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Transmission Growth-at-Risk: How Foreign Financial Vulnerabilities Shape U.S. Growth Prospects

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Abstract

We develop a Transmission Growth-at-Risk (TGaR) framework that incorporates foreign financial vulnerabilities as predictors of U.S. downside growth risk. We distinguish financial conditions, which measure current tightness in credit markets, from financial vulnerabilities, which measure structural fragilities that can amplify shocks. Elevated foreign financial vulnerabilities are associated with lower U.S. growth-at-risk, with transmission through both trade linkages and dollar integration channels. Asset valuation pressures and financial sector leverage abroad have the largest estimated amplification effects. Financial conditions primarily affect near-term tail risk, while foreign vulnerabilities weigh on U.S. GDP at a medium-term horizon. Out of sample, adding foreign vulnerabilities raises the predictive score by 53 percent at the 8-quarter horizon. Crisis-episode evidence points to the same interpretation. These findings show that monitoring foreign financial vulnerabilities is important for gauging U.S. growth prospects.

Keywords: Growth-at-Risk, Financial Vulnerabilities, International Transmission, Risk Assessment.
JEL Classification: E32, F42, G01, and G15.

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1 Introduction

In late 2009, fiscal concerns in Greece triggered a sovereign debt crisis that spread across peripheral Europe. Policymakers and market participants presumed that European financial stress would weigh on U.S. growth prospects, even as domestic U.S. financial conditions had been stabilizing. European banks held substantial sovereign exposures while operating with high leverage and significant reliance on short-term dollar funding, vulnerabilities that raised concerns about transmission to the United States. However, the channels through which such foreign vulnerabilities might affect U.S. growth, the mechanisms that could amplify shocks, and the magnitudes of potential effects remained poorly understood and unmeasured. More broadly, whether pre-existing foreign vulnerabilities exacerbate crises regardless of their origin, how they interact with financial condition shocks, and their quantitative importance remain open questions. Answering these questions matters: If foreign vulnerabilities amplify the domestic effects of shocks regardless of their origin, then monitoring foreign vulnerabilities becomes important for understanding the full scope of risks to U.S. growth.

This paper develops a Transmission Growth-at-Risk (TGaR) framework to measure these effects systematically. We distinguish between financial conditions, such as tightening credit markets, and financial vulnerabilities, such as accumulated leverage and asset overvaluation. Building on Adrian et al. (2019), we employ quantile regressions to estimate the 5th percentile of the conditional distribution of U.S. GDP growth, incorporating both foreign financial conditions and foreign financial vulnerabilities as explanatory variables. We incorporate foreign financial conditions and vulnerabilities across 21 foreign economies from 1995 to 2023. We orthogonalize foreign financial conditions with respect to U.S. conditions to isolate foreign-specific financial shocks. This framework allows us to test whether foreign vulnerabilities worsen U.S. downside growth risk, quantify amplification effects, and identify transmission channels through trade and financial linkages.

We make four contributions to the literature. First, we bring foreign financial vulnerabilities into the Growth-at-Risk framework and estimate their relationship with U.S. downside growth risk. Financial condition indexes (FCIs) measure the current tightness of credit markets. A tightening of financial conditions, that is, a worsening of FCIs, naturally corresponds to a transitory shock. Financial vulnerability indexes (FVIs) measure structural fragilities that amplify shocks' economic effects. We incorporate FVIs alongside FCIs for both U.S. and foreign economies into quantile Growth-at-Risk regressions. Financial conditions primarily affect near-term growth risk over the next four quarters, with effects that dissipate over time. By contrast, vulnerabilities have larger effects at medium-term horizons, consistent with vulnerabilities acting as slow-moving state variables. These horizon profiles suggest that vulnerabilities have persistent effects, beyond purely cyclical demand effects. To illustrate the economic magnitude of these estimates, during the 2010–12 European sovereign debt crisis, elevated European financial vulnerabilities worsened U.S. growth-at-risk by up to 2 percentage points despite stabilizing domestic conditions.

Second, we test whether vulnerabilities amplify the effects of financial condition shocks. Prior GaR studies focused on financial conditions (Adrian et al., 2019, 2022), while vulnerability research emphasized crisis prediction (Aikman et al., 2017; Lee et al., 2020). We model FCIs and FVIs jointly with interaction terms in the GaR framework. The estimates show that foreign financial condition shocks have small U.S. growth-at-risk effects when foreign vulnerabilities are low, but much larger effects when foreign vulnerabilities are elevated. This result supports the conceptual distinction between conditions as shocks and vulnerabilities as shock amplifiers.

Third, we quantify the transmission channels through which foreign vulnerabilities affect U.S. growth. We construct trade-weighted and dollar-integration-weighted foreign vulnerability indexes to distinguish between real and financial transmission channels. We find economically important estimates for both channels, with similar magnitudes. We also decompose foreign vulnerabilities into four components: valuation pressures, financial sector vulnerabilities, nonfinancial vulnerabilities, and sovereign vulnerabilities. Asset valuation pressures have the largest estimated amplification effects, with standardized coefficients several times larger than those of other components, followed by financial sector leverage.

Fourth, we examine the TGaR framework across multiple crisis episodes with distinct characteristics. The 2010–12 European sovereign debt crisis involved classic financial fragility. European banking sector vulnerabilities, including high leverage, dollar funding mismatches, and asset valuation pressures, elevated U.S. downside risk through trade and financial channels even as domestic U.S. conditions were stabilizing. The 2016 Brexit referendum provides a further test through a policy uncertainty episode. Foreign variables also add little predictive content during episodes where the relevant vulnerabilities were mainly domestic or concentrated in economies that receive limited weight in our broad cross-country aggregate, such as the Global Financial Crisis and the Asian Financial Crisis. These findings imply that monitoring foreign financial vulnerabilities is broadly important for gauging U.S. growth prospects.

We evaluate the framework through out-of-sample forecast exercises over 2000–23. Incorporating foreign vulnerabilities improves the predictive score for U.S. GDP growth at the eight-quarter horizon from 8.57 to 13.11, a 53% improvement, while matching the accuracy of four-quarter forecasts. This out-of-sample improvement supports the empirical importance of foreign vulnerabilities.

The paper is organized as follows: We first review the related literature. Section 2 discusses the Growth-at-Risk framework, the link between financial vulnerabilities and growth, and the channels through which foreign financial stress reaches the United States. Section 3 describes the data, introduces our TGaR framework, presents baseline estimation results, and evaluates out-of-sample forecast performance. Section 4 analyzes how foreign financial vulnerabilities transmit to the U.S. economy through trade and dollar funding channels, which foreign sectors matter most, and how vulnerabilities amplify financial shocks. Section 5 concludes.

Literature Review

This paper contributes to three major strands of literature: (1) Growth-at-Risk (GaR), (2) macroeconomic implications of financial conditions and vulnerabilities, and (3) transmission of foreign financial risks to the U.S.

The GaR framework gained prominence through Adrian et al. (2019), who established empirical links between financial conditions and the conditional distribution of GDP growth using quantile regressions. Their key insight was treating growth forecasts probabilistically and estimating potential outcomes under varied financial scenarios instead of producing point forecasts. Adrian et al. (2022) extended this framework to a panel of 11 advanced economies, examining how financial conditions affect growth distributions at multiple forecast horizons. Their central finding is an intertemporal risk trade-off: Loose financial conditions compress downside risk in the near term but increase it at medium-term horizons, with FCI coefficients on the fifth percentile reversing sign around 6-to-8 quarters. They also show that credit-to-GDP growth, a single-indicator vulnerability proxy, amplifies this trade-off, with their "credit boom" interaction term generating statistically significant declines in growth-at-risk at horizons of 6–10 quarters. This credit boom amplification finding provides early evidence that vulnerability-type measures matter beyond financial conditions for downside growth risk, a result we generalize with multi-sector FVIs. Prasad et al. (2019) applied the framework to emerging markets, while Plagborg-Møller et al. (2020) developed and employed local-projection-based GaR methods to study the effect of macroeconomic shocks on growth prospects. Related work by Jovanovic and Ma (2022) and Hengge (2019) uses GaR-style approaches to link economic uncertainty to downside risks in U.S. GDP growth. These studies focus on how domestic financial conditions affect domestic growth distributions within each country. For an open economy, a key gap remains: whether and how foreign financial vulnerabilities, distinct from foreign financial conditions, affect domestic growth distributions. Our contribution is to show that foreign vulnerabilities significantly worsen U.S. growth prospects, with effects that peak at medium-term horizons and operate through identifiable trade and financial channels.

Our paper also contributes to the literature on predicting the timing and economic severity of financial crises. Borio et al. (2018) document that credit booms and asset price run-ups tend to precede financial crises, while Gourinchas and Obstfeld (2012) analyze credit-to-GDP gaps as early warning indicators. Aikman et al. (2017) and Lee et al. (2020) integrate these insights by constructing financial vulnerability indexes that predict financial crises and banking system stress.[1] These papers establish vulnerabilities as important state variables for crisis prediction but do not address how vulnerabilities affect growth distributions conditional on financial conditions, whether their effects operate at different horizons than conditions, or how foreign vulnerabilities transmit to domestic outcomes. Our contribution is to show that vulnerabilities act as shock amplifiers across horizons and weigh on growth prospects beyond their role in predicting discrete crisis events.

The transmission of foreign financial risks to the U.S. economy has been studied from several angles. One strand documents the global financial cycle and outward spillovers from the United States: Rey (2015) shows that U.S. monetary policy drives a global financial cycle, while Bruno and Shin (2015) and Avdjiev et al. (2019) demonstrate that dollar appreciation tightens global financial conditions through banking channels, and Gopinath and Stein (2021) highlights the dollar's role in trade invoicing. A second strand examines transmission in the other direction, from foreign economies to the United States. Alpanda and Aysun (2014) estimate an international DSGE model showing that foreign financial shocks transmit to U.S. output through cross-border banking linkages. Forbes and Warnock (2012) document how capital flow surges and reversals propagate financial stress across borders, including to the United States. Kalemli-Ozcan et al. (2019) show that sovereign and corporate debt vulnerabilities in Europe during the crisis had real effects that extended beyond national borders. These studies establish that foreign financial stress can reach the United States

[1] Similarly, Aldasoro et al. (2018) provide evidence on the role of financial vulnerabilities in predicting banking crises across countries, and Schularick and Taylor (2012) highlight the importance of credit booms as precursors to financial crises. Lee et al. (2020) also shows that comprehensive financial vulnerability indexes explain cross-country variation in the severity of banking crises and the duration of recessions.

through identifiable channels, but they focus on the transmission of financial conditions or shocks. Our paper asks whether slow-moving foreign financial vulnerabilities, including high leverage, asset valuation pressures, and funding mismatches, worsen U.S. growth prospects through a distributional forecasting framework, which types of vulnerabilities matter most, and whether transmission operates through trade and financial channels with comparable magnitudes.

In summary, our paper sits at the intersection of these three literatures. We bring the vulnerability measurement tools of the crisis-prediction literature into the distributional forecasting framework of the GaR literature and apply them to the question of foreign-to-U.S. transmission that the international spillover literature has posed, but has not yet answered for structural fragilities.

2 Growth-at-Risk (GaR) Framework

The Growth-at-Risk (GaR) framework has been used widely as a quantitative approach to assess downside risks to economic growth originating from financial sector developments. Introduced by Adrian et al. (2019), the GaR framework estimates the empirical relationship between economic growth and U.S. financial conditions using quantile regressions.

2.1 Financial Vulnerabilities and Economic Growth

The existing Growth-at-Risk literature focuses mainly on financial conditions. Financial vulnerabilities receive less attention in this setting, even though the financial stability literature treats vulnerabilities as amplifiers of adverse shocks. In addition, several papers show that financial vulnerabilities predict both the timing and economic severity of financial crises (for example, Lee et al., 2020).

The connections between current financial conditions and future financial vulnerabilities give another reason to analyze both in the GaR framework. When financial conditions are loose, vulnerabilities can build up more quickly as firms, households, and financial intermediaries take on more debt and risk and valuation pressures increase. Such a build-up can lead to a greater risk of future financial crises and a sharper downturn in economic growth. Incorporating financial vulnerabilities in the GaR framework may clarify the nature of an intertemporal trade-off: lower growth vulnerability at the medium term may come at the cost of lower GaR or, more generally, lower expected growth in the short term, as in Adrian et al. (2022). That paper documents this trade-off using financial conditions whose coefficients reverse sign over the projection horizon, with negative coefficients in the near term and positive coefficients at medium-term horizons, consistent with endogenous risk-taking models (Brunnermeier and Sannikov, 2014). Our framework produces a different result for vulnerabilities: FVI coefficients remain negative across all horizons and grow in magnitude from 4-to-8 quarters, without sign reversal. This distinction supports treating conditions and vulnerabilities as different measures, with conditions capturing transitory shocks and vulnerabilities capturing persistent state variables that constrain potential output.

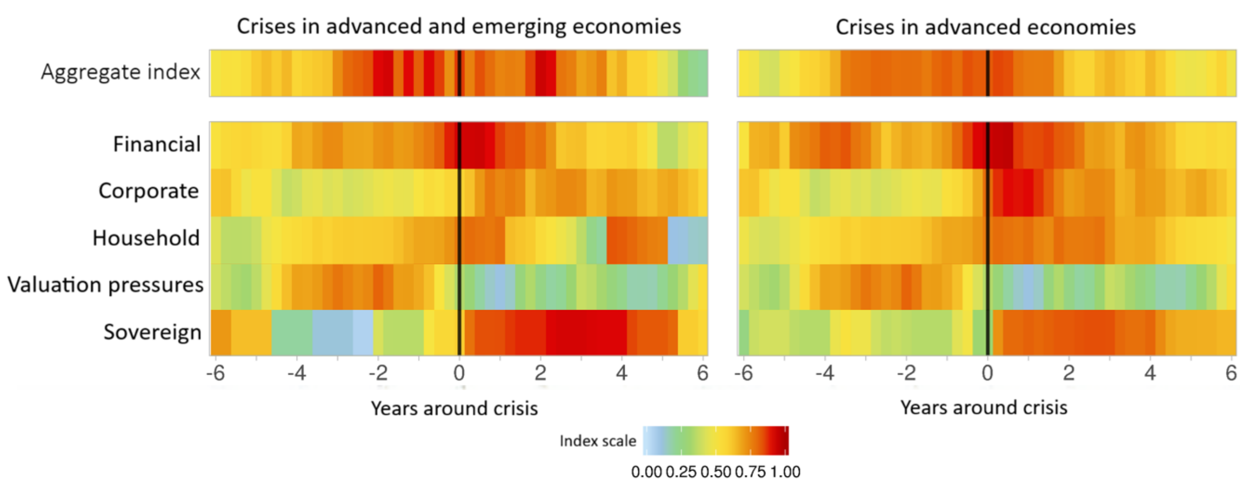
In translating the financial stability literature to the Growth-at-Risk literature, we treat financial vulnerabilities as structural factors or slowly moving state variables and a tightening of financial conditions as adverse financial shocks, with the extent of tightness indicating the magnitude of a shock.[2] In this framework, elevated financial vulnerabilities may weigh on economic growth directly and may amplify the effects of financial shocks. As structural factors, financial vulnerabilities can affect both the responsiveness of GaR to financial conditions and the level of growth risk more broadly.

Financial vulnerabilities can amplify adverse shocks and significantly affect GaR, particularly during economic downturns, for multiple reasons. For example, firms and households with high leverage are more vulnerable to interest rate hikes, credit tightening, or market stresses. These vulnerabilities can lead to a cascade of defaults, bankruptcies, and credit contraction, exacerbating the negative effect of the initial shock.

[2]This interpretation is consistent with the evidence in Lee et al. (2020) and Vermeulen et al. (2015) that changes in financial conditions or financial stress indexes are related to the occurrence of financial crises, there is only a very weak relationship or no relationship at all between these indexes and the onset of a crisis.

When translating the financial stability literature to the Growth-at-Risk literature, we have to quantify financial vulnerabilities. While the literature offers many options, we focus first on aggregate financial vulnerability indexes. The predictive performance of comprehensive financial vulnerability indexes exceeds especially at long horizons that of measures of a build-up in a specific financial vulnerability, the credit-to-GDP gap, or the total debt service ratio, see Lee et al. (2020).[3] We also examine the performance of sectoral components of comprehensive financial vulnerability indexes because we are interested in the term structure of growth-at-risk and because the literature shows that the predictive power of financial vulnerabilities varies across financial sectors and time horizons.

Figure 1. Sectoral Financial Vulnerabilities Around Crises



Note: This figure shows the average levels of vulnerability indexes across advanced and emerging economies around 21 financial crises during 1970–2017. The x-axis shows years before and after the crisis date (year 0). Warmer colors (orange/red) indicate higher vulnerability levels; cooler colors (green/blue) indicate lower levels. Crisis definitions and timing are from Laeven and Valencia (2020).

To illustrate how specific vulnerabilities function as early warning indicators at different horizons, we construct a heatmap using Lee et al. (2020)'s data. Figure 1 shows the average levels of the vulnerability indexes by sector across advanced economies around 21 financial crises documented by Laeven and Valencia (2020). The heatmap highlights which sectors

[3] The credit-to-GDP gap has been touted as one of the best predictors of systemic banking crises at longer horizons and, hence, suited to be the benchmark in setting counter-cyclical capital buffers, see Drehmann and Juselius (2014).

exhibit elevated vulnerabilities leading up to these crises. Warmer colors indicate higher vulnerability levels and cooler colors indicate lower vulnerability levels. Financial vulnerabilities tend to peak shortly before a crisis, consistent with their role as early warning indicators.

We note that financial vulnerabilities are also relevant for the economy outside financial crises. The literature suggests that financial vulnerabilities can pose downside risks to growth because they can generate macro-financial linkages. In financial accelerator theories, the relaxation of financial constraints during good times results in a high volume of credit and leverage that can later amplify the effect of negative shocks on future economic activity (Bernanke and Gertler, 1989; Holmström and Tirole, 1997; Brunnermeier and Sannikov, 2014). In belief-based theories (Minsky, 1977, 1986; Kindleberger, 1978; Bordalo et al., 2018), variations over time in investor beliefs result in elevated risk appetite during periods of optimism that lead to large expansions in credit and highly compressed risk spreads, which are predictably followed by a reversal in risk appetite, a widening of credit spreads, and a higher probability of crisis once risks materialize.

In addition to predicting crises, financial stress from abroad has direct implications for the U.S. economy, which we will discuss next.

2.2 Transmission of Financial Stress Abroad to the United States

The U.S. financial system's central role in global markets exposes it to foreign financial stress through multiple channels: dollar funding markets, Treasury markets, interconnectedness with foreign global systemically important banks, asset markets, and the real economy. The past three decades provide several examples, from the run on U.S. money market funds during the euro-area crisis of 2011 to earlier episodes such as the Asian financial crisis of 1997–98. The magnitude of transmitted shocks depends in part on the vulnerability of the foreign financial system. Foreign vulnerabilities, such as high leverage and significant external debt, can amplify global financial shocks (Rey, 2015), increasing default risk, deteriorating credit quality, and further tightening financial conditions abroad, which then spill over to the United States through its extensive economic and financial linkages.

3 Data and Estimation Results

3.1 Data

Data for GDP growth at the country level are sourced from the OECD Main Economic Indicators. The data for the U.S. NFCI are from the Chicago Fed, and the data for foreign country-level financial conditions are from the IMF.[4] The financial conditions indices are constructed based on the methodology from Koop and Korobilis (2014), which extracts latent FCIs from 18 financial variables (for example, interest rates, exchange rates) while accounting for growth and inflation through a time-varying parameter factor-augmented vector autoregression model. This approach purges the FCI of the effects of macroeconomic conditions and allows for evolving relationships between financial and macroeconomic variables over time. It is worth noting that the resulting FCIs are useful for predicting macroeconomic variables such as GDP growth and inflation. The baseline sample includes 21 major foreign economies and the United States and runs from 1995:Q1 to 2023:Q4.[5]

Financial vulnerability indexes are constructed following the methodology of Lee et al. (2020), which aggregates vulnerabilities across multiple dimensions that capture structural fragilities in the financial system. This index has been shown to outperform individual vulnerability measures in predicting both the timing and severity of financial crises. As we show in Appendix, our results are robust to using FVIs that are constructed based on other approaches.

The FVI that we use comprises four components that measure vulnerabilities across different sectors and markets:

[4]The results using the IMF's FCI for the U.S. are very similar to those using the Chicago Fed's NFCI. We use the NFCI as the benchmark FCI to compare our results with those from Adrian et al. (2019).

[5]The 21 major economies are: Australia, Austria, Belgium, Canada, China, Denmark, France, Germany, Hong Kong, Italy, Japan, Mexico, the Netherlands, New Zealand, Norway, Russia, South Korea, Spain, Sweden, Switzerland, and the United Kingdom. Data for China begin in 2000:Q1 and for Russia in 1998:Q1 due to availability constraints; the 1995:Q1 start date applies to the remaining 19 economies.

1. **Risk Appetite and Valuation Pressures:** Measured using three subcomponents: Housing market pressures (price-to-rent and price-to-income ratios), equity market pressures (price-to-earnings and dividend-to-yield ratios), and junk bond issuance relative to total bond issuance. Compressed valuations signal potential for sharp corrections that can trigger broader financial stress. Data are from the OECD, BIS property price statistics, national stock exchanges, and bond market databases.

2. **Financial Sector Vulnerabilities:** Aggregates banking sector and nonbank financial sector vulnerabilities. Banking sector vulnerabilities include four components: (i) leverage (bank credit to private nonfinancial sector relative to GDP, capital-to-assets ratios); (ii) maturity transformation (loans-to-deposits ratio); (iii) reliance on wholesale funding (financial institution liabilities to total assets); and (iv) interconnectedness (foreign assets to total assets, cross-border claims). Nonbank vulnerabilities are measured as nonbank-provided credit to the private nonfinancial sector relative to GDP. Data are from BIS credit statistics, IMF Financial Soundness Indicators, and statistics from central banks.[6]

3. **Nonfinancial Sector Vulnerabilities:** Combines household and corporate sector vulnerabilities. Household vulnerabilities include credit to households relative to GDP and household debt service ratios. Corporate vulnerabilities include debt-to-equity ratios, interest coverage ratios, credit to businesses relative to GDP, and corporate debt service ratios. Data are from BIS credit statistics and national accounts.

4. **Sovereign Vulnerabilities:** Measured using government debt to GDP ratio, fiscal deficit to GDP ratio, and government revenue to GDP ratio. Data are from IMF Government Finance Statistics and national sources.

Each component is standardized to have zero mean and unit variance. In the out-of-sample exercises below, the means and standard deviations are re-estimated recursively using

[6] We note that certain IMF series have been discontinued; for those variables, we rely on calculations by independent researchers using the same underlying methodology.

only information available through the forecast origin.

The aggregate FVI for each country is constructed as the simple average (equal-weighted) of the four standardized components:

$$FVI_{i,t} = \frac{1}{4}\sum_{j=1}^{4} z_{i,j,t} \tag{1}$$

where $z_{i,j,t}$ is the standardized value of component j for country i at time t. This equal-weighting approach avoids overfitting to any particular crisis episode and has been shown to perform well out-of-sample for crisis prediction (Lee et al., 2020).

The foreign aggregate FVI is constructed as an equal-weighted average across the 21 non-U.S. economies:

$$FVI_t^{FOR} = \frac{1}{21}\sum_{i \neq US} FVI_{i,t} \tag{2}$$

This equal-weighting baseline treats all major economies symmetrically. We adopt this specification as our baseline as a deliberate methodological choice to avoid look-ahead bias and overfitting to particular crisis episodes, not as a statement about the relative economic importance of individual countries. As we show later, trade-weighted and regression-based aggregation schemes yield somewhat stronger results, consistent with our findings in Section 4 that trade and dollar integration channels drive transmission. The optimized weights are also consistent with this channel interpretation. Vulnerabilities in countries with stronger U.S. trade and financial linkages carry more predictive content, as the channel-based analysis in Section 4 predicts.[7]

3.2 Transmission Growth-at-Risk (TGaR) Framework

Our TGaR approach incorporates foreign financial vulnerabilities as additional predictors for GDP growth. We therefore posit that foreign financial vulnerabilities can transmit risks to the U.S. economy, thereby affecting future downside growth risk. To investigate this

[7] The FVI is available for all 22 economies, the 21 foreign economies and the United States, over 1995:Q1 to 2023:Q4, with the exception of China (starting 2000:Q1) and Russia (starting 1998:Q1) due to data availability constraints.

link, we employ quantile regression models to estimate the conditional distribution of U.S. GDP growth at each point in time based on domestic and foreign financial conditions as well as financial vulnerabilities.

More specifically, the baseline model includes two terms from Adrian et al. (2019): Current GDP growth and the NFCI. The TGaR model further includes vulnerability indexes from the U.S. and foreign countries, as well as the foreign financial condition index. The extended quantile regression model can be expressed as:

$$\begin{aligned} Q^{US}_{GDP_{t+h|t}}(\tau) = \alpha(\tau) + \beta_1(\tau) \cdot GDP^{US}_t + \beta_2(\tau) \cdot FCI^{US}_t + \beta_3(\tau) \cdot FVI^{US}_t \\ + \beta_4(\tau) \cdot FVI^{FOR}_t + \beta_5(\tau) \cdot FCI^{FOR}_t + \epsilon_t(\tau) \end{aligned} \tag{3}$$

where $Q^{US}_{GDP_{t+h|t}}(\tau)$ is the τ-th quantile of the conditional distribution of U.S. GDP growth h periods ahead. GDP^{US}_t represents the current U.S. GDP growth, FCI^{US}_t is the Chicago Fed's U.S. Financial Conditions Index, FVI^{US}_t is the U.S. financial vulnerability index, FVI^{FOR}_t is the index of foreign financial vulnerabilities, and FCI^{FOR}_t is the foreign financial condition index. All coefficients $\alpha(\tau), \beta_1(\tau), \beta_2(\tau), \beta_3(\tau), \beta_4(\tau)$, and $\beta_5(\tau)$ correspond to the respective quantile τ.

The first two terms, GDP^{US}_t and FCI^{US}_t, are from Adrian et al. (2019), and the addition of FVI^{FOR}_t is the main extension in our model. The Transmission Growth-at-Risk (TGaR) is then defined as the τ = 5th percentile of the conditional GDP growth distribution from the model.

To isolate foreign-specific financial shocks, we orthogonalize the foreign FCI with respect to the U.S. FCI. Without orthogonalization, FCI^{FOR}_t could capture both foreign-specific shocks and components that reflect correlated global financial conditions. We regress foreign FCI on U.S. FCI and use the residuals:

$$FCI^{FOR}_t = \delta_0 + \delta_1 \cdot FCI^{US}_t + \eta_t \tag{4}$$

In all specifications, FCI^{FOR}_t in equation (3) refers to these orthogonalized residuals $\hat{\eta}_t$. This procedure makes the foreign FCI coefficient reflect shocks originating abroad, net of global factors that affect both U.S. and foreign financial conditions simultaneously. In the out-of-sample exercises, the orthogonalization in equation (4) is re-estimated recursively using information available through time t, and the resulting residuals are standardized using the same recursive window.[8]

A natural concern is whether U.S. economic developments could affect foreign vulnerabilities, potentially biasing our coefficient estimates through reverse causality. The main evidence against this concern comes from out-of-sample forecast performance: Foreign vulnerabilities measured at time t predict U.S. growth h quarters ahead with statistically significant accuracy gains (Section 3.4). If reverse causality explained the in-sample estimates, the relationship would be less likely to generalize beyond the estimation sample. Instead, we find a 53% improvement in out-of-sample predictive accuracy at the 8-quarter horizon, with gains that persist across multiple crisis regimes.

Several additional features of our empirical design reinforce this interpretation. First, financial vulnerabilities are slow-moving stock variables, including debt ratios, asset valuations, and leverage measures, that evolve gradually over quarters and years. In contrast, U.S. GDP growth is a quarterly flow variable. The sluggish adjustment of vulnerabilities limits the scope for contemporaneous feedback from quarterly U.S. growth fluctuations to foreign vulnerability levels.

Second, we include current U.S. GDP growth as a control variable in equation (3), which absorbs any contemporaneous correlation between U.S. economic conditions and foreign vulnerabilities.

Third, we orthogonalize foreign FCI with respect to U.S. FCI, removing components of

[8]We do not orthogonalize foreign FVI with respect to U.S. FVI in the baseline specification. Financial vulnerabilities are slow-moving stock variables that evolve over quarters and years, limiting the scope for contemporaneous confounding from common global factors. As a robustness check, Appendix orthogonalizes foreign FVI with respect to both U.S. FCI and U.S. FVI. The foreign FVI coefficient on the orthogonalized measure is -0.18 at the 8-quarter horizon, compared to -0.86 in the baseline, showing that foreign-specific vulnerabilities retain a statistically significant effect on U.S. growth after removing the component correlated with U.S. financial conditions and vulnerabilities.

foreign financial conditions that correlate with U.S. conditions. This orthogonalization helps isolate the component of foreign financial stress that is independent of U.S. developments. A related concern is that unobserved global factors, such as shifts in risk appetite, commodity price cycles, or synchronized monetary policy, could move both foreign FVI and U.S. growth simultaneously, biasing our estimates. We address this concern in Appendix by orthogonalizing foreign FVI with respect to both U.S. FCI and U.S. FVI. The orthogonalized foreign FVI coefficient at the 8-quarter horizon is -0.18 and remains statistically significant at the 5 percent level, showing that foreign vulnerabilities retain predictive content for U.S. downside growth risk after removing common global factors.

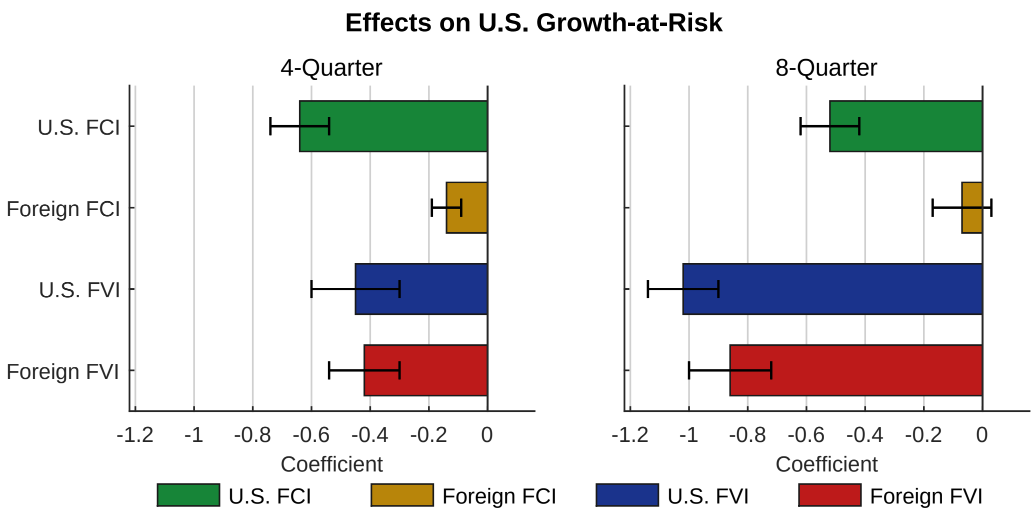
Finally, our crisis episode analysis examines events where the direction of the shock is easier to interpret. The 2010–12 European sovereign debt crisis originated in foreign economies, with foreign vulnerabilities preceding U.S. growth declines. Our identification approach is complementary to the granular instrumental variables (GIV) strategy employed by Adrian et al. (2022), who used bank-level expected default frequencies to instrument for aggregate financial conditions and found that instrumented coefficients exhibit the same sign-reversal pattern as OLS estimates, supporting a causal interpretation of the FCI–GaR relationship. The GIV approach instruments for financial conditions using firm-level heterogeneity. Our approach instead uses the predetermined nature of slowly moving vulnerability stocks and out-of-sample performance across multiple crisis regimes.

Note that quantile regressions use all data points in a sample but assign greater weight to observations closer to the quantile of interest. Hence, our estimation results are not solely attributable to the several adverse events abroad that our sample covers.

3.3 Estimation Results

Figure 2 reports the estimated 5th percentile coefficients from quantile regressions for 4-quarter and 8-quarter ahead predictions using the baseline TGaR model. All predictors are standardized to have a mean of zero and a unit variance before the estimation, which ensures comparability across variables. The whiskers in the figure represent 90 percent confidence intervals. The coefficients are statistically significant except for foreign FCI at the 8-quarter horizon, which is estimated imprecisely. As a robustness check in Appendix, we estimate the model at the 10th percentile, a commonly used downside-risk quantile in GaR applications (e.g., Gächter et al., 2023), and find that the main results remain statistically significant.

Figure 2. TGaR Coefficients at 4- and 8-Quarter Horizons



Note: This figure shows estimated coefficients from quantile regressions at the 5th percentile of future GDP growth at the 4- and 8-quarter horizons. The regressors include current U.S. GDP growth (not shown), U.S. and foreign financial conditions (FCI), and U.S. and foreign financial vulnerabilities (FVI), based on equation (3). Sample period: 1995:Q1–2023:Q4. All variables are standardized to have zero mean and unit variance. Horizontal whiskers represent 90 percent confidence intervals constructed using Newey-West standard errors with 4 lags.

The coefficient estimates show that tighter U.S. financial conditions significantly increase downside risks to U.S. GDP growth in the medium term (4 quarters ahead), but their effect diminishes over a medium-term horizon (8 quarters ahead). This finding is consistent with the results from the domestic GaR model of Adrian et al. (2019), which emphasizes the short-term relevance of domestic financial conditions in predicting U.S. growth-at-risk, and with the term structure documented by Adrian et al. (2022), where FCI coefficients on the fifth percentile are large and negative at near-term horizons but attenuate and eventually reverse sign at medium-term horizons.

In contrast, both U.S. and foreign financial vulnerabilities (FVI) exhibit stronger effects on downside risks to U.S. GDP growth over a longer horizon, with their adverse effects exceeding that of U.S. financial conditions at the 8-quarter horizon. These distinct effects across different horizons underscore the difference between the fast-moving nature of financial conditions and the slow-moving nature of FVI, a key point that we will revisit in a later section.

Furthermore, the figure shows that foreign financial vulnerabilities are statistically significant at both horizons, with magnitudes that are economically meaningful and larger than the effects of foreign FCI, which is not significant at the 8-quarter horizon. This finding indicates that foreign financial vulnerabilities weigh on U.S. downside growth risk, even after accounting for U.S. financial conditions and vulnerabilities. It also points to the transmission effect of foreign vulnerabilities, a topic that we explore in detail in Section 4.

Table 1 reports the full coefficient estimates from the baseline TGaR specification in equation (3) at both the 4-quarter and 8-quarter horizons, complementing the graphical presentation in Figure 2 with precise point estimates and robust t-statistics.[9]

To assess the time-series evolution of downside risks, we compare growth-at-risk predictions from two specifications. The first includes only U.S. financial conditions and vulnerabilities, while the second adds foreign financial conditions and vulnerabilities. Figure 3 plots the predicted 5th percentile growth-at-risk from both specifications at the 8-quarter horizon over our sample period.

Figure 3 shows two main results. First, the model incorporating foreign variables mostly predicts lower growth-at-risk than the U.S.-only specification. The average gap between the two specifications is approximately 0.3 percentage points over the sample period. Second, this gap varies over time, widening during episodes of elevated foreign financial stress. The

[9]We do not report a pseudo-R^2 for these quantile regressions because such measures are benchmark-dependent and are not directly comparable to the familiar goodness-of-fit interpretation of the OLS R^2. We therefore assess model fit and forecast value using the out-of-sample predictive scores reported in Section 3.4.

Table 1. Baseline TGaR Coefficient Estimates

Variable	4-Quarter Horizon	8-Quarter Horizon
U.S. FCI	-0.6374***	-0.5218***
	(-6.3812)	(-5.2147)
U.S. FVI	-0.4486***	-1.0187***
	(-2.9874)	(-8.4861)
Foreign FVI	-0.4231***	-0.8579***
	(-3.5268)	(-6.1284)
Foreign FCI	-0.1417***	-0.0724
	(-2.8349)	(-0.7246)

Note: This table reports estimated coefficients from quantile regressions at the 5th percentile of U.S. GDP growth at 4-quarter and 8-quarter horizons, based on equation (3). Current U.S. GDP growth is included as a control but not reported. Sample period: 1995:Q1–2023:Q4. All variables are standardized to have zero mean and unit variance. Robust t-statistics (Newey-West with 4 lags) are reported in parentheses. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Figure 3. U.S. Growth-at-Risk: The Role of Foreign Financial Variables

Note: This figure shows the predicted 5th percentile of U.S. GDP growth eight quarters ahead from two model specifications. The dashed blue line shows predictions from a model including only U.S. financial conditions and vulnerabilities. The solid red line shows predictions when foreign financial conditions and vulnerabilities are added to the model. Both models control for current GDP growth. Gray shaded regions indicate NBER-dated recessions. Sample period: 1995:Q1–2023:Q4. All variables are standardized.

euro-area sovereign debt crisis (2009–12) generates one of the largest gaps, with the red line falling up to 2 percentage points below the blue line as European banking sector stress and sovereign funding pressures intensified. Similarly, the Brexit referendum period (2016) coincides with a persistent widening of the gap, consistent with heightened uncertainty and financial market volatility emanating from the United Kingdom and Europe.

The Brexit episode differs from the European sovereign debt crisis because it was primarily a policy uncertainty event associated with European integration. Its effect is smaller than that of the European sovereign debt crisis, consistent with the more contained nature of the underlying vulnerabilities. The estimated effect is still economically meaningful and statistically significant, indicating that the TGaR framework captures transmission from policy uncertainty shocks as well as from banking and sovereign stress episodes.

The results above focus on episodes that originated abroad. The COVID-19 pandemic provides a different case because the shock was global. During this period, tighter foreign financial conditions and pre-existing foreign vulnerabilities are associated with materially worse U.S. outcomes than domestic factors alone would predict, with predicted growth-at-risk conditional on foreign developments being up to 1 percentage point lower than that implied solely by domestic developments.

The Global Financial Crisis provides an informative contrast. During 2007–09, the gap between the two specifications in Figure 3 is small, indicating that foreign variables add little predictive content for U.S. downside risk during this episode. This result is consistent with the nature of the crisis. The shock originated primarily in U.S. subprime mortgage and securitization markets and interacted with domestic vulnerabilities. Foreign financial vulnerabilities were not particularly elevated in the years preceding the crisis. European banking sector fragilities, including dollar funding mismatches and high leverage, emerged and intensified during the crisis as conditions deteriorated. Since the TGaR framework treats vulnerabilities as predetermined slow-moving state variables, the model assigns little incremental role to foreign variables when foreign vulnerabilities are not elevated ex ante.

The late 1990s present a similar result for the Asian Financial Crisis. Despite the substantial financial disruption across East Asia in 1997–98, the gap between the two specifications remains narrow during this period. Two features of the episode explain this result. First, the vulnerabilities that precipitated the crisis were concentrated in a small number of economies, such as South Korea, that receive modest weight in our equal-weighted aggregate of 21 predominantly advanced economies. Second, several of these economies enter our sample with limited history, with China starting in 2000:Q1 and Russia starting in 1998:Q1, which further reduces the East Asian signal in the aggregate index. This result reflects our baseline aggregation scheme, which avoids foresight bias by treating all economies symmetrically. As we show in Section 3.4, trade-weighted and regression-based aggregation schemes that upweight economies with stronger U.S. linkages yield somewhat stronger results overall, consistent with our transmission channel findings in Section 4. The Asian crisis result therefore reflects the composition of our index and should not be read as evidence against foreign vulnerability effects during that episode.

These time-varying results point to a key feature of foreign vulnerability transmission: the estimates depend on the state of foreign financial systems. Foreign variables matter most when broad-based vulnerabilities across major advanced economies are elevated, as in the European sovereign debt crisis. They matter less when the shock and vulnerabilities are predominantly domestic, as in the Global Financial Crisis, or when the relevant vulnerabilities are concentrated in economies that receive limited weight in the cross-country aggregate, as in the Asian Financial Crisis. When foreign vulnerabilities are contained, U.S. downside risks are largely determined by domestic factors. When major foreign economies experience financial stress through banking sector fragility, sovereign debt concerns, or policy uncertainty, the transmission to U.S. growth-at-risk becomes economically significant. This evidence motivates our detailed examination of transmission channels in what follows.

3.4 Out-of-Sample Forecast Performance

We evaluate the framework through out-of-sample forecasts over 2000–23. Using an expanding window approach, we begin with a training sample from 1995:Q1 to 1999:Q4, estimate the conditional predictive distribution, and generate forecasts for 2000:Q1. We then expand the sample forward one quarter at a time through 2023:Q4. At each forecast origin, standardization, orthogonalization, quantile-regression estimation, and density fitting use only information available through time t, producing real-time out-of-sample density forecasts for the entire evaluation period.

Following Adrian et al. (2019), we estimate equation (3) across a grid of quantiles and fit a skewed-t distribution to the estimated conditional quantiles at each forecast origin. We then assess the reliability of the resulting predictive distribution using predictive scores. The predictive score is the predictive density generated by the model and evaluated at the realized value of GDP growth. For each time period t and forecast horizon h, we compute the average predictive score as:

$$\overline{PS}_h = \frac{1}{T}\sum_{t=1}^{T} \hat{f}_{y_{t+h}|x_t}(y_{t+h}^{realized} \mid x_t), \tag{5}$$

where $\hat{f}_{y_{t+h}|x_t}(\cdot \mid x_t)$ is the estimated conditional density of GDP growth h quarters ahead and $y_{t+h}^{realized}$ is actual realized growth. Higher predictive scores indicate more accurate density forecasts because they assign greater density to the realized outcomes.

We compare four nested specifications that isolate each component's marginal contribution: (1) the Adrian et al. (2019) baseline with U.S. GDP growth and U.S. FCI, (2) adding U.S. FVI, (3) adding orthogonalized foreign FCI, and (4) the full TGaR model adding foreign FVI. Table 2 reports predictive scores by model and horizon.

Table 2 shows four results. First, foreign financial vulnerabilities provide the largest predictive gain. Adding foreign FVI improves the 8-quarter predictive score by 3.76 points, accounting for 83% of the total 4.54-point improvement over the Adrian et al. (2019) baseline. This improvement persists despite foreign FVI being added last, after controlling for domestic vulnerabilities and foreign conditions.

Second, predictive gains concentrate at medium-term horizons. The full TGaR model improves 8-quarter forecasts by 53% over the baseline but only 2.8% at 4 quarters. This asymmetry is consistent with the term structure results from the earlier section: financial

Table 2. Out-of-Sample Predictive Scores

Model Specification	4-Quarter	8-Quarter	Δ 8Q
(1) Adrian et al. (2019) baseline	4.25	8.57	–
(2) + U.S. FVI	4.29	9.12	+0.55
(3) + Foreign FCI	4.31	9.35	+0.78
(4) Full TGaR: + Foreign FVI	**4.37**	**13.11**	**+4.54**
Marginal contributions at 8-quarter horizon:			
U.S. FVI		+0.55	
Foreign FCI		+0.23	
Foreign FVI		**+3.76**	
Relative improvement over baseline	2.8%	**53.0%**	

Note: This table shows out-of-sample predictive scores for four TGaR model specifications. The predictive score is the predictive density evaluated at realized GDP growth, with higher scores indicating more accurate density forecasts. The out-of-sample evaluation period is 2000:Q1–2023:Q4, using an expanding window with initial training period 1995:Q1–1999:Q4. At each forecast origin, all transformations, quantile regressions, and density estimates are computed using only information available through that date.

vulnerabilities, as slow-moving structural variables, have their largest influence at medium-term horizons, while financial conditions matter primarily near-term. The out-of-sample evidence shows that this distinction translates into forecast improvements at policy-relevant horizons.

Third, marginal contributions align with coefficient magnitudes. Foreign FVI's 3.76-point contribution at 8 quarters reflects its large, stable regression coefficients across the growth distribution documented earlier. U.S. FVI contributes a more modest 0.55 points, consistent with its smaller coefficients, while foreign FCI adds 0.23 points, aligning with its limited significance at the 8-quarter horizon. This consistency between in-sample estimates and out-of-sample performance supports the estimated relationships.

Fourth, all models improve monotonically. Each component enhances predictive accuracy without reducing performance elsewhere. This result indicates that the TGaR framework captures distinct dimensions of risk. Foreign vulnerabilities complement the other predictors, adding independent content after controlling for domestic and foreign financial conditions.

Overall, incorporating foreign financial vulnerabilities produces the largest forecast improvement at the medium-term horizon most relevant for financial stability monitoring. The 53% improvement indicates that monitoring foreign structural fragilities is useful for assessing U.S. growth risks.

4 Transmission Channels

Financial vulnerabilities in foreign countries can affect the U.S. economy through various transmission channels. In this paper, we focus on two transmission channels: (1) the real channel (international trade), where foreign financial vulnerabilities weigh on foreign economic growth, which in turn affects the U.S. economy, and (2) the financial channel (financial integration/U.S. dollar funding), where reliance on U.S. dollar-denominated borrowing amplifies the effects of foreign financial vulnerabilities. Before turning to U.S. transmission, we first show that financial vulnerabilities shape the conditional distribution of growth in foreign economies.

4.1 Domestic Growth-at-Risk (DGaR)

For the real transmission channel to operate, foreign vulnerabilities must worsen foreign growth, which then reduces trade flows with the United States. We first establish this building block: Financial vulnerabilities significantly affect the conditional distribution of GDP growth in foreign economies. Adrian et al. (2022) estimate Growth-at-Risk for a panel of 11 advanced economies but use financial conditions as predictors, supplemented only by credit-to-GDP growth as a single vulnerability-type indicator. The crisis-prediction literature (Lee et al., 2020) shows that vulnerabilities predict the timing and severity of banking crises, but does not estimate their effects on growth distributions. We bridge these literature strands by extending Adrian et al. (2022) with financial vulnerability indexes alongside financial conditions, estimating their effects on downside growth risk in foreign economies. Our approach generalizes the credit-to-GDP growth variable in Adrian et al. (2022) by incorporating multi-sector vulnerability measures that capture leverage, valuations, and funding fragilities across the financial system. As we show in our robustness analysis (Table B1), the credit-to-GDP ratio alone performs poorly as a vulnerability proxy in the TGaR framework (OOS predictive score of 7.42 at 8 quarters versus 13.11 for the LPS index), consistent with the value of a multi-dimensional vulnerability measure.

We estimate a panel quantile regression across all countries in the sample (excluding the United States) to assess the effect of financial conditions and financial vulnerabilities on domestic growth. The panel quantile regression model is specified as follows:

$$Q^{FOR}_{GDP_{i,t+h|t}}(\tau) = \alpha_i(\tau) + \beta_1(\tau) \cdot FCI^{FOR}_{i,t} + \beta_2(\tau) \cdot FVI^{FOR}_{i,t} + \gamma_i(\tau) \cdot C_{i,t} + \epsilon_{i,t}(\tau) \qquad (6)$$

where $Q^{FOR}_{GDP_{i,t+h|t}}(\tau)$ is the τ-th quantile of the conditional distribution of GDP growth for country i, h periods ahead, $FCI^{FOR}_{i,t}$ is the financial conditions index for country i at time t, $FVI^{FOR}_{i,t}$ is the financial vulnerability index for country i at time t, and $C_{i,t}$ contains control variables including risk factors such as the VIX, dollar index, macro uncertainty for country i, and U.S. financial conditions index. The term $\alpha_i(\tau)$ captures country fixed effects.[10]

We estimate the panel quantile regression both without and with country fixed effects, as earlier for the 5th quantile. Table 3 reports the estimated coefficients for financial conditions ($FCI_{i,t}$) and financial vulnerabilities ($FVI_{i,t}$) in two specifications: the baseline model and the model with risk factor controls. We find that $FCI_{i,t}$ is statistically significant across all specifications, while $FVI_{i,t}$ is significant in most specifications and consistently so at the 8-quarter horizon. The finding that $FCI_{i,t}$ has an economically meaningful effect is consistent with Adrian et al. (2022). The finding that $FVI_{i,t}$ is statistically and economically significant in foreign economies, particularly at medium-term horizons, extends this result to financial vulnerabilities. As for relative importance of the two predictors, the $FCI_{i,t}$ consistently has a larger effect on downside risks to growth than $FVI_{i,t}$, as indicated by their respective standardized coefficients.

[10] Adrian et al. (2022) also estimate a panel quantile regression model with country dummies, but for 11 advanced economies and without controls for foreign financial vulnerabilities.

Table 3. Domestic Growth-at-Risk: Panel Quantile Regression

Variable	Baseline	Baseline	With Controls	With Controls
4-quarter horizon				
Financial Conditions	-0.2845^{**}	-0.3012^{**}	-0.2621^{**}	-0.2134^{**}
	(-2.38)	(-2.35)	(-2.28)	(-2.15)
Financial Vulnerability	-0.0924^{*}	-0.1058^{*}	-0.0718	-0.0512
	(-1.82)	(-1.78)	(-1.42)	(-1.08)
8-quarter horizon				
Financial Conditions	-0.3012^{**}	-0.3214^{**}	-0.2814^{**}	-0.2257^{**}
	(-2.45)	(-2.42)	(-2.37)	(-2.30)
Financial Vulnerability	-0.1335^{**}	-0.1472^{**}	-0.1218^{**}	-0.1014^{*}
	(-2.12)	(-2.10)	(-2.05)	(-1.94)
Country Fixed Effects	$\times$	✓	$\times$	✓

Note: This table reports estimated coefficients from panel quantile regressions of domestic GDP growth four and eight quarters ahead on country-level financial conditions and financial vulnerabilities. Sample: 21 countries (excluding U.S.), 1995:Q1–2023:Q4. All variables are standardized to have zero mean and unit variance. t-statistics (standard errors clustered at country level) are reported in parentheses. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

The results in Table 3 show the role of financial conditions and financial vulnerabilities in affecting downside risks to domestic growth across countries. At the 8-quarter horizon, the financial conditions index (FCI) is statistically significant at the 5% level in the baseline specification, with a coefficient of -0.3012, consistent with the finding from Adrian et al. (2019) for the United States. The financial vulnerability index (FVI) is also significant at the 5% level, with a smaller negative coefficient of -0.1335. When country fixed effects are included, the FCI coefficient becomes slightly larger in magnitude at -0.3214, while the FVI coefficient increases to -0.1472 in absolute value. The 4-quarter estimates have the same sign and remain significant in the baseline columns, although the FVI coefficient is smaller. With global risk controls, FCI remains significant across specifications. FVI remains significant at the 8-quarter horizon and is estimated less precisely at the 4-quarter horizon. Overall, the results indicate that financial vulnerabilities contribute to downside growth risks across countries, especially at the medium-term horizon.

4.2 Real Channel

A potential transmission channel through which foreign financial vulnerabilities may affect U.S. growth is their direct effect on foreign economies, which can reduce trade flows with the United States and subsequently weigh on the U.S. economy. To test this channel directly, we measure each country's trade link with the United States, defined as the total imports and exports of goods and services from the United States. We then split the sample into two groups based on above-median and at-or-below-median U.S. trade link exposure and estimate the TGaR model for each subsample.[11]

Table 4. TGaR by U.S. Trade Link Intensity

Variable	High U.S. Trade Link	Low U.S. Trade Link
4-quarter horizon		
Foreign FCI	-0.8254^{***}	-0.2451^{*}
	(-2.65)	(-1.90)
Foreign FVI	-0.4812^{***}	-0.1614^{*}
	(-3.15)	(-1.78)
High–Low (FVI)	-0.3198^{**}	
	(-2.40)	
8-quarter horizon		
Foreign FCI	-0.5701^{***}	-0.2764
	(-2.80)	(-1.50)
Foreign FVI	-0.5032^{***}	-0.1711^{*}
	(-3.28)	(-1.75)
High–Low (FVI)	-0.3321^{**}	
	(-2.55)	

Note: This table reports estimated TGaR coefficients for two subsamples of countries: High U.S. trade links (above-median trade share) and low U.S. trade links (at-or-below-median trade share). Foreign FCI and FVI are aggregated separately for each subsample using equal weights. Sample period: 1995:Q1–2023:Q4. All variables are standardized to have zero mean and unit variance. Robust t-statistics (Newey-West with 4 lags) are reported in parentheses. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 4 presents the TGaR results for countries with high and low trade links with the United States. The results indicate that countries with stronger trade ties to the United

[11] Countries with above-median trade links with the U.S., listed alphabetically, are: Canada, China, France, Germany, Italy, Japan, Mexico, the Netherlands, South Korea, and the United Kingdom.

States (that is, high U.S. trade link) experience significantly larger negative effects on their GDP growth due to foreign financial conditions and foreign financial vulnerabilities compared to countries with weaker trade links (that is, low U.S. trade link).

For the 4-quarter horizon, the FVI coefficient is -0.48 for countries with high U.S. trade link, highly significant at the 1% level, while for low U.S. trade link countries, the coefficient is smaller at -0.16 and only weakly significant at the 10% level. Similarly, the FCI coefficient is -0.83 for high U.S. trade link countries, significantly larger than the -0.25 for low U.S. trade link countries. At the 8-quarter horizon, the FVI coefficient is -0.50 for high U.S. trade link countries (1% significance), compared to -0.17 for low U.S. trade link countries (10% significance). The FCI coefficient is also larger for high U.S. trade link countries at -0.57 compared to -0.28 for low U.S. trade link countries.

These results show that the intensity of the real transmission channel is closely linked to the strength of bilateral trade. It is worth noting that shifts in global trade patterns, potentially driven by new trade policies, could affect these dynamics. For example, a broad decline in trade volumes might attenuate this transmission channel. In contrast, trade diversion could reconfigure the set of countries whose vulnerabilities pose the greatest risk to the U.S. through trade. While the specific country exposures may change, the underlying trade channel, as captured by our framework, would remain relevant for assessing evolving risks from abroad.

All in all, the results suggest that elevated financial vulnerabilities abroad pose risks to economic growth and that these risks worsen the United States' economic prospects because of international trade linkages.

4.3 Financial Channel

Financial integration takes various forms, and we focus on a particular one. The U.S. dollar plays a central role in the global financial system as the dominant currency for international lending and borrowing. While this international role of the dollar offers numerous benefits to the economies and financial system, it may also serve as a conduit of foreign financial stress. For example, vulnerable foreign financial and non-financial sectors could engage in fire sales of U.S. assets or scramble for U.S. dollar liquidity in times of stress abroad, causing spillovers into the U.S. economy and financial system.

To investigate this channel, we use the data on the dollar share of U.S. dollar assets and liabilities of foreign economies from Benetrix et al. (2019), who provide the currency composition of the international investment positions for dozens of countries. We define a measure of dollar integration as a country's share of external assets and debt liabilities in U.S. dollars. Specifically, to measure country i's dollar integration, we use external assets and liabilities denominated in U.S. dollars for the country i. We then split the sample into two groups: Countries with above-median dollar integration (that is, those whose average U.S. dollar assets and liabilities is above the median) and countries with at-or-below-median dollar integration. Next, we run the TGaR model for each subsample.[12]

Table 5 reports the TGaR results for countries with high and low dollar integration. The results indicate that both foreign financial conditions (FCI) and foreign financial vulnerabilities (FVI) have negative effects on U.S. GDP growth, with stronger and more precise estimates for countries with high dollar integration. For the 4-quarter horizon, the FVI coefficient for countries with high dollar integration is -0.43 and is highly significant, while for countries with low dollar integration, the FVI coefficient is -0.14 and is significant at the 10% level. At the 8-quarter horizon, the FVI coefficient is -0.47 for high dollar integration countries (significant at the 1% level) and -0.18 for low dollar integration countries (significant at the 10% level). The low-dollar FCI coefficient at the 8-quarter horizon is estimated less precisely.

The final row of the table shows the difference between the FVI coefficients for the two subsamples (high minus low). The differences are statistically significant at the 5% level, with a magnitude of about -0.29 at both horizons. These results suggest that countries

[12] Countries with above-median dollar integration, listed alphabetically, are: Canada, Germany, Italy, Japan, Mexico, the Netherlands, South Korea, Spain, Switzerland, and the United Kingdom.

Table 5. TGaR by Dollar Integration

Variable	High Dollar Integration	Low Dollar Integration
4-quarter horizon		
Foreign FCI	-0.7624^{**}	-0.2531^{*}
	(-2.55)	(-1.85)
Foreign FVI	-0.4312^{***}	-0.1402^{*}
	(-3.10)	(-1.92)
High–Low (FVI)	-0.2910^{**}	
	(-2.35)	
8-quarter horizon		
Foreign FCI	-0.5554^{***}	-0.2754
	(-2.65)	(-1.60)
Foreign FVI	-0.4712^{***}	-0.1795^{*}
	(-3.25)	(-1.70)
High–Low (FVI)	-0.2917^{**}	
	(-2.20)	

Note: This table reports estimated TGaR coefficients for two subsamples of countries: High dollar integration (above-median dollar asset and liability share) and low dollar integration (at-or-below-median). Foreign FCI and FVI are aggregated separately for each subsample using equal weights. Sample period: 1995:Q1–2023:Q4. All variables are standardized to have zero mean and unit variance. Robust t-statistics (Newey-West with 4 lags) are reported in parentheses. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

with higher dollar integration are more important conduits of financial stress from abroad.

In terms of the marginal effects of foreign financial variables, the trade and financial channels are similarly economically significant. The standardized regression coefficients on foreign financial vulnerabilities in the first columns of Tables 4 and 5 are statistically comparable, although the regression coefficient for the trade channel is slightly higher. We do not take a stance on which channel is larger, as the evidence supports the presence of both channels.

A natural concern is that the high-trade and high-dollar groups overlap substantially, so Tables 4 and 5 may partly identify the same set of highly connected economies. Appendix Table A2 addresses this concern by forming the trade comparison after excluding the above-median dollar-integration countries and by forming the dollar-integration comparison after excluding the above-median U.S. trade-link countries. The high–low FVI gap remains significant for both channels, indicating that the trade and dollar-integration results are not explained by the overlapping high-exposure countries.

4.4 Which Foreign Vulnerabilities Matter the Most?

Next, we investigate which components of foreign vulnerabilities contribute most to the downside risk of U.S. GDP growth. By doing so, we aim to better understand the channels through which foreign vulnerabilities weigh on U.S. growth risks, as each component may operate through either or both real and financial channels. To achieve this, we replace the aggregated foreign vulnerability index in the baseline model with its four aggregated components: (1) asset valuation pressures, (2) financial sector vulnerabilities (financial sector leverage), (3) nonfinancial sector vulnerabilities (combining household and corporate leverage), and (4) sovereign vulnerabilities (government debt and fiscal deficits). We aggregate household and corporate leverage into a single nonfinancial sector measure as both represent private-sector debt vulnerabilities. Additionally, we orthogonalize foreign valuation pressures with respect to U.S. valuation pressures to isolate the foreign-specific effects.

We anticipate that vulnerabilities in certain sectors may be more important than those in other sectors, by analogy with the crisis prediction literature. For example, Lee et al. (2020) find that asset valuation pressures, in particular, tend to peak a couple of years before banking crises and corrections to valuations are well underway before the crises occur. Figure 1 illustrates this timing.

Table 6 shows the results of the quantile regressions with these components, reporting the coefficients of each foreign vulnerability component for both 4-quarter and 8-quarter ahead predictions. The results indicate that all components are significant at the 10% level, except for the financial sector component in the 8-quarter horizon.

In terms of magnitude, valuation pressures have the largest effect on downside risk, followed by financial sector vulnerabilities, sovereign vulnerabilities, and nonfinancial sector

Table 6. Foreign Vulnerability Components and U.S. Growth-at-Risk

	Valuation	Financial	Nonfinancial	Sovereign
4-quarter horizon				
Coefficient	-0.5824^{**}	-0.2172^{*}	-0.0824^{**}	-0.1117^{*}
	(-2.12)	(-1.71)	(-1.99)	(-1.89)
8-quarter horizon				
Coefficient	-0.9241^{**}	-0.1533	-0.0413^{**}	-0.1421^{*}
	(-2.45)	(-1.45)	(-2.01)	(-1.79)

Note: This table reports estimated coefficients from quantile regressions that replace the aggregate foreign FVI with its four aggregated components: Asset valuation pressures, financial sector leverage, nonfinancial sector leverage (household and corporate combined), and sovereign vulnerabilities (government debt and fiscal deficits). Each component enters separately in the regression. Sample period: 1995:Q1–2023:Q4. All variables are standardized to have zero mean and unit variance. Robust t-statistics (Newey-West with 4 lags) are reported in parentheses. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

vulnerabilities. At the 8-quarter horizon, their coefficient (-0.92) is roughly six times that of financial sector leverage (-0.15) and over twenty times that of nonfinancial sector vulnerabilities (-0.04). This ranking likely reflects the role valuations play as triggers for financial stress, whereas leverage determines the depth of resulting contractions. When foreign asset valuations are stretched, even modest condition shocks can precipitate corrections that propagate through mark-to-market losses, margin calls, and forced deleveraging, consistent with the fire-sale externality mechanism emphasized by Brunnermeier and Sannikov (2014). This interpretation is also consistent with belief-based theories (Bordalo et al., 2018), where compressed risk premia during elevated valuations reverse when conditions tighten. Figure 1 lines up with this ordering: Valuation pressures peak earliest before crises and correct most sharply, consistent with their role as a leading amplifier. Sovereign and nonfinancial sector vulnerabilities have a smaller, yet still significant, effect on downside risks. This ranking holds for both the 4-quarter and 8-quarter horizons.

4.5 Amplification Effects of Foreign Vulnerability

To investigate the effect of foreign financial vulnerabilities further, we modify our TGaR framework to gauge the effects of foreign financial shocks on U.S. economic growth and the role of foreign financial vulnerabilities in amplifying these effects.

We note that FCIs and FVIs are very distinct concepts, with the former being a natural candidate for a measure of a financial shock. FCIs are coincident indexes, that is, they are designed to measure the market-implied severity of developments as they occur. By contrast, FVIs are early warning indicators of financial crises, that is, they are slowly changing, are based on structural vulnerabilities, and are designed to predict over a medium-term horizon the timing of a crisis and its economic severity. Indeed, the results of Vermeulen et al. (2015) suggest only a very weak relationship between FCIs (or rather financial stress indexes, FSIs) and the onset of a banking crisis. Similarly, Lee et al. (2020) shows that, for the United States, the financial stress indexes suggested below normal or normal stress levels five-to-two years ahead of the 2007–09 financial crisis, whereas their and Aikman et al. (2017)'s FVIs reached extremely elevated levels two-to-three years before the crisis.

To capture the amplification effect of FVIs, we expand the quantile regression baseline model by adding foreign FCIs and the interaction terms of these orthogonalized FCIs with foreign FVIs. This interaction specification is analogous in spirit to the credit boom indicator in Adrian et al. (2022), who interacted loose financial conditions with rapid credit-to-GDP growth and found significant amplification of downside risk at medium-term horizons. Our approach generalizes theirs by replacing a binary credit boom dummy with a continuous FVI measure and by examining cross-border amplification. The expanded model is expressed as follows:

$$\begin{aligned} Q^{US}_{GDP_{t+h|t}}(\tau) = {} & \alpha(\tau) + \beta_1(\tau) \cdot GDP^{US}_t + \beta_2(\tau) \cdot FCI^{US}_t \\ & + \beta_3(\tau) \cdot FVI^{US}_t + \beta_4(\tau) \cdot FCI^{FOR}_t + \beta_5(\tau) \cdot FVI^{FOR}_t \\ & + \beta_6(\tau) \cdot FVI^{FOR}_t \times FCI^{FOR}_t + \epsilon_t(\tau) \end{aligned} \tag{7}$$

In this equation, FCI_t^{FOR} represents the foreign financial conditions index, which captures the overall financial conditions in major foreign economies. To isolate the foreign component, this measure is orthogonalized to the U.S. FCI. The coefficient $\beta_4(\tau)$ therefore captures the baseline effect of foreign financial shocks on U.S. growth-at-risk. The interaction term $FVI_t^{FOR} \times FCI_t^{FOR}$ is the key variable of interest, capturing the amplification effect of financial vulnerabilities. A negative coefficient $\beta_6(\tau)$ would suggest that the current level of financial vulnerabilities amplifies the effect of foreign financial conditions.

Table 7. Amplification Effects of Foreign Vulnerabilities

	Component Interacted with Foreign FCI:				
	Aggregate	Valuation	Financial	Nonfinancial	Sovereign
4-quarter horizon					
Interaction (β_6)	−0.1845**	−0.2321*	−0.1273**	−0.1011**	−0.0914
	(−2.18)	(−1.95)	(−2.06)	(−2.21)	(−1.14)
8-quarter horizon					
Interaction (β_6)	−0.2134**	−0.3210**	−0.2213**	−0.0173**	−0.0511
	(−2.25)	(−1.98)	(−1.99)	(−2.13)	(−1.13)

Note: This table reports interaction coefficients (β_6) from quantile regressions at the 5th percentile. The "Aggregate" column uses the full foreign FVI interacted with foreign FCI. The remaining columns show results from separate regressions where the aggregate foreign FVI is replaced by one specific component and its interaction with foreign FCI. Sample period: 1995:Q1–2023:Q4. All variables are standardized to have zero mean and unit variance. Robust t-statistics (Newey-West with 4 lags) are reported in parentheses. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 7 reports the estimates of the expanded quantile regression model (7) with the aggregate foreign FVI and with all the four components. The results indicate that most interaction terms are statistically significant, which highlights the amplifying effects of foreign vulnerabilities on the relationship between foreign financial conditions and U.S. growth at risk.

In the out-of-sample exercise, adding the aggregate amplification term to the full TGaR specification improves the 8-quarter predictive score relative to model (4) in Table 2, but only marginally. The gain is 0.17 points, suggesting that amplification terms add some forecast content beyond the full TGaR model while the main predictive improvement still comes from including foreign vulnerabilities directly.

In terms of individual components, valuation pressures exhibit the largest amplification effect on the relationship between foreign financial conditions and U.S. growth-at-risk, suggesting that heightened valuation pressures in foreign markets significantly exacerbate the adverse effects of foreign FCIs on U.S. economic growth. This is consistent with the findings of Brunnermeier (2009), who argued that asset price bubbles and subsequent corrections could lead to severe financial instability and economic downturns.

Following valuation pressures, vulnerabilities in the financial sector also show a substantial amplification effect. This indicates that vulnerabilities within the foreign financial sector can significantly magnify the negative effect of foreign financial conditions on the U.S. economy, which highlights the consequences of the rising interconnectedness of global financial systems. This finding is consistent with Kaminsky and Reinhart (1999), where they show how banking sector crises can lead to widespread financial contagion, affecting both domestic and international markets.

Although the interaction terms for nonfinancial sector vulnerabilities are smaller in magnitude compared to the other two sectors, their statistical significance indicates that they also amplify the effects of shocks in foreign financial conditions on U.S. growth. These vulnerabilities, such as high corporate debt levels, can constrain business investment and economic expansion, further compounding the adverse effects of financial shocks. For instance, Mian and Sufi (2014) argues that addressing vulnerabilities in the nonfinancial sector is crucial to prevent severe economic contractions.

We do not find evidence that sovereign vulnerabilities, which include high public debt and fiscal deficits, amplify financial shocks.

4.6 Robustness Checks

We conduct several robustness checks in Appendix and Online Appendix. In Appendix, we estimate the model at the 10th percentile of the distribution of U.S. growth rates to examine a broader downside-tail threshold. We also separate the trade and dollar-integration channels after removing the high-exposure overlap, orthogonalize foreign FVIs with respect to U.S. financial variables, and use alternative measures of financial vulnerabilities, including the IMF's Financial Soundness Indicators. These checks show that our results do not depend on the Lee et al. (2020) vulnerability measures. In the Online Appendix, we examine predictive scores for alternative financial vulnerability measures, address concerns about country size effects and the length of the sample period, and explore alternative weighting schemes in constructions of FVIs. These results support the main findings.

5 Conclusion

This paper develops a Transmission Growth-at-Risk framework that distinguishes foreign financial conditions (transitory credit market shocks) from foreign financial vulnerabilities (structural fragilities that amplify shocks). This conceptual distinction, incorporated into quantile regressions for U.S. GDP growth, reveals international transmission mechanisms absent from the Growth-at-Risk literature.

Foreign financial vulnerabilities exhibit different temporal dynamics than financial conditions. Conditions primarily affect near-term tail risk, while vulnerabilities weigh on the entire growth distribution at medium-term horizons with coefficients stable across quantiles. This result is consistent with vulnerabilities operating as slow-moving state variables. The contrast with Adrian et al. (2022) is instructive: Their FCI coefficients on the fifth percentile reverse sign over the projection horizon, consistent with an endogenous risk-taking channel where today's loose conditions sow tomorrow's fragilities. Our FVI coefficients show no such reversal. They grow in magnitude through the 8-quarter horizon, supporting the interpretation that vulnerabilities represent pre-existing structural constraints on growth.

Foreign vulnerabilities amplify financial condition shocks. When vulnerabilities are low, foreign financial shocks have small U.S. effects. When vulnerabilities are elevated, similar shocks produce larger effects. This nonlinearity supports treating vulnerabilities as state-dependent propagation channels. Amplification is strongest for asset valuation pressures and financial sector leverage, where theory predicts that tightening credit can trigger forced deleveraging and fire sales (Brunnermeier and Sannikov, 2014). The interaction structure connects to belief-based theories (Bordalo et al., 2018; Minsky, 1977) where compressed risk premia during elevated valuations reverse when conditions tighten.

Foreign vulnerabilities transmit through both trade linkages and dollar funding channels with similar magnitudes. This result is useful because prior work on international spillovers often emphasizes financial channels (Rey, 2015; Bruno and Shin, 2015). The similar magnitudes suggest reinforcing channels: trade disruptions reduce foreign income, tighter foreign financial conditions trigger deleveraging, and deleveraging can further reduce trade credit. This interconnection may explain why foreign vulnerabilities have larger medium-term effects than domestic vulnerabilities.

The crisis-episode evidence is consistent with the same interpretation. The 2010–12 European sovereign debt crisis and the 2016 Brexit referendum provide complementary evidence: the framework captures transmission through banking sector fragility and policy uncertainty. The COVID-19 episode shows that pre-existing foreign vulnerabilities also weigh on U.S. downside risk when the shock is global. At the same time, foreign variables add little predictive content during the Global Financial Crisis, when the shock and vulnerabilities were predominantly domestic, and during the Asian Financial Crisis, when the relevant vulnerabilities were concentrated in economies that receive limited weight in our broad cross-country aggregate. These episodes reduce the concern that foreign FVI improves fit by absorbing noise across all episodes.

The framework delivers a 53% forecast improvement at the 8-quarter horizon, where the estimated vulnerability effects are largest. The alignment between theoretical prediction, in-sample coefficients, and out-of-sample performance supports the proposed transmission channels. Forecast gains are largest during foreign stress episodes, consistent with vulnerabilities acting as state-dependent amplifiers. The stable performance across multiple crisis regimes also helps address identification concerns, since spurious correlations or reverse causality would be less likely to generate consistent out-of-sample predictive content across distinct regimes.

Incorporating foreign financial vulnerabilities into growth risk frameworks shows that international macro-financial linkages operate through distinct channels at different horizons. Looking ahead, the TGaR framework can be extended to emerging market economies, where vulnerability dynamics may differ, and adapted for use in macroprudential stress testing, where incorporating foreign vulnerability states could improve the calibration of adverse scenarios.

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A Appendix: Key Robustness Checks

This appendix presents detailed results from robustness checks summarized in the main text. We examine the estimation results for a less extreme GaR tail, specifically the 10th percentile, to show that the results also hold at a broader downside-tail threshold. We then examine the separation of trade and dollar-integration channels after removing overlapping high-exposure countries, orthogonalized vulnerabilities to address common global factor concerns, and alternative vulnerability measures to show that our results do not depend on the Lee et al. (2020) vulnerability measures.

A.1 10th percentile Growth-at-Risk

To assess whether foreign vulnerabilities affect a broader downside tail, we estimate our baseline TGaR model at the 10th percentile. This quantile is frequently used in GaR applications as a measure of downside risk. For example, Gächter et al. (2023) estimate panel quantile-regression models for the conditional 10th percentile of GDP growth. The table below reports the 5th-percentile estimates from the baseline specification and the corresponding 10th-percentile robustness estimates at the 4-quarter and 8-quarter horizons. The 10th-percentile coefficients are smaller in magnitude than the 5th-percentile coefficients, as one would expect when moving away from the extreme left tail, but the foreign FVI coefficient remains large and highly significant.

A.2 Separating Trade and Dollar Integration Channels

Tables 4 and 5 split countries by trade links and dollar integration separately. Since several countries are highly exposed along both dimensions, we conduct an additional robustness exercise that keeps the two comparisons separate. Countries are first ranked by their average U.S. trade exposure and by their average dollar integration over the sample. For the trade comparison, we remove the above-median dollar-integration countries used in Table 5 and compare the three highest and three lowest countries by U.S. trade exposure among

Table A1. TGaR Coefficients Across the Growth Distribution

Variable	**5th percentile**	**10th percentile**
4-quarter horizon		
U.S. FCI	-0.6374^{***}	-0.5418^{***}
	(-6.3812)	(-5.4240)
U.S. FVI	-0.4486^{***}	-0.3813^{**}
	(-2.9874)	(-2.5393)
Foreign FVI	-0.4231^{***}	-0.3596^{***}
	(-3.5268)	(-2.9978)
Foreign FCI	-0.1417^{***}	-0.1204^{**}
	(-2.8349)	(-2.4097)
8-quarter horizon		
U.S. FCI	-0.5218^{***}	-0.4435^{***}
	(-5.2147)	(-4.4325)
U.S. FVI	-1.0187^{***}	-0.8659^{***}
	(-8.4861)	(-7.2132)
Foreign FVI	-0.8579^{***}	-0.7292^{***}
	(-6.1284)	(-5.2091)
Foreign FCI	-0.0724	-0.0615
	(-0.7246)	(-0.6159)

Note: This table reports estimated coefficients from quantile regressions of U.S. GDP growth four and eight quarters ahead on current GDP growth (not shown), U.S. and foreign financial conditions (FCI), and U.S. and foreign financial vulnerabilities (FVI). Sample period: 1995:Q1–2023:Q4. All variables are standardized to have zero mean and unit variance. Robust t-statistics (Newey-West with 4 lags) are reported in parentheses. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

the remaining countries. This yields a high-trade group consisting of Australia, China, and France, and a low-trade group consisting of New Zealand, Norway, and Sweden. For the dollar-integration comparison, we remove the above-median U.S. trade-link countries used in Table 4 and compare the three highest and three lowest countries by dollar integration among the remaining countries. This yields a high-dollar group consisting of Hong Kong, Spain, and Switzerland, and a low-dollar group consisting of Austria, Belgium, and Denmark. The exercise asks whether each channel remains operational when the same highly connected countries are not allowed to drive both results.

The results support both channels. After excluding the above-median dollar-integration countries, the high–low difference in the foreign FVI coefficient remains negative and statist-

Table A2. Channel Robustness Excluding High-Exposure Country Overlap

	Trade Exposure		Dollar Integration	
Variable	High Trade	Low Trade	High Dollar	Low Dollar
4-quarter horizon				
Foreign FCI	-0.6463^{**}	-0.2684^{**}	-0.5127^{**}	-0.1716
	(-2.34)	(-2.04)	(-2.08)	(-1.52)
Foreign FVI	-0.3297^{**}	-0.1499^{*}	-0.2958^{**}	-0.1059
	(-2.36)	(-1.72)	(-2.19)	(-1.34)
High–Low (FVI)	-0.1798^{**}		-0.1899^{*}	
	(-2.01)		(-1.89)	
8-quarter horizon				
Foreign FCI	-0.4027^{**}	-0.1873	-0.3842^{**}	-0.1768
	(-2.06)	(-1.18)	(-2.01)	(-1.12)
Foreign FVI	-0.3719^{**}	-0.1468	-0.3486^{**}	-0.1324
	(-2.36)	(-1.42)	(-2.28)	(-1.36)
High–Low (FVI)	-0.2251^{**}		-0.2162^{**}	
	(-2.12)		(-2.05)	

Note: This table repeats the 4-quarter and 8-quarter TGaR channel regressions using groups that avoid overlap in the competing exposure measure. Countries are ranked by average U.S. trade exposure and average dollar integration over the sample. In the trade comparison, both the high- and low-trade groups exclude the above-median dollar-integration countries used in Table 5. High and low trade are defined as the three highest and three lowest countries by U.S. trade exposure among the remaining countries. The high-trade group includes Australia, China, and France. The low-trade group includes New Zealand, Norway, and Sweden. In the dollar-integration comparison, both the high- and low-dollar groups exclude the above-median U.S. trade-link countries used in Table 4. High and low dollar integration are defined as the three highest and three lowest countries by dollar integration among the remaining countries. The high-dollar group includes Hong Kong, Spain, and Switzerland. The low-dollar group includes Austria, Belgium, and Denmark. Foreign FCI and FVI are aggregated separately for each group using equal weights. Sample period: 1995:Q1–2023:Q4. All variables are standardized to have zero mean and unit variance. Robust t-statistics (Newey-West with 4 lags) are reported in parentheses. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

ically significant when comparing Australia, China, and France with New Zealand, Norway, and Sweden. After excluding the above-median U.S. trade-link countries, the corresponding difference also remains negative and statistically significant when comparing Hong Kong, Spain, and Switzerland with Austria, Belgium, and Denmark. The regression coefficients are comparable in magnitude for both channels. Trade exposure and dollar integration each identify economically meaningful transmission of foreign vulnerabilities to U.S. downside growth risk.

A.3 Orthogonalized Foreign Financial Vulnerabilities

We first address whether foreign vulnerabilities capture common global factors. When global risk appetite declines or commodity prices swing, vulnerabilities tend to rise simultaneously across countries. In this scenario, the foreign FVI coefficient in our baseline regressions could partly reflect how global factors affect both foreign and U.S. vulnerabilities, instead of how foreign vulnerabilities specifically reduce U.S. growth. To isolate the component of foreign vulnerabilities that is independent of U.S. financial conditions, we orthogonalize foreign FVI with respect to U.S. variables.

Specifically, we regress foreign FVI on U.S. FCI and U.S. FVI:

$$FVI_t^{FOR} = \gamma_0 + \gamma_1 \cdot FCI_t^{US} + \gamma_2 \cdot FVI_t^{US} + \nu_t \tag{A1}$$

and use the residuals $\hat{\nu}_t$ as our measure of foreign-specific vulnerabilities. These residuals capture the component of foreign vulnerabilities that cannot be explained by concurrent U.S. financial conditions or U.S. vulnerabilities. We then re-estimate equation (3) using the orthogonalized foreign FVI in place of the original foreign FVI.

Table A3 presents the results. Column (1) reproduces our baseline estimates for comparison. Column (2) shows results using orthogonalized foreign FVI.

The results in Table A3 show that the main findings hold under orthogonalization. In Column (2), the coefficient on orthogonalized foreign FVI remains statistically significant at the 5 percent level for both horizons. At the 8-quarter horizon, the orthogonalized coefficient is -0.18 compared to -0.86 in the baseline. The orthogonalization removes the component of foreign FVI correlated with U.S. variables, so the remaining coefficient captures the part of foreign vulnerabilities that is less directly related to U.S. financial conditions and vulnerabilities. This result addresses the concern that our baseline coefficients might reflect common

Table A3. Robustness Check: Orthogonalized Foreign FVI

	(1) Baseline	(2) Orthog. FVI
4-quarter Horizon (5th percentile)		
Foreign FVI	-0.4231^{***}	-0.2423^{**}
	(-3.53)	(-2.05)
U.S. FCI	-0.6374^{***}	-1.6412^{**}
	(-6.38)	(-2.47)
Foreign FCI	-0.1417^{***}	-0.4689^{**}
	(-2.83)	(-2.32)
U.S. FVI	-0.4486^{***}	-0.7234^{**}
	(-2.99)	(-2.28)
8-quarter Horizon (5th percentile)		
Foreign FVI	-0.8579^{***}	-0.1756^{**}
	(-6.13)	(-1.98)
U.S. FCI	-0.5218^{***}	-1.2034^{**}
	(-5.21)	(-2.28)
Foreign FCI	-0.0724	-0.3178^{**}
	(-0.72)	(-2.15)
U.S. FVI	-1.0187^{***}	-0.9756^{**}
	(-8.49)	(-2.01)
Orthogonalized For. FVI	No	Yes

Note: This table reports estimated coefficients from quantile regressions of U.S. GDP growth on current GDP growth (not shown), U.S. and foreign financial conditions (FCI), and U.S. and foreign financial vulnerabilities (FVI). Column (1) reproduces baseline results from the main text. Column (2) uses foreign FVI orthogonalized with respect to U.S. FCI and U.S. FVI to isolate foreign-specific vulnerabilities. Sample period: 1995:Q1–2023:Q4. All variables are standardized to have zero mean and unit variance. Robust t-statistics (Newey-West with 4 lags) are reported in parentheses. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

global factors that affect both foreign and U.S. vulnerabilities simultaneously, such as swings in global risk appetite or synchronized commodity price movements. The coefficient remains negative and statistically significant, indicating that foreign financial vulnerabilities reduce U.S. growth through direct economic linkages, including reduced foreign demand for U.S. exports, disruptions in dollar funding markets, and heightened uncertainty about foreign counterparties.

A.4 Alternative Financial Vulnerability Measures

To test the robustness of our TGaR framework, we use alternative measures of financial vulnerabilities, starting with the IMF's Financial Soundness Indicators (FSIs). The FSIs track key metrics related to the financial sector's health, providing insights into systemic risks with a focus on the banking sector. While both the LPS and FSIs aim to identify systemic vulnerabilities, FSIs focus primarily on the banking sector, whereas the LPS offers a broader view, capturing risks across financial, nonfinancial, sovereign, and valuation sectors.

Table A4. TGaR Results Using IMF Financial Soundness Indicators

	Foreign FSI	U.S. FCI	Foreign FCI	U.S. FSI
4-quarter horizon				
Coefficient	-0.2315^{**}	-1.6123^{**}	-0.4952^{**}	-0.6897^{**}
	(-1.99)	(-2.51)	(-2.18)	(-2.01)
8-quarter horizon				
Coefficient	-0.1624^{**}	-1.0953^{**}	-0.3157^{**}	-1.0054^{*}
	(-2.05)	(-2.26)	(-1.99)	(-1.71)
4-quarter horizon (with interaction)				
× Foreign FCI	-0.1318^{**}	-1.2785^{**}	-0.3422^{**}	-0.5589^{**}
	(-2.08)	(-2.09)	(-2.06)	(-2.06)
8-quarter horizon (with interaction)				
× Foreign FCI	-0.2289^{**}	-0.8695^{**}	-0.3382^{**}	-1.0341^{**}
	(-2.01)	(-2.05)	(-2.02)	(-2.02)

Note: This table reports estimated TGaR coefficients using IMF Financial Soundness Indicators (FSI) as alternative measures of financial vulnerabilities instead of the Lee et al. (2020) FVI. The IMF FSIs include capital adequacy ratios, nonperforming loan ratios, and return on assets. Sample period: 1995:Q1–2023:Q4. All variables are standardized to have zero mean and unit variance. Robust t-statistics (Newey-West with 4 lags) are reported in parentheses. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

We replace the LPS with the IMF's FSI and run the same TGaR regressions, controlling for both U.S. and foreign FCI. Table A4 reports the coefficients for each variable in predicting U.S. downside risk for both 4-quarter and 8-quarter horizons. The results show that, similar to the LPS, the foreign FSI is significant at the 5% level in predicting U.S. downside risk at both the 4-quarter and 8-quarter horizons. This negative effect remains statistically significant at the 8-quarter horizon, although it is smaller in magnitude than the coefficient of the foreign FCI.

Table A4 also includes the results with interaction terms between foreign FSIs and financial conditions. The estimates show that all interaction terms are statistically significant, indicating the amplifying effects of foreign FSI on the relationship between foreign financial conditions and U.S. downside growth risk.

B Online Appendix: Additional Checks

In this online appendix, we examine the predictive scores for alternative vulnerability measures, country size effects, the estimation results for an extended sample, and alternative aggregation schemes of financial vulnerability indexes.

B.1 Predictive Scores for Alternative Financial Vulnerability Measures

Table B1 compares the out-of-sample (OOS) predictive scores for U.S. downside risk across four models: The "none" model, which includes current U.S. GDP growth and U.S. FCI as in Adrian et al. (2019), and three alternative models incorporating different measures of foreign financial vulnerabilities. The alternative measures are: the Lee et al. (2020) index (hereafter LPS), the IMF Financial Soundness Indicators (FSI), and the credit-to-GDP ratio.

Table B1. Out-of-Sample Predictive Scores: Alternative Vulnerability Measures

Measure of Financial Vul.	Predictive Scores	
	4-quarter horizon	8-quarter horizon
None	4.25	8.57
LPS	4.37	13.11
IMF FSI	4.58	13.29
Credit-to-GDP ratio	4.28	7.42

Note: The "None" model includes only U.S. GDP growth and U.S. FCI, following Adrian et al. (2019). LPS, IMF FSI, and Credit-to-GDP models sequentially add U.S. FVI, Foreign FCI, and the respective foreign vulnerability measure. The predictive score is the predictive density evaluated at realized GDP growth. The same recursive forecast protocol as in Table 2 is used.

The results show that all three alternative measures outperform the "none" model in the 4-quarter horizon, indicating that accounting for foreign financial vulnerabilities enhances the model's predictive ability for U.S. downside risk within a year. In addition, both LPS and IMF FSI significantly outperform the "none" model at the 8-quarter horizon, showing stronger predictive power for medium-term risks. We attribute the poor performance of the credit-to-GDP ratio to its narrow scope. Adrian et al. (2022) find that credit-to-GDP growth significantly amplifies the effects of loose financial conditions on domestic growth-at-risk, but this single indicator captures only one dimension of financial vulnerability, the buildup of private credit relative to output. It misses fragilities in asset valuations, financial sector leverage, funding structures, and sovereign balance sheets that matter for cross-border transmission. The strength of the comprehensive financial vulnerability index is that it aggregates across multiple financial sectors instead of focusing narrowly on credit expansion relative to GDP.[13]

B.2 Control for Country Sizes

Another concern is that the baseline model uses equal-weighted foreign FCI and FVI, which might underweight the effect of larger countries (by GDP) on U.S. downside risk. Therefore, we take two steps to address this issue. First, we use GDP-weighted foreign FCI and FVI to better reflect the relative importance of larger economies. Second, we split the sample into two groups, large and small countries, based on their GDP and re-estimate the TGaR model for each subsample.[14]

The results in Table B2 show that the coefficients remain statistically significant for the GDP-weighted FCI and FVI, similar to the baseline. When splitting the sample by country sizes, both large and small country subsamples have statistically significant coefficients for foreign FCI and FVI. Nevertheless, the coefficients are generally larger for large countries, especially at the 4-quarter horizon. Over an 8-quarter horizon, the magnitude of coefficients converges between large and small countries, which suggests that both large and small economies contribute meaningfully to U.S. growth risks in the medium term.

[13]In addition to the same narrow focus, a related measure, the credit-to-GDP gap, suffers from trend estimation problems, see Edge and Meisenzahl (2011). In our analysis (not shown), it performs even worse than the credit-to-GDP ratio. It also materially underperforms the comprehensive index as an early warning indicator of financial crises, see Lee et al. (2020).

[14]The large countries based on 2023 GDP are China, Japan, Germany, United Kingdom, France, Canada, Italy, South Korea, and Australia. The small countries are Austria, Belgium, Denmark, Hong Kong, Mexico, the Netherlands, New Zealand, Norway, Russia, Spain, Sweden, and Switzerland.

Table B2. TGaR Results: Controlling for Country Size

	GDP Weighted	Large Countries	Small Countries
4-quarter horizon			
Foreign FVI	-0.2512^{**}	-0.2685^{**}	-0.2117^{**}
	(-2.12)	(-2.24)	(-2.01)
U.S. FCI	-1.6189^{**}	-1.6024^{**}	-1.6331^{**}
	(-2.45)	(-2.35)	(-2.52)
Foreign FCI	-0.4621^{**}	-0.4254^{**}	-0.4724^{*}
	(-2.37)	(-2.30)	(-1.95)
U.S. FVI	-0.7142^{**}	-0.7024^{**}	-0.7455^{**}
	(-2.30)	(-2.25)	(-2.40)
8-quarter horizon			
Foreign FVI	-0.1835^{**}	-0.1934^{**}	-0.1525^{**}
	(-2.05)	(-2.10)	(-1.97)
U.S. FCI	-1.1422^{**}	-1.1155^{**}	-1.1711^{**}
	(-2.26)	(-2.22)	(-2.30)
Foreign FCI	-0.3127^{**}	-0.3024^{**}	-0.3224^{*}
	(-2.18)	(-2.12)	(-1.78)
U.S. FVI	-0.9543^{**}	-0.9441^{*}	-0.9625^{**}
	(-2.01)	(-1.95)	(-2.05)

Note: This table reports estimated TGaR coefficients for three specifications. The "GDP Weighted" column aggregates foreign FCI and FVI using PPP-adjusted GDP weights (base year 2019) instead of equal weights. The "Large Countries" and "Small Countries" columns use equal weights within each subsample, splitting countries by 2023 GDP into a large-economy group (China, Japan, Germany, United Kingdom, France, Canada, Italy, South Korea, and Australia) and a small-economy group (the remaining 12 countries). Sample period: 1995:Q1–2023:Q4. All variables are standardized to have zero mean and unit variance. Robust t-statistics (Newey-West with 4 lags) are reported in parentheses. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

B.3 Extended Sample

To assess the robustness of our main results, we extend the sample backward to January 1991 but rely on a smaller set of countries due to data limitations.[15]

Table B3 reports the predictive scores for different model specifications, consistent with the baseline case. The results show that the TGaR model incorporating foreign FVI improves

[15] The extended sample includes Australia, Austria, Canada, China, Denmark, France, Germany, Italy, Japan, the Netherlands, New Zealand, Norway, South Korea, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

Table B3. Out-of-Sample Predictive Scores: Extended Sample (1991–2023)

Model	Predictive Scores	
	4-quarter horizon	8-quarter horizon
U.S. FCI Only	4.14	8.14
U.S. FCI + FVI	4.29	9.35
U.S. FCI + FVI + Foreign FCI	4.41	9.59
TGaR	4.48	12.77

Note: This table reports out-of-sample predictive scores for different TGaR model specifications using an extended sample period. The predictive score is the predictive density evaluated at realized GDP growth. The training sample begins in 1991:Q1 and expands forward. Out-of-sample predictions begin in 2000:Q1 and run through 2023:Q4. The same recursive forecast protocol as in Table 2 is used. The extended sample includes 18 countries (compared to 22 in the baseline) due to data availability constraints.

the out-of-sample predictive accuracy over both the 4-quarter and 8-quarter horizons, even under the extended sample period.

B.4 Optimal Foreign FVI

In this section, we explore different approaches to aggregating the Foreign Financial Vulnerability Index (FVI) across both sectors and countries. We consider the performance of GDP-weighted and trade-weighted country aggregates, employing principal component analysis (PCA) for sectoral aggregation, and constructing weights based on the sector-specific coefficients from Table 6.

The baseline equal-weighted FVI achieves an OOS predictive score of 13.11, which is higher than the GDP-weighted approach. However, the trade-weighted aggregation yields a slight improvement, with an OOS score of 13.51 and a lower BIC, suggesting that vulnerabilities in economies with stronger U.S. trade linkages have greater predictive power for U.S. downside risk. Regression-based weighting using Table 6 improves predictability further, particularly when combined with trade-weighted country aggregation, achieving an OOS score of 14.35.

The optimized methods perform better in sample, but the baseline method remains

Table B4. Alternative Weighting Schemes for Foreign FVI

Sectoral Weights	Country Weights	Predictive Score	BIC
Equal-Weighted	Equal-Weighted	13.11	275.4
Equal-Weighted	GDP-Weighted	12.69	282.1
Equal-Weighted	Trade-Weighted	13.51	268.7
PCA-Based	Equal-Weighted	13.64	264.3
PCA-Based	GDP-Weighted	13.01	271.5
Regression-Based	Equal-Weighted	13.89	258.9
Regression-Based	Trade-Weighted	14.35	249.6

Note: This table reports 8-quarter out-of-sample predictive scores and Bayesian Information Criterion (BIC) values for different weighting schemes used to construct the foreign FVI. The predictive score is the predictive density evaluated at realized GDP growth. Each row represents a different approach to aggregating vulnerabilities across sectors and across countries. The baseline specification uses equal weights across both sectors and countries. Sample period: 1995:Q1–2023:Q4. Out-of-sample evaluation begins in 2000:Q1. The same recursive forecast protocol as in Table 2 is used.

useful. The agnostic baseline method does not prioritize particular sectors or countries based on historical experience. If future episodes differ from the historical sample, the baseline method may perform better than the optimized alternatives. Therefore, we view the baseline and optimized methods as complementary.