2 EFFECTS OF SOVEREIGN CREDIT RATING CHANGES ON EXCHANGE RATES[1]

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Abstract

Using quarterly macroeconomic data for 41 countries, this study examines how sovereign credit rating changes affect exchange rates. An innovation in rating changes has statistically significant short-run effects on exchange rate movements in some subsamples. The exchange-rate response is statistically significant in the high-GDP subsample but not in the low-GDP subsample. Our empirical results suggest that monitoring credit rating changes can be useful for tracking exchange rate movements in high-GDP countries.

Keywords: *Exchange rates; Sovereign credit ratings*.

JEL classification: *G15, G24, F31, F37*

1. Introduction

Credit rating agencies assign ratings by evaluating the likelihood that the government will service its debt obligations, considering potential risk factors. Sovereign ratings are differentiated by currency and maturity. In the context of sovereign credit ratings, the term refers to the foreign currency long-term issuer ratings. Sovereign credit ratings indicate the likelihood of sovereign default and the expected loss of government bonds. Therefore, sovereign credit ratings serve as important inputs in pricing government bonds and guiding investment decisions. In sovereign credit rating markets, there are three internationally recognized Credit Rating Agencies (CRAs): S&P Global Ratings, Moody's Ratings, and Fitch Ratings.

After the global financial crisis and European sovereign debt crisis, the major credit rating agencies have increasingly emphasized the role of fiscal structure in sovereign rating assessments. There are some cases in which ratings have been downgraded because of concerns about worsening fiscal conditions. For example, S&P Global Ratings downgraded France's sovereign rating, citing fiscal sustainability concerns, in May 2024. Also, in the post-COVID period, expanded fiscal spending has been cited as a risk factor for sovereign rating downgrades. This raises the question of how the macroeconomy responds to sovereign rating downgrades. As sovereign credit ratings indicate the default risk of a country, the changes affect the exchange rates through a risk premium (Kim, Cho, and Ryu, 2025a). Exchange rates matter because they affect domestic inflation and trade conditions. After 2010, with increasing trade disputes and geopolitical risk (Kim, Paik, and Ryu, 2025), it is important to monitor the foreign

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exchange (FX) market around rating changes (Nam and Ryu, 2025). Motivated by this question, we aim to trace the exchange rate responses to changes in sovereign credit ratings. Prior studies report that the determinants of sovereign risk vary across stages of economic development (Hilscher and Nosbusch, 2010; Klusak et al., 2023). This implies that the macroeconomic effects may vary depending on a country's structural characteristics.

We compile a broad cross-country quarterly panel of macroeconomic indicators from 2000Q1 to 2025Q2 for 41 countries. Using these data, we estimate a panel vector autoregression (PVAR) model to analyze macroeconomic dynamics following sovereign rating changes. Because the variables interact with each other, the PVAR methodology may be more appropriate to capture dynamics than standard panel regression and to control for potential channels. In addition, we analyze the impulse response functions (IRFs) to trace dynamic responses and transmission pathways. Also, to examine whether macroeconomic responses vary across countries' characteristics, we divide subsamples based on GDP level and general government debt to GDP ratio, and conduct the same analysis. The heterogeneous exchange-rate response is clearest across the GDP split: the response is statistically significant in the high-GDP subsample but not in the low-GDP subsample. For the debt split, the low-debt pattern appears in the IRF analysis, but the supplementary regressions suggest a more cautious interpretation. We interpret these differences as reflecting heterogeneity in financial access and external dependence (Nam, Batten, and Ryu, 2025). Existing PVAR studies often focus on relatively homogeneous regions such as East Asia or the European Union. In contrast, we compile a cross-country sample that is not restricted to a specific region. Therefore, we provide relatively general evidence on heterogeneous responses to sovereign rating changes and implications for exchange-rate dynamics.

The rest of this paper is organized as follows. Section 2 reviews the existing literature, while Section 3 describes the data and the empirical model. In Section 4, we conduct an empirical analysis using the Panel VAR approach. Finally, Section 5 provides concluding remarks.

2. Related Literature and Research Background

The literature on sovereign credit ratings can be broadly classified into two strands: *i*) studies on the determinants of sovereign ratings and *ii*) studies on the economic effects of rating changes. These two topics are inherently connected because macroeconomic developments can induce changes in sovereign ratings, and, in turn, rating actions can feed back into macroeconomic outcomes. Since the 1990s, as the importance of sovereign credit ratings has increased, studies have examined the determinants of sovereign ratings using cross-country panel data. Cantor and Packer (1996) provide the earliest empirical analyses, using 1995 data for 49 countries from S&P Global Ratings and Moody's Ratings. They identify per capita income, inflation, the level of economic development, and default history as statistically significant determinants. However, the effects of the current account and fiscal balance are found to be weak. Afonso, Gomes, and Rother (2011) distinguish between short- and long-run determinants using panel data. In the short run, per capita income, economic growth, government debt, and the fiscal balance are significant. In the long run, government effectiveness, external debt, foreign exchange reserves, and default history emerge as major indicators. Bissoondoyal-Bheenick (2005) similarly highlights per capita income and inflation as core determinants for lower-rated countries. Amstad and Packer (2015) investigate changes in the rating practices of the three major agencies across the pre- and post-crisis periods. They analyze the determinants of sovereign ratings separately for advanced and emerging economies.

A second strand of the literature examines the effects of sovereign credit rating changes. Kim and Wu (2008) provide evidence that both the level and changes of sovereign credit ratings have statistically significant effects on capital flows and indicators of financial development. Their findings reinforce the view that sovereign ratings can transmit to the real economy through financial transactions. Schumacher (2014) uses a PVAR framework to examine the dynamic relationship between macroeconomic variables and sovereign credit ratings, using European data. The study finds evidence of bidirectional effects between ratings and macroeconomic fundamentals. He also shows that rating fluctuations can adversely affect the business cycle. Kang and Min (2016) use a panel VAR approach to investigate the interaction between sovereign ratings and macroeconomic variables for seven East Asian economies. Their results indicate that rating outlooks, rather than the sovereign rating level, exert a stronger influence on credit default swap spreads and stock market indices. Kenourgios, Umar, and Lemonidi (2020) estimate the effects of sovereign rating announcements on 10-year government bond yields. They find that the impact of negative events (downgrades) is larger than that of positive events (upgrades). They show that market responses are heterogeneous across countries depending on their stage of development. Kladakis and Skouralis (2025) report that rating downgrades significantly lower the 5% left tail quantile of GDP growth four quarters ahead. Therefore, downgrading increases downside risks to macroeconomic fluctuations. They show that the effects of upgrades are small or statistically indistinct, whereas downgrade effects are larger. Kim, Cho, and Ryu (2025b) document that a proxy for risk aversion predicts future real economic activity. This suggests that the risk aversion change from credit rating changes may affect the macroeconomic variables. Beyond bond and foreign exchange markets, recent evidence suggests that sovereign rating actions also affect broader financial-system risk, and that negative rating signals tend to have stronger effects than positive ones (Sahibzada, Rizwan, and Qureshi, 2022). This perspective is relevant to our cross-country heterogeneity analysis, because the exchange-rate effects of rating changes may also depend on countries' fiscal conditions and their capacity to absorb sovereign risk shocks.

Existing studies generally suggest that sovereign credit news and sovereign risk are meaningfully related to exchange-rate movements, but the magnitude, timing, and channels of transmission vary across settings. Alsakka and Ap Gwilym (2012) show that foreign exchange markets react to sovereign credit news and that the effects differ across country characteristics, while Alsakka and Ap Gwilym (2013) further document that, during the European sovereign debt crisis, both own-country and spillover effects became stronger, with outlook and watch signals often exerting larger effects than actual rating changes. Using a treatment-effect framework, Balima, Minea, and Vinturis (2023) find that both positive and negative sovereign rating events significantly affect effective exchange rates, with larger responses to negative events and stronger effects under flexible exchange-rate regimes. Relatedly, Della Corte et al. (2022) show that increases in sovereign risk are associated with currency depreciation and heightened downside risk in foreign exchange markets, highlighting the importance of the risk-premium channel. Bernoth and Herwartz (2021) emphasize that exchange-rate-related sovereign-risk responses depend on countries' external balance-sheet structures, suggesting that macro-financial transmission is shaped by underlying vulnerability and foreign-currency exposure. Prior studies show that exchange-rate responses to sovereign credit news vary with country characteristics and market conditions. Building on this literature, we examine whether such heterogeneity is also observed in a broad cross-country PVAR setting.

3. Data and Methodology

We use the World Bank's Quarterly Public Sector Debt database, specifically the series Gross PSD, General Government, all maturities, all instruments, nominal value, percent of GDP. The sample comprises 41 countries for which this series is available for at least 65 quarters. This restriction is imposed because QPSD data contains relatively many missing observations and

because the number of countries that report this series consistently is limited. The analysis covers 2000Q1–2025Q2, and we construct an unbalanced country–quarter panel over this period.

First, the key variable, sovereign credit rating, is obtained from the LSEG (London Stock Exchange Group). Table 1 reports the sovereign rating categories assigned by each credit rating agency and their corresponding numerical scores. Sovereign ratings are reported on the following scale: AAA–SD for S&P Global Ratings, Aaa–C for Moody's Ratings, and AAA–D for Fitch Ratings. Following the literature, we convert ratings into a numeric measure ranging from 21 (highest) to 0 (lowest) (Gehring and Lang, 2020; Slapnik and Lončarski, 2021, 2023). In addition, prior studies document that the ratings assigned by the three major credit rating agencies tend to move closely together (Alsakka and Ap Gwilym, 2013; Chen et al., 2019). Cross-agency rating differentials are typically observed within two notches (Hill, Brooks, and Faff, 2010), and for many countries, they are identical or differ by no more than one notch. To mitigate limitations in the time-series coverage and cross-country availability of agency-specific ratings, we construct an average rating by averaging the three agencies' numerical scores and use this measure in empirical analysis. When only one agency rating is available for a given country, we use that single observation; when two or more agency ratings are available, we compute their simple average. The other variables, GDP, CPI, Balance of Current Account (BCA), and the exchange rate, are obtained from the International Monetary Fund (IMF) database.

Table 1. Sovereign credit rating scales of each agency

Grade	Numeric transformation	S&P Global Ratings	Moody's Ratings	Fitch Ratings
Investment grade	21	AAA	Aaa	AAA
	20	AA+	Aa1	AA+
	19	AA	Aa2	AA
	18	AA-	Aa3	AA-
	17	A+	A1	A+
	16	A	A2	A
	15	A-	A3	A-
	14	BBB+	Baa1	BBB+
	13	BBB	Baa2	BBB
	12	BBB-	Baa3	BBB-
Speculative grade	11	BB+	Ba1	BB+
	10	BB	Ba2	BB
	9	BB-	Ba3	BB-
	8	B+	B1	B+
	7	B	B2	B
	6	B-	B3	B-
	5	CCC+	Caa1	CCC+
	4	CCC	Caa2	CCC
	3	CCC-	Caa3	CCC-
	2	CC	Ca	CC
	1	C	C	C
	0	SD		D

Notes: This table presents each credit rating agency's rating scale and the corresponding scores assigned to each rating. Moody's Ratings uses numerical modifiers. S&P Global Ratings and Fitch Ratings use plus or minus signs to differentiate ratings within the same grade.

Table 2 summarizes the variables used in the analysis, and reports their descriptive statistics, definitions, units, data sources, and correlation between each variable. Panel A provides the definitions, units, and sources of each variable. Macroeconomic values are selected from those commonly used in the sovereign credit rating literature. We use them to control for potential channels affecting exchange rates. We include the logarithm of GDP, inflation, the current account balance to GDP ratio, the general government debt to GDP ratio, and the logarithm of the exchange rate (local currency to USD). GDP reflects a country's level of development and debt servicing capacity and thus may be positively associated with credit ratings. At the same time, rating changes can alter borrowing conditions, which may affect investment and GDP.

Table 2. Variables

Panel A. Definition and source

	Description	Source
Rating_avr	Mean of the numeric transformation of each CRA's sovereign ratings (we use a single rating if only one exists).	Authors' calculation
Rating_S	Numeric transformation of the long-term foreign currency sovereign credit rating converted from letter grades to an ordinal numeric scale of S&P Global Ratings.	LSEG
Rating_M	Numeric transformation of the long-term foreign currency sovereign credit rating of Moody's Ratings.	LSEG
Rating_F	Numeric transformation of the long-term foreign currency sovereign credit rating of Fitch Ratings.	LSEG
LGDP	Logarithm of GDP.	IMF
EXC	Logarithm of the exchange rate of local currency to USD.	IMF
CPI	First differences of the log Consumer Price Index.	IMF
BCA	Balance of current account to GDP ratio.	IMF
DEBT	General government debt to GDP ratio.	World Bank

Panel B. Summary statistics

	N	Mean	SD	Min	P25	Med	P75	Max
Rating_avr	4,140	15.57	4.690	2	12	16	20.67	21
Rating_S	3,856	15.99	4.450	0	12	16	21	21
Rating_M	4,082	15.59	4.806	1	12	16	21	21
Rating_F	3,774	16.22	4.222	2	13	17	21	21
LGDP	4,170	10.72	1.872	6.02	9.14	10.95	12.18	14.30
EXC	4,182	1.098	2.007	-0.715	-0.187	0.010	1.981	8.481
CPI	4,095	0.008	0.012	-0.034	0.001	0.006	0.013	0.108
DEBT	3,853	67.97	39.96	2.243	40.35	58.35	84.92	230.7
BCA	4,087	-0.012	0.073	-0.627	-0.050	-0.014	0.026	0.376

Panel C. Correlation

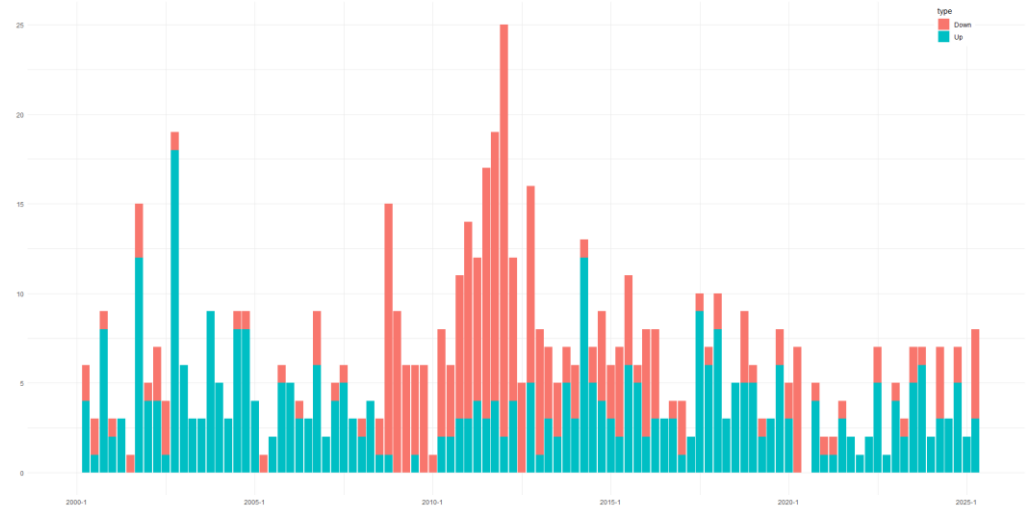
	Rating_avr	LGDP	EXC	CPI	DEBT
LGDP	0.537				
EXC	-0.319	-0.041			
CPI	-0.170	-0.123	0.119		

DEBT	0.038	0.499	-0.066	-0.159	
BCA	0.395	0.283	-0.069	-0.241	0.061

Notes: Panel A reports the definition and source of each variable. In Panel B, N, Mean, SD, Min, P25, Med, P75, and Max denote the number of observations, average, standard deviation, minimum value,, 25th percentile, median, 75th percentile, and maximum value, respectively. Panel C reports the correlation between each variable.

Following the fiscal crisis, credit rating agencies became more sensitive to macroeconomic variables and fiscal indicators. Figure 1 reports the quarterly total number of sovereign rating actions (upgrades and downgrades) by each rating agency observed in the sample and shows a tendency for downgrades to become relatively more frequent after the global financial crisis. Up to and including 2008Q2, the quarterly average number of upgrades was 4.84, and that of downgrades was 1.53. However, from 2008Q3 onward, the quarterly average number of downgrades rose to 4.64, while the quarterly average number of upgrades fell to 3.44.

Figure 1. Quarterly credit rating change trend



Notes: This figure represents the total number of quarterly adjustments of each CRA. Red segments mean downgrades and blue segments indicate upgrades. The x-axis (y-axis) denotes quarters (the number of adjustments).

Table 3 reports unit root test results and cointegration test results. To specify an appropriate model, we conduct the Fisher-ADF test and Levin-Lin-Chu (LLC) test on each panel variable. The Fisher-ADF test conducts an ADF test for each unit and then combines the *p*-values to construct a panel test statistic. The null hypothesis is that a unit root is present in all cross sections, whereas the alternative hypothesis is that at least one cross-section is stationary. The LLC test extends the ADF framework to panel data by assuming a common autoregressive coefficient across cross sections. The null hypothesis is that there is a common unit root against the alternative of no common unit root. Panel A reports unit root test statistics and *p*-values. The Fisher-ADF and LLC test results provide evidence of unit roots in LGDP and DEBT. For the remaining variables, we cannot find strong evidence in support of unit roots. Subsequently, LGDP and DEBT are suspected to be an I(1) process; therefore, we conduct the Pedroni Panel cointegration test to

examine whether they are cointegrated. The results fail to reject the null hypothesis that there is no cointegration between LGDP and DEBT. Panel B represents the Pedroni cointegration test.

Table 3. Unit root test and cointegration test

Panel A. Unit root test

	Fisher-ADF				LLC		
	None	Drift	Trend		None	Drift	Trend
Rating_avr	57.05	123.32***	124.53***		-0.794	-3.516***	-1.093
	(0.928)	(0.000)	(0.000)		(0.213)	(0.000)	(0.137)
LGDP	2.27	78.52	63.14		14.22	-6.76***	-4.78***
	(1.000)	(0.5882)	(0.939)		(1.000)	(0.000)	(0.000)
BCA	334.2***	335.2***	381.9***		-7.59***	-2.52***	-2.67**
	(0.000)	(0.000)	(0.000)		(0.000)	(0.006)	(0.004)
DEBT	41.44	73.84	82.12		3.052	-2.327***	0.598
	(1.000)	(0.72)	(0.4755)		(0.999)	(0.02)	(0.725)
EXC	78.14	115.7***	71.47		2.532	-4.062***	-5.190***
	(0.600)	(0.009)	(0.790)		(0.994)	(0.000)	(0.000)
CPI	335.1***	-20.46***	-19.22***		-14.12***	-9.46***	-9.46***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)

Panel B. Pedroni cointegration test between LGDP and DEBT

	None	Drift	Trend
V	-4.785	-3.195	0.070
	(1.000)	(0.999)	(0.472)
Rho	-0.592	1.821	2.615
	(0.276)	(0.965)	(0.995)
PP	-2.017**	1.016	1.549
	(0.021)	(0.845)	(0.939)
ADF	-2.181**	0.689	0.062
	(0.014)	(0.754)	(0.542)

*Notes: Panel A represents the unit root test results. Panel B represents Pedroni cointegration test results. Both panels report the p-values in parentheses and the test statistics for each test. Fisher-ADF and LLC denote Fisher augmented Dickey–Fuller and Levin-Lin-Chu tests, respectively. V, Rho, PP, and ADF denote Panel v-Statistic, Panel rho-Statistic, Panel PP-Statistic, and Panel ADF-Statistic values, respectively. None, Drift, and Trend indicate no intercept and trend, only intercept, and intercept and trend, respectively. ** and *** indicate significance at the level of 5% and 1%, respectively.*

Considering these time series properties and heterogeneous country-level differences in levels, we estimate a PVAR model with first-differenced variables. First differencing removes time-invariant country-specific intercept components. It allows us to focus on short-term dynamics and avoid spurious regression. However, this approach has the limitation that it is difficult to analyze long-term relationships. Specifying a VAR model requires an optimal lag length. Accordingly, we select a lag order of 4 based on the Schwarz information criterion.

It is necessary to set an appropriate ordering for interpreting the dynamic relationship of each endogenous variable. First, as our study's purpose is to find the effect of credit rating changes, we place D(Rating_avr) in the first order. We use the Granger causality test as additional information rather than a definitive identification strategy[3]. Our ordering is mainly based on economic theory and assumptions. The results of Granger causality are in the next section. The ordering is [D(Rating_avr), D(EXC), D(CPI), D(BCA), D(DEBT), D(LGDP)]. This ordering is consistent with economic intuition. A change in sovereign credit ratings can affect financial conditions, which are rapidly incorporated into the exchange rates. Exchange rate movements may be transmitted to domestic inflation through import costs and inflation expectations. Changes in prices can influence the current account balance. The government debt ratio is assumed to adjust more slowly, reflecting the lag of policy processes. GDP responds with the greatest delay because production and expenditure decisions adjust gradually relative to financial variables. To examine cross-sectional dependence, we conduct the Pesaran CD (cross-sectional dependence) test on each VAR equation without the year-fixed effects reported in the next section. The CD test results indicate the presence of cross-sectional dependence, so we include the year-fixed effects in our model to mitigate this dependence.[4] The model equation is

$$Y_{i,t} = A_1 Y_{i,t-1} + A_2 Y_{i,t-2} + A_3 Y_{i,t-3} + A_4 Y_{i,t-4} + C + \tau_t + e_{i,t}, \quad (1)$$

where $Y_{i,t}$ is a vector of endogenous variables including $\{D(Rating\_avr)_{i,t}, D(EXC)_{i,t}, D(CPI)_{i,t}, D(BCA)_{i,t}, D(DEBT)_{i,t}, D(LGDP)_{i,t}\}$. $D(Rating\_avr)_{i,t}$, $D(EXC)_{i,t}$, $D(CPI)_{i,t}$, $D(BCA)_{i,t}$, $D(DEBT)_{i,t}$, and $D(LGDP)_{i,t}$ are the first difference of average rating, the log difference of the exchange rate, the second difference of CPI, the difference of the balance of current account to GDP ratio, the difference of the general government debt to GDP ratio, and the log difference of GDP. i indexes countries and t indexes time (quarters). A_l is the coefficient matrix for each lag, and τ_t captures year-fixed effects. C is a vector of constants. $e_{i,t}$ denotes the error term.

Our model is estimated using the pooled least squares method rather than GMM. We acknowledge that GMM-based estimators are often preferred in dynamic panel settings with severe endogeneity and short time dimensions. However, our panel is characterized by a relatively long time dimension and a moderate number of countries, so the standard rationale for short-panel GMM is less compelling in our setting. Moreover, in our data, GMM-based PVAR estimates were highly sensitive to lag and instrument choices, suggesting that the practical costs of internal-instrument estimation may outweigh its theoretical advantages. We therefore retain the pooled specification as our main model and interpret the results conservatively as evidence of dynamic comovement rather than strict causal transmission.

4. Empirical Results

We conduct Granger causality tests as descriptive evidence on predictive relationships. These tests do not identify contemporaneous restrictions. They are not used as a formal basis for structural identification. Table 4 reports the Granger causality test results. The results provide partial support for ordering in our model. EXC appears to be the most rapidly adjusting variable; placing it second is supported by test results. In addition, BCA and

3 It is common practice to use Granger causality tests to choose the Cholesky ordering in VAR models, even though this approach is not theoretically well grounded. Granger causality reflects incremental predictive content between two variables, rather than a unidirectional causal structure of the kind implied by a recursive (Cholesky) identification scheme.

4 Including quarter fixed effects in addition to year fixed effects does not qualitatively alter the results.

CPI show bidirectional relationships. We position CPI ahead of BCA because CPI is predicted by a larger set of variables within the system. However, the ordering of DEBT and LGDP relies more on economic intuition than on the statistical test results. We assume that fiscal planning and the overall movement of the real economy respond more slowly than other variables in the system.

Table 4. Pairwise Granger Causality test

Null Hypothesis:	N	F-Statistic	Prob
CPI does not Granger-cause BCA	3,842	10.29***	0.000
BCA does not Granger-cause CPI		8.293***	0.000
DEBT does not Granger-cause BCA	3,610	1.573	0.179
BCA does not Granger-cause DEBT		2.379*	0.050
EXC does not Granger-cause BCA	3,923	1.357	0.246
BCA does not Granger-cause EXC		1.722	0.142
LGDP does not Granger-cause BCA	3,923	6.702***	0.000
BCA does not Granger-cause LGDP		1.992*	0.093
Rating_avr does not Granger-cause BCA	3,881	10.95***	0.000
BCA does not Granger-cause Rating_avr		9.274***	0.000
DEBT does not Granger-cause CPI	3,641	2.736**	0.027
CPI does not Granger-cause DEBT		16.54***	0.000
EXC does not Granger-cause CPI	3,931	6.387***	0.000
CPI does not Granger-cause EXC		4.132***	0.002
LGDP does not Granger-cause CPI	3,919	8.521***	0.000
CPI does not Granger-cause LGDP		4.076***	0.003
Rating_avr does not Granger-cause CPI	3,922	4.756***	0.001
CPI does not Granger-cause Rating_avr		1.030	0.390
EXC does not Granger-cause DEBT	3,685	2.007*	0.091
DEBT does not Granger-cause EXC		3.078**	0.015
LGDP does not Granger-cause DEBT	3,685	30.26***	0.000
DEBT does not Granger-cause LGDP		3.139**	0.014
Rating_avr does not Granger-cause DEBT	3,681	26.66***	0.000
DEBT does not Granger-cause Rating_avr		15.65***	0.000
LGDP does not Granger-cause EXC	4,006	7.093***	0.000
EXC does not Granger-cause LGDP		67.43***	0.000
Rating_avr does not Granger-cause EXC	3,972	3.415***	0.009
EXC does not Granger-cause Rating_avr		3.539***	0.007
Rating_avr does not Granger-cause LGDP	3,960	7.810***	0.000
LGDP does not Granger-cause Rating_avr		4.740***	0.001

*Notes: This table shows pairwise Granger causality test statistics and p-values. Null Hypothesis, N, F-statistic, and Prob denote the null hypothesis tested, the number of observations, the F-test statistics, and the p-values, respectively. In the PVAR specification, the lag order is set to four. Observations are identical within each pair. The null hypothesis is that "variable A does not Granger-cause variable B". If this hypothesis is rejected, we interpret the result as evidence that A has predictive power for B. *, **, and *** indicate significance at the level of 10%, 5%, and 1%, respectively.*

We first conduct Pesaran's CD test for each VAR equation estimated without year-fixed effects to examine the cross-sectional dependence. The results, reported in Table 5, reject the null hypothesis of cross-section independence for all equations. This suggests that the residuals are affected by common shocks across countries. To mitigate this concern, we include year fixed effects in the baseline specification, while acknowledging that this is a partial rather than complete treatment of cross-sectional dependence.

Table 5. Pesaran CD test

Equation	CD statistics	*p*-value
D(Rating_avr) equation	11.87	0.000
D(EXC) equation	238.673	0.000
D(BCA) equation	17.26	0.000
D(CPI) equation	116.202	0.000
D(DEBT) equation	67.637	0.000
D(LGDP) equation	237.875	0.000

Notes: This table reports Pesaran's CD test for the cross-sectional dependence for each equation in the VAR system estimated without year-fixed effects. Equation *denotes each equation in the system.* CD statistic*s are the test statistics for the null hypothesis of cross-section independence in the residuals.* p-value *reports the significance level of the test.*

Based on the criteria outlined in the previous section, we estimate the VAR model. Table 6 reports the estimated coefficients and *t*-statistics of the one-period lagged value of D(Rating_avr) on the other endogenous variables in the VAR model. The full coefficient table is reported in Appendix A. The analysis reveals that D(Rating_avr) at the first lag shows significant predictive power for changes in DEBT and LGDP. However, it does not show a statistically significant influence on D(EXC), D(CPI), and D(BCA). Given that VAR models incorporate numerous lagged variables, they are susceptible to the multicollinearity problem. To handle the limitations of interpreting individual coefficients, we conduct an IRF analysis.

Table 6. VAR estimates

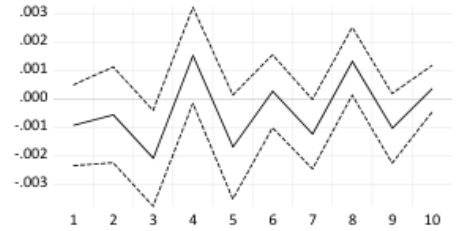
	D(EXC)	D(CPI)	D(BCA)	D(DEBT)	D(LGDP)
Coef	-0.002	0.000	-0.005*	-1.105***	0.011***
t-statistics	(-0.69)	(-0.34)	(-1.74)	(-7.18)	(3.41)

*Notes: This table reports the estimated coefficients (Coef) and t-statistics for the one-period lagged value of D(Rating_avr) on the other endogenous variables. * and *** indicate significance at the level of 10% and 1%, respectively.*

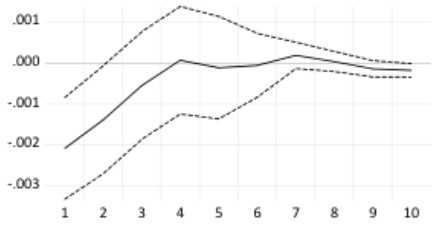
Figure 2 reports IRFs for the full sample. Each graph shows responses of other endogenous variables to an innovation in D(Rating_avr). Innovations are identified using a Cholesky decomposition with degrees-of-freedom adjustment. For D(BCA) and D(CPI), the responses are not statistically significant within the 95% confidence interval. In contrast, the response of D(EXC) is statistically significant in the short run, but the significance disappears from the second period onward. Because EXC is the logarithm of the exchange rate, D(EXC) can be interpreted as the approximate quarterly percentage change in the exchange rate. The IRF indicates that a positive innovation in the change in sovereign credit rating leads D(EXC) to move in the negative direction by approximately 0.1–0.3 percentage points. Given that the exchange rates are defined as local currency per USD, negative responses suggest that a positive (negative) innovation in D(Rating_avr) leads to local currency appreciation (depreciation). BCA, which is closely linked to

exchange rates, does not show a significant change. This suggests that the responses of BCA are sluggish. The delayed adjustment in the BCA may originate from stickiness in trade contracts. D(LGDP) and D(DEBT) show significant positive and negative responses, respectively. These results warrant cautious interpretation because of potential reverse causality. Both variables are standard macroeconomic determinants of sovereign ratings. Consistent with the literature, D(LGDP) has a positive relationship with D(Rating_avr), and D(DEBT) has a negative relationship with D(Rating_avr).

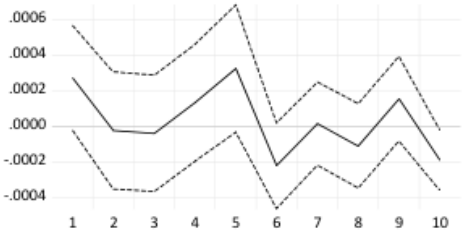
Figure 2. IRFs for the full sample



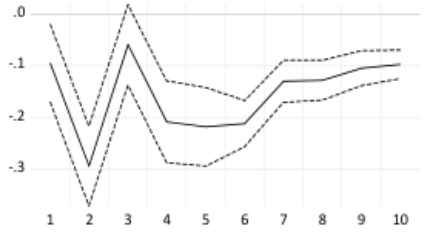
(a) Response of D(BCA) to D(Rating_avr)



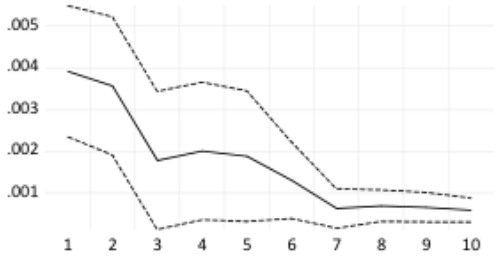
(b) Response of D(EXC) to D(Rating_avr)



(c) Response of D(CPI) to D(Rating_avr)



(d) Response of D(DEBT) to D(Rating_avr)



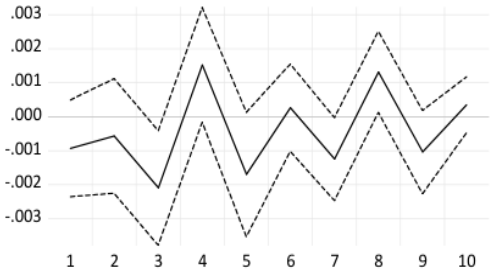
(e) Response of D(LGDP) to D(Rating_avr)

Notes: Each panel presents impulse response functions over a 10-quarter horizon. Panels (a), (b), (c), (d), and (e) present responses of D(BCA), D(EXC), D(CPI), D(DEBT), and D(LGDP), respectively. The dashed lines denote 95% confidence intervals, which are estimated using an analytic (asymptotic) method.

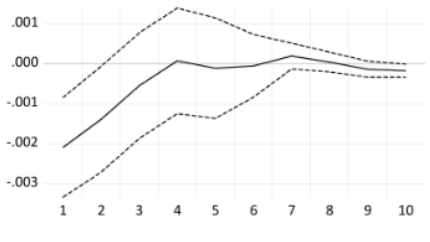
Because the IRF method is sensitive to Cholesky ordering, we use the generalized IRF, which does not depend on Cholesky ordering for the robustness check. Figure 3 reports generalized

IRFs. The generalized IRFs are qualitatively similar to those in Figure 2. This supports the robustness of our results to the ordering assumptions.

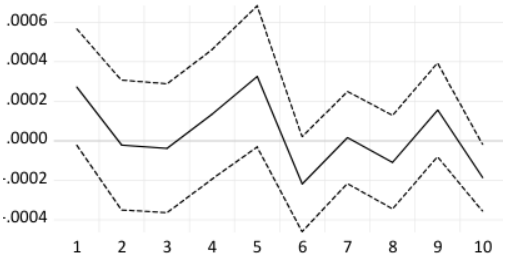
Figure 3. Generalized IRFs for the full sample



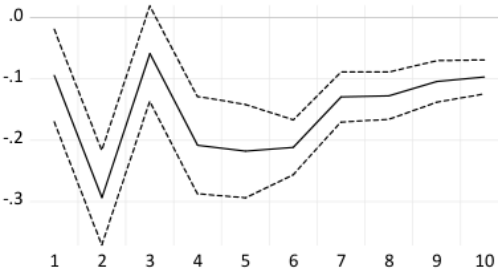
(a) Response of D(BCA) to D(Rating_avr)



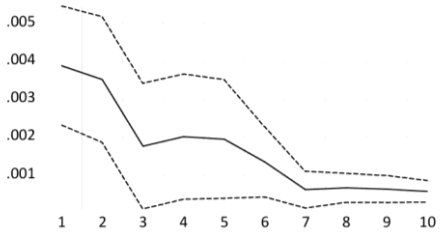
(b) Response of D(EXC) to D(Rating_avr)



(c) Response of D(CPI) to D(Rating_avr)



(d) Response of D(DEBT) to D(Rating_avr)



(e) Response of D(LGDP) to D(Rating_avr)

Notes: Each panel presents generalized impulse response functions over a 10-quarter horizon. Panels (a), (b), (c), (d), and (e) present responses of D(BCA), D(EXC), D(CPI), D(DEBT), and D(LGDP), respectively. The dashed lines denote 95% confidence intervals, which are estimated using an analytic (asymptotic) method.

We compute each country's time-series average GDP and form two subsamples based on this average. We then estimate the same PVAR specification for each subsample separately. The top 30% subsample is defined as the high-GDP countries, and the bottom 30% subsample as the low-GDP countries. Table 7 and Figure 4 report the VAR coefficients and IRFs for the GDP-based subsamples, respectively. In Figure 4, at the 95% confidence level, the exchange rate response to an innovation in D(Rating_avr) is statistically significant in the high-GDP countries, whereas it

is not statistically significant in the low-GDP countries. Nam and Ryu (2026) show that gross financial openness, measured by foreign assets and liabilities, has an inverted U-shape link with financial development. Nam, Bilgin, and Ryu (2025) show that trade development and financial development have a positive relationship in ASEAN countries. Consistent with this view, our results suggest that high-GDP countries, which may have more external assets and debt or higher trade development, may experience a more rapid integration of credit ratings into exchange rates, because of higher financial openness. In low-GDP countries, the impact on exchange rates might be limited due to relatively lower levels of external openness. This suggests that sovereign rating changes may be more relevant for understanding short-run exchange-rate dynamics in high-GDP countries.

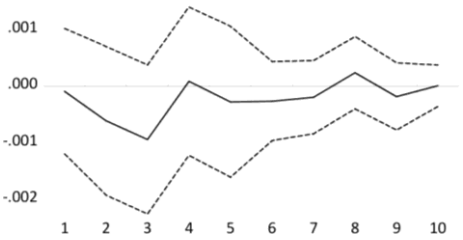
Table 7. VAR estimates for the GDP subsample

	D(EXC)	D(CPI)	D(BCA)	D(DEBT)	D(LGDP)
high-GDP	-0.011	0.000	-0.003	-0.053	0.014
	(-1.52)	(0.26)	(-0.93)	(-0.15)	(1.62)
low-GDP	-0.002	-0.001	-0.003	-0.809***	0.014**
	(-0.55)	(-0.39)	(-0.61)	(-3.06)	(2.72)

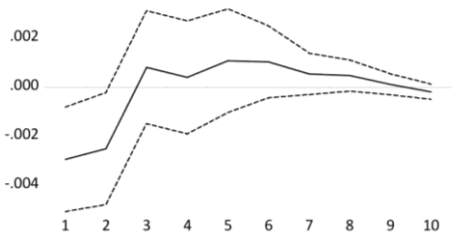
*Notes: This table reports the estimated coefficients and t-statistics in parentheses for the one-period lagged value of D(Rating_avr) on the other endogenous variables. high-GDP and low-GDP represent high-GDP and low-GDP subsamples, respectively. Columns report the coefficients from the D(EXC), D(CPI), D(BCA), D(DEBT), and D(LGDP) equations in the VAR system. ** and *** indicate significance at the level of 5% and 1%, respectively.*

Figure 4. IRFs for subsamples by GDP levels

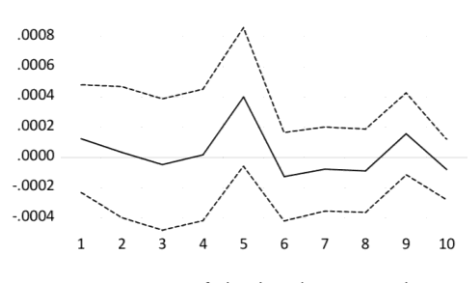
Panel A. IRFs for the high-GDP countries



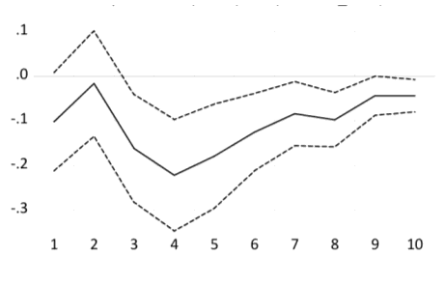
(a) Response of D(BCA) to D(Rating_avr)



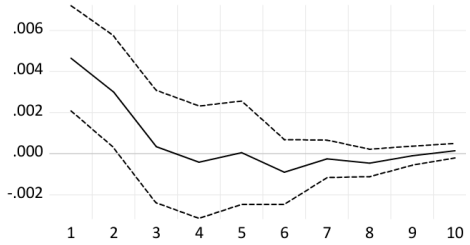
(b) Response of D(EXC) to D(Rating_avr)



(c) Response of D(CPI) to D(Rating_avr)

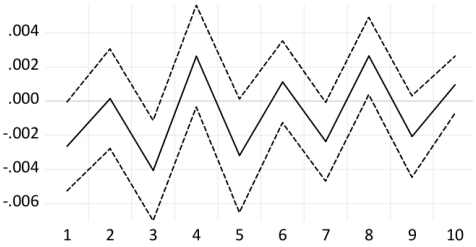


(d) Response of D(DEBT) to D(Rating_avr)

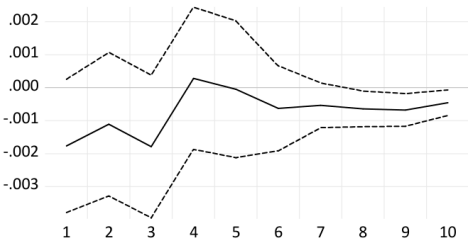


(e) Response of D(LGDP) to D(Rating_avr)

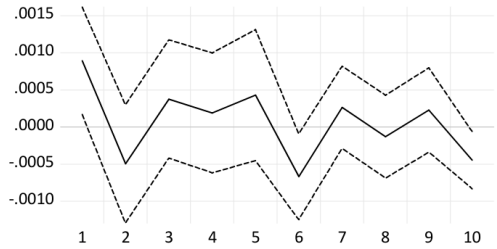
Panel B. IRFs for the low-GDP countries



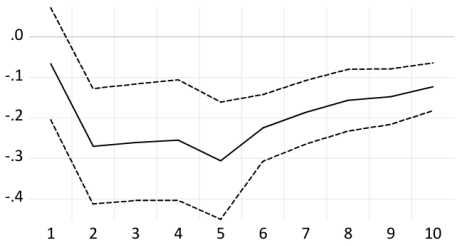
(a) Response of D(BCA) to D(Rating_avr)



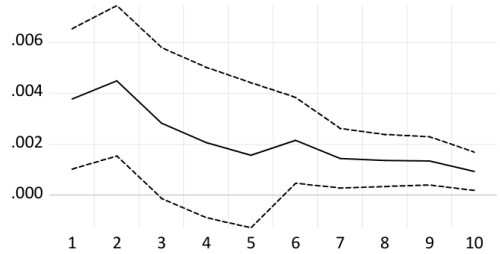
(b) Response of D(EXC) to D(Rating_avr)



(c) Response of D(CPI) to D(Rating_avr)



(d) Response of D(DEBT) to D(Rating_avr)



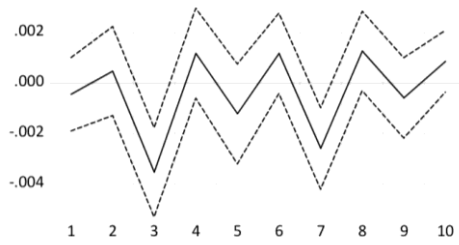
(e) Response of D(LGDP) to D(Rating_avr)

Notes: Panel A (B) presents impulse response functions for the high (low) GDP countries over a 10-quarter horizon. Panels (a), (b), (c), (d), and (e) present the response of D(BCA), D(EXC), D(CPI), D(DEBT), and D(LGDP), respectively. The dashed lines denote 95% confidence intervals, which are estimated using an analytic (asymptotic) method.

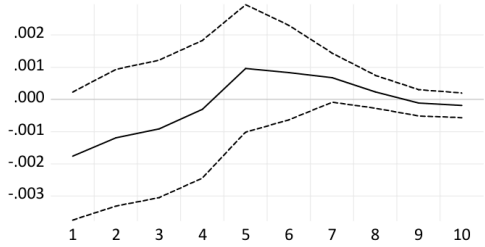
Table 8 and Figure 5 report the VAR coefficients and IRFs for the debt-based subsamples, respectively. As in the GDP split section, we compute each country's time-series average of DEBT and form two subsamples accordingly, and estimate the same PVAR specification. Countries in the highest 30% of DEBT are classified as high-debt countries, whereas those in the lowest 30% are classified as low-debt countries. For the high-debt countries, the exchange-rate responses are not statistically significant, whereas for the low-debt countries, the exchange-rate responses are statistically significant and appear more pronounced. This pattern should not be interpreted as implying that low-debt countries are more fragile overall. Rather, lower public debt may buffer broader financial stress following sovereign rating shocks, while the adjustment to rating news may be reflected more directly in asset prices such as the exchange rate. In contrast, for some high-debt countries, rating shocks may be absorbed through other macro-financial channels rather than through immediate exchange-rate adjustment. In this sense, beyond the level of public debt itself, the currency composition of debt and the structure of external financing may be more relevant for shaping the transmission of rating shocks (Jahan and Ryu, 2026). Therefore, our result for low-debt countries is better understood as evidence of a different adjustment margin, rather than stronger overall vulnerability. For low-debt countries, this pattern suggests that monitoring credit rating changes may still be useful for tracking short-run exchange-rate movements, although the supplementary regression results indicate that this interpretation should be made with caution.

Figure 5. IRFs for subsamples by DEBT level

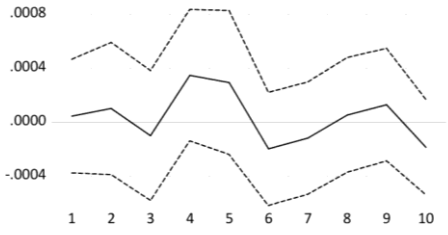
Panel A. IRFs for the high-debt countries



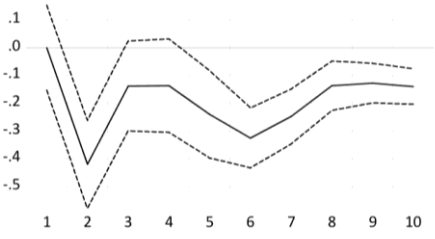
(a) Response of D(BCA) to D(Rating_avr)



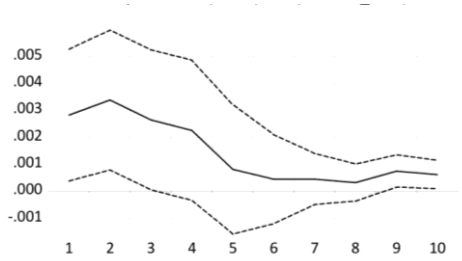
(b) Response of D(EXC) to D(Rating_avr)



(c) Response of D(CPI) to D(Rating_avr)

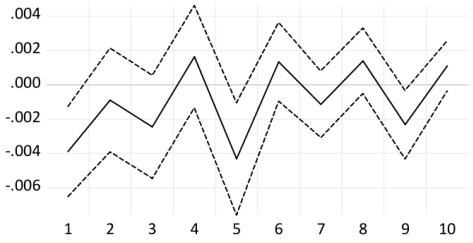


(d) Response of D(DEBT) to D(Rating_avr)

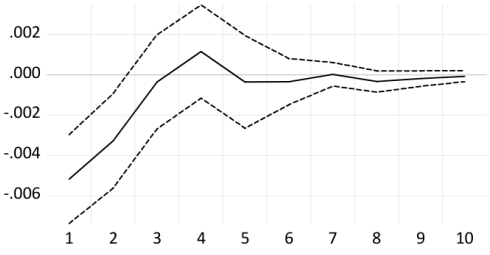


(e) Response of D(LGDP) to D(Rating_avr)

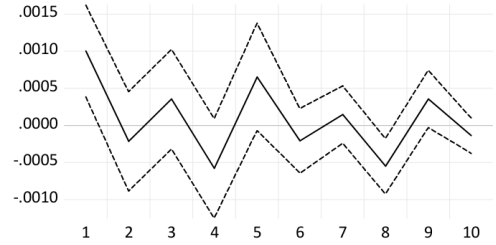
Panel B. IRFs for low-debt countries



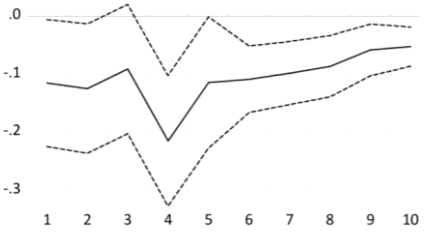
(a) Response of D(BCA) to D(Rating_avr)



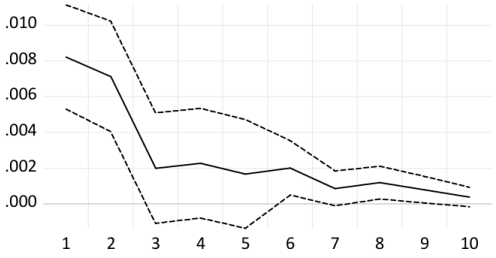
(b) Response of D(EXC) to D(Rating_avr)



(c) Response of D(CPI) to D(Rating_avr)



(d) Response of D(DEBT) to D(Rating_avr)



(e) Response of D(LGDP) to D(Rating_avr)

Notes: Panel A (B) presents impulse response functions for the high (low) debt countries over a 10-quarter horizon. Panels (a), (b), (c), (d), and (e) present the response of D(BCA), D(EXC), D(CPI), D(DEBT), and D(LGDP), respectively. The dashed lines denote 95% confidence intervals, which are estimated using an analytic (asymptotic) method.

Table 8. VAR estimates for the DEBT subsample

	D(EXC)	D(CPI)	D(BCA)	D(DEBT)	D(LGDP)
high-debt	-0.001	0.000	0.001	-1.313***	0.008**
	(-0.45)	(0.71)	(0.55)	(-5.07)	(2.01)
low-debt	-0.009	0.001	-0.015*	-0.302	0.020***
	(-1.42)	(0.61)	(-1.91)	(-0.92)	(3.25)

*Notes: This table reports the estimated coefficients and t-statistics in parentheses for the one-period lagged value of D(Rating_avr) on the other endogenous variables. high-debt and low-debt represent the high-debt subsample and the low-debt subsample, respectively. Columns report the coefficients from the D(EXC), D(CPI), D(BCA), D(DEBT), and D(LGDP) equations in the VAR system. *, **, and *** indicate significance at the level of 10%, 5%, and 1%, respectively.*

To provide supplementary evidence for our hypothesis, we additionally estimate a set of simple panel regressions with interaction terms and country fixed effects. These regressions are not intended to replace the subsample PVAR analysis, but rather to complement it by offering a more direct and transparent test of whether exchange-rate responses to sovereign rating changes differ systematically across country groups. Specifically, we regress exchange-rate changes on sovereign rating changes and their interactions with the high-GDP and low-debt group indicators, while controlling for country fixed effects. In this framework, the interaction term directly captures whether the sensitivity of exchange-rate movements to rating changes is stronger in a given subgroup relative to the reference group. The estimated regression equation is given as follows.

$$Y_{i,t} = \beta_1 \cdot D(Rating\_avr)_{i,t} + \beta_2 \cdot D(Rating\_avr)_{i,t} \times high\_GDP + \sigma_i + \tau_t + e_{i,t}, \quad (2)$$

$$Y_{i,t} = \beta_1 \cdot D(Rating\_avr)_{i,t} + \beta_2 \cdot D(Rating\_avr)_{i,t} \times low\_debt + \sigma_i + \tau_t + e_{i,t}, \quad (3)$$

where $Y_{i,t} \in \{D(EXC)_{i,t}, D(EXC)_{i,t+1}\}$. $D(Rating\_avr)$ is the difference of the quarterly average credit rating. $high\_GDP$ (low_debt) denotes the dummy variable indicating the high-GDP (low-debt) countries. σ_i (τ_t) captures country-fixed (year-fixed) effects. $e_{i,t}$ is the error term.

Table 9 provides supplementary regression evidence on whether exchange-rate responses to sovereign rating changes differ systematically across country groups. The results show that the interaction term between $D(Rating_avr)$and the high-GDP indicator is negative and statistically significant in both the contemporaneous and one-quarter-ahead specifications. This implies that, relative to the reference group, exchange rates in high-GDP countries respond more strongly to sovereign rating changes. Since EXC is defined as the logarithm of the local currency per U.S. dollar, the negative interaction coefficient indicates that an improvement in sovereign ratings is associated with a stronger appreciation response in high-GDP countries. This finding is consistent with the subsample PVAR results, in which the exchange-rate response is statistically significant in the high-GDP group but not in the low-GDP group. By contrast, the interaction term with the low-debt indicator is negative but not statistically significant in either specification. Therefore, the supplementary panel regressions do not provide equally strong direct evidence for the low-debt

heterogeneity documented in the IRF analysis. We interpret Table 9 as partial supporting evidence for our broader argument: the heterogeneous exchange-rate response to sovereign rating changes is particularly clear in high-GDP countries, while the low-debt pattern appears more strongly in the dynamic subsample PVAR framework than in this reduced-form regression setting. Table 9 should be viewed as a complementary and more transparent check, rather than as a replacement for the baseline PVAR evidence.

Table 9. Supplementary regression analysis

	(1) $D(EXC)_{i,t}$	(2) $D(EXC)_{i,t+1}$	(3) $D(EXC)_{i,t}$	(4) $D(EXC)_{i,t+1}$
D(Rating_avr)	-0.006 (-1.231)	-0.003 (-1.461)	-0.005 (-1.497)	-0.002 (-1.342)
D(Rating_avr) ×high_GDP	-0.021** (-2.284)	-0.010** (-2.107)		
D(Rating_avr) ×low_debt			-0.011 (-1.155)	-0.003 (-0.722)
Country-fixed effects	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes
Observations	2583	2557	2599	2573
R^2	0.197	0.246	0.222	0.285

Notes: This table reports supplementary panel regression coefficients and t-statistics in parentheses. Robust standard errors are clustered at the country level. $D(EXC)_{i,t}$ *and* $D(EXC)_{i,t+1}$ *are contemporaneous and one-quarter-ahead changes in the exchange rate, respectively.* $D(Rating\_avr)$ *denotes the quarterly change in the average sovereign credit rating.* $high\_GDP$ *and* low_debt *are group indicators defined from countries' time-series average GDP and DEBT, respectively, where the top 30% are classified as high-GDP countries and the bottom 30% as low-debt countries.* $D(Rating\_avr) \times high\_GDP$ *and* $D(Rating\_avr) \times low\_debt$ *are interaction terms between D(Rating_avr) and the dummy variables* $high\_GDP$ *and* low_debt*, respectively. R2 denotes the plain R-squared. The data consist of an unbalanced panel, and there may be minor variations in the number of valid observations across subsamples. All specifications include country-fixed effects and year-fixed effects. t-statistics are reported in parentheses. ** indicates significance at the 5% level.*

5. Conclusion

Using a broad and long cross-country panel, we estimate a PVAR model and interpret sovereign rating changes as the shock of interest within this framework. The IRF results show that exchange-rate responses differ across subsamples defined by economic development and public debt. In particular, the exchange-rate response is more clearly identified in the high-GDP subsample, while the low-debt pattern appears more strongly in the dynamic subsample PVAR analysis than in the supplementary reduced-form regressions. These heterogeneous responses may reflect differences in financial openness, external dependence, and the structure of external financing, although our study does not directly test these mechanisms. Our findings suggest that sovereign credit rating changes contain useful information for tracking short-run exchange-rate movements, especially in economically more developed countries. Future research may examine the channels through which rating shocks are transmitted to exchange rates.

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Appendix A. Panel VAR estimates

	$D(Rating\_avr)_{i,t}$	$D(EXC)_{i,t}$	$D(CPI)_{i,t}$	$D(BCA)_{i,t}$	$D(DEBT)_{i,t}$	$D(LGDP)_{i,t}$
$D(Rating\_avr)_{i,t-1}$	0.255***	-0.002	0.000	-0.005*	-1.105***	0.011***
	(-15.12)	(-0.69)	(-0.34)	(-1.74)	(-7.18)	(3.41)
$D(Rating\_avr)_{i,t-2}$	0.091***	-0.001	-0.000	-0.011***	0.184	0.005
	(-5.21)	(-0.40)	(-0.27)	(-3.59)	(-1.16)	(-1.55)
$D(Rating\_avr)_{i,t-3}$	-0.035**	0.000	0.001	0.001	-0.482***	0.006*
	(-2.01)	(-0.09)	(-1.13)	(-0.40)	(-3.02)	(-1.91)
$D(Rating\_avr)_{i,t-4}$	0.131***	-0.000	0.001*	-0.007**	-0.500***	0.005
	(-7.70)	(-0.17)	(-1.93)	(-2.23)	(-3.22)	(-1.63)
$D(EXC)_{i,t-1}$	-0.103	0.343***	0.010	-0.020	-7.457***	-0.515***
	(-0.47)	(-11.05)	(-1.30)	(-0.50)	(-3.73)	(-12.83)
$D(EXC)_{i,t-2}$	0.038	-0.290***	-0.010	0.048	-3.731*	0.350***
	(-0.17)	(-9.01)	(-1.31)	(-1.19)	(-1.80)	(-8.39)
$D(EXC)_{i,t-3}$	-0.017	0.021	0.012	-0.004	-13.520***	0.104***
	(-0.08)	(-0.68)	(-1.56)	(-0.11)	(-6.80)	(-2.59)
$D(EXC)_{i,t-4}$	-0.174	-0.179***	-0.026***	-0.030	1.646	0.327***
	(-0.78)	(-5.68)	(-3.35)	(-0.75)	(-0.81)	(-8.02)
$D(CPI)_{i,t-1}$	-0.351	-0.139**	-0.649***	-0.023	-10.275**	0.118
	(-0.70)	(-1.97)	(-37.17)	(-0.26)	(-2.27)	(-1.29)
$D(CPI)_{i,t-2}$	-0.227	-0.028	-0.484***	-0.255**	-12.318**	0.034
	(-0.41)	(-0.36)	(-24.81)	(-2.57)	(-2.43)	(-0.34)
$D(CPI)_{i,t-3}$	0.130	0.066	-0.484***	-0.079	-12.157**	-0.006
	(-0.24)	(-0.85)	(-25.01)	(-0.80)	(-2.42)	(-0.06)
$D(CPI)_{i,t-4}$	-0.998**	-0.045	0.143***	-0.144	5.391	-0.060
	(-2.01)	(-0.65)	(-8.20)	(-1.63)	(-1.19)	(-0.66)
$D(BCA)_{i,t-1}$	-0.049	0.000	-0.007**	-0.661***	-1.013	-0.009
	(-0.52)	(-0.03)	(-2.19)	(-39.42)	(-1.18)	(-0.54)
$D(BCA)_{i,t-2}$	-0.206**	-0.006	-0.011***	-0.587***	-1.972**	-0.000
	(-1.97)	(-0.38)	(-3.10)	(-31.48)	(-2.07)	(-0.04)
$D(BCA)_{i,t-3}$	-0.269**	0.009	-0.004	-0.459***	-0.362	-0.017
	(-2.58)	(-0.60)	(-1.15)	(-24.67)	(-0.38)	(-0.91)
$D(BCA)_{i,t-4}$	-0.117	-0.014	-0.009***	0.171***	-0.082	0.002
	(-1.24)	(-1.06)	(-2.61)	(-10.16)	(-0.10)	(-0.12)
$D(DEBT)_{i,t-1}$	-0.005***	0.000	0.000*	-0.000	-0.044***	0.001***
	(-2.73)	(-1.05)	(-1.88)	(-0.33)	(-2.60)	(-2.76)
$D(DEBT)_{i,t-2}$	-0.002	-0.000	0.000	0.000	-0.008	0.002***
	(-1.33)	(-1.41)	(-0.26)	(-0.35)	(-0.49)	(-5.20)
$D(DEBT)_{i,t-3}$	-0.010***	0.000	-0.000**	-0.000	0.039**	-0.000
	(-5.25)	(-1.27)	(-2.24)	(-1.03)	(-2.26)	(-0.02)
$D(DEBT)_{i,t-4}$	-0.004*	0.000	0.000***	-0.000	0.190***	-0.000
	(-1.95)	(-0.81)	(-2.97)	(-0.86)	(-11.33)	(-1.49)
$D(LGDP)_{i,t-1}$	0.276	0.097***	0.008	0.026	-9.867***	-0.210***
	(-1.58)	(-3.91)	(-1.36)	(-0.84)	(-6.18)	(-6.53)

	$D(Rating\_avr)_{i,t}$	$D(EXC)_{i,t}$	$D(CPI)_{i,t}$	$D(BCA)_{i,t}$	$D(DEBT)_{i,t}$	$D(LGDP)_{i,t}$
$D(LGDP)_{i,t-2}$	0.110	-0.009	-0.009	0.078**	-2.040	0.034
	(-0.58)	(-0.33)	(-1.38)	(-2.29)	(-1.17)	(-0.96)
$D(LGDP)_{i,t-3}$	0.099	0.064***	0.004	0.007	-15.22***	0.053*
	(-0.57)	(-2.63)	(-0.60)	(-0.21)	(-9.70)	(-1.68)
$D(LGDP)_{i,t-4}$	-0.089	-0.006	-0.030***	0.000	4.214***	0.121***
	(-0.51)	(-0.25)	(-4.95)	(-0.01)	(-2.66)	(-3.80)
Year-fixed	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.20	0.34	0.57	0.55	0.27	0.28
Adjusted-R^2	0.18	0.33	0.57	0.55	0.26	0.27

*Notes: This table reports the VAR model's coefficient estimates, t-statistics in parentheses. D(Rating_avr)i,t, D(EXC)i,t, D(CPI)i,t, D(BCA)i,t, D(DEBT)i,t, and D(LGDP)i,t are the first difference of average credit rating, log difference of the exchange rate, second difference of CPI, first difference of balance of current account to GDP ratio, first difference of general government debt to GDP ratio, and log difference of GDP at time t and for individual country i, respectively. We include the year dummy variable as an exogenous variable in VAR systems to control for the common shock, which can work in a way like year-fixed effects. R2 and Adjusted-R2 are R-squared and adjusted R-squared values, respectively. *, **, and *** indicate significance at the level of 10%, 5%, and 1%, respectively.*