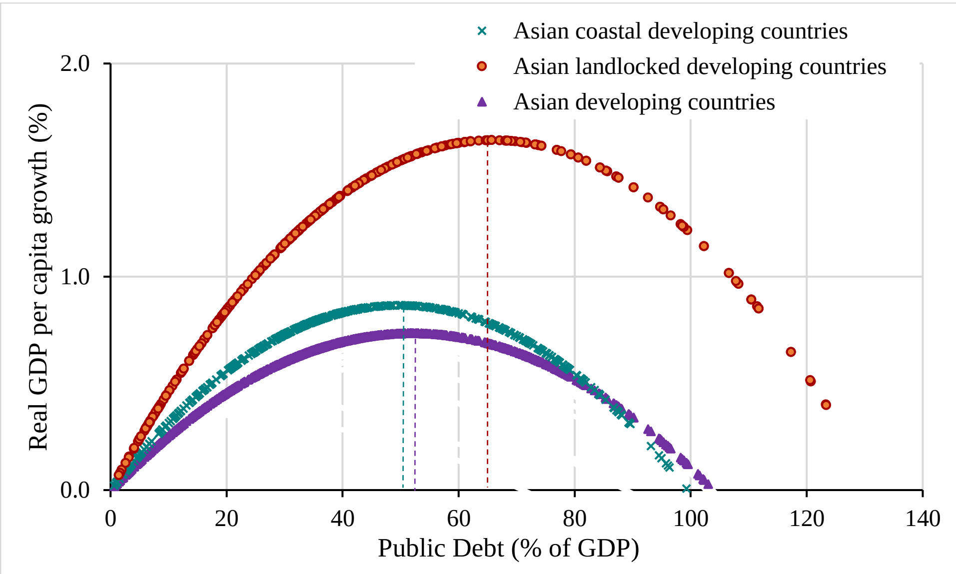
Explanatory Variables	**(1) Whole sample**	**(2) Coastal economies**	**(3) Landlocked economies**
log(gdppc(-1))	-1.719*** (0.146)	-1.543*** (0.155)	-0.075 (0.129)
pubdebt(-1)	0.028* (0.016)	0.034* (0.018)	0.049 (0.041)
$\boldsymbol{pubdebt(-1)^2}$	-0.0002** (0.0001)	-0.0004** (0.0001)	-0.0004 (0.0003)
fisbal(-1)	0.177*** (0.031)	0.071*** (0.026)	0.086 (0.077)
cap(-1)	0.091** (0.013)	0.141*** (0.021)	0.030 (0.030)
popg(-1)	-0.567*** (0.093)	-0.499*** (0.098)	-0.412 (0.604)
fdi(-1)	0.106*** (0.028)	0.098** (0.039)	0.118** (0.048)
inf(-1)	-0.091*** (0.027)	-0.097*** (0.032)	-0.115** (0.059)
r(-1)	-0.029 (0.019)	-0.085*** (0.030)	0.099 (0.175)
Constant	15.329*** (1.438)	12.636*** (1.662)	3.172 (2.141)
Observation	523	386	128
R-squared	0.42	0.47	0.15
Adjusted R-squared	0.41	0.46	0.08
Debt turning point	*52.0%*	*50.0%*	*66.0%*

Notes: Figures in () standard errors. '***', '**', and '*' denote significance at 1%, 5%, and 10%, respectively.
Source: Authors' calculations.

The coefficients on other explanatory variables (initial income per capita, fiscal balance as a percent of GDP, Gross fixed capital formation as a percent of GDP, population growth, FDI as a percent of GDP, inflation, and real interest rate) are of the expected sign and mostly (except for initial real interest rate) significant at conventional levels. The results suggest an existence of a conditional convergence and provide evidence that higher initial fiscal balance, capital formation, FDI, lower initial population growth, and inflation stimulate the real GDP per capita in Asian developing economies.

Columns (2) and (3) of Table 2 show the regression results for Asian coastal and landlocked developing economies, respectively. The coefficients of initial public debt variables for the coastal developing economies are statistically significant, confirming the non-linear effect of public debt on growth. The estimated coefficients of the public debt variables for the coastal economies are in line with the expected sign, but they are not statistically significant. Using the estimated coefficients, we plot the relationship between the real GDP per capita and public debt as a percent of GDP in Figure 2. The debt turning point is estimated for Asian developing economies at 52 percent. The estimated public debt to GDP turning point is 50.0 percent for coastal economies. The debt turning point is calculated for Asian landlocked developing economies at 66 percent if we use the estimated coefficients. These results show that public debt's effects on growth differ between Asian coastal and landlocked developing economies. At the peak positive impacts of public debt on the growth, the growth contributions are estimated as 0.73, 0.87, and 1.64 percentage points for Asian developing economies, Asian coastal developing economies, and Asian landlocked economies, respectively.

Figure 2. Estimated relationship between growth and public debt



Source: Authors' calculation.

For Asian Coastal developing economies, all coefficients on other explanatory variables are of the expected sign and significant at conventional levels. As a difference from the whole sample (Asian developing economies), the higher real interest rate negatively affects the growth in the Coastal economies. However, the coefficients on FDI as a percent of GDP and inflation are only significant at a 5 percent level in the case of Asian landlocked developing economies. The finding implies that higher FDI and lower inflation are vital determinants of real GDP per capita growth in Asian landlocked developing economies.

3.3 Panel VAR analysis

Before estimating the VAR models discussed in Section 2.2, we need to build new series of $dum_{(+)i,t} \times debt_{i,t}$ and $dum_{(-)i,t} \times debt_{i,t}$. In doing so, we calculate $dum_{(+)i,t}$ and $dum_{(-)i,t}$ dummy variables using specific threshold levels ($debt^*$). As estimated in Section 3.2, specific threshold levels are chosen as $debt^* = 52\%$ for Asian developing economies,

$debt^* = 50\%$ for Asian coastal developing economies, and $debt^* = 66\%$ for Asian developing economies.

The lag length of the VAR is chosen using standard information criteria (Akaike information criterion, AIC or Schwarz Criterion, SC). For the VAR system of Asian developing economies, SC suggests that the lag length is 1, while AIC indicates the lag length is 3. For the system of Asian coastal developing economies, both SC and HQ suggest that the lag length is 1. For the VAR system of Asian landlocked developing economies, SC suggests that the lag length is 1, while AIC indicates the lag length is 2. For the baseline VARs for three different panel data, we choose the lag length of 1, which ensures no serial correlation, and the VAR satisfies the stability condition. VAR(2) model is also estimated in the robustness check section, and the results have been robust.

Covariance stationarity (a stable VAR) is crucial to derive a VAR representation with constant coefficients[6]. In this paper, we test the properties of VAR residuals using 'Inverse roots of AR characteristic polynomial'. The results shown in Figure A.1 of the Appendix imply that the estimated baseline VAR(1) models are stable (stationary) since all roots have a modulus of less than one and lie inside the unit circle.

3.3.1 Baseline impulse responses

What are public debt's effects and transmission mechanisms on growth, inflation, and interest rate?

We first discuss the whole sample (Asian developing economies) responses to an unanticipated increase in public debt as a percent of GDP before moving to implications for Asian coastal and landlocked developing economies. We scale the initial shock so that it causes a 1 percentage point increase in the public debt indicators. In all figures, the solid lines are the point impulse responses, while the dashed lines represent the 95 percent confidence interval of the estimated responses. In Figure 3, we show generalized impulse responses of key macroeconomic variables (real GDP per capita growth, inflation, real interest rate, and public debt) to shocks to public debt below or equal to the threshold level ($dum_{(+)i,t} \times debt_{i,t}$) and public debt above the threshold level ($dum_{(-)i,t} \times debt_{i,t}$).

The impulse responses suggest that the effect of public debt on real GDP per capita is non-linear. For instance, when public debt is below or equal to the threshold level, a 1 percentage point increase in public debt as a percent of GDP ($dum_{(+)i,t} \times debt_{i,t}$) leads to 0.03 percentage point rise in real GDP per capita growth 1 year after the shock. However, in a case where public debt is above the threshold level, the same size shock in public debt ($dum_{(-)i,t} \times debt_{i,t}$) leads to 0.1 percentage point decrease in real GDP per capita growth during the impact period.

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[6] Canova (2007) has pointed out that unit root tests still have poor small sample properties and suggested that if doubts about the test exist, one can directly check the reasonableness of the stationarity assumption by examining estimated residuals: a VAR is stable if VAR residuals do not display unit root type behavior. He suggests that a level VAR could be appropriate if it is stable.

The decline in growth is statistically significant at a 95 percent confidence level for the first 4 years. The results suggest that the response of the growth to public debt shock is not only non-linear but also asymmetric, depending on the public debt level.

Figure 3 shows that the negative response of inflation to public debt shock does not depend on the size of public debt. However, the only impact period response of inflation to $dum_{(-)i,t} \times debt_{i,t}$ shock is statistically significant at a 95 percent confidence level. It implies that higher public debt (exceeding the threshold level of 50 percent of GDP) weakens economic activities, leading to lower inflation.

We also find that the response of the real interest rate to public debt shock differs depending on the size of the public debt. If public debt is above the threshold level, the positive public debt shock increases the real interest rate, but the effect is statistically significant starting the fifth year. The result implies that the higher public debt lowers inflation and increases macro risks reflected in the nominal interest rate, and the responses result in higher real interest rates. Instead, the positive public debt shock leads to a decline in the real interest rate if public debt is below or equal to the threshold level. Another observation is that the response of public debt to its shock is more persistent when public debt exceeds the threshold level.

Figure 4 shows impulse responses of key macroeconomic variables to public debt shocks in the case of Asian coastal developing economies. The significant non-linear effect of public debt on growth and symmetric growth response depending on public debt level are obtained. A difference from the results found in the case of the whole sample is that growth responses to the debt shock are statistically significant for a much longer period.

The negative response of inflation to $dum_{(-)i,t} \times debt_{i,t}$ shock is statistically significant at 95 percent confidence level for the first two years. The positive response of real interest rate to $dum_{(-)i,t} \times debt_{i,t}$ shock is statistically significant starting the first year. However, responses of inflation and real interest rate to $dum_{(-)i,t} \times debt_{i,t}$ shocks are not statistically significant. The results suggest that public debt matters substantially for key macro variables once public debt exceeds the threshold level. The inflation and real interest rate channels of public debt are evident in such economies. Our finding on the importance of the interest rate channel is in line with Baldacci and Kumar (2010) who find that higher public debt can crowd out investment by raising long-term interest rates, and as a result, private sector entrepreneurs face higher capital costs, and productivity is dampened, reducing growth potential.

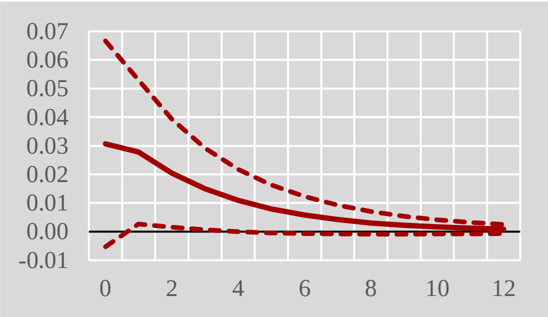
The response of public debt to its own shock is more persistent if public debt goes beyond the threshold level, particularly for Asian coastal developing economies.

We also conducted same exercise for Asian developing landlocked economies, and the results are shown in Figure 5. Our results show that public debt has almost no impact on key macro variables as responses to both $dum_{(+)i,t} \times debt_{i,t}$ and $dum_{(-)i,t} \times debt_{i,t}$ shocks are not statistically significant at a 95 confidence level. The only exception is that an increase in public debt leads to 0.05 percentage point decline in real GDP per capita growth on the impact period when the public debt exceeds the threshold level (66 percent of GDP). The results also suggest that public debt's inflation and interest rate channels are weak and not statistically significant.

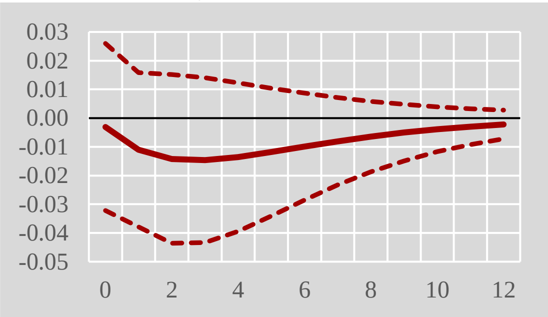
Figure 3. Generalized impulse response functions of growth, inflation and real interest rate to debt shocks: Asian developing economies

$dum_{(+)i,t} \times debt_{i,t}$ shock

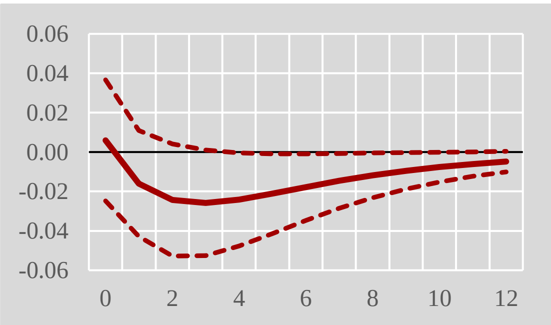
A) Real GDP per capita growth (g_i)



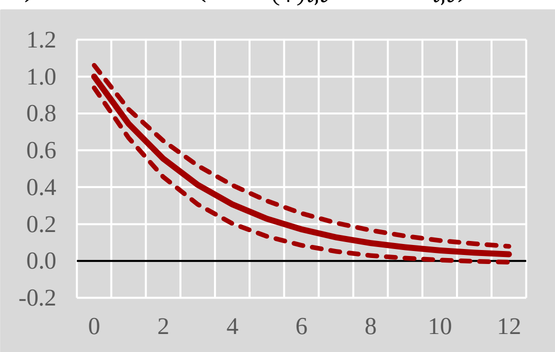
B) Inflation (inf_i)



C) Real interest rate (r_i)

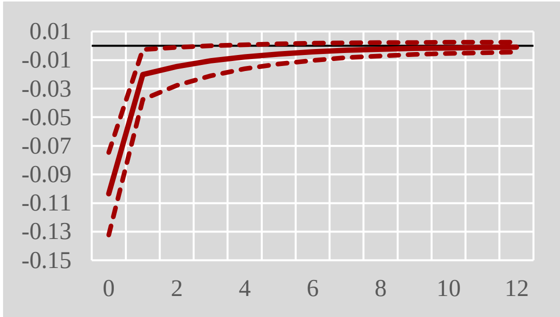


D) Public debt ($dum_{(+)i,t} \times debt_{i,t}$)

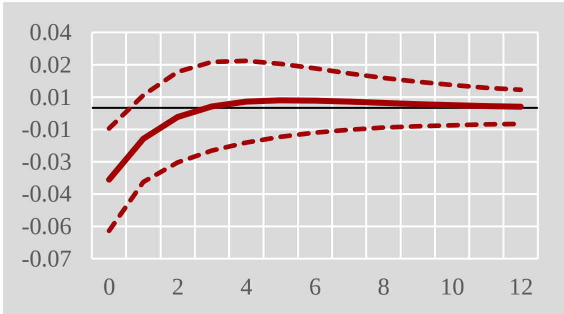


$dum_{(-)i,t} \times debt_{i,t}$ shock

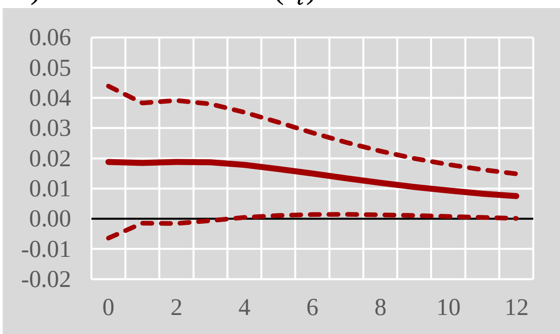
A) Real GDP per capita growth (g_i)



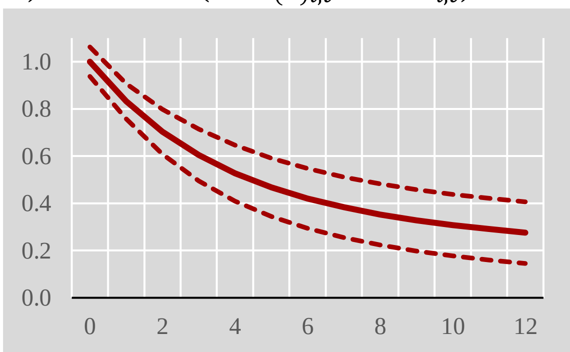
B) Inflation (inf_i)



C) Real interest rate (r_i)

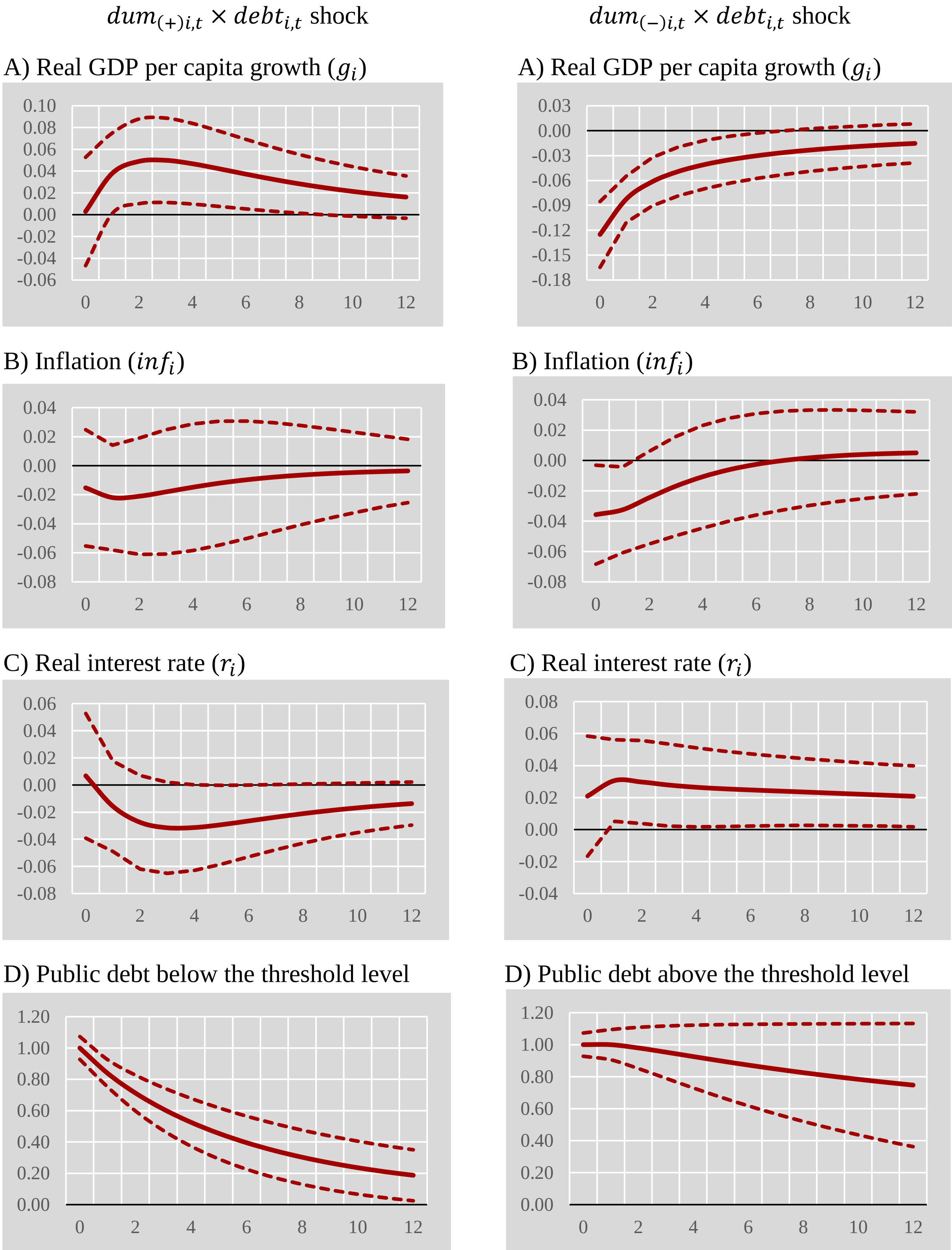


D) Public debt ($dum_{(-)i,t} \times debt_{i,t}$)



Notes: Figures show point responses, together with 95 percent confidence interval. Horizon is annually.

Figure 4. Generalized impulse response functions of growth, inflation and real interest rate to debt shocks: Asian coastal developing economies

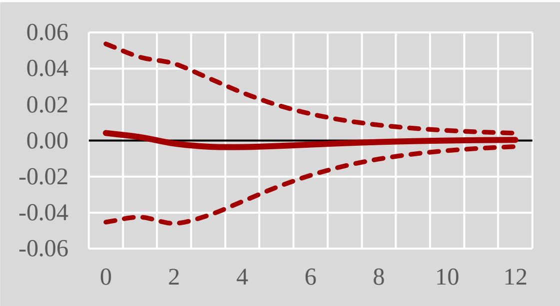


Notes: Figures show point responses, together with 95 percent confidence interval. Horizon is annually.

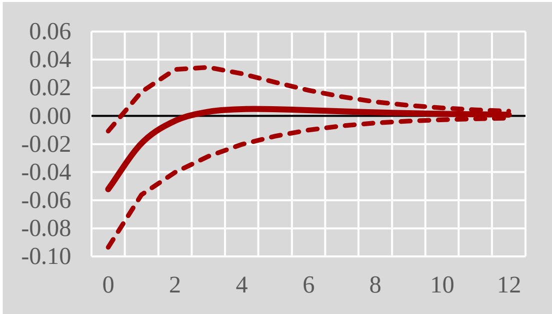
Figure 5. Generalized impulse response functions of growth, inflation and real interest rate to debt shocks: Asian landlocked developing economies

$dum_{(+)i,t} \times debt_{i,t}$ shock | $dum_{(-)i,t} \times debt_{i,t}$ shock

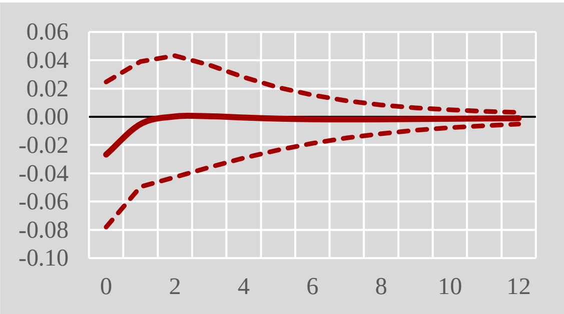
A) Real GDP per capita growth (g_i)



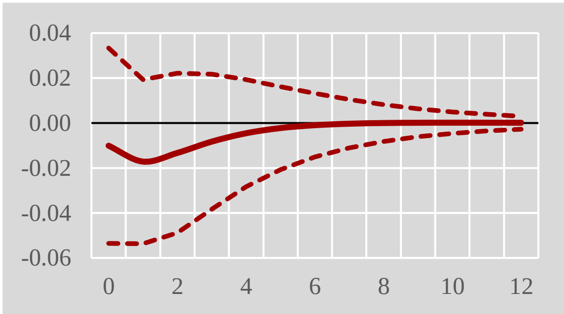
A) Real GDP per capita growth (g_i)



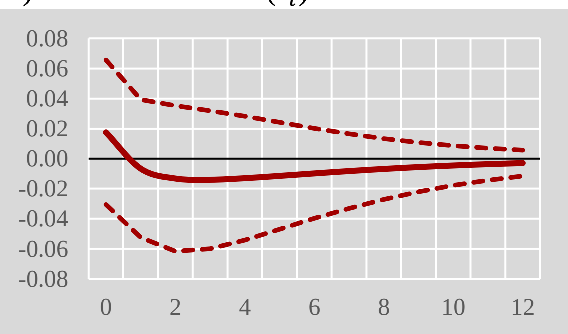
B) Inflation (inf_i)



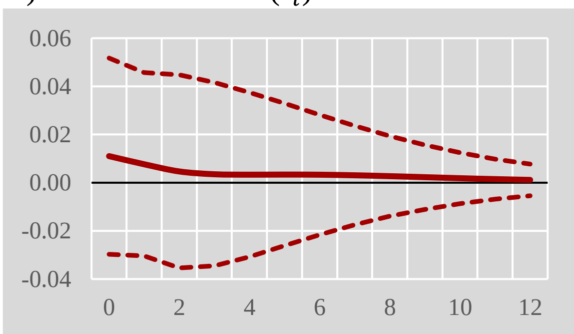
B) Inflation (inf_i)



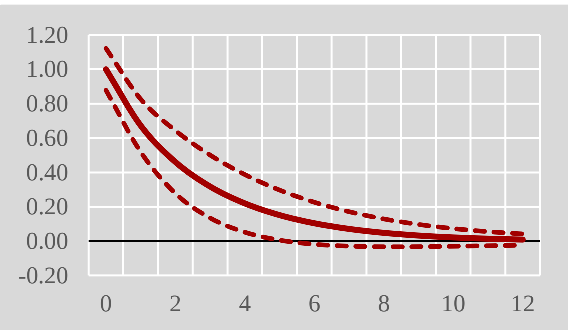
C) Real interest rate (r_i)



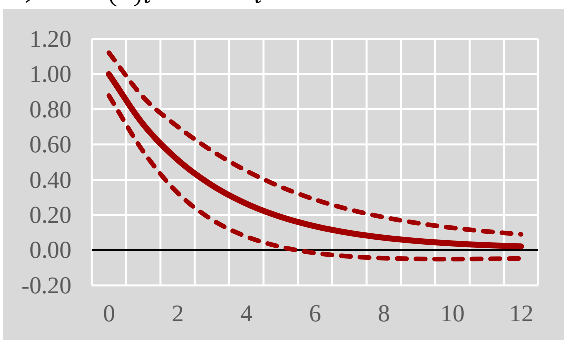
C) Real interest rate (r_i)



D) $dum_{(+)i} \times debt_i$



D) $dum_{(-)i} \times debt_i$



Notes: Figures show point responses, together with 95 percent confidence interval. Horizon is annually.

How does public debt respond to growth, inflation, and interest rate shocks?

Figure 6 shows generalized impulse responses of public debt indicators ($dum_{(+)i,t} \times debt_{i,t}$ and $dum_{(-)i,t} \times debt_{i,t}$) to growth, inflation, and real interest rate shocks in the whole sample (Asian developing economies). The results suggest that the responses of the public debt to these shocks are non-linear and asymmetric depending on the public debt level.

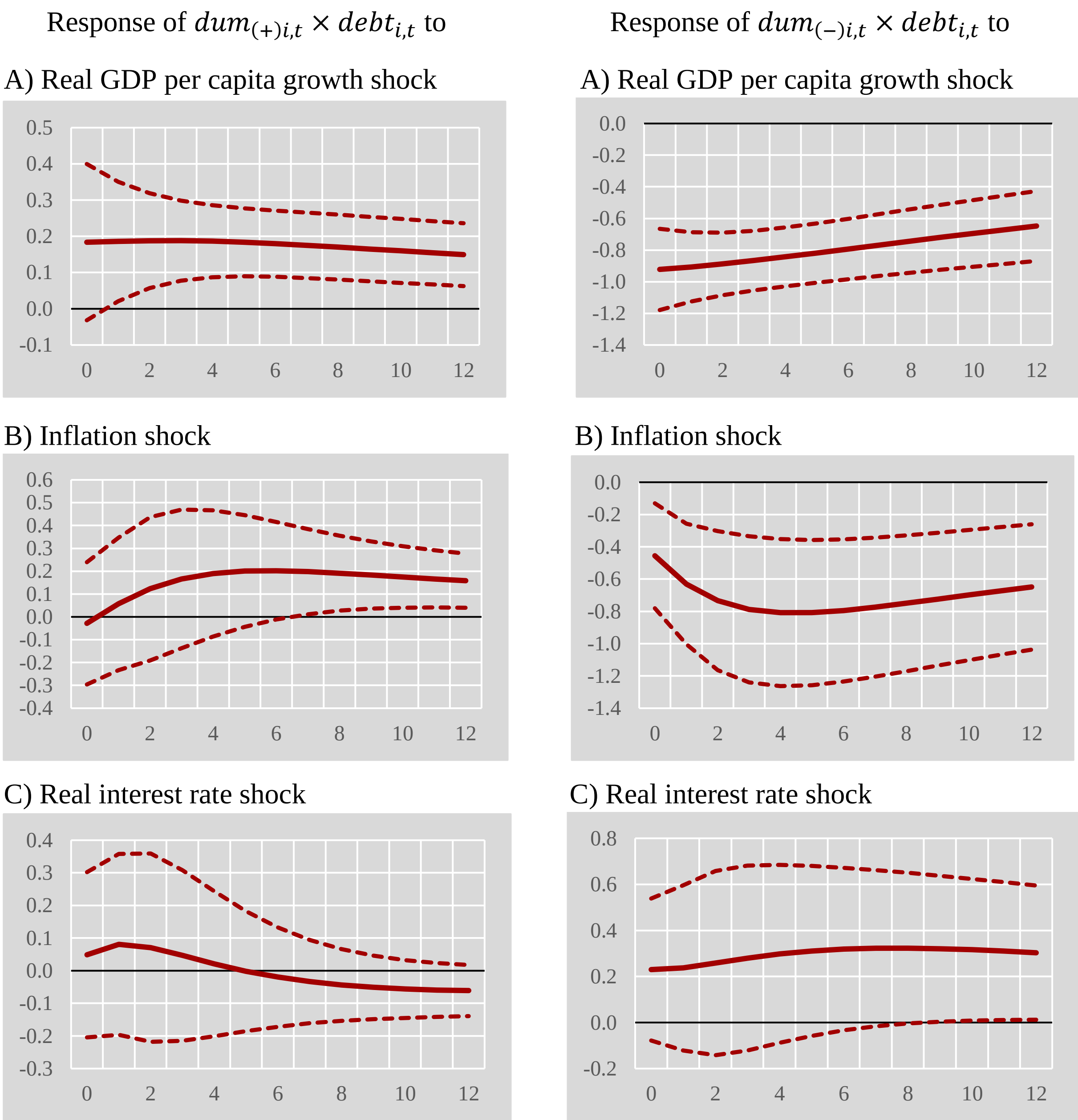
A 1 percentage point increase in the growth rate leads to 0.2 percentage points rise in $dum_{(+)i,t} \times debt_{i,t}$ and 0.8-0.9 percentage points fall in $dum_{(-)i,t} \times debt_{i,t}$ for the first 5 years, respectively. The responses of the debt indicators to the growth shock are persistent and statistically significant at the 95 percent significance level, except for the impact period in the case of $dum_{(+)i,t} \times debt_{i,t}$. The mutual feedback effects between growth and public debt align with Lim's findings (2019). A novel finding from this paper is that the two-way effects are much stronger when the public debt exceeds the threshold level (52 percent of GDP).

A positive inflation shock leads to a significant and persistent decrease in the public debt indicator once the public debt reaches a higher level above the threshold. However, in the case of lower public debt, the response of the public debt indicator ($dum_{(+)i,t} \times debt_{i,t}$) to the inflation shock is not statistically significant for the first 6 years. The results suggest that the mutual feedback effects between public debt and inflation exist only when the public debt exceeds the threshold level. Responses of public debt indicators to a positive real interest rate shock are not statistically significant at a 95 percent confidence level. However, as expected, a rise in real interest rate leads to an initial increase in public debt for the two cases, below and above the threshold level.

We also conduct the same exercise for the sample of Asian coastal developing economies and report the results in Figure 7. The results are qualitatively the same as found in the whole sample. However, the magnitude of the responses is much stronger for this sub-sample. For instance, a 1 percentage point increase in the growth rate leads to 0.54 percentage points rise in $dum_{(+)i,t} \times debt_{i,t}$ and 1.76 percentage points fall in $dum_{(-)i,t} \times debt_{i,t}$ in the fourth year, respectively. A 1 percentage point increase in the inflation rate causes 1 percentage points decline in $dum_{(+)i,t} \times debt_{i,t}$ in fifth year. We do not find any significant feedback effect from the real interest rate to public debt indicators.

Figure 8 displays responses of public debt indicators to growth, inflation, and real interest rate shocks for Asian landlocked developing economies. Except for the response of $dum_{(-)i,t} \times debt_{i,t}$, the responses are not statistically significant to the growth shock at a 95 percent confidence level. This finding implies that the two-way effects between growth and public debt are only held once the public debt exceeds its threshold level in the economies. The results may also indicate that the public debt indicators are mainly changed by more exogenous factors such as politically driven fiscal deficit or quasi-fiscal operations implemented by the state-owned and global commodity prices.

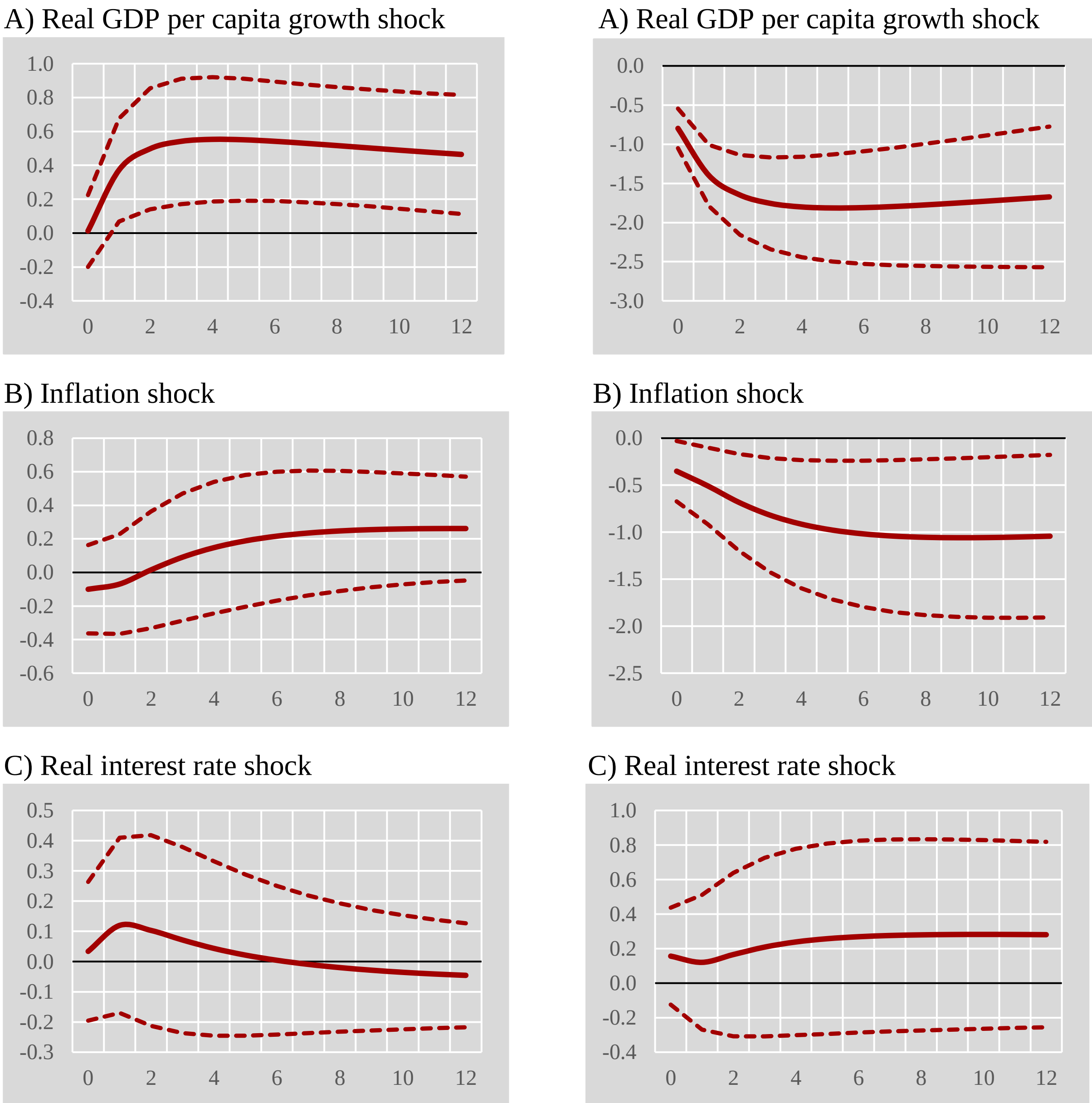
Figure 6. Generalized impulse response functions of debt indicators to growth, inflation and real interest rate shocks: Asian developing economies



Notes: Figures show point responses, together with 95 percent confidence interval. Horizon is annually.

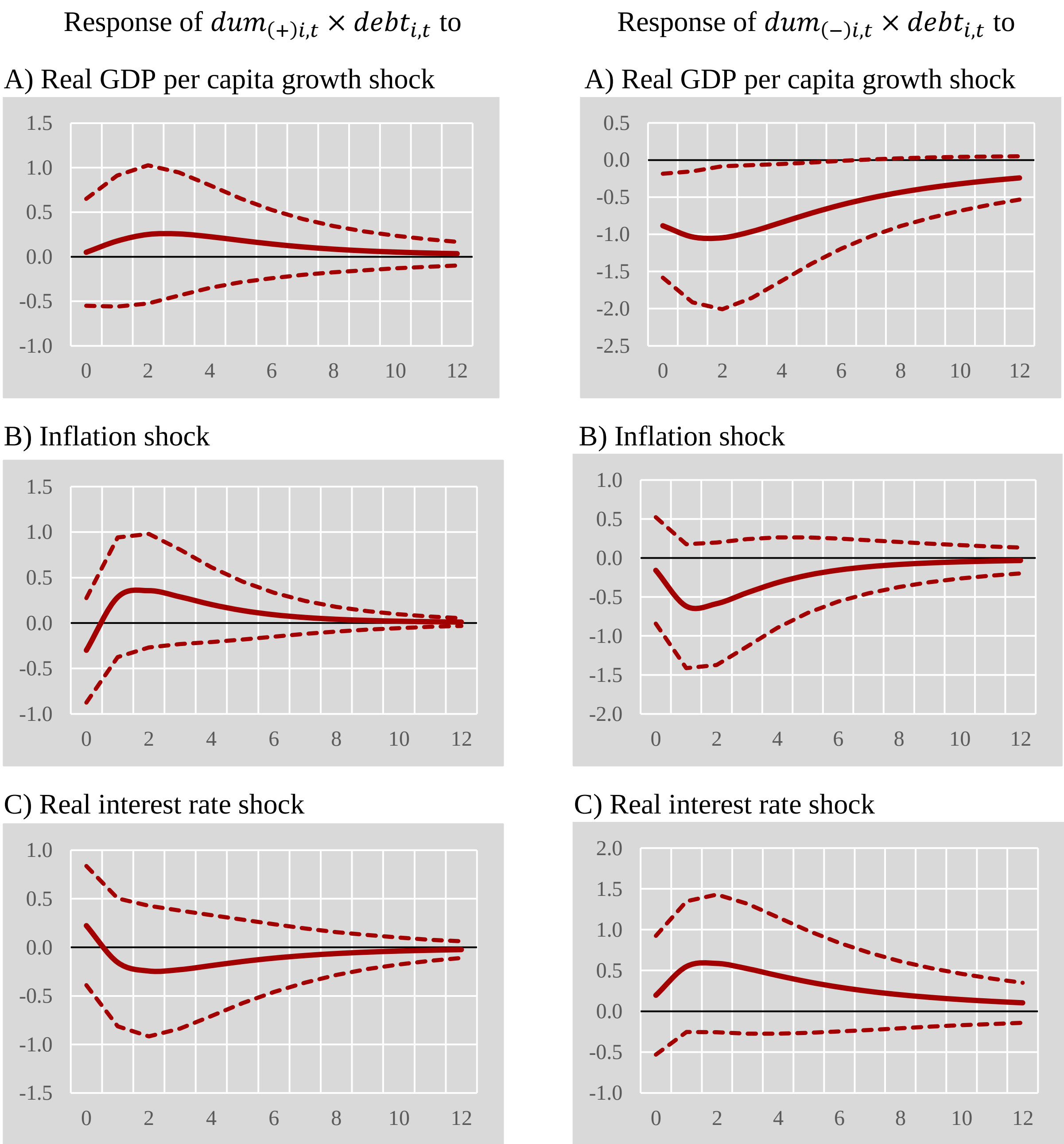
Figure 7. Generalized impulse response functions of debt indicators to growth, inflation and real interest rate shocks: Asian coastal developing economies

Response of $dum_{(+)i,t} \times debt_{i,t}$ to | Response of $dum_{(-)i,t} \times debt_{i,t}$ to



Notes: Figures show point responses, together with 95 percent confidence interval. Horizon is annually.

Figure 8. Generalized impulse response functions of debt indicators to growth, inflation and real interest rate shocks: Asian landlocked developing economies



Notes: Figures show point responses, together with 95 percent confidence interval. Horizon is annual.

3.3.2 Variance decompositions

Variance decomposition analysis helps examine the importance of public debt shocks in growth, inflation, and real interest rate movements. Table 3 shows the contribution shocks to the variances of the GDP per capita growth, inflation, and real interest rate in VAR models.

Table 3. Variance decomposition of domestic variables, percent of variance

Shock	**Growth (g)**				**Inflation (inf)**				**Real interest rate (r)**			
	Horizon (years)				Horizon (years)				Horizon (years)			
	1	5	10	20	1	5	10	20	1	5	10	20
	VAR(1) for Asian developing economies											
$\boldsymbol{dum_{(+)} \times debt}$	0.56	1.47	1.54	1.55	0.01	0.42	0.63	0.64	0.03	1.20	1.85	1.93
$\boldsymbol{dum_{(-)} \times debt}$	23.9	23.7	23.6	23.6	6.94	7.22	7.31	7.33	2.61	1.96	2.06	2.53
$\boldsymbol{g}$	75.5	74.7	74.6	74.6	0.20	0.20	0.20	0.20	0.00	0.02	0.02	0.02
$\boldsymbol{inf}$	0.13	0.21	0.22	0.22	92.8	91.8	91.5	91.4	1.00	6.16	6.87	6.84
$\boldsymbol{r}$	0.01	0.01	0.01	0.01	0.11	0.34	0.38	0.38	96.4	90.7	89.2	88.7
	VAR(1) for Asian coastal developing economies											
$\boldsymbol{dum_{(+)} \times debt}$	0.00	2.71	4.39	4.90	0.15	0.58	0.68	0.71	0.02	1.16	2.22	2.67
$\boldsymbol{dum_{(-)} \times debt}$	24.1	23.6	23.3	23.3	5.03	8.63	8.69	8.80	1.18	1.88	2.26	4.33
$\boldsymbol{g}$	75.9	72.6	71.2	70.6	2.48	2.18	2.30	2.30	0.06	3.03	3.13	3.29
$\boldsymbol{inf}$	0.00	0.57	0.66	0.69	92.3	88.0	87.8	87.6	0.41	4.62	4.98	4.90
$\boldsymbol{r}$	0.31	0.47	0.47	0.47	0.31	0.57	0.59	0.59	98.3	89.3	87.3	84.8
	VAR(1) for Asian landlocked developing economies											
$\boldsymbol{dum_{(+)} \times debt}$	0.02	0.04	0.06	0.06	0.80	0.65	0.66	0.67	0.39	0.68	0.93	0.97
$\boldsymbol{dum_{(-)} \times debt}$	25.9	22.2	22.2	22.2	9.58	13.1	13.2	13.2	6.93	5.07	5.38	5.43
$\boldsymbol{g}$	73.9	74.6	74.4	74.3	0.21	3.57	3.75	3.75	0.12	3.23	4.12	4.12
$\boldsymbol{inf}$	1.22	2.19	2.18	2.19	89.4	82.0	81.6	81.6	2.50	4.19	4.12	4.12
$\boldsymbol{r}$	0.33	0.99	1.10	1.10	0.15	0.65	0.78	0.78	90.1	86.8	85.6	85.5

Regardless of the horizon, $dum_{(+)} \times debt$ shock (i.e., changes in the public debt indicator when it is below the threshold level) explains a small portion of the volatility in the macro variables for all three samples. For instance, the shock accounts for less than 3 percent of the 5-year-ahead fluctuations in GDP per capita growth for three groups of countries. Instead, our results show that $dum_{(-)} \times debt$ shock (i.e., changes in the public debt indicator when it is above the threshold level) accounts for more than 23 percent of the 1-year ahead fluctuations in GDP per capita growth. The same shock respectively accounts for 7 percent and 2 percent of the 5-year ahead fluctuations in inflation and real interest rate for Asian developing economies. The results reconfirm that movements in public debt (as a percent of GDP) have a meaningful impact on macro variables once the debt level exceeds the threshold level.

4. Robustness checks

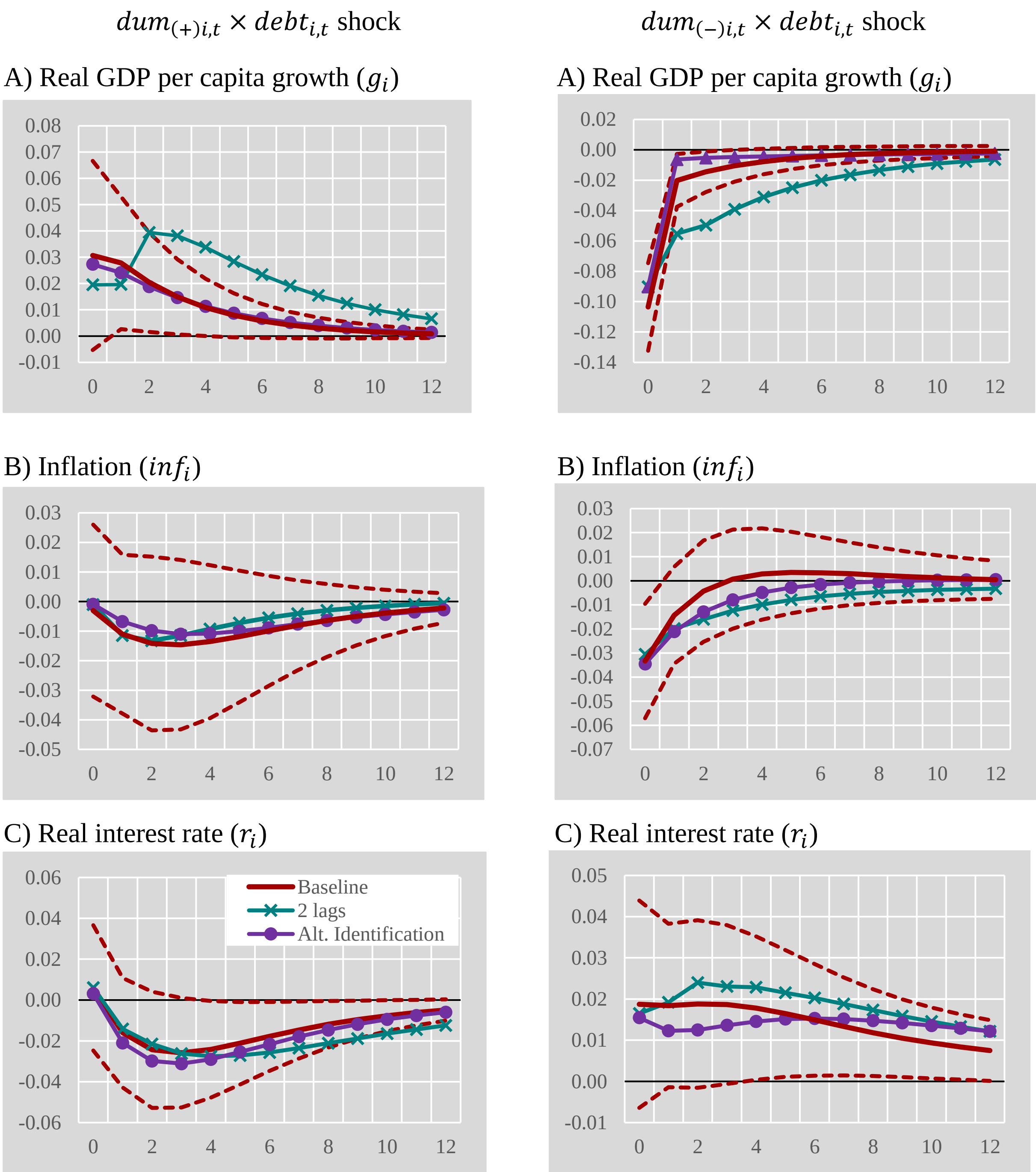
In this section, we discuss the robustness of our results to different model specifications: i) the number of lags and ii) shock identification.

Our key findings are robust for alternative specifications. To check the robustness of the results, the models are also estimated using two lags. Results are shown as aqua colour lines with "x" marker in figures. We show results of the robustness analysis of impulse responses to debt indicator shocks in Figure 9 (for Asian developing economies), Figure A.2 (for Asian coastal developing economies), and Figure A.3 (for Asian landlocked developing economies). The robustness results of impulse responses of debt indicators to growth, inflation, and real interest rate shocks are presented in Figure 10, Figure A.4, and Figure A.5. The responses from the VAR(2) models are qualitatively the same as obtained from the baseline VAR(1) models. Except for a few cases in the sample of Asian developing economies, impulse responses remain within the confidence intervals of the baseline impulse responses.

An alternative shock identification is employed. Our alternative identification aligns with the existing literature (i.e., Blanchard and Perotti 2002, Lim et al. 2019). We adopted a recursive identification scheme with a lower-triangular impact matrix for VAR(1) models. In the alternative identification, we separately include $dum_{(+)i,t} \times debt_{i,t}$ and $dum_{(-)i,t} \times debt_{i,t}$ variables in the system. Therefore, the ordering of variables is set as $dum_{(+)i,t} \times debt_{i,t}, g_{i,t}, inf_{i,t}, r_{i,t}$ and $dum_{(-)i,t} \times debt_{i,t}, g_{i,t}, inf_{i,t}, r_{i,t}$. The public debt indicator is placed first in the identification, followed by per capita GDP growth, as employed by Lim et al. (2019). Hence, per capita GDP growth changes do not prompt any immediate feedback response from the public debt indicators. Identification for the remaining two variables in the specification is based on the conventional Cholesky ordering standard in the literature-such as that places the inflation after the per capita GDP growth, and the interest rate is more endogenous than the inflation and the growth. Thus, public debt, growth, and inflation affect the interest rate contemporaneously and with a lag; however, the interest rate only affects these variables with a lag.

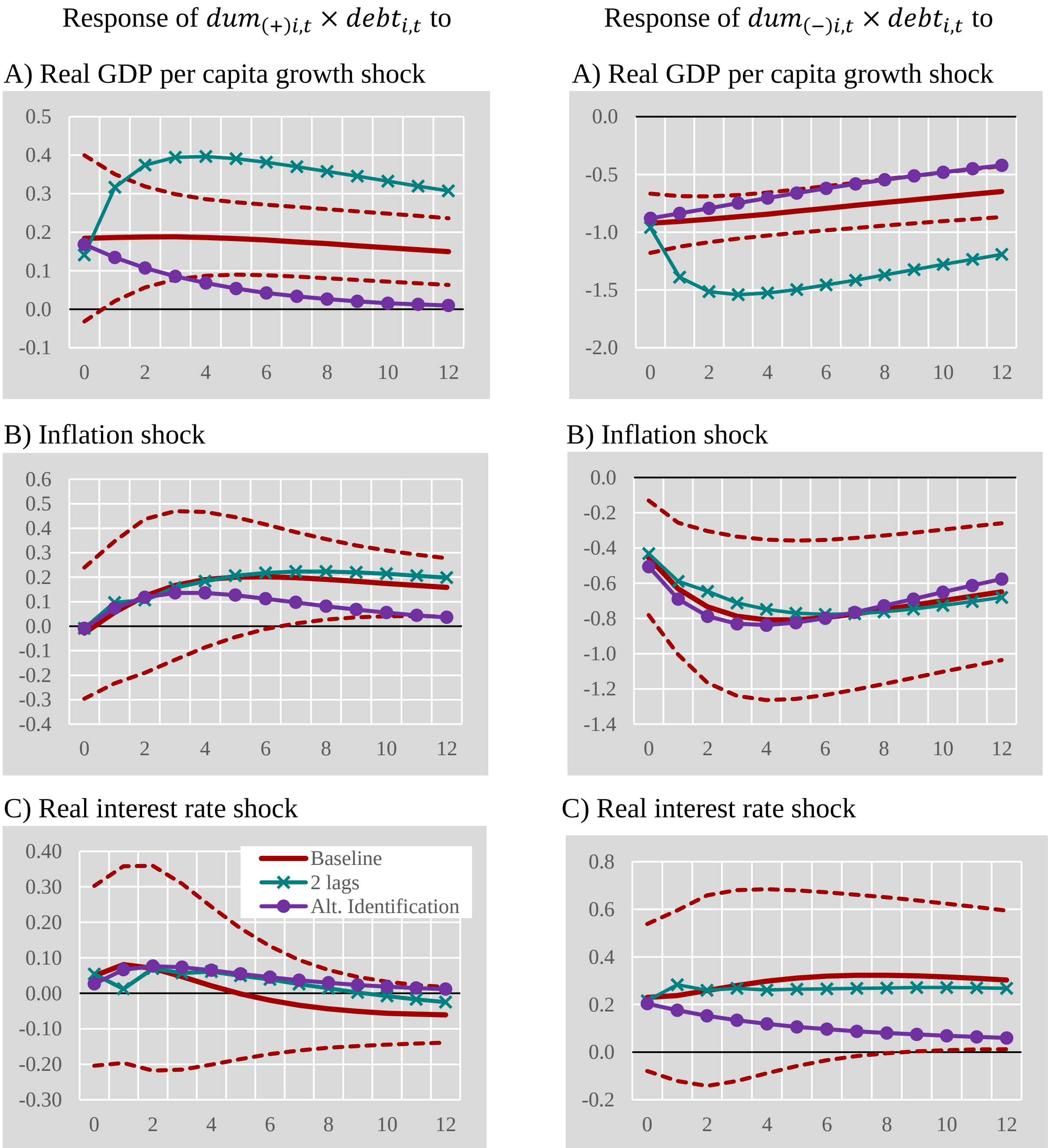
Results from the alternative identifications are shown as purple lines with "o" marker in the figures. The responses from the alternative identification are generally like those of the baseline models. All 'alternative identification' impulse responses remain within the confidence intervals of the baseline impulse responses.

Figure 9. Robustness of impulse responses to debt shocks: Asian developing economies



Notes: Figures show point responses and a 95 percent confidence interval is included for the baseline case. Horizon is annual.

Figure 10. Robustness of impulse responses of debt indicators to growth, inflation and real interest rate shocks: Asian developing economies



Notes: Figures show point responses and a 95 percent confidence interval is included for the baseline case. Horizon is annual.

5. Conclusion

In this paper, we have examined the non-linear effects of public debt on economic growth in Asian developing economies using both panel GMM regression approach and panel VAR models. We also analyzed geographical (cross-country) heterogeneity in the non-linear effects by separating the samples for coastal and landlocked economies.

Several novel and interesting results are obtained. First, based on the single regression approach, we find a statistically significant non-linear effect of public debt (as a percent of

GDP) on GDP per capita growth (i.e., an inverted U-shaped relationship), particularly in the samples of whole Asian developing economies and Asian coastal developing economies. The debt turning point (the threshold level) is estimated at 52 percent, 50 percent, and 66 percent for Asian developing economies, Asian coastal developing economies, and Asian landlocked developing economies, respectively. Second, panel VAR analysis reveals that the response of the growth, inflation, and real interest rate to changes in public debt (as a percent of GDP) is non-linear and asymmetric depending on the public debt level. The asymmetry exists in the signs, magnitude, and statistical significance of the impulse responses.

We also find the non-linear and asymmetric effect of the growth, inflation, and real interest rate on public debt (as a percent of GDP). The statistically significant two-way effects between the growth and the public debt are more evident when the public debt exceeds its threshold level in the economies. In such a case, public debt shocks account for more than 23 percent of the 1-year-ahead fluctuations in GDP per capita growth. Third, there exists geographical heterogeneity in the mutual feedback effects between the macro variables (i.e., GDP per capita growth, inflation, and real interest rate) and public debt (as a percent of GDP). For instance, we find strong and statistically significant mutual feedback effects in the case of Asian coastal developing economies. The inflation and real interest rate channels of public debt are also evident in coastal economies. However, they are not the case for Asian landlocked developing economies, except for the mutual relationship between growth and public debt. These results remain robust when the model specification is changed in terms of sample size, number of lags, and identification method.

These findings provide some practical and policy implications. First, to avoid adverse growth effects, Asian developing economies should aim to keep their public debt ratios at their own sustainable (the estimated threshold) levels, preferably below 50 percent of GDP for coastal developing economies and 66 percent of GDP for landlocked developing economies. Second, it is better to use geographic (or region)-specific debt threshold levels and asymmetric response coefficients (depending on debt level) in public debt policy analysis as there is a non-negligible cross-country heterogeneity and non-linear relationship between the growth and public debt. Moreover, it is better to note that appropriate policies for one region or country can be misguided in another.

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Appendix

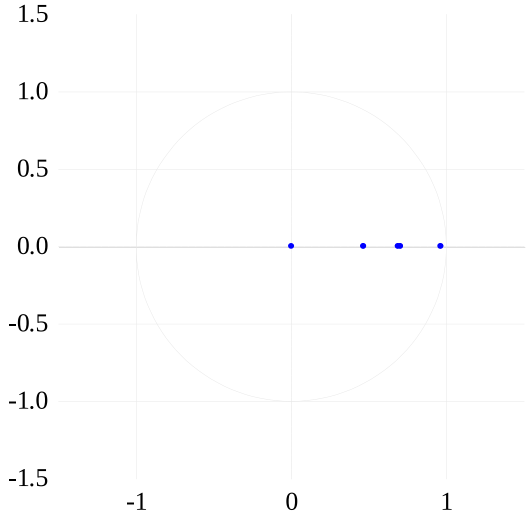
Table A.1. Results of Unit Root Tests

H_0: The variable has a unit root	ADF Test		PP Test		Order of Integration
	Level	First difference	Level	First difference	
Asian developing economies					
$\boldsymbol{g}$	218.57***	537.62***	229.94***	651.13***	$I(0)$
$\boldsymbol{log(gdppc)}$	56.86	277.43***	37.99	301.65***	$I(1)$
$\boldsymbol{pubdebt}$	99.57**	254.82***	101.98**	262.47***	$I(0)$
$\boldsymbol{fisbal}$	152.58***	567.53***	126.47***	666.58***	$I(0)$
$\boldsymbol{cap}$	132.74***	238.59***	105.58***	376.29***	$I(0)$
$\boldsymbol{popg}$	311.57***	401.54***	129.98***	193.31***	$I(0)$
$\boldsymbol{fdi}$	136.49***	403.62***	159.35***	747.01***	$I(0)$
$\boldsymbol{inf}$	262.92***	1024.47***	362.05***	1045.97***	$I(0)$
$\boldsymbol{r}$	137.32***	316.96***	195.21***	1000.98***	$I(0)$
Asian coastal developing economies					
$\boldsymbol{g}$	147.59***	357.42***	137.06***	433.13***	$I(0)$
$\boldsymbol{log(gdppc)}$	33.82	148.62***	17.71	158.61***	$I(1)$
$\boldsymbol{pubdebt}$	67.63**	169.97***	65.45**	187.84***	$I(0)$
$\boldsymbol{fisbal}$	82.49***	365.21***	73.97***	430.37***	$I(0)$
$\boldsymbol{cap}$	95.07***	275.49***	75.75***	268.54***	$I(0)$
$\boldsymbol{popg}$	82.45***	214.29***	79.07***	105.38***	$I(0)$
$\boldsymbol{fdi}$	97.94***	407.07***	92.94***	453.52***	$I(0)$
$\boldsymbol{inf}$	172.36***	476.80***	205.23***	775.39***	$I(0)$
$\boldsymbol{r}$	137.91***	334.36***	135.18***	883.84***	$I(0)$
Asian landlocked developing economies					
$\boldsymbol{g}$	70.97***	180.20***	92.88***	217.99***	$I(0)$
$\boldsymbol{log(gdppc)}$	25.69	45.03***	12.09	61.26***	$I(1)$
$\boldsymbol{pubdebt}$	41.95**	84.85***	36.52**	74.63***	$I(0)$
$\boldsymbol{fisbal}$	70.09***	202.32***	52.50***	236.11***	$I(0)$
$\boldsymbol{cap}$	31.91*	121.16***	30.83*	110.55***	$I(0)$
$\boldsymbol{popg}$	60.03***	135.67***	50.91***	87.93***	$I(0)$
$\boldsymbol{fdi}$	57.08***	235.96***	66.41***	293.48***	$I(0)$
$\boldsymbol{inf}$	149.93***	194.19***	156.81***	270.58***	$I(0)$
$\boldsymbol{r}$	295.69***	112.98***	60.03***	117.14***	$I(0)$

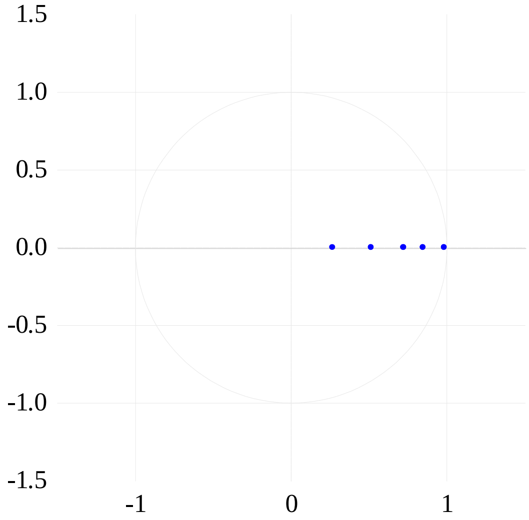
Notes: '***', '**' and '*' denote the level of significance at 1%, 5%, and 10%, respectively. Selection of lag length in the regression used in the tests are based on Schwarz Criterion. Tests for level data and differenced data are computed from regressions with intercept term.
Source: Authors' calculation

Figure A.1. Inverse roots of AR characteristic polynomial of baseline VARs

A. VAR(1) model for Asian developing economies



B. VAR(1) model for Asian coastal developing economies



C. VAR(1) model for Asian landlocked developing economies

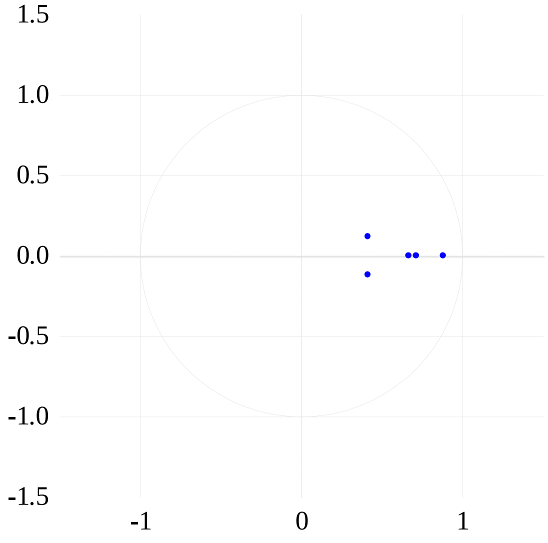
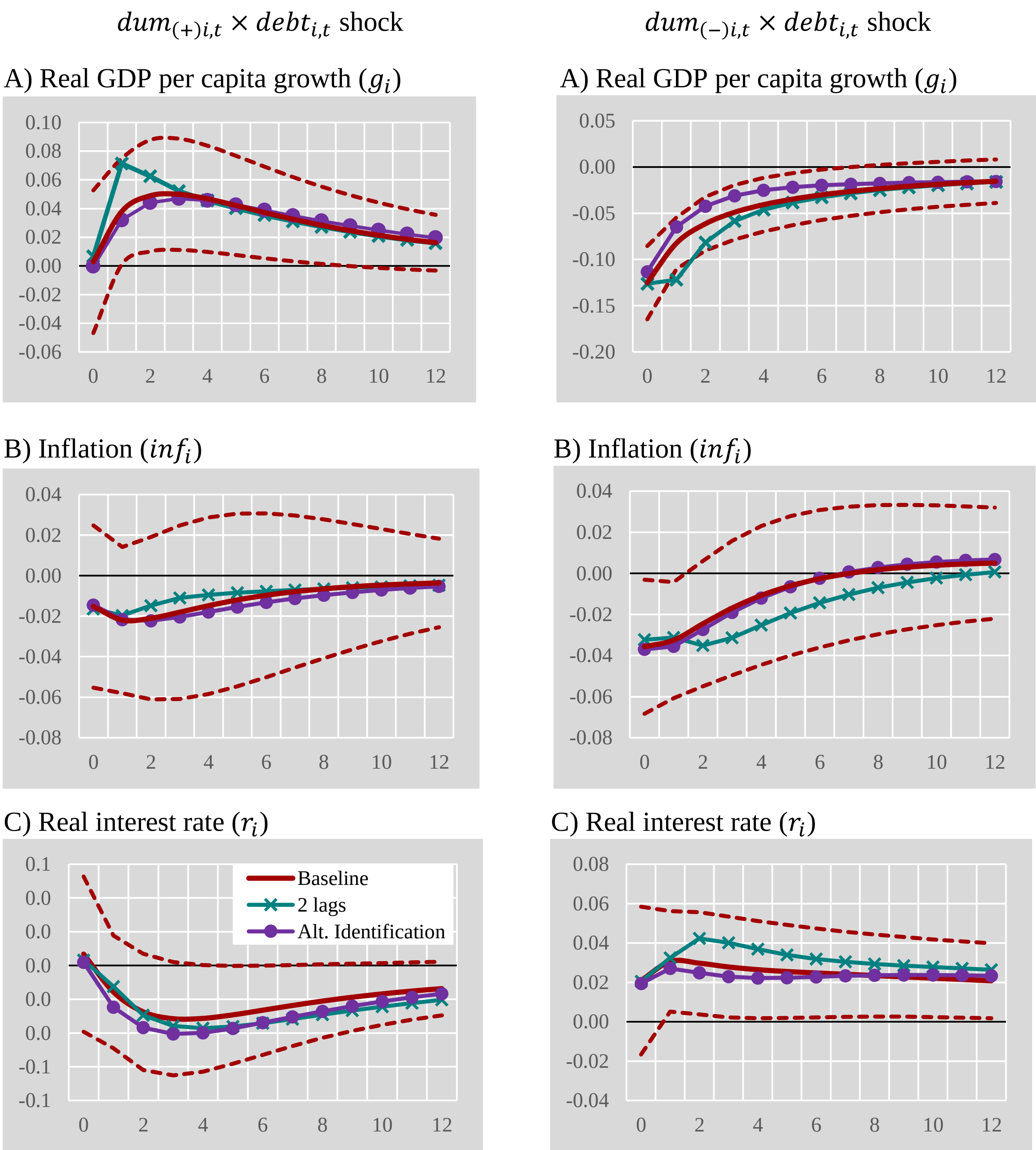


Figure A.2. Robustness of impulse responses to debt shocks: Asian coastal developing economies

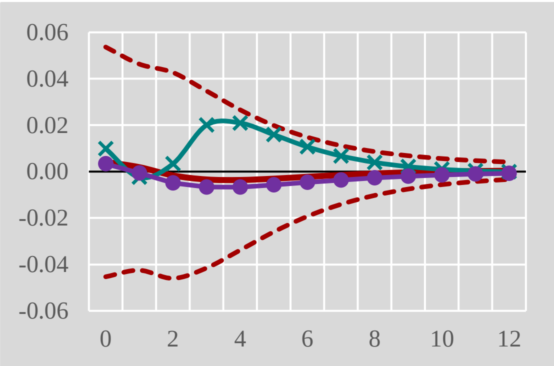


Notes: Figures show point responses, and 95 percent confidence interval is included for baseline case. Horizon is annually.

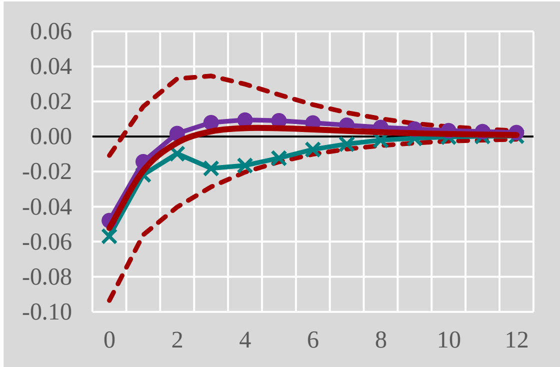
Figure A.3. Robustness of impulse responses to debt shocks: Asian landlocked developing economies

$dum_{(+)i,t} \times debt_{i,t}$ shock | $dum_{(-)i,t} \times debt_{i,t}$ shock

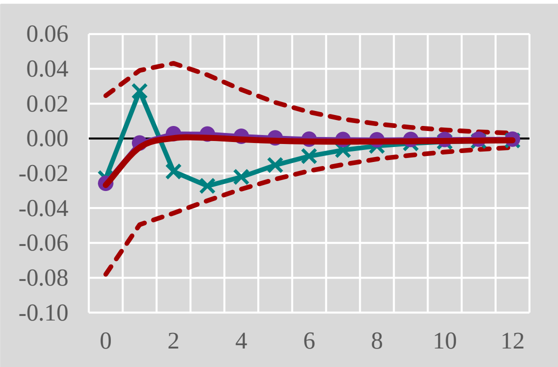
A) Real GDP per capita growth (g_i)



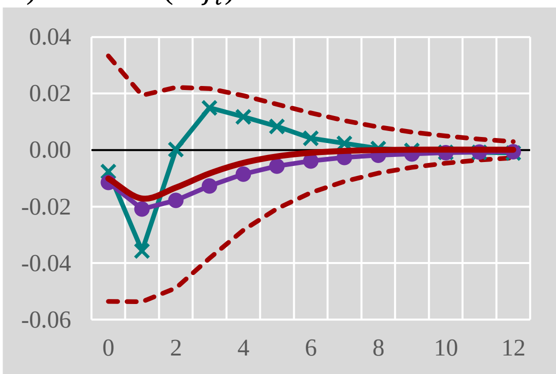
A) Real GDP per capita growth (g_i)



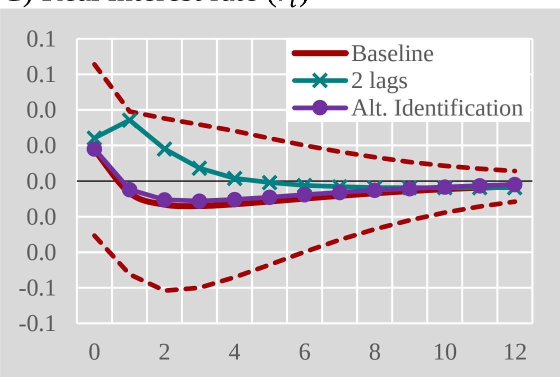
B) Inflation (inf_i)



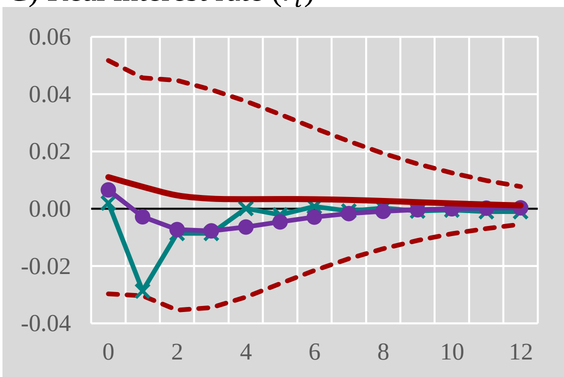
B) Inflation (inf_i)



C) Real interest rate (r_i)

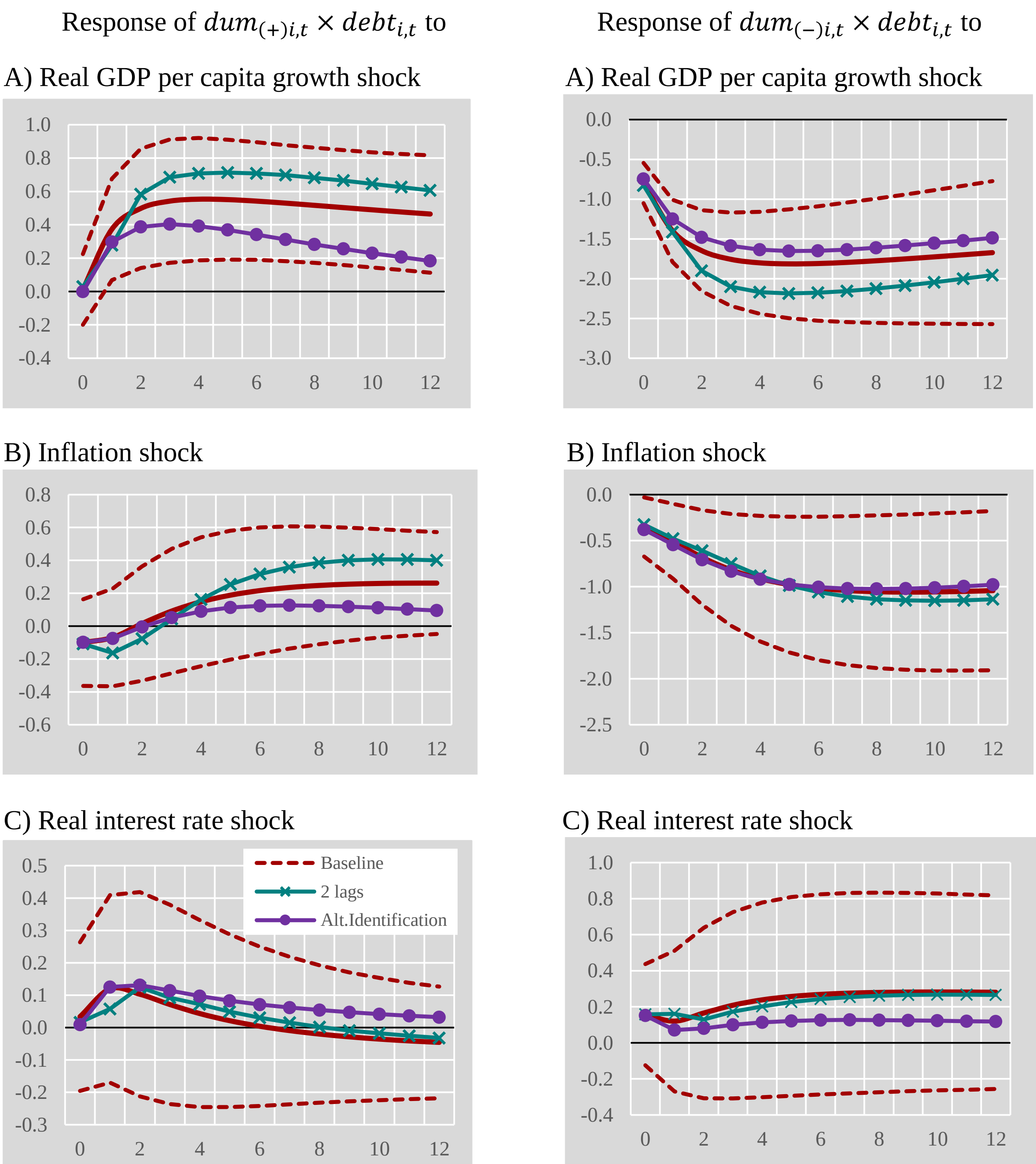


C) Real interest rate (r_i)



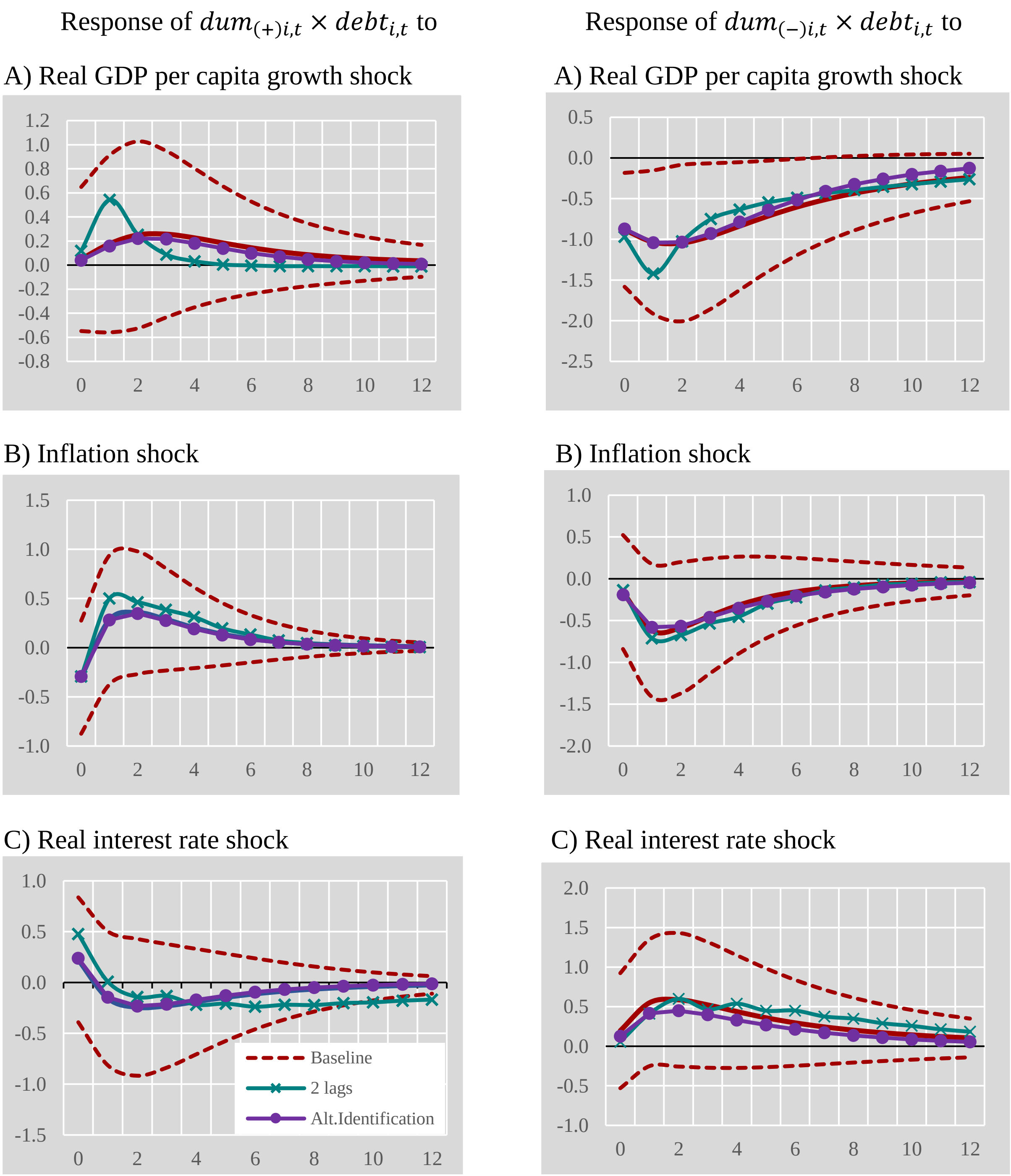
Notes: Figures show point responses, and 95 percent confidence interval is included for baseline case. Horizon is annually.

Figure A.4. Robustness of impulse responses of debt indicators to growth, inflation and real interest rate shocks: Asian coastal developing economies



Notes: Figures show point responses, and 95 percent confidence interval is included for baseline case. Horizon is annually.

Figure A.5. Robustness of impulse responses of debt indicators to growth, inflation and real interest rate shocks: Asian landlocked developing economies



Notes: Figures show point responses, and 95 percent confidence interval is included for baseline case. Horizon is annually.