OFFICE OF INTERNATIONAL AFFAIRS

GLOBAL EXCHANGE RATE ASSESSMENT FRAMEWORK METHODOLOGY

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[2] This version provides an update to the August 2020 methodology paper. Relative to the previous version, this paper presents re-estimated GERAF results using revised historical data as of May 2021 and provides further detail on the construction of the safe asset index employed in GERAF.

Contents

This paper explains the methodology underlying the Global Exchange Rate Assessment Framework (GERAF), a flexible tool created by the Department of the Treasury (Treasury) to study currency valuations. The model provides a rigorous, multilaterally consistent method for assessing external imbalances, exchange rate misalignment, and the role of policy in contributing to both.

This paper proceeds as follows. Section I provides a brief review of the literature on assessing currency valuations. Section II discusses GERAF's contribution to the applied practice of estimating currency valuations and notable differences from other currency valuation models. Section III describes the calculation of current account gaps, which forms the model's core. Section IV explains the transformation of current account gaps into exchange rate gaps. Section V concludes. Appendix A describes the construction of the novel safe asset index employed in GERAF. Appendix B lists data sources and descriptions. Appendix C lists countries included in the GERAF sample. Appendix D presents robustness checks and regression extensions.

I. Literature review

GERAF builds on a substantial body of literature and applied practices for assessing currency valuations. Given the complexity of the task, researchers have employed a variety of methods. Some confront the problem looking directly at exchange rates; others study the structure of current accounts and then translate those findings into exchange rates.

Estimating fair-value real exchange rates via their theoretical determinants is the most direct approach. For instance, one can estimate real effective exchange rates (REERs) directly in a Dynamic Equilibrium Exchange Rate (DEER) model, exploiting a panel cointegration approach to measure the long-run effect of factors such as productivity and terms of trade on exchange rates (Stolper and Fuentes (2007)). Such models are able to assess currencies on a relatively high-frequency basis but as a result do not have the ability to assess if these valuations are consistent with both internal balance (i.e., real output is close to potential) and external balance (i.e., external demand and the current account are at sustainable levels).

Conversely, exchange rate valuations can be estimated vis-à-vis those consistent with current account balances that achieve medium-term equilibrium in the global economy. This approach uses lower-frequency data that allows slower moving macroeconomic variables to be included, thus improving model fit and providing a richer explanation of exchange rate misalignments. Moreover, estimating exchange rate valuation via external accounts tends to yield more stable and statistically robust results due to lower-frequency data. Some examples include Fundamental Equilibrium Exchange Rate (FEER) based models, which estimate the impact of factors such as domestic demand gaps, external demand gaps, and lagged REERs on current accounts and then derive the underlying current account consistent with closed domestic and external demand gaps (i.e., both domestic and external demand are at their respective potential levels).[3] Other notable FEER-based models include the Peterson Institute of International Economics' FEER model (see Cline and Williamson (2008)). While better equipped to assess currency misalignment in a more globally consistent manner, this class of models typically does not take into account the impact of particular macroeconomic policies on exchange rates.

[3] See Stolper and Fuentes (2007).

The International Monetary Fund (IMF) applies both methods – looking directly at the REER and looking at the REER indirectly through current accounts – in its External Balance Assessment (EBA). As described in Cubeddu et al. (2019), the EBA provides a comprehensive framework for assessing exchange rate misalignments and quantifying the role of macroeconomic policies in contributing to those misalignments. The EBA's current account model variant first estimates the current account norm—that is, the cyclically adjusted current account that would occur when macroeconomic policies are set at desirable medium-term levels. Comparing the norm to the observed cyclically adjusted current account results in the current account gap, which can be further decomposed into policy gaps (owing to deviations of collective or individual policies from their desired levels) and residual gaps (other policy distortions, factors not explained by the model, and regression residuals). These current account gaps can then be transformed into implied REER gaps.

This approach provides a nuanced framework for assessing, among other factors, the impact of policies on currency valuations. By construction, the model is multilaterally consistent. Because most variables are expressed as deviations from GDP-weighted world averages, larger economies have a larger influence in shaping the contributions to current account norms (consistent with their greater economic weight). Consistency adjustments ensure that current account gaps add up to zero in nominal terms (i.e., fully addressing total gaps would mechanically eliminate excess imbalances). This approach also includes a large number of explanatory factors, including demographic variables that affect saving and investment behavior over the medium term. Finally, policy gaps can be broken down into domestic and foreign components. Doing so allows the estimated gap for each country to reflect domestic policy distortions as well as policy distortions in other countries.

II. GERAF contributions

GERAF builds on the EBA's current account model and norm-gap analysis as documented in Cubeddu et al. (2019) to create a flexible model that allows for rigorous estimation of currency valuations relative to the dollar. Employing a framework in line with the IMF EBA exercise allows us to assess an economy's current account and exchange rate based not only on structural factors and macroeconomic fundamentals, but macroeconomic policy distortions as well. Moreover, such a modeling framework allows us to disentangle the impact of domestic policy distortions versus those from abroad on excess imbalances.

Building on this approach, we make several contributions to the applied practice of assessing external imbalances based on fundamentals and policies. First, we construct and employ an index for assessing the relative quality of safe assets across countries. Second, we incorporate comprehensive estimates of foreign exchange intervention across all countries in the sample consistent with the methodology used in Treasury's Report to Congress on Macroeconomic and Foreign Exchange Policies of Major Trading Partners of the United States ("Treasury's Foreign Exchange Report").[4] Third, we account for differential impacts of foreign exchange intervention on current accounts in the presence of varying degrees of capital account mobility, allowing for a

[4] Treasury's report is submitted pursuant to the Omnibus Trade and Competitiveness Act of 1988, 22 U.S.C. § 5305, and Section 701 of the Trade Facilitation and Trade Enforcement Act of 2015, 19 U.S.C. § 4421.

refined explanation of the efficacy of foreign exchange intervention. (Notably, whereas the suite of EBA models assume that foreign exchange intervention can affect current account imbalances only when capital controls are present, GERAF estimates the contribution of foreign exchange intervention to external balances even when the capital account is fully open.) Fourth, in our normative assessment of excess imbalances, we introduce the concept of an "inertia gap." This latter component seeks to identify the portion of misalignments due to cumulative past policy distortions, notably those due to past foreign exchange intervention and their effect on net foreign asset positions.

A more detailed discussion of these contributions follows in Section III.

III. GERAF model specification and deriving current account gaps

Model specification and variable construction

GERAF's foundation is its empirical model of current account determinants. For a panel series of 51 countries (comprising 91% of world GDP in 2018) over the period 1986-2018, GERAF estimates the impact of the key drivers of current account balances using a panel-corrected standard error model.[5] The model breaks down these factors into four groups:

[5] In line with Cubeddu et al. (2019), the baseline GERAF specification employs a pooled Generalized Least Squares (GLS) method regression, controlling for cross-sectional dependence. The regression also includes a panel-wide AR(1) correction to control for potential autocorrelation in the dependent variable.

Cyclical factors:	***Macroeconomic fundamentals***:	***Structural fundamentals***:	***Policy variables***:
• Output gap	• Trade openness (exports + imports) / GDP	• Old-age dependency ratio (OADR)	• Cyclically adjusted fiscal balance/GDP
• Commodity terms of trade gap	• Net foreign assets (NFA)/GDP (lagged)	• Population growth	• Public health spending/GDP (lagged)
	• NFA/GDP * NFA debtor (lagged)	• Prime savers share	• Foreign exchange intervention (FXI):
	• Relative output per worker	• Life expectancy at prime age	○ FXI/GDP
	• Forecasted real GDP growth	• Life expectancy at prime age * Future OADR	○ FXI/GDP * Capital account openness
	• Safe asset index	• Institutional and political environment	• Detrended private credit/GDP
		• Oil and natural gas trade balance * Resource temporariness	• Capital controls:
			○ Relative output per worker * Capital account openness (lagged)
			○ Demeaned VIX * Capital account openness (lagged)
			○ Demeaned VIX * Capital account openness * Safe asset index (lagged)

Note: VIX index corresponds to the CBOE index measuring constant, 30-day expected volatility of the S&P 500 index.

As noted above, the GERAF model specification includes several novel variables:

Safe asset index: Cubeddu et al. (2019) and the methodology underlying earlier EBA model iterations (see Phillips et al. (2013)) include a reserve currency status variable that measures the share of a country's own currency in the total stock of global foreign exchange reserves. While such a variable may be intended to capture the "exorbitant privilege" of reserve currency countries, it fails to fully capture the impact of "flight to safety" pressures. For example, conventional safe haven currencies such as the Japanese yen or the Swiss franc are highly responsive to changes in investor sentiment in risk-off episodes but comprise relatively small shares of global foreign exchange reserves. Moreover, a variable based only on the stock of reserves will by construction assume an equal effect across all euro area countries, whereas country-specific risk premia vary. To refine the measurement of safe asset demand and its effect on financing current accounts, we introduce a country-specific safe asset index that intends to capture two facets of relative safeness of currencies and government securities: (i) price factors and (ii) quantity factors (see Figure 1).

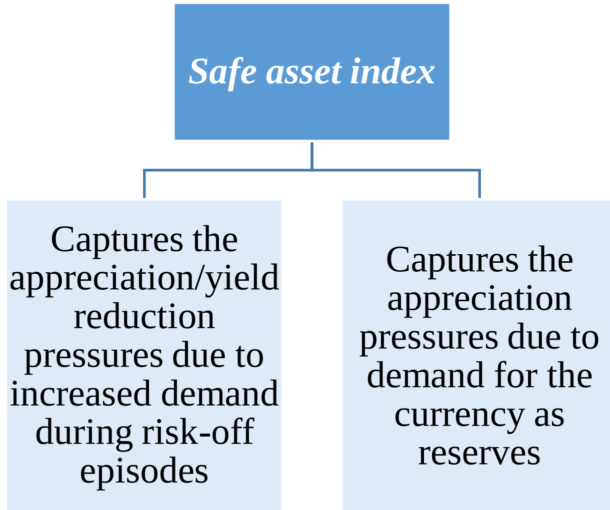

Figure 1: Safe asset index

To measure the price factors, we construct time-varying conditional correlations based on the nominal exchange rate (expressed as local currency per Special Drawing Right (SDR)),[6] the 10-year government bond yield, and the inverse of the VIX index.[7] The underlying notion is that in a risk-off environment, as uncertainty or volatility rises, a safe haven country will generally see its exchange rate appreciate and its government bond yields fall. Thus, the greater the co-movement between uncertainty and appreciation (interest rate reductions), the more the currency (government security) is in demand in a risk-off environment. The conditional correlations are estimated for each country on a monthly basis using a dynamic conditional correlation estimator, a particular type of multivariate generalized autoregressive conditional heteroskedasticity model (see Engle (2002); Engle and Sheppard (2001)).[8] The sum of these two conditional correlations can then be standardized relative to the entire panel of 51 countries and collapsed to the annual level. The trend component of this standardized index is then extracted in order for the variable to reflect longer-term, structural fundamentals in the relative price of safe assets. Lastly, the price factor index is weighted by the country's currency share of foreign exchange reserves. By doing this, the index combines price factors (which fluctuate in times of stress) with the long-term structural demand for safe assets (the quantity of global foreign exchange reserves, the shares of which exhibit relative stability over time). To our knowledge, this approach is novel and provides an intuitive, empirically grounded framework for measuring the relative safeness of currencies and government securities. This also complements existing theory-based measures of identifying safe haven currencies, such as the Global Risk Response index introduced in Goldberg and Krogstrup (2018).[9] For further description of the construction of the safe asset index variable, see Appendix A.

[6] The SDR is used as a numeraire for exchange rates in order to include exchange rate variation for the United States.
[7] Using the inverse of the VIX allows for an intuitive positive correlation between increasing uncertainty/volatility, increasing currency appreciation, and decreasing bond yields, where all three series move in the same direction.
[8] Such an approach allows conditional correlations to follow a GARCH (p,q)-like process, implicitly controlling for time-varying volatility.
[9] See Goldberg and Krogstrup (2018) for further discussion of the identification of safe haven currencies in the asset pricing literature.

As expected, this final index shows an outsized role of the United States (reflecting the substantial global demand to hold U.S. safe assets). Relative to a variable that was based only on the global stock of foreign exchange reserves, our safe asset index displays larger values for Japan and Switzerland (reflecting their role as safe havens), as well as heterogeneity across euro area countries. When placed in the GERAF baseline specification, the coefficient displays the expected negative sign and is statistically significant.

Refined estimates of foreign exchange intervention: The GERAF specification includes estimates of foreign exchange intervention consistent with the methodology set forth in Treasury's Foreign Exchange Report. Estimates are normally based on publicly available data for intervention on foreign asset purchases by authorities or estimated based on valuation-adjusted foreign exchange reserves. This adjustment requires assumptions about both the currency and asset composition of reserves in order to isolate returns on assets held in reserves and currency valuation moves from actual purchases and sales, including estimations of transactions in foreign exchange derivatives markets. Estimates can also be based on alternative data series when they provide a more accurate picture of foreign exchange balances than estimates derived from changes in valuation-adjusted reserves. These estimates are then combined with data reported to the IMF on official transactions in foreign exchange derivatives markets. Ultimately, this approach provides more refined intervention estimates than using changes in reserve asset positions or the flow of reserves from balance of payments statistics as a proxy for intervention.

Bayoumi, Gagnon, and Saborowski (2015) demonstrate that capital account mobility tends to lessen the impact of foreign exchange intervention on current accounts. Hence, in addition to foreign exchange intervention, GERAF includes foreign exchange intervention interacted with capital account openness to control for the differential effects of foreign exchange intervention across varying degrees of capital mobility. The full interpretation of the effect of foreign exchange intervention takes into account the combination of these regressors. In this context, both coefficients display the expected signs and are statistically significant in the baseline GERAF specification.

For a complete list of variables, sources, and descriptions, see Appendix B. For a complete list of countries in the sample, see Appendix C. Table 1 lists summary statistics for the panel sample of observations in the baseline regression specification.

As previously mentioned, the GERAF model specification is estimated across 51 economies and 33 years between 1986 and 2018. Each of the 23 independent variables takes the expected sign and is consistent with previous empirical findings in the literature. Additionally, the model fit is generally in line with different specifications found in the literature. Table 2 shows results for the baseline specification.

For robustness checks and regression extensions, see Appendix D.

Normative assessments of excess imbalances

GERAF can then provide a normative assessment of excess imbalances based on: (i) the historical relationship between the current account and each of the regressors; (ii) the deviations between observed and desired policy levels; (iii) the level of net foreign assets in the absence of official reserve positions (i.e., the inertia gap); and (iv) the regression residual.

As mentioned above, GERAF introduces the concept of an inertia gap so that normative current account assessments take into account the level of official reserve holdings. While larger net foreign asset positions are descriptively associated with higher current account balances, it is not the case that higher levels of official reserve holdings (i.e., greater precautionary external buffers) make higher current account balances warranted or desirable.[10] To this end, the inertia gap adjusts the contribution of net foreign assets to current account norms by stripping out official reserves from the total net foreign asset stock, essentially including only private net foreign assets in the final normative assessment of excess imbalances.[11]

The remainder of the GERAF norm and gap analysis is consistent with that in Cubeddu et al. (2019). The baseline GERAF specification is expressed as:

$$\left(\frac{CA}{GDP}\right)_{i,t} = \alpha + \beta^{cyc} X_{i,t}^{cyc'} + \beta X'_{i,t} + \delta Z'_{i,t} + \gamma P'_{i,t} + \varepsilon_{i,t} \tag{3.1}$$

where $X_{i,t}^{cyc'}$ denotes the vector of cyclical factors, $X'_{i,t}$ denotes the vector of macroeconomic and structural fundamentals, $Z'_{i,t}$ denotes the (lagged) net foreign asset position, and $P'_{i,t}$ denotes the vector of policy variables (set at their observed values). Here, α denotes the regression constant and $\varepsilon_{i,t}$ represents the regression residual (zero mean, normally distributed, and assumes an AR(1) process). Using the model coefficients, predicted current account values can be denoted as:

$$\widehat{\left(\frac{CA}{GDP}\right)}_{i,t} = \hat{\alpha} + \widehat{\beta^{cyc}} X_{i,t}^{cyc'} + \hat{\beta} X'_{i,t} + \hat{\delta} Z'_{i,t} + \hat{\gamma} P'_{i,t} \tag{3.2}$$

This can also be expressed in terms of deviations between observed and desired policy levels (the latter denoted as $P_{i,t}^{*'}$), as well as the deviation between the observed net foreign asset position and the adjusted net foreign asset position (the latter denoted as $Z_{i,t}^{\times'}$):

$$\widehat{\left(\frac{CA}{GDP}\right)}_{i,t} = \underbrace{\widehat{\beta^{cyc}} X_{i,t}^{cyc'}}_{Cyc.\ component} + \underbrace{\hat{\alpha} + \hat{\beta} X'_{i,t} + \hat{\delta} Z_{i,t}^{\times'} + \hat{\gamma} P_{i,t}^{*'}}_{Cyclically\ adjusted\ CA\ norm} + \underbrace{\hat{\delta}\left(Z'_{i,t} - Z_{i,t}^{\times'}\right)}_{Inertia\ gap} + \underbrace{\hat{\gamma}\left(P'_{i,t} - P_{i,t}^{*'}\right)}_{Policy\ gap} \tag{3.3}$$

Here, the cyclically adjusted current account norm corresponds to the current account that, according to the model, would exist if policies were set at their desired levels and with adjusted

[10] This normative view is consistent with the findings of Bayoumi, Gagnon, and Saborowski (2015), who find that lagged intervention positively impacts current accounts, potentially operating through the portfolio balance channel.
[11] In line with the specification in Cubeddu et al. (2019), GERAF uses lagged values of the net foreign asset position.

net foreign asset positions, accounting for observed macroeconomic and structural fundamentals and stripping out cyclical factors. The cyclical component corresponds to the portion of the predicted current account attributable to cyclical factors (i.e., output gaps and commodity terms of trade gaps). The inertia gap measures the degree to which official reserves (a subset of the net foreign asset position) contribute to the deviation between the predicted current account and its norm. Lastly, the policy gap measures the degree to which deviations between observed and desired policies impact the deviation between the predicted current account and its norm. For further discussion on the effect of policy gaps, see Box 1.

GERAF defines the observed cyclically adjusted current account as:

$$\left(\frac{CA}{GDP}\right)_{i,t}^{cyclically\ adjusted} = \left(\frac{CA}{GDP}\right)_{i,t} - \underbrace{\widehat{\beta^{cyc}} X_{i,t}^{cyc'}}_{Cyclical\ \ component} \tag{3.4}$$

Combining equations 3.1, 3.3, and 3.4 the cyclically adjusted current account can also be expressed as:

$$Cyclically\ adjusted\ CA = Cyclically\ adjusted\ CA\ norm + total\ CA\ gap \tag{3.5}$$

or:

$$Cyclically\ adjusted\ CA = Cyclically\ adjusted\ CA\ norm + inertia\ gap + policy\ gap + regression\ residual \tag{3.5}$$

While most variables are expressed relative to the annual GDP-weighted world average, further adjustments are necessary to ensure current account gaps over the GERAF sample add up to zero in nominal terms in each year (see Cubeddu et al. (2019)). In the case of GERAF, multilateral consistency adjustments are made to a portion of the cyclical component of the current account,[12] each individual policy gap, the inertia gap, and the residual. Country amounts are adjusted by a GDP-weighted share of each respective cumulative component (expressed in nominal terms) in every year. Thus, the GERAF sample current account statistical discrepancy is implicitly attributed to current account norms (i.e., GERAF does not attempt to model the statistical discrepancy of current accounts at the global level).

Similar to the methodology laid out in Cubeddu et al. (2019), GERAF can simultaneously estimate country-and-year-specific standard errors associated with each estimated current account norm. These standard errors, which can be applied to the norms or to the overall current account gaps, highlight the degree of model-implied uncertainty surrounding each estimated norm and gap. The corresponding upper and lower bounds can also be translated into exchange rate gaps, as explained further in Section IV.

The standard errors are estimated using the variance-covariance matrix of the regression as follows:

[12] For the cyclical component of the current account, this adjustment is only applied to the commodity of terms of trade gap, as output gaps by construction add up to zero.

$$\sqrt{\hat{V}\left(\frac{CA}{GDP}\right)_{i,t}^{cyclically\ adjusted\ norm}} = \sqrt{\hat{V}\left(\hat{\alpha}\ + \hat{\beta}X'_{i,t} + \hat{\delta}Z^{\times\prime}_{i,t} + \hat{\gamma}P^{*\prime}_{i,t}\right)} \qquad (3.6)$$

Box 1: Example of policy gaps

GERAF's normative analysis is founded on the gap between observed levels of policy variables and their desired levels. Treasury calibrates these desired levels for each year in line with Treasury's view of the policies that will achieve strong, sustainable, and balanced growth over the medium term (reflecting appropriate domestic and external balances for all countries).

To better understand the calculation of policy gaps, consider a simplified example where there are two countries in the world: A and B. Each accounts for half of the world economy. The only policy lever is fiscal policy, and the desirable fiscal policy for both countries is a balance of 0% of GDP. Suppose Country A has a balance of 0% of GDP and Country B has a balance of -4% of GDP (i.e., the fiscal balance is in deficit).

Let p_i denote the fiscal balance of country i expressed as a percent of GDP,
w denote the GDP-weighted world fiscal balance expressed as a percent of world GDP,
P_i denote the fiscal balance for country i relative to the world average w,
$*$ denote policies at their desirable levels.

The following results:

$$p_A = 0\%$$
$$p_B = -4\%$$
$$w = 0.5(0\%) + 0.5(-4\%) = -2\%$$
$$P_A = 0\% - (-2\%) = 2\%$$
$$P_B = -4\% - (-2\%) = -2\%$$
$$w^* = 0.5(0\%) + 0.5(0\%) = 0\%$$
$$p_A^* = p_B^* = 0\%$$
$$P_A^* = P_B^* = 0\%$$

The policy gaps are thus:

$$P_A^{GAP} = P_A - P_A^* = 2\%$$
$$P_B^{GAP} = P_B - P_B^* = -2\%$$

Note that both countries have policy gaps even though only Country B has an undesirable deficit. This results from defining variables relative to the world average: there will be a policy gap whenever a country's policy distortion (or lack thereof) differs from the world average.

We can isolate the role of domestic policy distortions in contributing to the total policy gap. The domestic policy gap is simply the difference between observed and desired policy:

$$p_A^{GAP,domestic} = p_A - p_A^* = 0\%$$

Country A's fiscal policy is at its desired level, so the entirety of its gap is due the policy distortion in Country B. As for country B, $p_B^{GAP,domestic} = -4\%$.

When assessing whether or not a country's policies are distorting its current account, it is helpful to look at the domestic policy gap. When assessing the total impact of policy distortions in a multilaterally consistent manner, it is most appropriate to look at the total policy gap.

IV. Exchange rate gaps

After calculating current account gaps – whether total gaps or those relating to specific policies – GERAF estimates the corresponding exchange rate gaps. The first transformation is from current account gaps to REER gaps, and the second transformation is from REER gaps to multilaterally consistent bilateral real exchange rate gaps.

Current account to REER conversion

To transform current account gaps into REER gaps, GERAF uses country-specific semi-elasticities that relate the responsiveness of the current account to the REER. The semi-elasticity is defined as follows:

$$\eta^{CA} = \frac{\Delta\left(\frac{CA}{GDP}\right)}{\frac{\Delta REER}{REER}} \tag{4.1}$$

Following the CGER-inspired approach outlined in Cubeddu et al. (2019), it is assumed that exchange rate adjustment occurs through the trade balance (TB). The trade balance semi-elasticity can be estimated as

$$\eta^{TB} = \eta^x s^x - \eta^m s^m \tag{4.2}$$

where η^x (η^m) is the elasticity of export (import) volume with respect to the REER,
s^x (s^m) is the share of nominal exports (imports) to GDP.

η^x and η^m are assumed to be common to every country and, as in Cubeddu et al. (2019), they are calibrated to -0.11 and 0.57 respectively. s^x and s^m are calculated for every country by averaging the share of exports and imports to GDP, respectively, over 2010-19. Intuitively, the formula shows that the more open an economy, the larger the semi-elasticity in absolute terms and thus the more responsive the trade balance to a change in the REER.

The conversion from CA gap to REER gap is then:

$$REER^{gap} = \frac{CA^{gap}}{\eta^{TB}} \tag{4.3}$$

Note that this semi-elasticity is used to convert the total current account gap into the total REER gap and current account gaps due to specific policy distortions into the REER gaps due to those distortions.

REER to bilateral real exchange rate conversion

Because REERs are weighted averages of bilateral real exchange rates, it is possible to convert REERs (and REER gaps) into a set of multilaterally consistent bilateral real exchange rates against the dollar (and bilateral real exchange rate gaps against the dollar). For this conversion, GERAF employs the method described in Alberola et al. (1999) and outlined below.

Begin with the definition of the REER for currency i:

$$q_i = \sum_{j}^{m} w_{ij} r_{ij} \tag{4.4}$$

where q_i is the log of the REER for currency i,
m is the number of currencies,
w_{ij} is the weight of currency j in the index for currency i, with $\sum_j^m w_{ij} = 1$ and $w_{ii} = 0$,
r_{ij} is the log of the real bilateral exchange rate between currencies i and j.

The set of REERs can be expressed in matrix notation as:

$$Q = (W - I)R \tag{4.5}$$

where Q is an $(m \times 1)$ column vector of REERs,
R is an $(m \times 1)$ column vector of the bilateral real exchange rates relative to the numeraire (in the present case, the dollar),
W is an $(m \times m)$ matrix of trade weights with zeroes along the diagonal,
I is the $(m \times m)$ identity matrix.

Given REERs (Q), the aim is to obtain bilateral real exchange rates relative to the dollar (R). The system is over determined, however, as there are m exchange rates in R but only $m - 1$ are independent. Thus $B = W - I$ is not invertible. The problem is solved by eliminating the row and column in B corresponding to the numeraire currency n, removing the entries in Q and R corresponding to the numeraire currency, and expressing the remaining REERs relative to the numeraire currency. Equation 4.5 becomes

$$Q_{-n} - 1 * q_n = B_{-n} R_{-n} - 1 * q_n \tag{4.6}$$

where the subscript $-n$ denotes that the numeraire currency has been deleted, 1 is a vector of 1's, and q_n is the trade-weighted average of the $n - 1$ bilateral rates for the numeraire currency.

Letting $C = B - 1 * (w_{n1}, w_{n2}, \ldots, w_{nn-1})$ equation 4.6 can be rewritten as

$$Q_{-n} - 1 * q_n = CR_{-n} \tag{4.7}$$

In terms of REER gaps and bilateral real exchange rate gaps, equation 4.7 becomes

$$\hat{Q}_{-n} - 1 * \hat{q}_n = C\hat{R}_{-n} \tag{4.8}$$

where ^ indicates deviations from equilibrium. The vector of bilateral real exchange rate misalignments vis-à-vis the numeraire is thus

$$\hat{R}_{-n} = C^{-1}\left(\hat{Q}_{-n} - 1 * \hat{q}_n\right) \tag{4.9}$$

GERAF follows this procedure with the dollar as numeraire to compute $\hat{R}_{-n}$, which consists of the bilateral real exchange rate misalignments against the dollar for the 50 other countries in the sample (the rest of the world is assumed to be broadly in line and does not factor into the analysis).

In addition to estimated REER gaps, $\hat{Q}_{-n}$, this transformation requires W, the matrix of weights. GERAF assigns currency weights based on trade flows and applies a double-weighting approach for exports that takes into account third-market effects as detailed in Turner and Van't dack (1993), which underpins the standard BIS method for computing REER trade weights. Currency j's weight in currency i's basket is as follows:

Import weight $\quad w_{ij}^m = \frac{m_i^j}{m_i}$

Export weight $\quad w_{ij}^x = \left(\frac{x_i^j}{x_i}\right)\frac{y_j}{y_j+\sum_h x_h^j} + \sum_{k\neq j}\left(\frac{x_i^k}{x_i}\right)\left(\frac{x_j^k}{y_k+\sum_h x_h^k}\right)$

Total weight $\quad w_{ij} = \left(\frac{m_i}{x_i+m_i}\right)w_{ij}^m + \left(\frac{x_i}{x_i+m_i}\right)w_{ij}^x$

where:

$x_i^j\left(m_i^j\right)$ is i's exports to (imports from) j,
$x_i(m_i)$ is i's total exports (imports),
y_j is home supply of domestic gross manufacturing output of economy j, and
$\sum_h x_h^j$ is the sum of exports from h to j excluding those from i.

Trade flows are calculated based on manufactured goods (SITC 5-8). Home supply of domestic gross manufacturing is proxied by manufacturing value added plus imports of manufactures minus exports of manufactures.

Thus, GERAF's final output is the vector $\hat{R}_{-n}$ of bilateral exchange rate gaps against the dollar. Note that the input vector of REER gaps, $\hat{Q}_{-n}$, will change according to the specific gap being investigated. For instance, $\hat{Q}_{-n}$ could consist of total REER gaps, in which case $\hat{R}_{-n}$ would represent total bilateral real exchange rate gaps with the dollar. Alternatively, $\hat{Q}_{-n}$ could consist of REER gaps due to a specific policy (e.g. fiscal policy), in which case $\hat{R}_{-n}$ would reflect bilateral real exchange rate gaps with the dollar resulting from fiscal policy distortions. Note also that these bilateral real exchange rate gaps are equivalent to bilateral nominal exchange rate gaps in this backward-looking exercise where inflation differentials are taken as given.

V. Conclusion

GERAF provides Treasury with a robust framework for assessing currency valuations on a variety of dimensions. Beginning with a model of current account determinants, it calculates the gap between the observed cyclically adjusted current account and the current account norm (the current account that would exist if policies were set at their desired levels and with adjusted net foreign asset positions, accounting for observed macroeconomic and structural fundamentals and stripping out cyclical factors). This gap – or portions of it depending on the specific policy distortions of interest – is then converted into the corresponding REER gap and bilateral exchange rate gap against the dollar, all while maintaining multilateral consistency. This tool will assist Treasury in its work on exchange rates.

References

Alberola, Enrique, Susana G. Cervero, Humberto Lopez, and Angel Ubide. 1999. "Global Equilibrium Exchange Rates: Euro, Dollar, 'Ins,' 'Outs,' and Other Major Currencies in a Panel Cointegration Framework." IMF Working Paper 99/175, International Monetary Fund, Washington, DC.

Bayoumi, Tamim, Joseph Gagnon, and Christian Saborowski. 2015. "Official financial flows, capital mobility, and global imbalances." *Journal of International Money and Finance* 52: 146-74.

Chinn, Menzie D., and Hiro Ito. 2006. "What matters for financial development? Capital controls, institutions, and interactions." *Journal of Development Economics* 81(1): 163-92.

Cline, William R., and John Williamson. 2008. "New estimates of fundamental equilibrium exchange rates." Policy Brief No. PB08-7. Peterson Institute for International Economics.

Cubeddu, Luis, Signe Krogstrup, Gustavo Adler, Pau Rabanal, Mai Chi Dao, Swarnali Ahmed Hannan, Luciana Juvenal, Nan Li, Carolina Osorio Buitron, Cyril Rebillard, Daniel Garcia-Macia, Callum Jones, Jair Rodriguez, Kyun Suk Chang, Deepali Gautum, and Zijao Wang. 2019. "The External Balance Assessment Methodology: 2018 Update." IMF Working Paper 19/65, International Monetary Fund, Washington, DC.

Drehmann, Mathias, Claudio Borio, and Kostas Tsatsaronis. 2011. "Anchoring Countercyclical Capital Buffers: The Role of Credit Aggregates." *International Journal of Central Banking* 7(4): 189-240.

Engle, Robert. 2002. "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models." *Journal of Business & Economics Statistics* 20(3): 339-50.

Engle, Robert, and Kevin Sheppard. 2001. "Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH." NBER Working Paper 8554, National Bureau of Economic Research.

Goldberg, Linda S., and Signe Krogstrup. 2018. "International Capital Flow Pressures." NBER Working Paper 24286, National Bureau of Economic Research.

Grigoli, Francesco, Alexander Herman, Andrew Swiston, and Gabriel Di Bella. 2015. "Output Gap Uncertainty and Real-Time Monetary Policy." IMF Working Paper 15/14, International Monetary Fund, Washington, DC.

Ilzetzki, Ethan, Carmen M. Reinhart, and Kenneth S. Rogoff. 2019. "Exchange Arrangements

Entering the Twenty-First Century: Which Anchor will Hold?" *The Quarterly Journal of Economics* 134(2): 599-646.

Phillips, Steve, Luis Catão, Luca Ricci, Rudolfs Bems, Mitali Das, Julia Di Giovanni, Filiz Unsal, Marola Castillo, Jungjin Lee, Jair Rodriguez, and Mauricio Vargas. 2013. "The External Balance Assessment (EBA) Methodology." IMF Working Paper 13/272, International Monetary Fund, Washington, DC.

Quinn, Dennis P. 1997. "The Correlates of Change in International Financial Regulation." *American Political Science Review* 91: 531-51.

Quinn, Dennis P., and A. Maria Toyoda. 2008. "Does Capital Account Liberalization Lead to Growth?" *Review of Financial Studies* 21(3): 1403-49.

Stolper, Thomas, and Monica Fuentes. 2007. "GSDEER and Trade Elasticities." Paper presented to a workshop at the Peterson Institute sponsored by Bruegel, KIEP, and the Peterson Institute, February.

Turner, Philip and Jozef Van't dack. 1993. "Measuring International Price and Cost Competitiveness." *BIS Economic Papers*, no 39.

Table 1. Summary Statistics

Variable	Obs.	Economies	Avg. years	Years	Mean	Std. dev.	Min	p10	p25	p50	p75	p90	Max	Kurtosis
Dependent variable														
Current account/GDP	1,279	51	25	1986 - 2018	-0.004	0.047	-0.146	-0.055	-0.034	-0.011	0.024	0.058	0.164	3.916
Cyclical factors														
Output gap	1,279	51	25	1986 - 2018	-0.001	0.030	-0.169	-0.034	-0.017	0.000	0.015	0.033	0.140	6.997
Commodity TOT gap	1,279	51	25	1986 - 2018	0.000	0.012	-0.076	-0.011	-0.005	0.000	0.005	0.011	0.072	10.658
Macroeconomic Fundamentals														
Trade openness/GDP	1,279	51	25	1986 - 2018	0.552	0.335	0.088	0.215	0.341	0.472	0.630	1.019	1.819	5.568
L. NFA/GDP	1,279	51	25	1986 - 2018	-0.217	0.416	-1.963	-0.661	-0.424	-0.225	-0.041	0.205	1.996	6.126
L. NFA/GDP * (Dummy if L.NFA/GDP < -60%)	1,279	51	25	1986 - 2018	-0.037	0.135	-1.363	-0.061	0.000	0.000	0.000	0.000	0.000	30.772
L.Output per worker, relative to top 3 economies	1,279	51	25	1986 - 2018	0.162	0.369	-0.390	-0.282	-0.159	0.072	0.468	0.612	1.125	2.258
Real GDP growth, forecast in 5 years	1,279	51	25	1986 - 2018	0.039	0.018	-0.021	0.018	0.024	0.035	0.051	0.065	0.100	2.594
Safe asset index	1,279	51	25	1986 - 2018	0.016	0.065	-0.054	0.000	0.000	0.000	0.000	0.040	0.566	43.572
Structural Fundamentals														
Old-age dependency ratio	1,279	51	25	1986 - 2018	0.250	0.099	0.102	0.136	0.159	0.257	0.334	0.384	0.594	2.063
Population growth	1,279	51	25	1986 - 2018	0.010	0.007	-0.007	0.001	0.004	0.010	0.015	0.021	0.030	2.645
Prime savers share	1,279	51	25	1986 - 2018	0.485	0.062	0.361	0.405	0.429	0.487	0.538	0.569	0.621	1.873
Life expectancy at prime age	1,279	51	25	1986 - 2018	31.046	3.185	21.663	26.867	28.754	31.420	33.559	35.013	37.567	2.795
Life expectancy at prime age * Future OADR	1,279	51	25	1986 - 2018	11.302	5.648	2.230	4.371	6.410	10.501	15.375	19.154	30.175	2.556
Institutional/political environment (ICGR-12)	1,279	51	25	1986 - 2018	0.725	0.125	0.293	0.563	0.632	0.738	0.831	0.876	0.961	2.649
Oil and natural gas trade balance * Resource temporariness	1,279	51	25	1986 - 2018	0.007	0.019	0.000	0.000	0.000	0.000	0.001	0.020	0.163	28.810
Policy Variables														
Cyclically-adjusted fiscal balance														
Observed	*1,279*	*51*	*25*	*1986 - 2018*	*-0.020*	*0.035*	*-0.247*	*-0.065*	*-0.038*	*-0.018*	*0.002*	*0.017*	*0.107*	*6.196*
Instrumented	*1,279*	*51*	*25*	*1986 - 2018*	*0.006*	*0.017*	*-0.051*	*-0.015*	*-0.007*	*0.005*	*0.017*	*0.029*	*0.064*	*3.040*
L.Public health spending/GDP	1,279	51	25	1986 - 2018	0.043	0.023	0.005	0.012	0.021	0.044	0.062	0.075	0.096	1.923
FXI/GDP														
Observed	*1,279*	*51*	*25*	*1986 - 2018*	*0.008*	*0.029*	*-0.198*	*-0.013*	*-0.002*	*0.000*	*0.014*	*0.035*	*0.280*	*24.455*
Instrumented	*1,279*	*51*	*25*	*1986 - 2018*	*0.002*	*0.011*	*-0.057*	*-0.009*	*-0.004*	*0.001*	*0.007*	*0.013*	*0.086*	*12.775*
FXI/GDP * K openness														
Observed	*1,279*	*51*	*25*	*1986 - 2018*	*0.005*	*0.022*	*-0.081*	*-0.009*	*-0.001*	*0.000*	*0.009*	*0.023*	*0.280*	*56.712*
Instrumented	*1,279*	*51*	*25*	*1986 - 2018*	*0.001*	*0.008*	*-0.056*	*-0.008*	*-0.003*	*0.001*	*0.005*	*0.009*	*0.042*	*8.640*
Detrended private credit/GDP	1,279	51	25	1986 - 2018	0.003	0.113	-0.653	-0.121	-0.043	0.010	0.063	0.123	0.388	6.721
L.Relative output per worker * K openness	1,279	51	25	1986 - 2018	0.183	0.323	-0.268	-0.152	-0.095	0.051	0.442	0.607	1.125	2.599
L.demeaned VIX * K openness	1,279	51	25	1986 - 2018	0.001	0.055	-0.103	-0.067	-0.039	-0.011	0.037	0.079	0.146	2.762
L.demeaned VIX * K openness * Safe asset index	1,279	51	25	1986 - 2018	0.000	0.004	-0.037	-0.001	0.000	0.000	0.000	0.001	0.066	88.951

Notes: Summary statistics are calculated based on the baseline regression sample. For easier interpretation of the data, variables shown here are not constructed relative to the annual world GDP-weighted average.

Source: U.S. Treasury staff calculations.

Table 2. GERAF Current Account Model: Baseline Specification

	(1) GERAF Baseline
Cyclical factors	
Output gap #	-0.344***
	(0.000)
Commodity TOT gap	0.258***
	(0.000)
Macroeconomic Fundamentals	
Trade openness/GDP #	0.019***
	(0.002)
L. NFA/GDP	0.027***
	(0.000)
L. NFA/GDP * (Dummy if L.NFA/GDP < -60%)	0.004
	(0.712)
L.Output per worker, relative to top 3 economies	0.034
	(0.105)
Real GDP growth, forecast in 5 years #	-0.254***
	(0.004)
Safe asset index	-0.039**
	(0.029)
Structural Fundamentals	
Demographic block	
Old-age dependency ratio #	-0.114***
	(0.005)
Population growth #	-0.622*
	(0.059)
Prime savers share #	0.227***
	(0.000)
Life expectancy at prime age #	-0.007***
	(0.000)
Life expectancy at prime age # * Future OADR	0.017***
	(0.000)
Institutional/political environment (ICGR-12) #	-0.058***
	(0.001)
Oil and natural gas trade balance * Resource temporariness #	0.515***
	(0.000)
Policy Variables	
Cyclically-adjusted fiscal balance (instrumented) #	0.527***
	(0.000)
L.Public health spending/GDP #	-0.254*
	(0.064)
FX Intervention	
FXI/GDP (instrumented) #	0.700***
	(0.003)
FXI/GDP (instrumented) # * K openness	-0.510*
	(0.071)
Detrended private credit/GDP #	-0.095***
	(0.000)
Capital Controls	
L.Relative output per worker * K openness	0.021
	(0.359)
L.demeaned VIX * K openness	0.028**
	(0.033)
L.demeaned VIX * K openness * Safe asset index	-0.064
	(0.554)
Constant	-0.019***
	(0.000)
Observations	1,279
Number of countries	51
R-squared	0.392
RMSE	0.019

"L." denotes variables expressed using a one year lag. "#" denotes variables expressed relative to the annual world GDP-weighted average. P-values in parentheses. Standard errors are robust to heteroskedasticity, autocorrelation and cross-sectional dependence. Regression includes a panel-wide AR(1) correction to control for potential autocorrelation in the dependent variable. ***, **, * next to a number indicate statistical significance at 1, 5 and 10 percent, respectively. Source: U.S. Treasury staff calculations.

Appendix A: Construction of a Novel Safe Asset Index

The safe asset index for country *i* at time *t* is constructed as follows:

$$SAI_{i,t} = \underbrace{\Omega_{i,t}^{permanent}}_{Price\ factor} \times \underbrace{\theta_{i,t}}_{Quantity\ factor} \quad \text{(A1.1)}$$

where $\Omega_{i,t}^{permanent}$ corresponds to the price factor (as described below) and $\theta_{i,t}$ corresponds to the quantity factor, as measured by the country currency's weight in the IMF Currency Composition of Official Foreign Exchange Reserves (COFER) portfolio.

The raw price factor, $\omega_{i,t}$, is estimated individually for each economy using a dynamic conditional correlation model — a particular type of multivariate generalized autoregressive conditional heteroskedasticity model (DCC-MGARCH) — using monthly level data.

Let $e_{i,t}^{LC/SDR}$ denote the nominal exchange rate, expressed in local currency per SDR,[13]

$i_{i,t}^{10Y}$ denote the 10-year sovereign bond nominal interest rate, and

$IVIX_t$ denote the inverse VIX index.

Here, the inverse VIX is expressed as the following, as to preserve the scale of discrete changes in the original VIX index:

$$IVIX_t = (-1 * VIX_t) + 100 \quad \text{(A1.2)}$$

Using the inverse of the VIX and the exchange rate expressed in local currency per SDR allows for an intuitive positive correlation between increasing uncertainty/volatility, increasing currency appreciation, and decreasing bond yields, where all three data series move in the same direction.

For most economies in the sample, the DCC-MGARCH model follows a GARCH(1,1) process. All variables are transformed such that they are stationary and are expressed in terms of change in percentage points. Hence, the variables in the DCC-MGARCH(1,1) specification are:

$\Delta\ ln\left(e_{i,t}^{LC/SDR}\right)$

$\Delta\left(i_{i,t}^{10Y}\right)$

$\Delta\ ln(IVIX_t)$

There are a small number of economies in the sample where the above specification fails to iterate properly. For these economies, the DCC-MGARCH model follows a GARCH(2,2) process with the variables expressed as the following:

[13] Using the SDR as a numeraire allows for a time-varying spot exchange rate for the U.S. dollar.

$\Delta\ ln\left(e_{i,t}^{LC/SDR}\right)$

$\Delta\left(i_{i,t}^{10Y}\right)$

$\Delta\ ln(IVIX_t)$

Lastly, for where either of the above specifications fail to iterate properly, the DCC-MGARCH model follows a GARCH(2,2) process with the variables expressed as the following:

$\Delta\ ln\left(e_{i,t}^{LC/SDR}\right)$

$\Delta\ ln\left(i_{i,t}^{10Y}\right)$

$\Delta\ ln(IVIX_t)$

$\omega_{i,t}$ is then calculated using the estimated dynamic conditional correlations:

$$\omega_{i,t} = \rho_{i,t}\left(i_{i,t}^{10Y}, IVIX_t\right) + \rho_{i,t}\left(e_{i,t}^{LC/SDR}, IVIX_t\right) \tag{A1.3}$$

where:

$\rho_{i,t}\left(i_{i,t}^{10Y}, IVIX_t\right) = estimated\ conditional\ correlation\ between\ i_{i,t}^{10Y}\ and\ IVIX_t$

$\rho_{i,t}\left(e_{i,t}^{LC/SDR}, IVIX_t\right) = estimated\ conditional\ correlation\ between\ e_{i,t}^{LC/SDR}\ and\ IVIX_t$

This raw price factor is then standardized across the entire panel sample:

$$\Omega_{i,t} = \left(\frac{\omega_{i,t} - \bar{\omega}}{\sigma_\omega}\right)_{i,t} \tag{A1.4}$$

After collapsing to the annual level, the permanent component of the raw price factor for each country is estimated using a Hodrick-Prescott filter:

$$\Omega_{i,t}^{permanent} = \min_{\tau}\left(\sum_{t=1}^{T}(y_t - \tau_t)^2 + \lambda\sum_{t=2}^{T-1}[(y_{t+1} - \tau_t) - (y_t - \tau_{t-1})]^2\right) \tag{A1.5}$$

where y_t corresponds to $\Omega_{i,t}$, τ_t is the trend component, and λ is set to 100.

Lastly, the final price factor, $\Omega_{i,t}^{permanent}$, is multiplied by the quantity factor, $\theta_{i,t}$, as measured by the country currency's weight in the IMF COFER portfolio:

$$SAI_{i,t} = \underbrace{\Omega_{i,t}^{permanent}}_{Price\ factor} \times \underbrace{\theta_{i,t}}_{Quantity\ factor} \tag{A1.6}$$

Appendix B: Data Sources and Descriptions

Table B1. GERAF Data Sources

Variable*	Sources**	Notes
Dependent variable		
Current account/GDP	IMF World Economic Outlook (WEO); national authorities; and Haver Analytics.	
Cyclical factors		
Output gap	IMF WEO; Haver Analytics; and Treasury staff estimates.	1/
Commodity TOT gap	IMF International Financial Statistics (IFS); Haver Analytics; and Treasury staff estimates.	2/
Macroeconomic Fundamentals		
Trade openness/GDP	IMF Direction of Trade Statistics (DOTS); IMF WEO; and Haver Analytics.	
L. NFA/GDP	IMF IFS; IMF WEO; and Haver Analytics.	
L. NFA/GDP * (Dummy if L.NFA/GDP < -60%)	IMF IFS; IMF WEO; Haver Analytics; and Treasury staff calculations.	
L.Output per worker, relative to top 3 economies	IMF WEO; national authorities; UN World Population Prospects, 2019 Revision; Haver Analytics; and Treasury staff calculations.	
Real GDP growth, forecast in 5 years	IMF WEO.	3/
Safe asset index	Chicago Board Options Exchange (CBOE); national authorities; IMF IFS; Bank of International Settlements (BIS); IMF Currency Composition of Official Foreign Exchange Reserves (COFER); Haver Analytics; and Treasury staff estimates.	4/

Table B1. GERAF Data Sources

Variable*	**Sources****	**Notes**
Structural Fundamentals		
Old-age dependency ratio (OADR)	UN World Population Prospects, 2019 Revision; and Haver Analytics.	
Population growth	UN World Population Prospects, 2019 Revision; and Haver Analytics.	
Prime savers share	UN World Population Prospects, 2019 Revision; and Haver Analytics.	
Life expectancy at prime age	UN World Population Prospects, 2019 Revision; and Haver Analytics.	
Life expectancy at prime age * Future OADR	UN World Population Prospects, 2019 Revision; and Haver Analytics.	
Institutional/political environment (ICGR-12)	PRS Group, International Country Risk Guide (ICRG).	
Oil and natural gas trade balance * Resource temporariness	IMF WEO; World Bank World Development Indicators (WDI); IMF Balance of Payments Statistics (BOPS); Haver Analytics; and British Petroleum Statistical Review of World Energy.	5/
Policy Variables		
Cyclically-adjusted fiscal balance		
Observed	*IMF Fiscal Monitor (FM); IMF WEO; Haver Analytics; and Treasury staff estimates.*	*6/*
Instrumented	*IMF FM; IMF WEO; Treasury staff estimates; national authorities; PRS Group, ICRG; CBOE; Ilzetzki, Reinhart, and Rogoff (2019); Haver Analytics; and Treasury staff calculations.*	*7/*
L.Public health spending/GDP	OECD Government Statistics; World Bank WDI; and Haver Analytics.	

Table B1. GERAF Data Sources

Variable*	**Sources****	**Notes**
FXI/GDP		
Observed	*IMF IFS; national authorities; IMF WEO; Bloomberg L.P.; Haver Analytics; Treasury staff calculations; and Treasury staff estimates.*	*8/*
Instrumented	*IMF IFS; national authorities; IMF WEO; Bloomberg L.P.; Haver Analytics; Treasury staff calculations; Treasury staff estimates; and World Bank WDI.*	*9/*
FXI/GDP * K openness		
Observed	*IMF IFS; national authorities; IMF WEO; Bloomberg L.P.; Haver Analytics; Treasury staff calculations; Treasury staff estimates; Quinn database; and Chinn-Ito database.*	*8/*
Instrumented	*IMF IFS; national authorities; IMF WEO; Bloomberg L.P.; Haver Analytics; Treasury staff calculations; Treasury staff estimates; World Bank WDI; Quinn database; and Chinn-Ito database.*	*10/*
Detrended private credit/GDP	BIS; World Bank WDI; IMF WEO; Haver Analytics; Drehmann et al. (2011); and Treasury staff estimates.	
L.Relative output per worker * K openness	IMF WEO; national authorities; UN World Population Prospects, 2019 Revision; Haver Analytics; Treasury staff calculations; Quinn database; and Chinn-Ito database.	
L.demeaned VIX * K openness	CBOE; Haver Analytics; Quinn database; and Chinn-Ito database.	
L.demeaned VIX * K openness * Safe asset index	CBOE; national authorities; IMF IFS; Bank of International Settlements (BIS); IMF Currency Composition of Official Foreign Exchange Reserves (COFER); Haver Analytics; Treasury staff estimates; Quinn database; and Chinn-Ito database.	
Other Data		
CA-REER semi elasticity	Cubeddu et al. 2019; IMF WEO; IMF IFS; national authorities; Haver Analytics; and Treasury staff calculations.	

Table B1. GERAF Data Sources

Variable*	Sources**	Notes
REER trade weights	UN COMTRADE; UN National Accounts; IMF DOTS; national authorities; Haver Analytics; and Treasury staff calculations.	11/
Additional Explanatory Variables (See Appendix D)		
Reserve currency status	IMF Currency Composition of Official Foreign Exchange Reserves (COFER); and Haver Analytics.	
Change in FX Reserves/GDP	IMF IFS; IMF WEO; and Haver Analytics.	
Real interest rates	IMF IFS; IMF WEO; national authorities; and Haver Analytics.	
Real interest rates * K openness	IMF IFS; IMF WEO; national authorities; Haver Analytics; Quinn database; and Chinn-Ito database.	
Inflation (period average)	IMF WEO; and Haver Analytics.	
Inflation (period average; bounded index, 0 to 1)	IMF WEO; Haver Analytics; and Treasury staff calculations.	12/
Share of urban population	World Bank WDI; and Haver Analytics.	
Young-age dependency ratio (YADR)	UN World Population Prospects, 2019 Revision; and Haver Analytics.	
Gini index	World Bank WDI; and Haver Analytics.	
Income share held by top ten percent	World Bank WDI; and Haver Analytics.	
Financial center dummy	IMF External Balance Assessment dataset (2019 vintage).	

Table B1. GERAF Data Sources

Variable*	Sources**	Notes
Fixed exchange rate regime dummy	Ilzetzki, Reinhart, and Rogoff (2019); and Treasury staff calculations.	

* Variable construction consistent with that of Cubeddu et al. (2019), unless otherwise noted.

** Where necessary and applicable, any gaps in data are filled with data from the 2019 vintage of the IMF External Balance Assessment dataset.

1/ Uses IMF desk estimates where available, otherwise estimated using via HP filter with λ=100 (which closely replicates IMF desk estimates, per Grigoli et al. (2015)).

2/ Gap estimated using via HP filter with λ=100.

3/ Collected from archived WEO databases.

4/ Country-specific index reflecting the relative quality of safe assets. To capture price factors, we estimate time-varying monthly conditional correlations between a) local currency-to-SDR exchange rates and the inverse of the VIX index, and b) 10-year sovereign bond yields and the inverse of the VIX index for each country. Conditional correlations are derived from country-specific dynamic conditional correlation multivariate generalized autoregressive conditional heteroskedasticity (DCC-MGARCH) estimations (see Engle (2002); Engle and Sheppard (2001)). The sum of these two conditional correlations are then standardized relative to the entire panel of countries, collapsed to the annual level, and then, in order to reflect more structural dynamics, we take the trend component of this standardized index using an HP filter where λ=100. Lastly, to capture quantity factors, the price factor index is weighted by the country's currency share of foreign exchange reserves in the COFER database.

5/ Variable construction broadly consistent with that of Cubeddu et al. (2019), but uses fuel trade balance instead of oil trade balance due to limited data availability.

6/ Variable construction broadly consistent with that of Cubeddu et al. (2019). Uses IMF desk estimates where available, otherwise estimated by taking the residual of a regression of the overall fiscal balance on the output gap. Unlike Cubeddu et al. (2019), which uses a country-specific regression approach, we prefer a pooled Ordinary Least Squares (OLS) fixed-effect regression specification. Doing so allows us to control for country-specific factors while simultaneously exploiting a much larger regression sample.

7/ Variable construction broadly consistent with that of Cubeddu et al. (2019), using a two-stage regression approach for instrumentation. Here, the first-stage regression uses the VIX index instead of U.S. corporate spreads as an instrument to proxy global risk aversion, and uses the ICRG democratic accountability sub-index instead of the Polity democracy ranking index as an instrument to proxy country-specific degrees of democracy. In line with Cubeddu et al. (2019), the first-stage regression uses a pooled OLS approach, and also controls for the independent model regressors.

8/ Uses methodology consistent with Treasury's Macroeconomic and Foreign Exchange Policies of Major Trading Partners of the United States. Estimates are normally based on publicly available data for intervention on foreign asset purchases by authorities, or estimated based on valuation-adjusted foreign exchange reserves. This adjustment requires assumptions about both the currency and asset composition of reserves in order to isolate returns on assets held in reserves and currency valuation moves from actual purchases and sales, including estimations of transactions in foreign exchange derivatives markets. Estimates can also be based on alternative data series when they provide a more accurate picture of foreign exchange balances than estimates derived from changes in valuation-adjusted reserves.

Table B1. GERAF Data Sources

Variable*	Sources**	Notes

9/ Variable construction broadly consistent with that of Cubeddu et al. (2019), using a two-stage regression approach for instrumentation. Here, the first-stage regression uses the same measures of global accumulation of reserves and reserve adequacy, but they are expressed relative to the global weighted-average instead of the emerging market average. In line with Cubeddu et al. (2019), the first-stage regression includes a dummy for emerging markets to control for emerging market-specific dynamics. The first-stage regression uses a pooled OLS approach, and also controls for the independent model regressors.

10/ Defined as instrumented FXI/GDP interacted with capital account openness.

11/ Variable construction broadly consistent with Turner and Van't dack (1993).

12/ Defined as inflation rate divided by one plus the rate of inflation.

Appendix C: List of Countries

Table C1. List of Countries

Argentina	Malaysia
Australia	Mexico
Austria	Morocco
Belgium	Netherlands
Brazil	New Zealand
Canada	Nigeria
Chile	Norway
China	Pakistan
Colombia	Peru
Costa Rica	Philippines
Czech Republic	Poland
Denmark	Portugal
Egypt	Russia
Finland	South Africa
France	Spain
Germany	Sri Lanka
Greece	Sweden
Guatemala	Switzerland
Hungary	Thailand
India	Tunisia
Indonesia	Turkey
Ireland	United Kingdom
Israel	United States
Italy	Uruguay
Japan	Vietnam
Korea	

Appendix D: Robustness Checks and Regression Extensions

Table D1. GERAF Current Account Model: Alternative Estimators

	(1) GERAF Baseline (PCSE)	(2) Pooled OLS	(3) Pooled OLS	(4) Pooled OLS	(5) Pooled OLS	(6) PCSE	(7) PCSE	(8) PCSE
Cyclical factors								
Output gap #	-0.344***	-0.189***	-0.307***	-0.193***	-0.313***	-0.355***	-0.350***	-0.355***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Commodity TOT gap	0.258***	0.129	0.255***	0.130	0.291***	0.331***	0.260***	0.356***
	(0.000)	(0.106)	(0.003)	(0.112)	(0.001)	(0.000)	(0.000)	(0.000)
Macroeconomic Fundamentals								
Trade openness/GDP #	0.019***	0.017***	0.054***	0.015***	0.050***	0.035***	0.018***	0.033***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.004)	(0.003)
L. NFA/GDP	0.027***	0.038***	0.028***	0.035***	0.023***	0.007	0.024***	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.294)	(0.000)	(0.900)
L. NFA/GDP * (Dummy if L.NFA/GDP < -60%)	0.004	-0.003	-0.026*	0.002	-0.026*	0.003	0.012	0.008
	(0.712)	(0.766)	(0.088)	(0.836)	(0.093)	(0.812)	(0.325)	(0.530)
L.Output per worker, relative to top 3 economies	0.034	0.035**	0.050*	0.039**	0.034	0.036	0.037*	0.015
	(0.105)	(0.034)	(0.100)	(0.020)	(0.243)	(0.299)	(0.082)	(0.675)
Real GDP growth, forecast in 5 years #	-0.254***	-0.508***	-0.492***	-0.516***	-0.522***	-0.278***	-0.251***	-0.278***
	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.004)	(0.003)
Safe asset index	-0.039**	-0.039***	-0.022	-0.045***	-0.051***	-0.019	-0.051***	-0.056***
	(0.029)	(0.001)	(0.170)	(0.001)	(0.003)	(0.319)	(0.007)	(0.008)
Structural Fundamentals								
Demographic block								
Old-age dependency ratio #	-0.114***	-0.101***	-0.194***	-0.111***	-0.189***	-0.132**	-0.120***	-0.106*
	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)	(0.028)	(0.004)	(0.083)
Population growth #	-0.622*	-0.601***	-1.156***	-0.566**	-0.792**	-0.726*	-0.520	-0.314
	(0.059)	(0.007)	(0.000)	(0.010)	(0.012)	(0.079)	(0.117)	(0.463)
Prime savers share #	0.227***	0.236***	0.071*	0.243***	0.078**	0.083	0.243***	0.092
	(0.000)	(0.000)	(0.069)	(0.000)	(0.049)	(0.151)	(0.000)	(0.109)
Life expectancy at prime age #	-0.007***	-0.006***	-0.002	-0.006***	-0.003	-0.000	-0.006***	-0.002
	(0.000)	(0.000)	(0.329)	(0.000)	(0.130)	(0.930)	(0.000)	(0.475)
Life expectancy at prime age # * Future OADR	0.017***	0.014***	0.016***	0.013***	0.014***	0.014*	0.016***	0.010
	(0.000)	(0.000)	(0.003)	(0.000)	(0.008)	(0.058)	(0.000)	(0.161)
Institutional/political environment (ICGR-12) #	-0.058***	-0.076***	-0.026	-0.075***	-0.027	-0.025	-0.065***	-0.033
	(0.001)	(0.000)	(0.232)	(0.000)	(0.245)	(0.251)	(0.000)	(0.147)
Oil and natural gas trade balance * Resource temporariness #	0.515***	0.527***	0.715***	0.522***	0.624***	0.814***	0.506***	0.739***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Policy Variables								
Cyclically-adjusted fiscal balance (instrumented) #	0.527***	0.756***	0.405***	0.726***	0.296*	0.272**	0.524***	0.207
	(0.000)	(0.000)	(0.010)	(0.000)	(0.057)	(0.032)	(0.000)	(0.105)
L.Public health spending/GDP #	-0.254*	-0.254**	-0.646***	-0.230**	-0.651***	-0.602***	-0.237*	-0.612***
	(0.064)	(0.011)	(0.000)	(0.024)	(0.000)	(0.001)	(0.088)	(0.001)
FX Intervention								
FXI/GDP (instrumented) #	0.700***	1.082***	0.522**	1.219***	0.610**	0.559**	0.694***	0.532**
	(0.003)	(0.000)	(0.035)	(0.000)	(0.033)	(0.012)	(0.006)	(0.027)
FXI/GDP (instrumented) # * K openness	-0.510*	-0.667**	-0.077	-0.631**	-0.087	-0.358	-0.437	-0.294
	(0.071)	(0.018)	(0.800)	(0.031)	(0.792)	(0.180)	(0.135)	(0.290)
Detrended private credit/GDP #	-0.095***	-0.108***	-0.071***	-0.102***	-0.064***	-0.078***	-0.092***	-0.072***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capital Controls								
L.Relative output per worker * K openness	0.021	0.015	0.012	0.016	0.020	0.004	0.025	0.014
	(0.359)	(0.383)	(0.650)	(0.352)	(0.455)	(0.876)	(0.277)	(0.628)
L.demeaned VIX * K openness	0.028**	0.015	0.040***	-0.048	-0.041	0.044***	-0.031	-0.038
	(0.033)	(0.335)	(0.004)	(0.372)	(0.387)	(0.001)	(0.455)	(0.350)
L.demeaned VIX * K openness * Safe asset index	-0.064	-0.012	-0.116	0.049	-0.060	-0.156*	-0.017	-0.105
	(0.554)	(0.940)	(0.236)	(0.753)	(0.545)	(0.073)	(0.882)	(0.237)
Constant	-0.019***	-0.016***	-0.040**	-0.025***	-0.039**	-0.037*	-0.031***	-0.031
	(0.000)	(0.000)	(0.017)	(0.008)	(0.028)	(0.056)	(0.000)	(0.123)
Country-fixed effects	No	No	Yes	No	Yes	Yes	No	Yes
Time-fixed effetcs	No	No	No	Yes	Yes	No	Yes	Yes
Observations	1,279	1,279	1,279	1,279	1,279	1,279	1,279	1,279
Number of countries	51	51	51	51	51	51	51	51
R-squared	0.392	0.613	0.743	0.627	0.757	0.540	0.419	0.566
RMSE	0.019	0.030	0.025	0.030	0.024	0.018	0.019	0.018

"L." denotes variables expressed using a one year lag. "#" denotes variables expressed relative to the annual world GDP-weighted average. P-values in parentheses. OLS standard errors are robust to heteroskedasticity; PCSE standard errors are robust to heteroskedasticity, autocorrelation and cross-sectional dependence. PCSE regressions include a panel-wide AR(1) correction to control for potential autocorrelation in the dependent variable. ***, **, * next to a number indicate statistical significance at 1, 5 and 10 percent, respectively.

Source: U.S. Treasury staff calculations.

Table D2. GERAF Current Account Model: Robustness

	(1) GERAF Baseline	(2)	(3)	(4)	(5)	(6)	(7)
Cyclical factors							
Output gap #	-0.344***	-0.372***	-0.368***	-0.380***	-0.380***	-0.369***	-0.370***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Commodity TOT gap	0.258***	0.298***	0.309***		0.246*		0.239*
	(0.000)	(0.000)	(0.000)		(0.073)		(0.083)
Commodity TOT gap * Trade openness				0.446***	0.069	0.488***	0.121
				(0.000)	(0.784)	(0.000)	(0.633)
Macroeconomic Fundamentals							
Trade openness/GDP #	0.019***	0.020***	0.022***			0.021***	0.021***
	(0.002)	(0.001)	(0.000)			(0.001)	(0.001)
L. NFA/GDP	0.027***	0.029***	0.028***	0.030***	0.030***	0.028***	0.029***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L. NFA/GDP * (Dummy if L.NFA/GDP < -60%)	0.004	0.005	0.004	0.003	0.002	0.006	0.005
	(0.712)	(0.707)	(0.768)	(0.806)	(0.878)	(0.626)	(0.691)
L.Output per worker, relative to top 3 economies	0.034	0.022	0.025	0.032	0.032	0.025	0.026
	(0.105)	(0.286)	(0.228)	(0.133)	(0.122)	(0.238)	(0.220)
Real GDP growth, forecast in 5 years #	-0.254***	-0.223**	-0.225***	-0.249***	-0.250***	-0.228***	-0.229***
	(0.004)	(0.011)	(0.010)	(0.004)	(0.004)	(0.009)	(0.009)
Safe asset index	-0.039**	-0.028		-0.051***	-0.050***	-0.034*	-0.033*
	(0.029)	(0.129)		(0.008)	(0.009)	(0.071)	(0.075)
Reserve currency status			-0.046***				
			(0.006)				
Structural Fundamentals							
Demographic block							
Old-age dependency ratio #	-0.114***	-0.103**	-0.095**	-0.123***	-0.121***	-0.107**	-0.105**
	(0.005)	(0.013)	(0.021)	(0.004)	(0.004)	(0.011)	(0.012)
Population growth #	-0.622*	-0.714**	-0.743**	-0.659**	-0.657**	-0.701**	-0.697**
	(0.059)	(0.032)	(0.028)	(0.050)	(0.050)	(0.037)	(0.037)
Prime savers share #	0.227***	0.207***	0.199***	0.229***	0.224***	0.216***	0.211***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Life expectancy at prime age #	-0.007***	-0.006***	-0.007***	-0.006***	-0.006***	-0.006***	-0.006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Life expectancy at prime age # * Future OADR	0.017***	0.017***	0.018***	0.014***	0.014***	0.017***	0.017***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Institutional/political environment (ICGR-12) #	-0.058***	-0.051***	-0.052***	-0.047***	-0.046***	-0.052***	-0.051***
	(0.001)	(0.004)	(0.003)	(0.009)	(0.009)	(0.003)	(0.003)
Oil and natural gas trade balance * Resource temporariness #	0.515***	0.510***	0.487***	0.472***	0.473***	0.508***	0.508***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Policy Variables							
Cyclically-adjusted fiscal balance (instrumented) #	0.527***	0.517***	0.489***	0.573***	0.568***	0.522***	0.518***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.Public health spending/GDP #	-0.254*	-0.338**	-0.347**	-0.259*	-0.256*	-0.336**	-0.333**
	(0.064)	(0.014)	(0.012)	(0.058)	(0.060)	(0.015)	(0.015)
FX Intervention							
FXI/GDP (instrumented) #	0.700***		0.664**	0.668***	0.686***	0.643**	0.661**
	(0.003)		(0.011)	(0.009)	(0.007)	(0.014)	(0.012)
FXI/GDP (instrumented) # * K openness	-0.510*		-0.488	-0.515	-0.515*	-0.488	-0.489
	(0.071)		(0.119)	(0.101)	(0.099)	(0.124)	(0.122)
(ΔFX Reserves)/GDP (instrumented) #		0.287***					
		(0.000)					
Detrended private credit/GDP #	-0.095***	-0.098***	-0.096***	-0.100***	-0.100***	-0.097***	-0.097***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capital Controls							
L.Relative output per worker * K openness	0.021	0.035	0.034	0.027	0.026	0.032	0.031
	(0.359)	(0.118)	(0.138)	(0.235)	(0.253)	(0.159)	(0.172)
L.demeaned VIX * K openness	0.028**	0.023*	0.020	0.017	0.021	0.021	0.024*
	(0.033)	(0.074)	(0.178)	(0.189)	(0.116)	(0.116)	(0.070)
L.demeaned VIX * K openness * Safe asset index	-0.064	-0.031		-0.008	-0.029	-0.023	-0.042
	(0.554)	(0.777)		(0.946)	(0.806)	(0.837)	(0.703)
L.demeaned VIX * K openness * Reserve currency status			0.106				
			(0.347)				
Constant	-0.019***	-0.020***	-0.019***	-0.015***	-0.015***	-0.020***	-0.020***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	1,279	1,291	1,291	1,303	1,303	1,291	1,291
Number of countries	51	51	51	51	51	51	51
R-squared	0.392	0.381	0.379	0.363	0.369	0.376	0.382
RMSE	0.019	0.019	0.019	0.019	0.019	0.019	0.019

Instrumented variables in each alternate specification control for the independent model regressors in their respective specification. "L." denotes variables expressed using a one year lag. "#" denotes variables expressed relative to the annual world GDP-weighted average. P-values in parentheses. Standard errors are robust to heteroskedasticity, autocorrelation and cross-sectional dependence. Regressions include a panel-wide AR(1) correction to control for potential autocorrelation in the dependent variable. ***, **, * next to a number indicate statistical significance at 1, 5 and 10 percent, respectively.
Source: U.S. Treasury staff calculations.

Table D3. GERAF Current Account Model: Extensions

	(1) GERAF Baseline	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Cyclical factors													
Output gap #	-0.344***	-0.356***		-0.356***		-0.367***	-0.359***	-0.368***	-0.372***	-0.398***	-0.398***	-0.383***	-0.369***
	(0.000)	(0.000)		(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Commodity TOT gap	0.258***	0.302***	0.243***	0.303***	0.243***	0.288***	0.294***	0.304***	0.298***	0.282***	0.276***	0.346***	0.295***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Macroeconomic Fundamentals													
Trade openness/GDP #	0.019***	0.022***	0.026***	0.023***	0.026***	0.020***	0.021***	0.021***	0.020***	0.015**	0.015**	0.025***	0.020***
	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.021)	(0.020)	(0.000)	(0.001)
L. NFA/GDP	0.027***	0.029***	0.025***	0.029***	0.025***	0.028***	0.028***	0.028***	0.029***	0.028***	0.028***	0.035***	0.029***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L. NFA/GDP * (Dummy if L.NFA/GDP < -60%)	0.004	0.005	0.007	0.005	0.007	0.006	0.006	0.004	0.004	0.007	0.008	0.004	0.005
	(0.712)	(0.699)	(0.596)	(0.704)	(0.600)	(0.632)	(0.650)	(0.717)	(0.710)	(0.550)	(0.491)	(0.803)	(0.696)
L.Output per worker, relative to top 3 economies	0.034	0.034	0.030	0.034	0.030	0.024	0.021	0.020	0.026	0.048**	0.047**	-0.003	0.027
	(0.105)	(0.160)	(0.239)	(0.163)	(0.243)	(0.248)	(0.314)	(0.354)	(0.211)	(0.036)	(0.040)	(0.911)	(0.214)
Real GDP growth, forecast in 5 years #	-0.254***	-0.244**	-0.289***	-0.244**	-0.289***	-0.235***	-0.229**	-0.231***	-0.260***	-0.259***	-0.265***	-0.168	-0.232***
	(0.004)	(0.012)	(0.005)	(0.013)	(0.005)	(0.009)	(0.010)	(0.009)	(0.003)	(0.005)	(0.004)	(0.145)	(0.008)
Safe asset index	-0.039**	-0.030	-0.019	-0.030	-0.019	-0.032*	-0.031*	-0.031*	-0.028	-0.033*	-0.036**	-0.037*	-0.032*
	(0.029)	(0.118)	(0.296)	(0.119)	(0.300)	(0.080)	(0.099)	(0.093)	(0.135)	(0.073)	(0.049)	(0.056)	(0.079)
Structural Fundamentals													
Demographic block													
Old-age dependency ratio #	-0.114***	-0.111**	-0.089*	-0.111**	-0.089*	-0.101**	-0.098**	-0.105**	-0.089**	-0.137***	-0.149***	-0.129***	-0.106**
	(0.005)	(0.013)	(0.054)	(0.013)	(0.054)	(0.016)	(0.020)	(0.011)	(0.033)	(0.002)	(0.001)	(0.005)	(0.011)
Population growth #	-0.622*	-0.799**	-1.012**	-0.799**	-1.012**	-0.680**	-0.704**	-0.689**	-0.090	-0.656*	-0.668*	-1.535***	-0.698**
	(0.059)	(0.042)	(0.015)	(0.042)	(0.015)	(0.046)	(0.040)	(0.039)	(0.828)	(0.060)	(0.055)	(0.000)	(0.035)
Prime savers share #	0.227***	0.194***	0.157***	0.195***	0.158***	0.210***	0.207***	0.212***	0.182***	0.140**	0.148**	0.206***	0.211***
	(0.000)	(0.001)	(0.007)	(0.001)	(0.007)	(0.000)	(0.000)	(0.000)	(0.001)	(0.026)	(0.019)	(0.001)	(0.000)
Life expectancy at prime age #	-0.007***	-0.008***	-0.008***	-0.008***	-0.008***	-0.006***	-0.006***	-0.007***	-0.008***	-0.006***	-0.006***	-0.005***	-0.006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Life expectancy at prime age # * Future OADR	0.017***	0.020***	0.022***	0.020***	0.022***	0.017***	0.017***	0.018***	0.019***	0.013***	0.014***	0.017***	0.017***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.001)	(0.000)	(0.000)
Institutional/political environment (ICGR-12) #	-0.058***	-0.055***	-0.098***	-0.055***	-0.098***	-0.052***	-0.045**	-0.053***	-0.062***	-0.052***	-0.051***	-0.064***	-0.050***
	(0.001)	(0.005)	(0.000)	(0.005)	(0.000)	(0.004)	(0.011)	(0.002)	(0.001)	(0.005)	(0.006)	(0.002)	(0.004)
Oil and natural gas trade balance * Resource temporariness #	0.515***	0.522***	0.552***	0.522***	0.552***	0.516***	0.523***	0.511***	0.518***	0.463***	0.471***	0.535***	0.505***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Policy Variables													
Cyclically-adjusted fiscal balance (instrumented) #	0.527***	0.480***	0.563***	0.477***	0.562***	0.554***	0.546***	0.512***	0.552***	0.602***	0.614***	0.562***	0.524***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.Public health spending/GDP #	-0.254*	-0.317**	-0.149	-0.318**	-0.149	-0.325**	-0.353**	-0.355**	-0.329**	-0.123	-0.107	-0.379**	-0.325**
	(0.064)	(0.035)	(0.340)	(0.034)	(0.339)	(0.021)	(0.012)	(0.013)	(0.016)	(0.402)	(0.467)	(0.022)	(0.017)
FX Intervention													
FXI/GDP (instrumented) #	0.700***	0.689**	0.837***	0.688**	0.837***	0.654**	0.643**	0.665**	0.622**	0.720***	0.702***	0.293	0.671**
	(0.003)	(0.012)	(0.003)	(0.012)	(0.003)	(0.013)	(0.015)	(0.011)	(0.016)	(0.007)	(0.008)	(0.294)	(0.010)
FXI/GDP (instrumented) # * K openness	-0.510*	-0.505	-0.663*	-0.504	-0.663*	-0.478	-0.464	-0.485	-0.438	-0.553*	-0.532	-0.052	-0.496
	(0.071)	(0.132)	(0.053)	(0.133)	(0.053)	(0.132)	(0.144)	(0.126)	(0.161)	(0.090)	(0.100)	(0.881)	(0.117)
Detrended private credit/GDP #	-0.095***	-0.094***	-0.106***	-0.094***	-0.106***	-0.100***	-0.099***	-0.097***	-0.099***	-0.094***	-0.094***	-0.093***	-0.098***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capital Controls													
L.Relative output per worker * K openness	0.021	0.024	0.029	0.024	0.029	0.032	0.035	0.035	0.026	0.003	0.005	0.058*	0.030
	(0.359)	(0.371)	(0.292)	(0.368)	(0.289)	(0.164)	(0.131)	(0.134)	(0.255)	(0.891)	(0.854)	(0.051)	(0.192)
L.demeaned VIX * K openness	0.028**	0.028**	0.020	0.028**	0.020	0.024*	0.023*	0.025*	0.025*	0.011	0.008	0.023	0.024*
	(0.033)	(0.048)	(0.161)	(0.047)	(0.158)	(0.069)	(0.075)	(0.053)	(0.052)	(0.413)	(0.524)	(0.122)	(0.069)
L.demeaned VIX * K openness * Safe asset index	-0.064	-0.056	-0.019	-0.057	-0.019	-0.036	-0.039	-0.045	-0.057	-0.022	-0.014	0.064	-0.039
	(0.554)	(0.618)	(0.855)	(0.615)	(0.851)	(0.736)	(0.719)	(0.679)	(0.597)	(0.837)	(0.892)	(0.557)	(0.726)
Real interest rates #		-0.001*	-0.001*										
		(0.074)	(0.052)										
Real interest rates * K openness #				-0.001*	-0.001*								
				(0.093)	(0.066)								
Inflation #						-0.000							
						(0.923)							
Inflation (bounded index, 0 to 1) #							0.025*						
							(0.063)						
Share of urban population #								0.010					
								(0.450)					
Young-age dependency ratio #									-0.025**				
									(0.015)				
Gini #										-0.095***			
										(0.000)			
Income share held by top ten percent #											-0.134***		
											(0.000)		
L.Financial center												-0.014	
												(0.116)	
Fixed exchange rate regime													0.001
													(0.716)
Constant	-0.019***	-0.021***	-0.025***	-0.021***	-0.025***	-0.020***	-0.021***	-0.020***	-0.018***	-0.012***	-0.011***	-0.008	-0.020***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.009)	(0.311)	(0.000)
Observations	1,279	1,138	1,138	1,138	1,138	1,276	1,276	1,291	1,291	1,158	1,156	892	1,291
Number of countries	51	51	51	51	51	51	51	51	51	50	50	40	51
R-squared	0.392	0.379	0.327	0.379	0.327	0.379	0.378	0.381	0.384	0.403	0.405	0.417	0.386
RMSE	0.019	0.019	0.020	0.019	0.020	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019

Instrumented variables in each alternate specification control for the independent model regressors in their respective specification. "L." denotes variables expressed using a one year lag. "#" denotes variables expressed relative to the annual world GDP-weighted average. P-values in parentheses. Standard errors are robust to heteroskedasticity, autocorrelation and cross-sectional dependence. Regressions include a panel-wide AR(1) correction to control for potential autocorrelation in the dependent variable. ***, **, * next to a number indicate statistical significance at 1, 5 and 10 percent, respectively.
Source: U.S. Treasury staff calculations.