Evolution of the International Monetary System from the Perspective of Trilemma Challenges *,**

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Abstract

The paper develops a new set of indexes of exchange rate stability (ERS), financial market openness (FMO), and monetary policy independence (MPI) to examine the issue of trilemma in international finance. It locates more than one hundred sample economies in the trilemma triangle over time—a useful way to illustrate the state and evolution of trilemma regimes. The paper argues that an important byproduct of using the Frankel-Wei and Kawai-Pontines methods to obtain the index of ERS, derived from the root mean squared error (RMSE) of regressions, is that they allow the identification of anchor currencies for individual economies as well as the computation of the size of major currency zones globally and regionally over time.

The paper yields several interesting results. First, the global economic share of the U.S. dollar (USD) zone, still the largest in the world, has declined over time due to the emergence of the euro (EUR) zone and the recent rapid rise of the renminbi (RMB) zone. At the same time, the share of the world economy not belonging to any major currency zone—thus adopting flexible exchange rates—has expanded over time. Second, from the trilemma perspective, both advanced economies and emerging & developing economies have generally moved toward greater exchange rate flexibility and financial market openness, with some exceptions. Today, the number of economies adopting the "corner regime" of maintaining freely flexible exchange rates, open financial markets, and independent monetary policy is rising among both advanced and emerging & developing economies. On the other hand, no advanced economy adopts another "corner regime" of closed financial markets with high degrees of ERS and MPI. Very few emerging & developing economies select the third "corner regime" of no MPI with high degrees of ERS and FMO, while members of the Euro Area, which are essentially advanced economies, adopt this corner. Other economies choose non-corner regimes, including the "middle ground." Finally, there is no single trilemma regime that delivers the best macroeconomic outcome for both advanced and emerging & developing economies.

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JEL Classification: F15, F21, F31, F36, F41, O24

I. Introduction

In an open economy, policymakers are considered to pursue stable and low-inflationary economic growth by choosing the best combination of international monetary frameworks—the degrees of exchange rate stability or flexibility, international capital mobility, and monetary policy autonomy. This is the basic idea behind the principle of Robert Mundell's "trilemma of international finance" (Mundell, 1963), which states that policymakers can choose only two out of the three monetary frameworks, i.e., ERS, FMO representing the degree of international capital mobility, and MPI. Simply put, they cannot attain all three to the full extent (or set them at any desired levels) at the same time.

Using this principle, one can describe the evolution of the international monetary system in modern times. For example, the gold standard system from the late 19th century to the beginning of the 20th century can be characterized by individual economies fixing their currencies to gold (thus making exchange rates stable) and allowing free cross-border movement of gold (thus maintaining free capital mobility and FMO), while abandoning independent monetary policy. The Bretton Woods system from 1945 to 1971 can be characterized by individual economies pegging their currencies to the USD and restricting cross-border capital mobility, thereby retaining MPI. The freely flexible exchange rate system, which has been adopted by an increasing number of countries since the collapse of the Bretton Woods system, is characterized by individual economies allowing exchange rates to be determined by supply and demand in the currency markets, ensuring free cross-border capital movements, and yet retaining MPI.

This paper attempts to investigate the evolution of the international monetary system from the perspectives of exchange rate arrangements and trilemma regimes for individual economies. An exchange rate arrangement for each economy can be represented by anchor currencies and the index of ERS. The paper utilizes the methods developed by Frankel and Wei (1994) and Kawai and Pontines (2016) to identify these. It uses the Frankel-Wei method when the Chinese yuan (or RMB) is not considered as a major anchor currency, while using the Kawai-Pontines method to estimate the weight of the RMB, in addition to those of traditional major currencies, in an economy's implicit currency basket. The ERS index is obtained from the RMSE of the Frankel-Wei or Kawai-Pontines regression, which shows how tightly or loosely an economy's exchange rate movements are explained by those of anchor currencies. Based on these, the paper examines the evolution of the international monetary system graphically for groups of economies classified by income level (high-, middle-, and low-income) and geographical region.

A trilemma regime can be defined by the combination of the three international monetary frameworks. This paper numerically expresses each economy's trilemma frameworks by constructing indexes for FMO and MPI in addition to ERS, and uses them to describe the evolution of the international monetary system over time for the last 50 years. Several authors, such as Aizenman, Chinn, and Ito (2010, 2013) and Ito and Kawai (2014a, 2014b, 2021), have indeed attempted to quantify the trilemma variables. This paper constructs a new set of trilemma indexes and presents visually the evolution of the international monetary arrangements by plotting trilemma combinations in triangles over time.

The paper also investigates how alternative trilemma regimes—defined by different combinations of the three trilemma indexes (ERS, FMO, and MPI)—affect macroeconomic performance. Are there certain trilemma regimes that deliver the best macroeconomic outcome, in the sense of achieving maximum output growth, inflation close to its target, and minimum output and inflation volatility? The paper compares key macroeconomic performance, i.e., the GDP growth and inflation rates and their volatility across different trilemma regimes.

The paper is organized as follows. Section II briefly explains the trilemma principle, its significance for the international monetary system, and ways of constructing the trilemma indexes. Section III identifies major anchor currencies and the degrees of exchange rate stability or flexibility for each economy over time and describes the evolution of exchange rate regimes using the global map. Section IV presents and investigates the changing sizes of major currency zones for the world as a whole and for various economy groups by taking into account the degrees of exchange rate stability/flexibility. Section V reviews the constructed trilemma indexes over time, analyzes the trilemma combinations for advanced and emerging & developing economies using the trilemma triangles, and maps the evolution of the trilemma regimes for individual economies over time. Section VI assesses the macroeconomic performance of advanced and emerging & developing economies under alternative trilemma regimes, i.e., three corner regimes, six non-corner regimes, and the "middle ground" that keeps the middle of all indexes. Section VII concludes the paper.

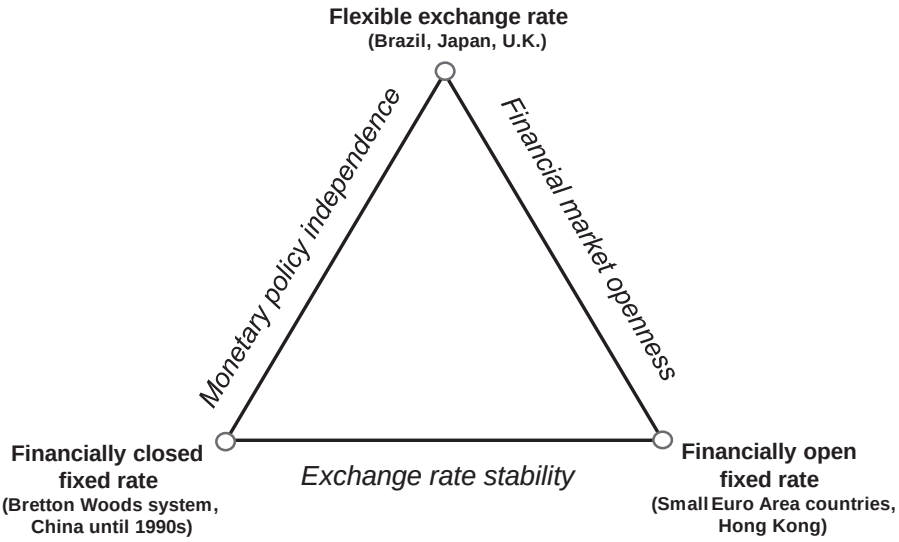
II. Trilemma in International Finance

II-1. Importance of the trilemma concept in international finance

Different countries have adopted different international monetary frameworks. Though not easy, it is possible to identify such monetary frameworks through the lens of the"impossible trinity" or "trilemma" in international finance. This hypothesis, first made popular by Mundell (1963), states that policymakers face a trade-off in choosing two out of the three monetary frameworks—ERS, FMO, and MPI. Figure 1 shows a trilemma triangle, where a country can select any point including three "corner solutions" and non-corner solutions along and inside the triangle.

Since the time of the gold standard, various countries have attempted to select different combinations of two out of the three monetary frameworks. In other words, history is full of

Figure 1: Trilemma triangle



Source: Compiled by authors.

"corner solutions." In the Bretton Woods system, countries sacrificed international capital mobility to retain ERS and MPI. Relatively small member countries in the Euro Area enjoy fixed exchange rates vis-à-vis other members and free capital mobility but essentially abandon MPI. Countries under today's freely flexible exchange rate system forgo ERS but ensure free cross-border capital movements and MPI.

Countries do not always have to adopt corner solutions. For example, a country can choose to attain one particular policy framework without achieving either of the remaining two. Or a country can implement a combination of monetary frameworks represented by a "dot" inside the triangle.[1]

A high degree of MPI allows monetary authorities to stabilize the economy against shocks, by smoothing output growth and inflation (at least in the short run in a world with price and wage rigidities), playing a lender of last resort function in the event of a banking sector crisis, or monetizing domestic public debt. ERS could provide a nominal anchor or help increase the credibility of monetary authorities particularly when their non-inflationary reputation is low, thereby contributing to more stable output growth (Aizenman, Chinn, and Ito, 2013). However, greater levels of ERS could also rid monetary authorities of a policy choice of using the exchange rate as a tool to absorb external shocks.[2] Financial liberalization can have pros and cons. Theoretically, countries with open financial markets can enjoy efficient resource allocation and risk sharing. However, such countries could be exposed to

[1] See Ito and Kawai (2014a) for details.

[2] Exchange rate rigidities could make policymakers blind in reading appropriate market pricing signals and therefore may make their economies prone to asset boom and bust cycles.

volatile international capital flows and thereby externally driven boom-bust cycles.

Despite the double-edged nature of these three frameworks, monetary authorities tend to show a bias toward their positive aspects and pursue higher levels in all three frameworks. However, in principle, again, they can only achieve the full extent of two frameworks, not all three. An ambitious or inappropriate pursuit of monetary frameworks can lead to economic disruptions. Hence, it would be useful for monetary authorities to clearly understand where their choices are positioned in the trilemma triangle, though this is not always an easy task.

II-2. Measuring the trilemma indexes

Although the concept of the monetary trilemma is fundamental to the field of international finance and macroeconomics, few studies have conducted systematic, quantitative analyses that include all three monetary frameworks simultaneously, because of the lack of metrics that systematically gauge the degree of the three frameworks adopted.

To examine the development of international monetary frameworks of individual economies, Aizenman, Chinn, and Ito (2013) and Ito and Kawai (2014b) developed a metrics of trilemma indexes, separately. Each set of the indexes has its own strengths and limitations.[3] This paper joins these efforts at further developing and improving metrics to describe international monetary frameworks by taking an approach similar to Ito and Kawai (2014b). Naturally, while there are no such things as perfect measures of the three trilemma indexes, the paper attempts to overcome the drawbacks of the previous indexes and capture subtleties of the three monetary frameworks in the trilemma hypothesis.

More specifically, the paper makes major modifications to the measure of ERS. The first modification is to introduce the Kawai-Pontines method for the period when the RMB is considered to play an anchor currency role, for which the conventional Frankel-Wei method does not deliver meaningful results. The reason is that the latter method involves a severe multicollinearity problem when the RMB, which tends to follow the movement of the U.S. dollar, is added to the right-hand side of the Frankel-Wei regression which includes the USD. The Kawai-Pontines method addresses the multicollinearity problem and yields superior and more stable and robust estimates on both the USD and RMB weights in an economy's implicit currency basket than the Frankel-Wei method. Appendix I provides detailed explanations of the Kawai-Pontines method. The second modification is to adopt the RMSE obtained from the Frankel-Wei and/or Kawai-Pontines regression as an indicator of exchange rate stability or flexibility. The RMSE has been proposed by Bleaney and Tian (2020) as a measure of exchange rate stability or flexibility, while Ito and Kawai (2014b) used the adjusted R^2 of the regression as its measure.

Essentially, the degree of ERS is obtained by observing how tightly an economy's exchange rate follows the exchange rate movements of a major anchor currency or a basket of such currencies, including the RMB in addition to the USD, EUR, British pound (GBP),

[3] On the comparisons of these indexes, refer to Ito and Kawai (2014a).

and Japanese yen (JPY). Currencies under fixed exchange rate arrangements are expected to achieve high levels of ERS against an anchor currency (or a basket of anchor currencies), while currencies under freely flexible exchange rate regimes show low levels of ERS. To measure the tightness or looseness of an economy's exchange rate movement with those of major currency exchange rates, the RMSE is obtained from the rolling regressions of the Frankel-Wei and/or Kawai-Pontines estimations.

FMO refers to the degree to which an economy has liberalized capital account transactions and allowed free cross-border mobility of capital. Economies with high levels of FMO naturally hold large amounts of external assets and liabilities, and vice versa. As in the case of Ito and Kawai (2014b), the degree of FMO is defined by the sum of external assets, excluding foreign exchange reserves, and liabilities adjusted for GDP and trade values. In other words, it is a *de facto* measure of FMO, rather than a *de jure* measure such as the one developed by Chinn and Ito (2008).

MPI means the monetary authorities can set policy instruments (such as the short-term interest rate) to pursue their policy objectives like low inflation and stable economic growth. Economies with high degrees of MPI can freely set monetary policy instruments to pursue stable economic growth at low and stable inflation, while economies with low degrees of MPI cannot do so—because of the adoption of fixed exchange rate regimes under free mobility of capital.

In constructing an index for MPI, this paper also follows Ito and Kawai (2014b) and runs several regressions for the domestic short-term interest rate and compares the extent to which the interest rate is explained by domestic factors (the GDP gap, the inflation rate, etc.) and the extent to which it is explained by foreign short-term interest rates. The paper assumes that the higher the degree of the former, the higher the degree of MPI, and vice versa. In other words, economies with high degrees of MPI are judged to be able to set their policy interest rates for the purpose of macroeconomic stabilization in a way similar to the Taylor rule, while economies with low degrees of MPI set policy interest rates in a way linked to foreign interest rates (Shambaugh, 2004, Obstfeld, Shambaugh, and Taylor, 2005). Foreign interest rates are defined as the weighted average of major country interest rates using coefficients on anchor currencies obtained from rolling regression equations of Frankel-Wei or Kawai-Pontines. A more detailed explanation of how to create a measure of MPI is provided in Appendix I.

All the trilemma indexes are defined to range between 0 (lowest degree) and 1 (highest degree). The pursuit of nuanced approaches, however, comes at the expense of a smaller coverage of sample economies. The indexes are available for about 100 economies for the period 1970-2021. Appendix II lists these economies and periods for which data are available.

III. Evolution of the Exchange Rate Arrangements

One of the most useful byproducts of running the Frankel-Wei and Kawai-Pontines regressions is that they provide information on exchange rate arrangements—including information on anchor currencies and measures of exchange rate stability or flexibility—for

each economy and over time where data are available. Using such information, this section discusses the evolution of exchange rate arrangements by identifying major anchor currencies and the degree of ERS for individual economies and computing the size of the major currency zones for the world as a whole and by region over the last half century.

III-1. Anchor currencies and the degrees of ERS

The Frankel-Wei and Kawai-Pontines regression results for all sample economies and all sample years are reported separately in excel format that is available on the web link.[4] The results include the estimated coefficients on the USD, EUR, GBP, JPY, and RMB, standard errors, p-values, and the RMSE of the regression. Each regression is based on monthly observations with a 36-month window. The degree of exchange rate stability or flexibility is identified by the RMSE value. A smaller value for RMSE means a higher explanatory power for the regression, a higher extent to which the target economy's exchange rate is linked to a major anchor currency (or a basket of major currencies), and thus a higher degree of ERS, while a larger value for RMSE means a lower degree of ERS (or a higher degree of exchange rate flexibility). More specifically, an economy's exchange rate regime can be identified as a fixed rate regime if RMSE < 0.01, a managed exchange rate regime if $0.01 \leqq$ RMSE < 0.02, a flexible exchange rate regime if $0.02 \leqq$ RMSE < 0.03, and a highly flexible exchange rate regime if RMSE $\geqq 0.03$.[5]

As examples, Table 1 summarizes regression results for the BRICS countries (Brazil, Russia, India, China, and South Africa) for selected years during 1961-2021. It reports not only the estimated coefficients on anchor currencies but also the values of the RMSE and the ERS index. The ERS index is constructed by normalizing the RMSE so that its maximum value is 1 (complete currency pegging) and the minimum value is zero (complete currency floating).[6]

[4] See the following web link: https://www.mof.go.jp/pri/publication/financial_review/fr_list8/r153/r153_kekka.xlsx

[5] Bleaney and Tian (2020) use 0.02 as the threshold value of RMSE to make a distinction between low volatility and high volatility. This paper uses the same principle and further classifies the low volatility part into fixed and managed regimes and the high volatility part to flexible and highly flexible rate regimes.

[6] See Appendix I for detailed explanations.

Table 1: Frankel-Wei and Kawai-Pontines estimation results for BRICS countries

Country	Year	USD	EUR	GBP	JPY	RMB	RMSE	ERS	ER regime
Brazil	1970	0.430	0.167	-1.396**	1.799	—	0.0097	0.6831	Fixed
	1980	1.005***	-0.123	0.030	0.088	—	0.0164	0.4632	Managed
	1990	1.161**	-1.373	-0.615	1.827**	—	0.0306	0.0000	Highly flexible
	2000	1.110	-0.370	0.161	-0.217	0.316	0.0306	0.0000	Highly flexible
	2010	0.429	-0.041	0.479*	-0.249	0.383*	0.0306	0.0000	Highly flexible
	2020	-0.224	0.558	0.234	-0.197	0.629**	0.0306	0.0000	Highly flexible
	2021	-0.173	0.504	0.014	-0.036	0.690**	0.0306	0.0000	Highly flexible
China	1961	1.000***	0.000	0.000	0.000	—	0.0000	1.0000	Fixed
	1970	1.000***	0.000	0.000	0.000	—	0.0000	1.0000	Fixed
	1980	0.504***	0.400**	0.114	-0.019	—	0.0092	0.6993	Fixed
	1990	0.990***	-0.158	-0.029	0.196	—	0.0172	0.4384	Managed
	2000	0.999***	0.001	-0.001	0.001	—	0.0001	0.9959	Fixed
	2010	0.927***	0.026	0.021	0.027	—	0.0049	0.8400	Fixed
	2020	0.566***	-0.037	0.347**	0.123	—	0.0131	0.5278	Managed
	2021	0.764***	0.089	0.256**	-0.108	—	0.0105	0.6563	Managed
India	1961	0.120	0.015	0.868***	-0.003	—	0.0008	0.9750	Fixed
	1970	0.090	0.009	0.839***	0.062	—	0.0018	0.9420	Fixed
	1980	0.369***	0.047	0.580***	0.004	—	0.0118	0.6129	Managed
	1990	0.824***	0.062	0.325***	-0.211***	—	0.0077	0.7473	Fixed
	2000	0.779***	-0.076	0.151*	0.073*	0.073	0.0087	0.7147	Fixed
	2010	0.508***	0.312**	0.188	-0.001	-0.008	0.0213	0.3037	Flexible
	2020	0.708***	0.053	-0.120	-0.050	0.409***	0.0158	0.4847	Managed
	2021	0.891***	-0.062	-0.020	-0.095	0.286**	0.0134	0.5615	Managed
Russia	2000	1.991**	-0.412	-0.487	0.120	-0.212	0.0306	0.0000	Highly flexible
	2010	0.422**	0.445**	-0.341	-0.049	0.523***	0.0269	0.1192	Flexible
	2020	0.579	-0.673	0.465	-0.087	0.718***	0.0306	0.0000	Highly flexible
	2021	0.624	-0.743	0.285	-0.110	0.944***	0.0306	0.0000	Highly flexible
South Africa	1961	0.075	0.001	0.933***	-0.009	—	0.0007	0.9782	Fixed
	1970	0.272***	0.006	0.777***	-0.055	—	0.0005	0.9826	Fixed
	1980	0.948***	-0.017	0.056	0.013	—	0.0073	0.7620	Fixed
	1990	0.285**	0.524**	0.064	0.127	—	0.0217	0.2910	Flexible
	2000	0.501*	0.240	-0.328	0.125	0.462***	0.0278	0.0898	Flexible
	2010	0.678**	0.929**	0.097	-0.699***	-0.005	0.0306	0.0000	Highly flexible
	2020	-0.256	0.015	0.010	0.037	1.194***	0.0306	0.0000	Highly flexible
	2021	-0.078	-0.004	0.136	-0.033	0.979***	0.0293	0.0418	Flexible

ER = exchange rate; ERS = exchange rate stability; EUR = Euro; GBP = British pound; JPN = Japanese yen; RMB = renminbi; RMSE = root mean squared error; USD = U.S. dollar.

Note: The Frankel-Wei and Kawai-Pontines methods are applied to 1961-1990 and 2000-2021, respectively. EUR refers to DEM (Deutschemark) in 1961-1990. A single asterisk (*), two asterisks (**), and three asterisks (***) indicate that the coefficients are statistically significant at the 10%, 5%, and 1% levels, respectively.

Source: Compiled by authors from their estimations.

Results reveal several interesting points. First, exchange rate arrangements are different across countries and over time. Either a single currency or a basket of currencies is identified as an anchor for exchange rate stabilization or management purposes. Even under flexible or highly flexible exchange rate regimes, anchor currencies are often identified although the degree of anchoring in these cases is loose. Second, the general trend is a shift from fixed exchange rate regimes in early decades, such as 1961-1980, to managed, flexible, or highly flexible rate regimes in recent decades. Indeed, all the BRICS countries, other than China, are under flexible or highly flexible exchange rate regimes in recent years. Third, the USD is the most popular currency used as an anchor, followed by the EUR (or the Deutschemark [DEM] until 1998) and then the GBP, while the use of the JPY has been limited. Fourth, the RMB has been under either fixed or managed exchange rate regimes with the USD as the major anchor currency and is not yet under a flexible exchange rate regime even in the most recent years. Nonetheless, it has emerged rapidly as an exchange rate anchor for many economies, including BRICS countries, since 2000, often in the context of flexible and highly flexible rate regimes.

III-2. Mapping the evolution of the exchange rate arrangements

Figure 2 provides snapshots on the evolution of exchange rate arrangements over the past 50 years by focusing on anchor currencies and the degrees of exchange rate stability (or flexibility) for individual economies in the world.[7] Each economy in the world map is colored based on the anchor currency with the statistically significant, highest estimated weight among those of the major currencies. The USD is shown in blue, the EUR in green, the GBP in orange, the JPY in yellow, and the RMB in red. For example, in the 1975 world map, a number of economies (including Canada, Colombia, Indonesia, Mexico, Nigeria, and Thailand) are colored in dark blue because the estimated USD weight is the highest and the level of the RMSE is low (or the ERS index is high).

In the map, each color is tinted according to the level of the RMSE, which is categorized into three ranges of goodness of fit. An economy with a low RMSE (i.e., a high degree of ERS) is shown in a dark color, while an economy with a high RMSE (i.e., a low degree of ERS) is shown in a light color. More concretely, when the RMSE in a particular year is less than 0.01, the economy is considered as having a high degree of ERS and thus painted with the darkest color.[8] The RMSE greater than 0.02 would be categorized as a low degree of ERS (or a high degree of exchange rate flexibility) and painted with the lightest color. The range in-between ($0.01 < \text{RMSE} \leqq 0.02$) is the intermediate level. Accordingly, economies like Brazil, China, and Egypt are colored in lighter blue, while economies like Australia, Indonesia, and South Africa are col-

[7] Annual data series is created from the estimation results (i.e., the estimated coefficients on major anchor currencies and the estimated RMSE as a measure of goodness of fit) obtained from the 36-month rolling regressions as of December of each year. For example, the results shown in Figure 2 for the year of 1975 are those of the estimation with the sample period of January 1973 through December 1975.

[8] Each major currency country or region itself, i.e., the United States, the Euro Area, the United Kingdom, Japan, or China (which is treated as a non-major currency country until 1998 and is assumed to play a major currency role from 1999) is also painted in the darkest colors, i.e., blue, green, orange, yellow, and red, respectively.

ored in the lightest blue.[9]

Painting each economy with a different color density increases the nuance of the analysis. Researchers who have implemented the Frankel-Wei or Kawai-Pontines method have not incorporated information measured by the goodness of fit. In other words, their approaches do not clarify whether the regression results have sufficiently high explanatory power or not. For example, Ito (2017), Tovar and Nor (2018), Ilzetzki, Reinhart, and Rogoff (2019), Ito and McCauley (2019, 2020), and others apply the Frankel-Wei and/or Kawai-Pontines method to illustrate the development of the "RMB zone." However, they do not study the implications of the explanatory power of the estimating equation, measured by such statistics as the RMSE.

Figure 2 reveals several interesting observations. First of all, the USD has been the most dominant anchor currency in the last five decades. In the aftermath of the collapse of the Bretton Woods system in 1973, major advanced economies have shifted to flexible exchange rate regimes, but many emerging & developing economies, except for some that pegged their exchange rates to former colonial powers' currencies, decided to continue to stabilize their exchange rates against the USD. In the early 1990s, many of the former Soviet Union republics began to adopt the USD as their anchor currency.

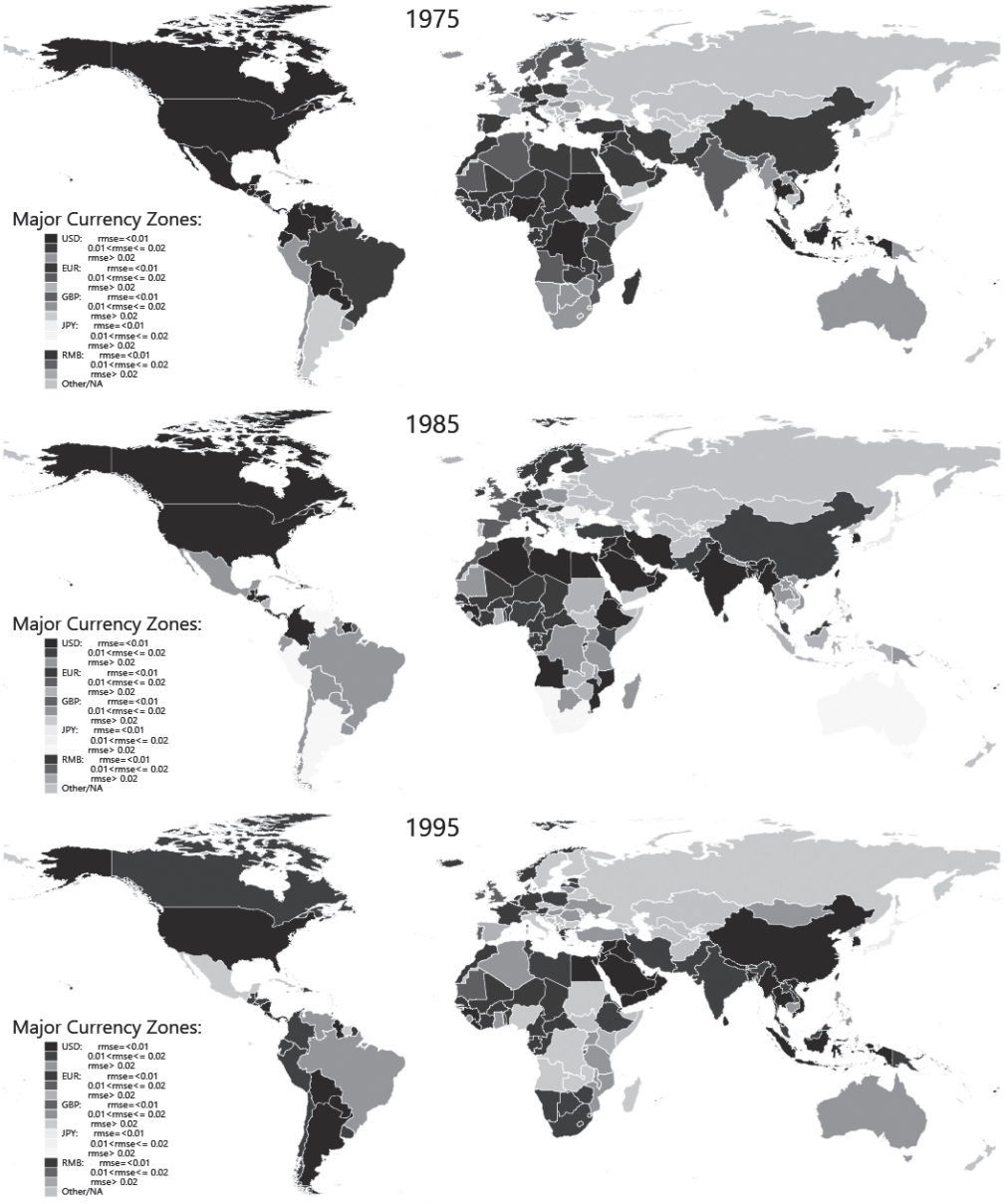
Second, the EUR (or DEM until 1998) solidified its hold in Western Europe and spread eastward in the 1990s and 2000s. Economies in western and central Africa which had pegged their currencies to the French franc began to choose the EUR as their exchange rate anchor. However, outside the Euro Area, its vicinity, and western and central Africa, one does not observe the dominant presence of the EUR. Its sphere of influence is not comparable to that of the USD. This is consistent with what is suggested by other measures on the use of major currencies, such as their shares in trade invoicing, international debt issuance, cross-border banking loans, and central banks' foreign exchange reserves. Roughly speaking, in these different financial assets, the share of the USD is around 50-60% while that of the EUR is around 20-40%.

Third, the number of economies that use the GBP and/or the JPY as an anchor currency have been limited in the last five decades. By the mid-1970s, the number of economies that stabilized exchange rates against mainly the GBP had diminished (Schenk, 2010, Schenk and Singleton, 2015). As of 1975, only Guyana, India, Ireland, and Sierra Leone appeared to assign the highest weight to the GBP among major currencies. As of 2021, there is virtually no economy that does so.

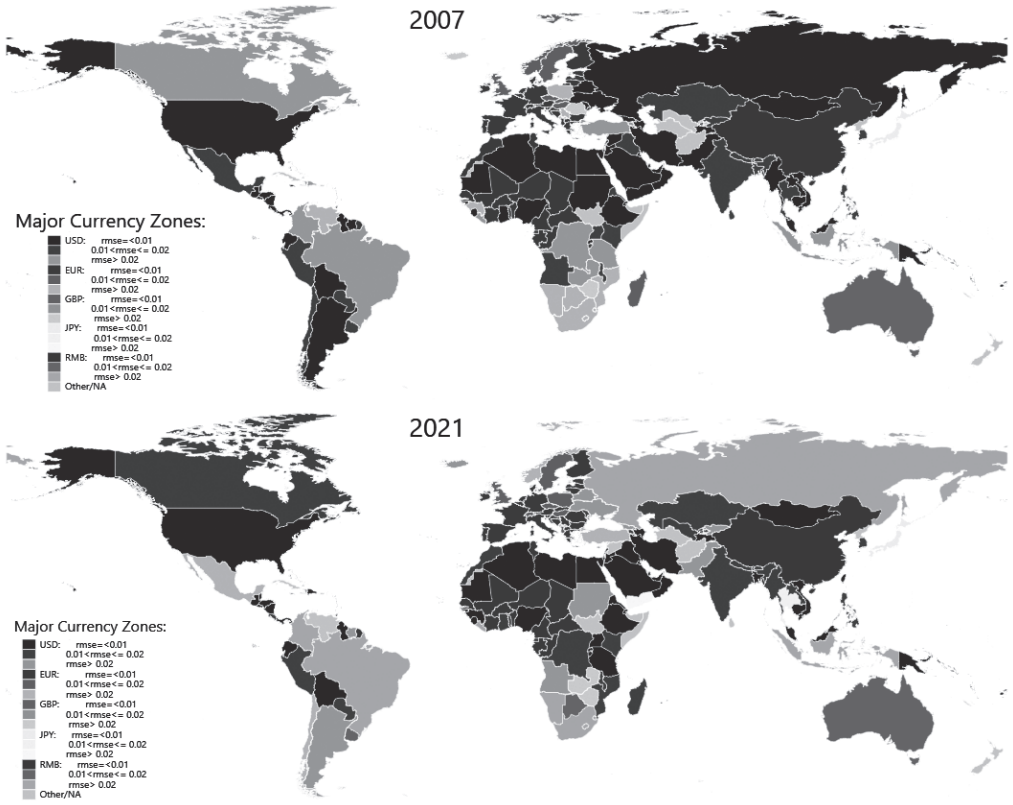
The JPY does not have its own sphere of influence either. In 1985 when the Japanese economy was in its heyday, close to thirty economies (including Iran, Myanmar, Romania, Samoa, Singapore, and Sweden) stabilized their currencies at least partially against the JPY. Especially in Romania, Samoa, and Singapore, the JPY had the highest weights as an anchor among the major currencies. The anchor currency role of the yen has declined since then, and only 20 and 7 economies used the JPY as a partial anchor in 2020 and 2021, respectively. One interesting point is that, in Thailand in 2021, the estimated weight of the JPY

[9] For a color version of the figure, see the following web link: https://www.mof.go.jp/english/pri/publication/pp_review/ppr20_2_2_figures-and-tables.pdf

Figure 2: Evolution of the major currency zones
2A: Currency zones constructed from the Frankel-Wei method: 1975, 1985, and 1995



2B: Currency zones constructed from the Kawai-Pontines method: 2007 and 2021



Note: A color version of the figure is available at a link shown in footnote 9.
Source: Compiled by authors from their estimations.

(0.410) barely exceeded that of the RMB (0.406), and the economy is classified as belonging to the JPY zone. With the value of the RMSE at 0.016, the Thai baht was under a managed exchange rate regime and Thailand is colored with the second darkest yellow. However, the estimated weights on the JPY and RMB are very close to each other, and it is fair to say that Thailand belongs to the JPY and RMB zones to about the same extent.

Fourth, although China is treated as a major currency country from 1999, the maps show only a few economies belong to the RMB zone. Recently, many researchers identified several economies as belonging to the RMB zone. However, most of such economies loosely stabilize their exchange rates against the RMB as indicated by the weak explanatory power of the estimation, i.e., the high values of the RMSE. As of 2021, several economies (including Australia, Botswana, Brazil, Colombia, Indonesia, Russia, and Uruguay) are identified as assigning the highest weights to the RMB as an anchor among the major currencies. However, the RMSEs of these economies are high so that their currencies are not judged to be closely tied to the RMB. If the goodness of fit were not considered, such highly flexible exchange rate countries as Brazil and Russia might be categorized as RMB-zone economies. In determining

which major currency zone an economy belongs to, it is important to factor in how tightly (or loosely) the economy's currency is linked to major currencies.

IV. Major Currency Zones for the World and Developing Economy Regions

IV-1. Computing the size of major currency zones

This section calculates the economic size of currency zones formed by the major currencies (i.e., the USD, EUR, GBP, JPY, and RMB), using the weights on anchor currencies and the magnitude of the RMSE obtained from Frankel-Wei or Kawai-Pontines regressions. The calculation procedures adopted here are basically the same as those of Kawai and Akiyama (1998) with an innovation introduced.[10] First, each major currency country or region (i.e., the United States, the Euro Area, the United Kingdom, Japan, or China) itself is assumed to be the core of a currency zone of its own. However, China is treated as a non-major currency country during 1961-1998 and as a possible major anchor currency from 1999. Second, if an economy rigidly pegs its exchange rate to a particular major currency, its entire economy is classified as belonging to the currency zone formed by this major currency. If an economy stabilizes its exchange rate against a basket of major currencies, the economy is divided into different currency zones according to the estimated currency weights. The coefficients which are estimated to be positive and statistically significant, at least at the 10% level, are interpreted as meaningful weights on major currencies.[11]

An innovation adopted here, beyond the Kawai-Akiyama procedures, is that when an economy stabilizes its exchange rate against a major currency or a currency basket in a tight or loose way, the calculation of the size of currency zones takes into account the degree of ERS. That is, in dividing an economy into different currency zones in accordance with the estimated currency weights, the weights applied now reflect the degree of ERS.

For example, when an economy has a statistically significant and positive weight on a major currency with a very high degree of ERS (i.e., with a very low RMSE), the entire portion of the economy reflected by the currency weight is considered to belong to the major currency zone. When an economy has a significant and positive weight on a major currency with an intermediate degree of ERS, less than the full portion of the economy reflected by the estimated weight is considered to belong to the major currency zone. When an economy has a significant and positive weight on a major currency with a very low degree of ERS (i.e., with a very high RMSE), no portion of the economy reflected by the currency weight is considered to belong to the major currency zone. In this case, the economy is judged as having a highly

[10] At the time of publication of Kawai and Akiyama (1998), however, the RMB was not considered as a major currency and the Kawai-Pontines method was not available.

[11] Furthermore, if the estimated coefficients are negative, they are simply neglected even when statistically significant. If the sum of positive, statistically significant coefficients exceeds unity, they are proportionally re-scaled downward so that the sum of the new weights becomes unity. If the sum of positive, statistically significant coefficients falls short of unity, their values themselves are used as currency weights and the remaining part is considered as a residual, i.e., not belonging to any currency zone.

flexible exchange rate regime, with its own floating zone, and thus does not belong to any major currency zone.

IV-2. Major currency zones: Global analysis

Table 2 reports the estimated size of major currency zones in the world as percentage shares of world GDP. The world is comprised of 150-172 economies depending on the year. Table 2A shows results when the value of ERS (i.e., "tightness" or "looseness" of ERS) is not taken into account, while Table 2B reports results when such a difference is taken into account. In each table, a particular major currency zone is defined as the sum of the major currency country or area itself and the zone formed by other economies, which is the aggregated value across all non-major currency economies.

The difference between Tables 2A and 2B lies in the calculation of major currency zones formed by other (i.e., non-major currency) economies as well as residuals. In Table 2A, the size of each major currency zone formed by other economies is obtained by dividing individual economies into the five currency zones and the residual according to the estimated weights on major currencies, regardless of the magnitude of ERS, and aggregating these values across all economies. A residual is the part of the economy which does not belong to any currency zone.

In Table 2B, the size of each major currency zone formed by non-major currency economies is obtained by considering the magnitude of ERS. More specifically, the weight used for dividing each economy into a major currency zone is the multiple of the estimated currency weight and the ERS. So, an economy that rigidly pegs its exchange rate to a particular major currency with the currency weight of unity is considered to fully belong to the zone formed by this major currency. Economy *j* that assigns statistically significant, positive weights (β_{kj} where *k* refers to a major currency) to particular major currencies *k* (= 1, 2, .., 5) with intermediate levels of ERS is divided into zones formed by such major currencies according to the weights given by β_{kj} * ERS_j. Finally, economies that adopt highly flexible rate regimes are considered not to belong to any major currency zone even when they assign significant and positive weights to particular major currencies. This procedure is arbitrary but a powerful way to capture the different degrees of ERS in calculating the size of currency zones.

Tables 2A and 2B provide the same message qualitatively, but there are some quantitative differences. That is, the economic size of each major currency zone formed by other economies reported in Table 2B is smaller than that in Table 2A, and that the economic size of the residual reported in Table 2B is larger than that in Table 2A. The reason for this difference is that, as Table 2B reports the size of each major currency zone by adjusting for the ERS, it is naturally smaller than in the case of Table 2A. This also means that the residual part which does not belong to any currency zone, in Table 2B, is larger than that in Table 2A. The difference is particularly significant for the RMB zone as many economies which assign significant and positive weights to the RMB in their currency baskets do so in a relatively loose way with low values of ERS.

Table 2: Size of major currency zones, % shares in world GDP

2A. Not adjusted for exchange rate stability or flexibility (measured by ERS)

	World GDP		USD zone			EUR zone			GBP zone			JPY zone			RMB zone			Residual
Year	USD Bill	%	Total	United States	Other	Total	Euro Area	Other	Total	United Kingdom	Other	Total	Japan	Other	Total	China	Other	
1961	1,255	100.0	71.7	44.9	26.8	7.9	6.8	1.1	14.2	6.2	8.0	4.3	4.3	0.0	—	—	—	1.9
1970	2,778	100.0	68.2	38.6	29.6	8.2	7.8	0.4	9.4	4.7	4.7	7.8	7.7	0.1	—	—	—	6.4
1980	10,855	100.0	51.6	26.5	24.9	25.8	8.8	17.1	8.5	5.2	3.3	11.9	10.2	1.7	—	—	—	2.2
1990	21,872	100.0	46.3	27.6	18.2	27.1	8.1	19.0	8.3	5.0	3.3	15.9	14.3	1.6	—	—	—	2.4
2000	33,577	100.0	45.5	31.1	13.5	22.5	18.7	3.8	5.5	5.0	0.5	15.1	14.8	0.3	6.6	3.6	3.0	4.8
2010	66,003	100.0	36.7	23.2	14.2	26.4	19.0	7.3	6.9	3.8	3.1	9.2	8.7	0.5	14.2	9.2	5.0	6.6
2020	84,625	100.0	38.7	25.2	13.1	20.7	15.4	5.3	4.2	3.3	0.9	6.0	6.0	0.3	25.8	17.4	8.5	4.3
2021	95,153	100.0	38.0	24.2	13.9	20.4	15.2	5.2	4.4	3.3	1.0	5.7	5.2	0.5	27.8	18.6	9.2	3.7

2B. Adjusted for exchange rate stability or flexibility (measured by ERS)

	World GDP		USD zone			EUR zone			GBP zone			JPY zone			RMB zone			Residual
Year	USD Bill	%	Total	United States	Other	Total	Euro Area	Other	Total	United Kingdom	Other	Total	Japan	Other	Total	China	Other	
1961	1,255	100.0	70.8	44.9	25.9	7.9	6.8	1.1	14.1	6.2	7.9	4.3	4.3	0.0	—	—	—	2.8
1970	2,778	100.0	67.8	38.6	29.1	8.2	7.8	0.4	9.3	4.7	4.6	7.8	7.7	0.1	—	—	—	7.0
1980	10,855	100.0	44.7	26.3	18.3	20.4	8.8	11.6	7.3	5.2	2.1	11.4	10.2	1.2	—	—	—	16.3
1990	21,872	100.0	39.3	27.3	12.1	23.3	8.1	15.2	7.6	5.0	2.6	14.7	14.3	0.4	—	—	—	15.1
2000	33,577	100.0	37.8	30.5	7.2	21.3	18.7	2.6	5.3	5.0	0.3	15.0	14.8	0.2	4.6	3.6	0.9	16.1
2010	66,003	100.0	29.1	22.8	6.3	21.6	19.0	2.5	4.3	3.8	0.5	8.9	8.7	0.2	9.8	9.2	0.5	26.5
2020	84,625	100.0	34.3	24.7	9.6	18.2	15.4	2.8	3.9	3.3	0.6	6.2	6.0	0.2	19.8	17.4	2.5	17.6
2021	95,153	100.0	34.7	24.2	10.5	18.0	15.2	2.8	4.0	3.3	0.7	5.5	5.2	0.3	21.4	18.6	2.8	16.3

ERS = exchange rate stability; EUR = Euro; GBP = British pound; JPN = Japanese yen; RMB = Chinese renminbi; USD = U.S. dollar.
Note: Each major currency zone includes the major currency country (or area) itself and other economies that assign statistically significant, positive coefficients at the 10% level to that major currency. EUR refers to DEM (Deutschemark) in 1961-1990, and the Euro Area refers to Germany in 1961-1990, the eleven member countries of the Euro Area in 2000, the sixteen members in 2010, and the nineteen members in 2020-2021. China is treated as a non-major currency economy during 1961-1990. Residual is the part that cannot be explained by the identified currency weights and hence is considered to represent a floating regime zone.
Source: Compiled by authors from their estimations.

By focusing on Table 2B, one can make several observations. First, the share of the USD zone was large at around 70% of world GDP in 1961-1970 but has diminished over time by about 35 percentage points to 35% in 2020-2021. The reason is that both the shares of the U.S. economy and other USD-zone economies in the world have declined. Second, the global share of the EUR-zone (the DEM zone until 1998) rose from 1961 to 1990, reaching 23%, as the share of other EUR-zone economies rose, but has gradually declined to 18% in 2020-2021 because the relative shares of both the Euro Area and other EUR-zone economies have decreased. Third, the share of the GBP zone, which was 14% in 1961, has declined as a trend over time, reaching 4% in recent years. Fourth, the share of the JPY zone rose until 2000, reaching 15%, mainly because of the expansion of the Japanese economy, but has diminished since then to 6% in 2020-2021 due to the continuous shrinkage of the global share of the Japanese economy. The share of other JPY-zone economies, which recorded 1% in 1980, has also declined. Fifth, in contrast, the share of the RMB zone has increased persistently over time, reaching more than 20% of the global economy in 2021, because of the sustained expansion of the Chinese economy and other RMB-zone economies. The RMB zone is now the second largest after the USD zone, followed by the EUR, JPY, and GBP zones. Finally, the share of the residual, i.e., the global economy that does not belong to any major currency zone, increased from 3% in 1961 to 26% in 2010 and has remained 16-18% in recent years.

In summary, the economic share of the USD zone has declined noticeably since the breakdown of the Bretton Woods system, because the share of the EUR zone (the DEM zone until 1998) expanded up to around 1990 (and then began to decrease), the share of the JPY zone expanded until around 2000 (and then contracted), and the share of the RMB zone has increased in recent years. The RMB now complements the anchor currency role played by the USD, EUR, GBP, and JPY. Nonetheless, the USD zone remains the most dominant currency zone, accounting for 11% of non-major currency economies' GDP, well above the shares of those of the RMB and EUR zones (both 3%). In addition, the global economic share of a zone that does not belong to any major currency zone and adopts a freely flexible rate regime expanded rapidly until 2010, has since declined slightly, but has remained high at 17-18% in recent years.

IV-3. Major currency zones: Analysis by economy group

This subsection compares and examines the size of major currency zones in advanced economies and emerging market & developing economies, as well as for various regions of the latter economies. Table 3 summarizes the results with and without adjustment for the ERS. Information in this table differs from that in Table 2, as it does not include any major currency country or region (i.e., the U.S., the Euro Area, the U.K., Japan, or China).[12] In other words, the major currency zones in this table refer only to those formed by non-major currency economies.

[12] As in Table 2, China is treated as a non-major currency economy during 1961-1998 and is assumed to play a major anchor currency role from 2000.

Table 3: Size of the major currency zones by income and region, % shares in GDP

3A. All non-major currency economies, excluding China after 2000

	GDP	Not adjusted for exchange rate stability/flexibility							Adjusted for exchange rate stability/flexibility						
Year	USD Bill	Total	USD	EUR	GBP	JPY	RMB	Res.	Total	USD	EUR	GBP	JPY	RMB	Res.
1961	477	100.0	70.7	3.0	21.2	0.1	—	5.0	100.0	68.5	3.0	20.9	0.1	—	7.5
1970	1,149	100.0	71.7	1.0	11.4	0.3	—	15.5	100.0	70.7	1.0	11.1	0.3	—	16.9
1980	5,399	100.0	51.0	34.4	6.7	3.4	—	4.4	100.0	37.0	23.5	4.3	2.4	—	32.8
1990	9,969	100.0	42.1	42.0	7.3	3.4	—	5.2	100.0	26.6	33.5	5.8	0.8	—	33.3
2000	9,301	100.0	54.6	14.0	2.0	1.0	11.0	17.4	100.0	26.4	9.5	1.2	0.6	3.5	58.9
2010	24,382	100.0	38.2	20.1	8.5	1.4	13.8	18.1	100.0	17.2	7.0	1.3	0.5	1.5	72.6
2020	28,246	100.0	42.1	15.9	2.7	1.0	25.4	12.9	100.0	28.7	8.4	1.9	0.7	7.4	52.9
2021	31,805	100.0	41.5	15.4	3.0	1.6	27.5	11.0	100.0	31.5	8.3	2.0	0.9	8.4	48.8

3B. Advanced economies, excluding the US, the Euro Area, the UK, and Japan

	GDP	Not adjusted for exchange rate stability/flexibility							Adjusted for exchange rate stability/flexibility						
Year	USD Bill	Total	USD	EUR	GBP	JPY	RMB	Res.	Total	USD	EUR	GBP	JPY	RMB	Res.
1961	279	100.0	71.0	5.2	18.4	0.0	—	5.4	100.0	69.4	5.1	18.4	0.0	—	7.0
1970	662	100.0	75.8	0.5	7.8	0.0	—	16.0	100.0	74.1	0.5	7.8	0.0	—	17.7
1980	2,987	100.0	27.0	55.2	6.8	5.4	—	5.7	100.0	17.4	36.8	4.6	3.7	—	37.5
1990	6,379	100.0	26.4	60.1	9.3	0.7	—	3.5	100.0	16.5	49.0	7.3	0.6	—	26.6
2000	3,486	100.0	49.9	22.1	2.5	0.6	16.1	9.0	100.0	19.2	15.6	1.2	0.5	7.1	56.4
2010	7,131	100.0	20.0	28.1	15.6	2.1	18.8	15.4	100.0	6.9	11.2	2.2	0.5	2.3	76.9
2020	8,658	100.0	36.1	19.9	6.9	3.1	25.4	8.7	100.0	24.4	12.5	4.6	2.2	13.5	42.8
2021	9,983	100.0	31.6	16.7	6.6	2.5	29.8	12.8	100.0	22.5	12.3	4.4	1.8	16.3	42.6

3C. Emerging and developing economies, excluding China after 2000

	GDP	Not adjusted for exchange rate stability/flexibility							Adjusted for exchange rate stability/flexibility						
Year	USD Bill	Total	USD	EUR	GBP	JPY	RMB	Res.	Total	USD	EUR	GBP	JPY	RMB	Res.
1961	199	100.0	70.4	0.0	25.0	0.3	—	4.3	100.0	67.2	0.0	24.5	0.2	—	8.1
1970	487	100.0	66.2	1.8	16.4	0.6	—	14.9	100.0	66.0	1.7	15.7	0.6	—	15.9
1980	2,412	100.0	81.1	8.5	6.6	1.0	—	2.8	100.0	61.6	6.8	3.9	0.7	—	27.0
1990	3,590	100.0	70.5	9.2	3.6	8.3	—	8.4	100.0	44.9	5.5	3.0	1.2	—	45.3
2000	5,815	100.0	57.5	9.0	1.7	1.3	7.9	22.6	100.0	30.8	5.7	1.2	0.7	1.2	60.4
2010	17,251	100.0	45.9	16.8	5.5	1.1	11.6	19.2	100.0	21.5	5.2	0.9	0.4	1.1	70.8
2020	19,588	100.0	44.8	14.2	0.8	0.0	25.4	14.8	100.0	30.6	6.6	0.6	0.0	4.7	57.4
2021	21,822	100.0	46.0	14.8	1.4	1.2	26.4	10.2	100.0	35.6	6.5	0.9	0.6	4.8	51.7

3Da. Emerging and developing Asia, excluding China after 2000

	GDP	Not adjusted for exchange rate stability/flexibility							Adjusted for exchange rate stability/flexibility						
Year	USD Bill	Total	USD	EUR	GBP	JPY	RMB	Res.	Total	USD	EUR	GBP	JPY	RMB	Res.
1961	105	100.0	61.3	0.0	33.3	0.5	—	4.9	100.0	60.7	0.0	32.5	0.4	—	6.4
1970	188	100.0	54.8	0.4	29.7	0.0	—	15.1	100.0	54.8	0.4	27.9	0.0	—	16.8
1980	580	100.0	56.0	15.1	22.1	0.9	—	5.8	100.0	44.2	10.6	13.0	0.7	—	31.6
1990	1,032	100.0	86.8	1.1	9.3	1.2	—	1.7	100.0	58.3	0.4	8.0	1.1	—	32.3
2000	1,071	100.0	48.6	0.2	6.6	3.4	3.0	38.2	100.0	29.9	0.1	4.7	2.4	0.5	62.4
2010	3,672	100.0	46.5	16.2	0.5	2.2	10.6	23.9	100.0	20.7	5.4	0.3	1.3	1.2	71.0
2020	5,945	100.0	59.9	0.5	0.0	0.1	31.6	7.8	100.0	36.8	0.5	0.0	0.0	14.5	48.1
2021	6,565	100.0	58.5	0.3	0.1	3.2	32.5	5.5	100.0	43.1	0.3	0.1	1.5	14.5	40.6

3Db. Emerging and developing Europe

	GDP	Not adjusted for exchange rate stability/flexibility							Adjusted for exchange rate stability/flexibility						
Year	USD Bill	Total	USD	EUR	GBP	JPY	RMB	Res.	Total	USD	EUR	GBP	JPY	RMB	Res.
1961	8	100.0	100.0	0.0	0.0	0.0	—	0.0	100.0	100.0	0.0	0.0	0.0	—	0.0
1970	17	100.0	100.0	0.0	0.0	0.0	—	0.0	100.0	100.0	0.0	0.0	0.0	—	0.0
1980	198	100.0	98.6	0.7	0.5	0.2	—	0.0	100.0	59.4	0.6	0.4	0.2	—	39.5
1990	319	100.0	71.0	20.2	0.7	0.2	—	8.0	100.0	27.1	10.4	0.6	0.1	—	61.7
2000	1,036	100.0	49.9	36.3	0.4	0.1	9.6	3.8	100.0	12.7	20.0	0.3	0.1	3.4	63.5
2010	3,558	100.0	29.0	37.6	7.0	0.3	16.7	9.3	100.0	2.3	18.5	0.0	0.0	2.9	86.4
2020	3,669	100.0	4.7	32.1	1.1	0.0	40.2	21.9	100.0	0.4	25.1	0.7	0.0	0.0	73.7
2021	4,279	100.0	4.5	31.2	1.2	0.0	41.4	21.7	100.0	0.6	23.4	0.8	0.0	0.3	74.9

3Dc. Latin America and the Caribbean

	GDP	Not adjusted for exchange rate stability/flexibility							Adjusted for exchange rate stability/flexibility						
Year	USD Bill	Total	USD	EUR	GBP	JPY	RMB	Res.	Total	USD	EUR	GBP	JPY	RMB	Res.
1961	39	100.0	94.7	0.0	3.9	0.0	—	1.4	100.0	93.1	0.0	4.0	0.0	—	3.0
1970	163	100.0	72.3	0.0	1.6	0.0	—	26.1	100.0	72.0	0.0	1.6	0.0	—	26.4
1980	745	100.0	98.1	0.2	0.0	1.4	—	0.3	100.0	71.2	0.2	0.0	0.8	—	27.8
1990	1,043	100.0	58.8	0.0	0.6	23.6	—	17.0	100.0	30.6	0.0	0.4	0.5	—	68.5
2000	2,188	100.0	57.9	0.0	0.0	0.2	10.5	31.5	100.0	27.6	0.0	0.0	0.0	0.9	71.5
2010	5,171	100.0	31.9	2.5	11.7	0.0	16.5	37.4	100.0	10.6	0.1	2.4	0.0	0.1	86.9
2020	4,288	100.0	17.4	29.8	0.0	0.0	26.9	25.9	100.0	13.1	1.8	0.0	0.0	0.3	84.9
2021	4,962	100.0	24.9	32.1	0.0	0.4	27.5	15.0	100.0	14.1	2.5	0.0	0.3	0.5	82.5

3Dd. Middle East and Central Asia

	GDP	Not adjusted for exchange rate stability/flexibility							Adjusted for exchange rate stability/flexibility						
Year	USD Bill	Total	USD	EUR	GBP	JPY	RMB	Res.	Total	USD	EUR	GBP	JPY	RMB	Res.
1961	20	100.0	67.6	0.0	20.3	0.0	—	12.0	100.0	67.3	0.0	20.3	0.0	—	12.4
1970	61	100.0	85.8	0.5	7.6	5.3	—	0.8	100.0	85.6	0.5	7.4	5.3	—	1.2
1980	612	100.0	84.7	9.5	1.3	0.8	—	3.7	100.0	74.6	7.9	1.1	0.7	—	15.6
1990	865	100.0	76.8	14.6	2.6	4.0	—	2.1	100.0	65.9	9.4	2.0	2.9	—	19.7
2000	1,128	100.0	82.4	8.1	1.9	3.0	1.6	3.0	100.0	65.2	6.6	1.5	1.2	0.1	25.3
2010	3,536	100.0	83.0	10.1	1.5	2.5	0.5	2.5	100.0	65.4	7.1	0.8	0.5	0.3	25.9
2020	4,069	100.0	83.2	1.9	3.0	0.1	1.6	10.1	100.0	61.5	1.3	2.4	0.1	0.7	34.0
2021	4,672	100.0	90.0	1.2	5.2	0.6	1.0	2.0	100.0	82.6	1.0	3.3	0.1	0.6	12.5

3De. Sub-Saharan Africa

	GDP	Not adjusted for exchange rate stability/flexibility							Adjusted for exchange rate stability/flexibility						
Year	USD Bill	Total	USD	EUR	GBP	JPY	RMB	Res.	Total	USD	EUR	GBP	JPY	RMB	Res.
1961	27	100.0	64.2	0.0	33.4	0.0	—	2.3	100.0	45.8	0.0	32.7	0.0	—	21.5
1970	57	100.0	56.4	13.2	29.1	0.0	—	1.3	100.0	56.4	12.3	29.1	0.0	—	2.2
1980	277	100.0	68.0	20.3	7.2	1.1	—	3.4	100.0	46.1	18.7	4.2	0.9	—	30.2
1990	332	100.0	40.5	40.1	0.7	0.8	—	17.9	100.0	14.7	24.4	0.5	0.5	—	59.8
2000	392	100.0	33.6	14.0	0.1	0.8	19.5	31.9	100.0	7.7	12.7	0.1	0.4	1.8	77.3
2010	1,314	100.0	54.4	34.3	0.3	0.4	8.8	1.8	100.0	11.3	11.7	0.0	0.3	2.4	74.3
2020	1,618	100.0	56.5	13.1	0.1	0.0	23.8	6.5	100.0	46.2	13.0	0.1	0.0	0.7	39.9
2021	1,344	100.0	41.2	17.8	0.3	0.0	33.1	7.6	100.0	26.4	17.8	0.2	0.0	12.0	53.7

EUR = Euro; GBP = British pound; JPY = Japanese yen; Res. = residual: RMB = renminbi; USD = U.S. dollar.
Note: Each major currency zone here includes only part of those economies that assign statistically significant, positive coefficients at the 10% level to that major currency. EUR refers to DEM (Deutschemark) in 1961-1990. The Euro Area refers to Germany in 1961-1990, the eleven member economies of the Euro Area in 2000, the sixteen members in 2010, and the nineteen members in 2020-2021. China is treated as a non-major currency economy during 1961-1990 and a major currency country. As a result, GDP in the table (shown in 3A-3C and 3Da) includes China's GDP during 1961-1990 but excludes it during 2000-2021. Residual is the part that cannot be explained by the identified currency weights and hence is considered to represent a floating regime zone.
Source: Compiled by authors from their estimations.

Table 3A reports results for all non-major currency economies, excluding the U.S., the Euro Area, the U.K., Japan, and China (excluding China after 2000). It shows that the size of the USD zone used to be dominant in 1961-1970, accounting for more than 70% of these economies, but has declined over time to 41% (without adjustment for ERS) or 31% (with such adjustment) in recent years. This share is still the largest, followed by those of the RMB and EUR zones. An interesting observation is that the recent RMB-zone share is high at 27% without adjustment for ERS, while it is much smaller at 8% with such adjustment. This suggests that economies that select the RMB as an exchange rate anchor do not necessarily pur-

sue high degrees of currency stabilization.

Another interesting observation is that the residual is much larger with ERS adjustment than without. For example, the share of the residual used to be only 5% (without adjustment for ERS) or 7% (with adjustment) in 1961, began to rise over time to 18% (without adjustment) or 73% (with adjustment) in 2010 and has since declined to 11% (without adjustment) or 48% (with adjustment) in the most recent year. In other words, the share of the economy adopting freely floating exchange rates, measured as the residual, increased from the time of the collapse of the Bretton Woods system until the global financial crisis, and although it declined somewhat thereafter, it still maintains a high share. The global share of the freely flexible rate zone among non-major currency economies, which is close to 50% in recent years when adjusted for ERS, may be surprisingly high.

These basic observations carry over to the remainder of Table 3, but there are some differences in results across economy groups classified by income and region. The following discussion focuses on the ERS-adjusted case for comparative analysis.

Comparison of results for advanced economies (reported in Table 3B) with those for emerging & developing economies (reported in Table 3C) reveals some interesting differences. First, during the period 1961-1970, the share of the USD zone in advanced economies was higher than that in emerging & developing economies, but since 1980, the USD zone share in emerging & developing economies has been higher. Second, the shares of the EUR and RMB zones are generally higher in advanced economies than in emerging & developing economies. Third, the share of the residual is generally higher in emerging & developing economies than in advanced economies, with some exceptions. This suggests that emerging & developing economies tend to have higher degrees of exchange rate flexibility than advanced economies. However, at the time of the global financial crisis of 2010, advanced economies preferred greater exchange rate flexibility, as indicated by the high share of the residual in group GDP.

In the emerging & developing world, some clear differences across regions can be observed (Table 3D). In emerging & developing Asia, the share of the USD zone has been persistently high with a declining trend and still maintains a relatively high level of 43% in 2021. The share of the RMB zone is highest in Asia among all regions, recording 14% in 2021. In emerging & developing Europe, the share of the USD zone was very high (59% to 100%) in 1961-1980, but fell sharply after 1990, and was overtaken by the share of the EUR zone, which has become the largest currency zone in the region, accounting for 23% (with the residual accounting for 75%) in 2021. In Latin America and the Caribbean (LAC), the share of the USD zone was also very high at over 70% in 1961-1980, but has declined since 1990, reaching 14% in 2021. Other currency zone shares are very small, indicating a large size of the residual in the region. In the Middle East and Central Asia, the share of the USD zone has remained consistently very high, recording 83% in 2021. In Sub-Saharan Africa, the share of the USD zone was high at 46-56% in 1961-1980, and although it has declined since then, it has been relatively high, registering 26% in recent years. In the early years, the share of the GBP zone was relatively large in the region, but since 1990 it has declined sharply and been replaced by the share of the EUR zone, which reached 18% in recent years. The RMB zone is

also increasing its presence, with a 12% share in 2021.

The size of the residual is largest in LAC followed by Europe while it is smallest in the Middle East and Central Asia. This suggests that emerging & developing economies in LAC and Europe pursue relatively high degrees of exchange rate flexibility, while economies in the Middle East and Central Asia prefer relatively high degrees of ERS. The degrees of ERS in Sub-Saharan Africa and Asia are in-between those of the above two regional groups.

To summarize, the global share of the USD zone is trending downward following the emergence of the EUR and the recent rapid rise of the RMB. Nevertheless, the USD zone remains the world's largest currency zone, particularly in emerging & developing regions such as the Middle East and Central Asia and Asia since 1980. The share of the EUR zone is relatively large in advanced economies, having exceeded the share of the USD zone during 1980-2010 (but falling behind the USD-zone share later in 2020-2021). The EUR-zone share has been largest in emerging & developing Europe since 2000 and second largest in Sub-Saharan Africa. The share of the RMB zone has become comparable to the EUR-zone share globally in recent years and surpassed the latter in advanced economies since 2010. In Asia where the USD zone remains dominant has the largest RMB-zone share among all regions in 2020-2021. The residual part of the world economy, which does not belong to any major currency zone and is judged to adopt freely flexible exchange rates, has been expanding mainly in emerging & developing regions, especially in LAC and Europe.

V. Evolution of the Trilemma Regimes

As explained in Section II, trilemma indexes are constructed based on the methodology explained in Appendix I for more than 100 economies for which data are available. This section examines how the combinations of trilemma indexes—which define trilemma regimes—in these economies have evolved over time. This analysis helps to further understand the changing nature of the international monetary system over the past 50 years.

V-1. General trends of the trilemma indexes

It is useful to first describe the general trend of the estimated trilemma indexes. Figure 3 illustrates the average values of the three trilemma indexes for advanced economies, emerging market & middle-income economies (EMMIEs), low-income economies(LIEs), and the Association of Southeast Asian Nations (ASEAN) countries.[13] A few points need to be kept in mind when creating the trilemma indexes. The indexes of ERS for the Euro Area, the U.K., Japan, and China are constructed using the RMSE obtained from the Frenkel-Wei regressions of the EUR, GBP, JPY, and RMB rates on the USD rate (in the case of the RMB, the EUR,

[13] The groupings of "advanced economies," "emerging market & developing economies," and "low-income countries" are based on the IMF's classification. ASEAN countries include Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam, but Lao PDR is not analyzed here due to the lack of relevant data. See Appendix II for the list of sample economies and their categorization.

GBP, and JPY rates are also added to the USD rate on right-hand side of the regression). Thus, the ERS is a common value for the Euro Area member countries. In addition, the index of MPI for each Euro Area member country is constructed by judging whether the short-term euro interest rate (common to all member countries) can be better explained by the domestic factors (GDP gap, inflation rate, etc.) of each country or the USD short-term interest rate. The indexes of FMO for the major currency countries are constructed similarly to those of other economies.

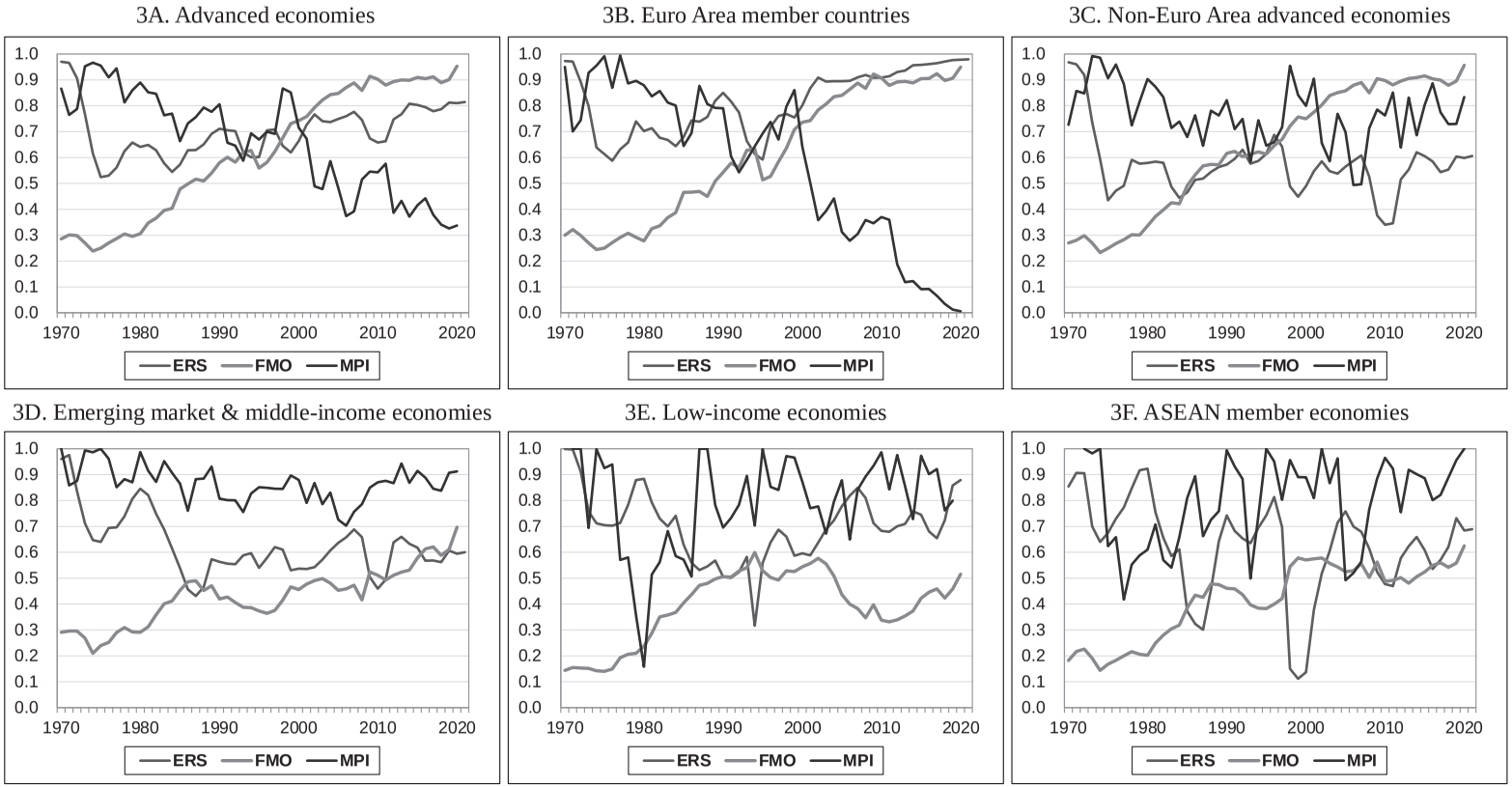
Figure 3A shows that advanced economies have achieved a high level of FMO over time. It started from a low level in the 1970s and early 1980s, rose afterward, and reached a very high level in the 2000s. In the 1970s, advanced economies adopted a trilemma combination of relatively high levels of ERS and MPI and a low level of FMO. Over time, they have shifted to another trilemma combination of a relatively high level of ERS and a high degree of FMO with a low level of MPI. This combination is surprising for advanced economies, but this is largely due to the fact that the Euro Area member countries maintain rigid intraregional ERS (through the adoption of a common currency) and a high degree of FMO by abandoning MPI (Figure 3B). On the other hand, advanced economies outside the Euro Area have adopted a trilemma combination of a low degree of ERS, a high degree of FMO, and a relatively high level of MPI (Figure 3C).

EMMIEs have consistently maintained relatively high levels of MPI while steadily increasing FMO and maintaining some degree of ERS (Figure 3D). The ERS was at a relatively high level in the 1970s, declined in around 1980, and has remained at intermediate levels since then. In the 1970s, the FMO was at a low level, almost the same level as that of the advanced economy group, but it did not rise as rapidly as that of the advanced economies afterward, reaching only the intermediate level in recent years. Nonetheless, the MPI has been persistently high, especially at a level comparable to or higher than that of the non-Euro Area advanced economies.

LIEs have restored relatively high levels of ERS since the 2000s, after experiencing declining stability in the 1980s and 1990s, and maintained relatively high levels of MPI by limiting a rise in FMO (Figure 3E). In recent years, the ERS has been higher and the FMO has been lower than in EMMIEs, as the latter declined from around 2000 to 2010 and has not recovered sufficiently since then. Interestingly, the MPI declined sharply in around 1980, but has since recovered and remains at a relatively high level.

The trilemma indexes for the ASEAN group show a relatively similar pattern to that of the EMMIE group, except for the sharp drop in the ERS index in the mid-1980s and late 1990s (Figure 3F). The ERS in ASEAN countries has shown large ups and downs with a gradual declining trend over the past 50 years, and has remained at an intermediate level with an upward trend for the past decade. The FMO rose in two phases in the mid-1980s and in the late 1990s, then stopped rising and has hovered at intermediate levels in recent years. ASEAN member economies, unlike LIEs, have not reversed the level of FMO even in the aftermath of the Asian and global financial crises. Nevertheless, the FMO lags far behind that for advanced economies, suggesting that there is room for further financial opening. Al-

Figure 3: Trilemma indexes by economy group



ERS = Exchange rate stability; FMO = Financial market openness; MPI = Monetary policy independence.
Note: The groupings of "advanced economies," "emerging market and middle-income economies," and "low-income economies" are based on the IMF's classification. Appendix II lists the sample economies and categorization.
Source: Complied by authors from their estimations.

though the index for MPI exhibits greater fluctuations than that for the EMMIE group, it has achieved a level higher than those for this group and the advanced economy group, implying that ASEAN has been strengthening its MPI to stabilize the economy.

V-2. Analysis using the trilemma triangle

The most intuitive way to illustrate the evolution of trilemma combinations for an economy is to plot them in a trilemma triangle and see how they move over time, as is done in Figure 4. No previous literature, except the current authors' work such as Ito and Kawai (2014b, 2021), has plotted the combination of the three indexes in a trilemma triangle.

Figure 4A plots the trilemma combinations in equilateral trilemma triangles for different economy groups for three five-year periods: 1986-1990, 2001-2005, and 2016-2020. Each point in the triangles represents the average value for the five years indicated. Economies are classified into three groups, i.e., advanced economies, EMMIEs, and LIEs. In order to plot the trilemma combination in an equilateral triangle with a height of 1, the sum of the three trilemma indexes must equal two. As the constructed indexes do not always sum up to two, an adjustment is made so that the sum of the three adjusted indexes is exactly equal to two.[14] Several interesting observations can be made.

With regard to advanced economies, while various combinations of trilemma indexes are observed in the late 1980s and early 2000s, they shifted to exhibit higher degrees of financial market opening in the late 2010s. Advanced economies can be classified into three types. The first type, mainly made up of Euro Area members, seeks to achieve the "financially open fixed rate" corner with high levels of ERS and FMO. The second type, including Iceland, Japan, Norway, and the U.K., pursues the "flexible exchange rate" corner with a low degree of ERS and high degrees of FMO and MPI. The third type, consisting of Czech Rep., Israel, and Singapore, sets the three indexes at intermediate levels and does not aim for any corner. Interestingly, several advanced economies used to achieve the remaining "financially closed fixed rate" corner with high levels of ERS and MPI in the early years, but has moved away from such a corner in recent years.

EMMIEs allow varying levels of ERS with lower FMO and greater MPI than advanced economies. Looking at the first half of the 2000s, EMMIEs can be broadly divided into two types. The first type consists of economies that maintain high levels of MPI under varying degrees of ERS and FMO. The second type achieves the "financially closed fixed rate" corner, or close to it, with relatively high levels of ERS and MPI and a limited degree of FMO. In the second half of the 2010s, all types of economies generally reduced ERS and increased FMO. Several economies especially within the first type, including Argentina, Brazil, Mexico, Russia, South Africa, and Turkey, have moved towards the "flexible exchange rate" corner. A few economies, such as Algeria, Guatemala, Morocco, and Romania, still adopt the "financially closed

[14] Essentially, as the sum of the three indexes can be expressed as $ERS_{it} + FMO_{it} + MPI_{it} = 2B_{it}$, the adjusted indexes are obtained by dividing the original indexes by B_{it}, where subscript i refers to an economy and t a year.

fixed rate" corner.

The combinations of trilemma indexes in LIEs differ from those in advanced economies and EMMIEs. LIEs have not opened up their financial markets as much as advanced economies and appear to value ERS more highly than EMMIEs. In addition, although they tend to maintain relatively high levels of MPI, their levels are as high as those in EMMIEs. As a result, they are generally positioned close to the traditional "financially closed fixed rate" corner throughout the periods. In the late 1980s, there was an economy in the "flexible exchange rate" corner (Nigeria), but since the 2000s there has been no such economy. Moreover, there is no LIE in the "financially open fixed rate" corner.

Figure 4B illustrates the trilemma combinations of several regional groups for the emerging and developing world (including both middle- and low-income economies), each for the three periods of 1986-1990, 2001-2005, and 2016-2020.[15]

Economies in East Asia and the Pacific are quite diverse in trilemma combinations. For comparative purposes, trilemma combinations for advanced economies (Australia, Hong Kong, Japan, Rep. of Korea, Singapore, and Taiwan) are also plotted here. Emerging and developing economies in the region seek varying levels of ERS, FMO, and MPI. The ASEAN economies, in particular, are mostly positioned in the middle of the triangle. In contrast, Japan, China, and Hong Kong have realized three different corners. Japan has achieved the "flexible exchange rate" corner, China has achieved the "financially closed fixed rate" corner,[16] and Hong Kong has achieved the "financially open fixed rate" corner. Interestingly, however, in the recent period (2016-2020), both China and Hong Kong have moved away from their respective corners towards the middle of the triangle.[17]

Economies in Europe and Central Asia, mostly comprised of the former socialist economies, including the former Soviet Union republics, have experienced the most drastic transformation of open macroeconomic policy frameworks since their economic transition. As of the early 2000s, most economies in the region limited FMO, which is not surprising given the fact that many of them were formerly under central planning.[18] As of the latest period (2016-2020), economies in the region can be classified into three types. One type, including Georgia, Kazakhstan, Russia, Turkey, and Ukraine, has adopted the "flexible exchange rate" corner. The second type, including Estonia, Latvia, Lithuania, and Slovenia, has achieved the "financially open fixed rate" corner by opening financial markets and pursuing currency stabilization against the euro or participation in the Euro Area. The third type, including Czech Rep. and Hungary, maintains the middle ground by achieving some intermediate degrees of ERS, FMO, and MPI.

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[15] Regional classifications here rely on those of the World Bank.

[16] China's trilemma indexes are available only from 1992 due to data limitations.

[17] In the latest period (2016-2020), Hong Kong maintains high degrees of both ERS and FMO (values of 0.96 and 1.00, respectively) while achieving a high degree of MPI (value of 0.66). This may suggest that the Hong Kong Monetary Authority is trying to defy the trilemma constraint. By adjusting all three indexes so that their sum becomes 2, Hong Kong's position turns out to be closer to the middle ground than to the no-monetary independence corner.

[18] The trilemma combinations for these former socialist economies in Europe and Central Asia are not shown in the trilemma triangle for the 1986-1990 period due to the lack of data.

Some economies in LAC already had relatively low levels of ERS early in the sample period. In the early 2000s, economies in the region tended to retain MPI with varying degrees of ERS. In the latest period, economies can be divided into two types. One type, including Argentina, Brazil, Chile, Colombia, Mexico, and Uruguay, chooses the "flexible exchange rate" corner, and the other type, including Costa Rica, Ecuador, and Peru, selects the "middle ground."

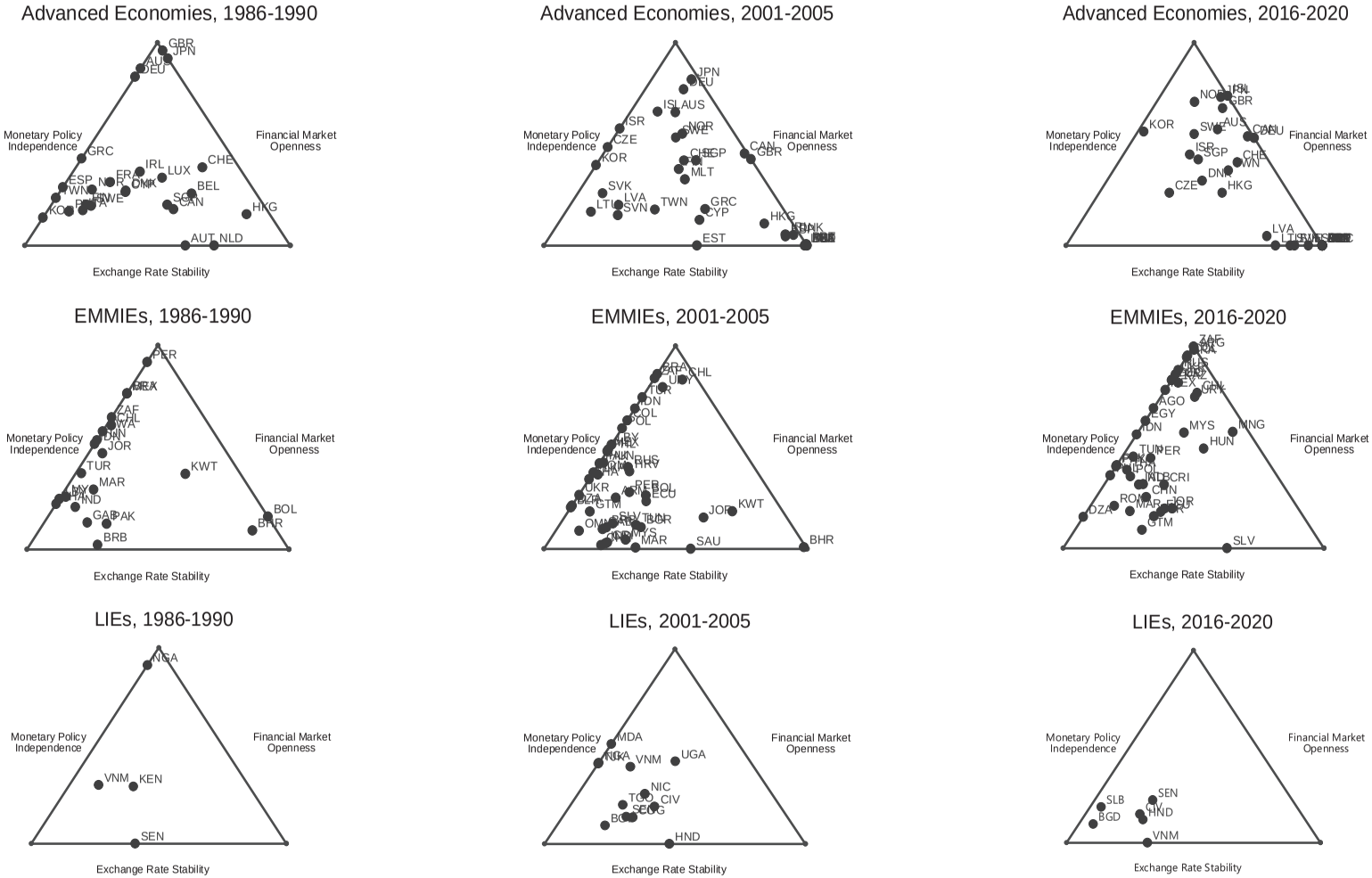
The Middle East and North Africa (MENA), South Asia, and Sub-Saharan Africa regions have small sample sizes that make it difficult to draw general conclusions, although some similarities and differences can be observed among these regions. One similarity is that most of the plotted points are located in areas with a relatively high degree of MPI and a relatively low degree of FMO. Thus, virtually no economy in these regions is located in the "financially open fixed rate" corner of the triangle. One difference is that many economies in the MENA adopted high levels of ERS with varying degrees of FMO during the early 2000s (but some reduced the level of ERS in the late 2010s). Another difference is that at least one economy in Sub-Saharan Africa (South Africa) has maintained the "flexible exchange rate" corner since the 2000s, but as far as the available data shows, there is no such economy in the other two regions.

Figure 4C illustrates the evolution of trilemma combinations for selected Asian economies once in every five years over the period 1975-2020. Each point represents the average value for the past five years, including the year indicated. The general trend is that the trilemma combinations have moved away from the "financially closed fixed rate" corner (except for Hong Kong and Singapore which started from different points) over time by making exchange rates more flexible and opening financial markets. The ASEAN economies have reduced the levels of ERS and maintained relatively high degrees of MPI after the Asian currency crisis but, apart from Singapore, they are yet to achieve high levels of FMO.

Asia's largest economies, China and Japan, have followed very different trilemma combination trajectories. China has long maintained the "financially closed fixed rate" corner, by seeking high levels of ERS and MPI while limiting FMO. Since the global financial crisis, however, China seems to have moved toward the "middle ground," with deliberate decreases in ERS and increases in FMO. Japan started to gradually reduce ERS in the early 1970s after the collapse of the Bretton Woods system, and achieved considerable degrees of FMO by the 1990s, realizing the "flexible exchange rate" corner. Being large economies, both China and Japan have pursued high degrees of MPI during most of the sample period.

Figure 4: Trilemma combinations in trilemma triangles by income group, regional group, and selected Asian economies

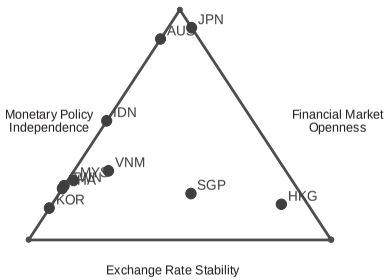
4A: Trilemma triangles – economies in the world by income group for three periods



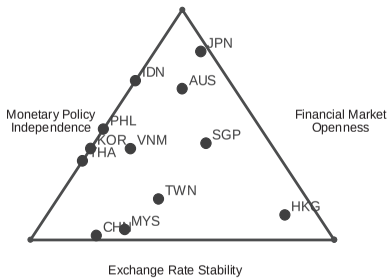
Source: Compiled by authors from their estimations.

4B: Trilemma triangles – emerging market & developing countries by regional group for three periods

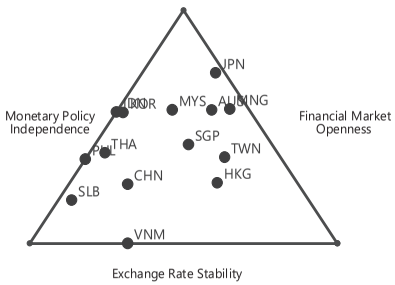
East Asia and the Pacific, 1986-1990



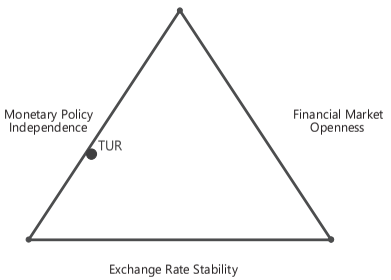
East Asia and the Pacific, 2001-2005



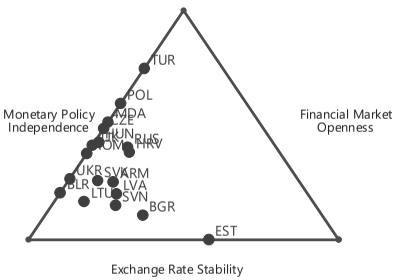
East Asia and the Pacific, 2016-2020



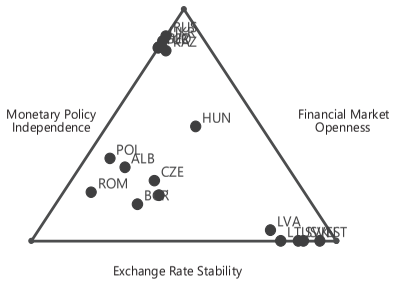
Europe & Central Asia, 1986-1990



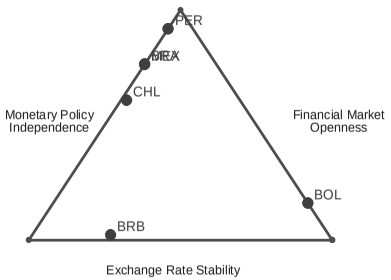
Europe & Central Asia, 2001-2005



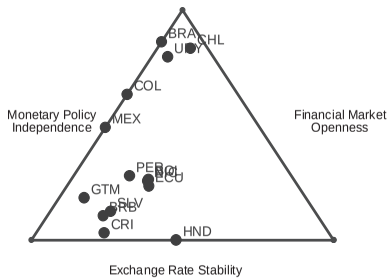
Europe & Central Asia, 2016-2020



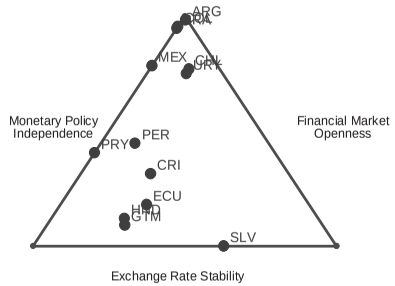
Latin Ame. and the Carib., 1986-1990



Latin Ame. and the Carib., 2001-2005

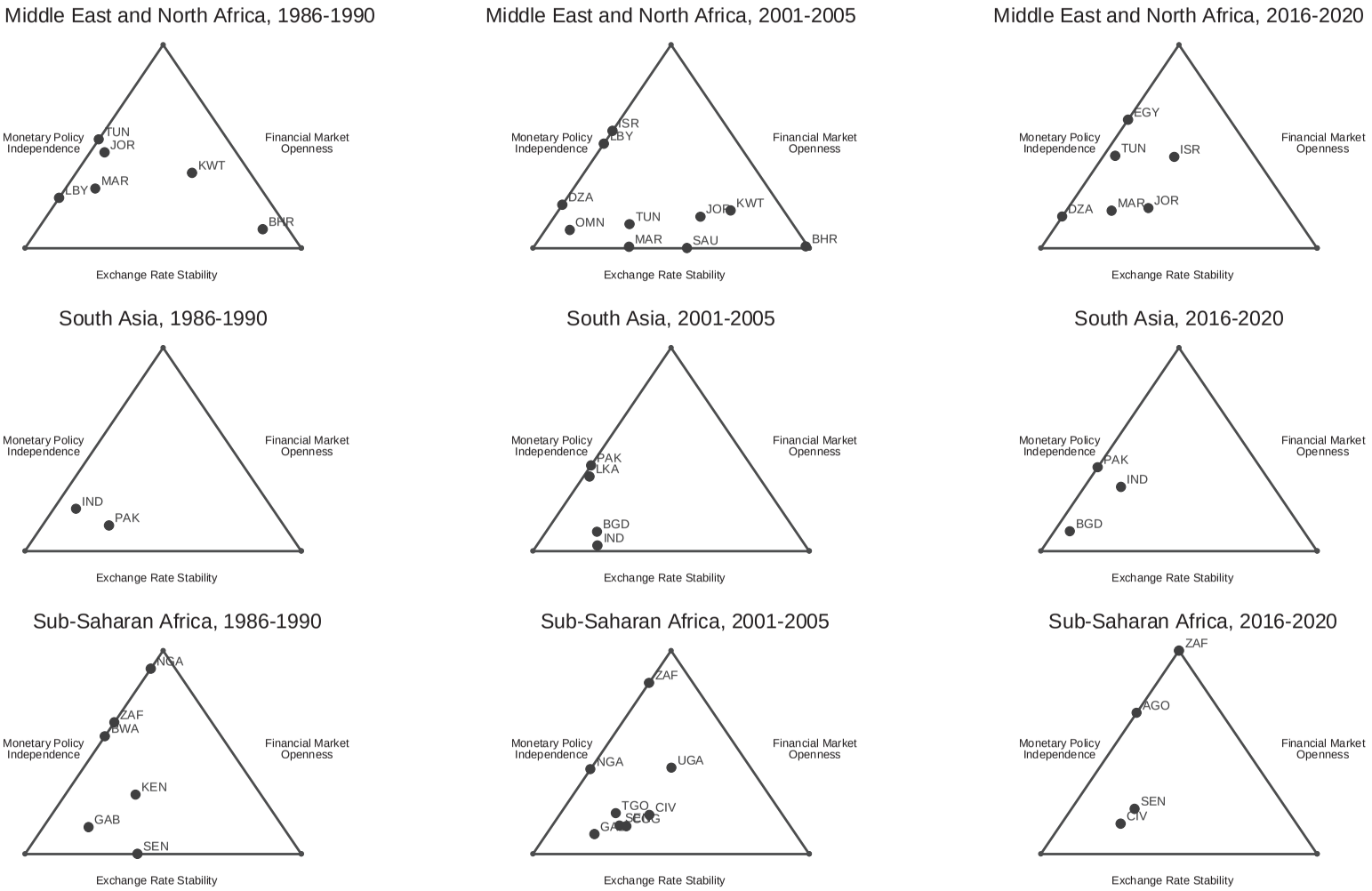


Latin Ame. and the Carib., 2016-2020



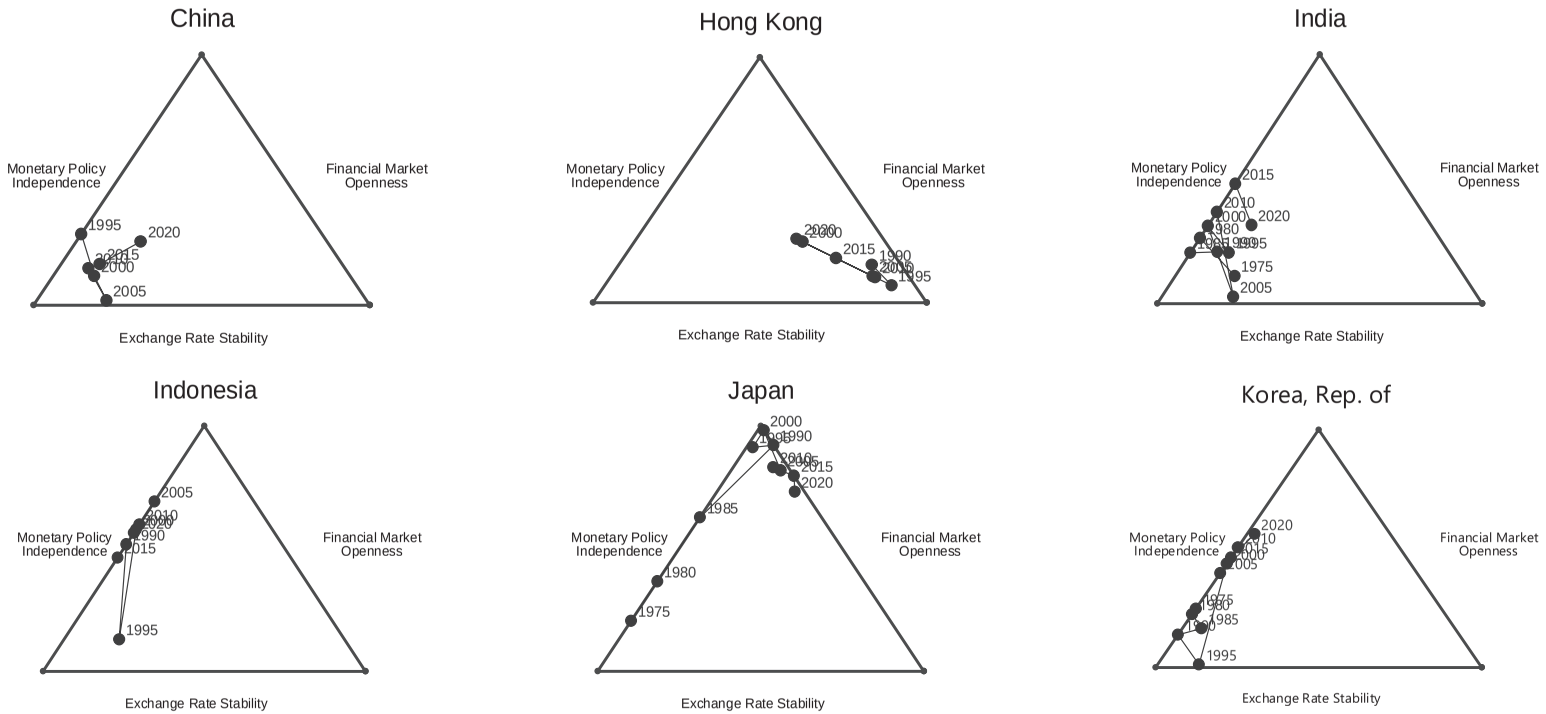
Source: Compiled by authors from their estimations.

4B: Trilemma triangles – emerging market & developing countries by regional group for three periods (continued)

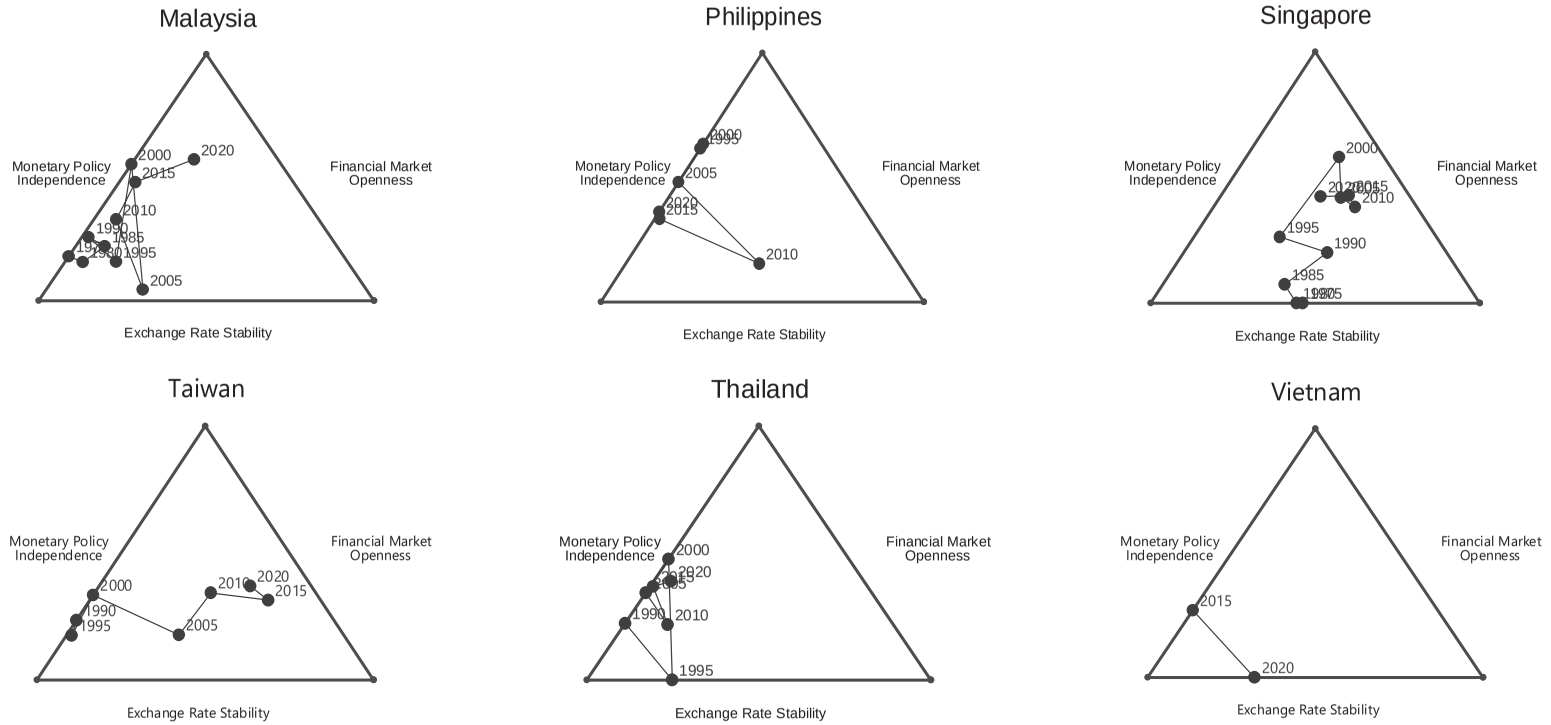


Source: Compiled by authors from their estimations.

4C: Trilemma triangles – evolution for selected economies in Asia, 1975 – 2020



4C: Trilemma triangles – evolution for selected economies in Asia, 1975 – 2020 (continued)



Source: Compiled by authors from their estimations.

V-3. Mapping the evolution of the trilemma regimes

This subsection draws the representative trilemma regimes in the world map and visibly shows their evolution over time by focusing on the three corner regimes and the middle ground. A trilemma regime is defined by the position of each economy in the trilemma triangle. As shown in Figure 5, ten different trilemma regimes are defined by first dividing the large trilemma triangle into nine equal sized, smaller triangles, named A to I, and then adding another triangle of the same small size, called M, at the center of the larger triangle. Smaller tringles A, E, and I approximate the corner regimes and smaller triangle M represents the middle ground.

The division of the large triangle into nine equal sized, smaller triangles reflects the procedure of defining three levels of ERS, FMO, and MPI, i.e., high, middle and low. For example, regime A is characterized by the combination of high ERS, low FMO, and high MPI, which approximates the "financially closed fixed rate" corner. Regime E represents the combination of high ERS, high FMO, and low MPI and matches the "financially open fixed rate" corner. Regime I is marked by the combination of low ERS, high FMO, and high MPI and corresponds to the "flexible exchange rate" corner.

There are seven non-corner regimes. For example, regime B represents the combination of high ERS, middle FMO, and high MPI. Regime M is presented on the notion that some economies may not choose any corner regime because they would prefer middle ground combinations of trilemma indexes. Although this regime has overlaps with the other six non-corner regimes and does not constitute an exclusive triangle, it deserves attention.

Figure 6 visually presents economies that have attained one of the three corner regimes, the middle ground, or one of the remaining six non-corner regimes in the global map for the four periods, 1981-1985, 1991-1995, 2001-2005, and 2016-2020.[19] There are many economies whose trilemma regimes cannot be defined due to the lack of data, but the figure still provides some general trends on the evolution of the trilemma regimes.

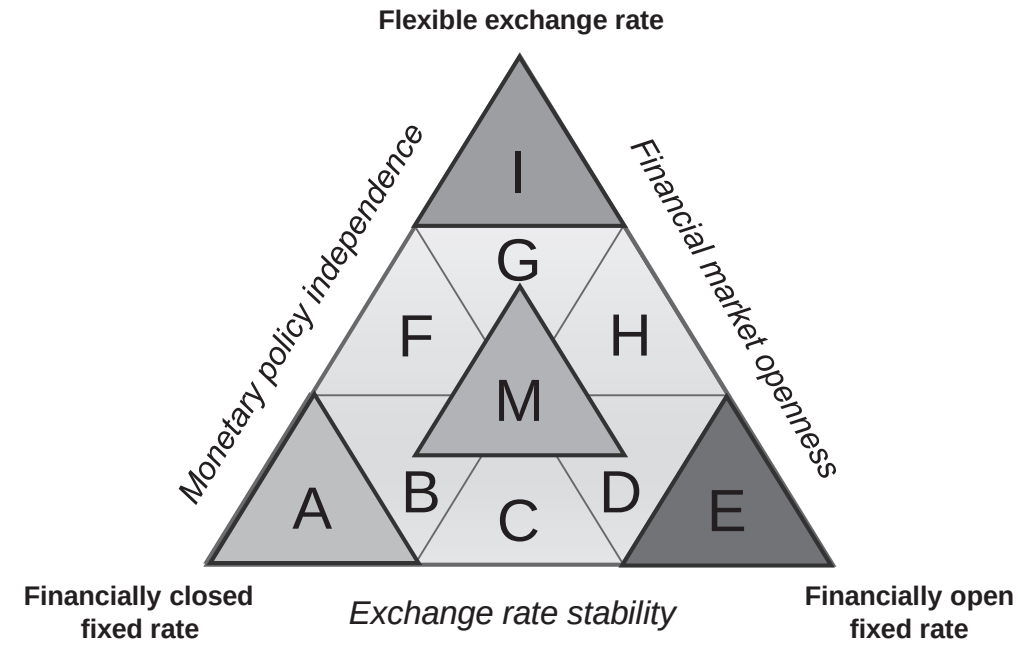
The figure shows that, among the three corner regimes, regime A was dominant in the first three periods (1981-2005) but has lost dominance afterwards, while regimes E and I have gained traction since the early 2000s. In the most recent period (2016-2020), regimes E and I are roughly equally selected and regime A has been selected by only a few economies (Algeria, Bangladesh, Romania, and Vietnam). China and India, two large emerging economies, adopted regime A until the third period (2001-2015), left this regime afterward, and moved to non-corner regimes. Regime E has gained traction because a large number of small economies joined the Euro Area to enjoy intraregional ERS through the adoption of a common currency, while maintaining open financial markets and giving up independent monetary policy. An increasing number of economies have chosen regime I: not only advanced economies (such as Iceland, Japan, Norway, and the U.K.) but also emerging & developing economies (such

[19] For a color version of Figure 6, see the following web link:https://www.mof.go.jp/english/pri/publication/pp_review/ppr20_2_2_figures-and-tables.pdf

as Argentina, Brazil, Mexico, Russia, South Africa, and Turkey) have adopted lower levels of ERS and higher levels of FMO, thereby retaining MPI.

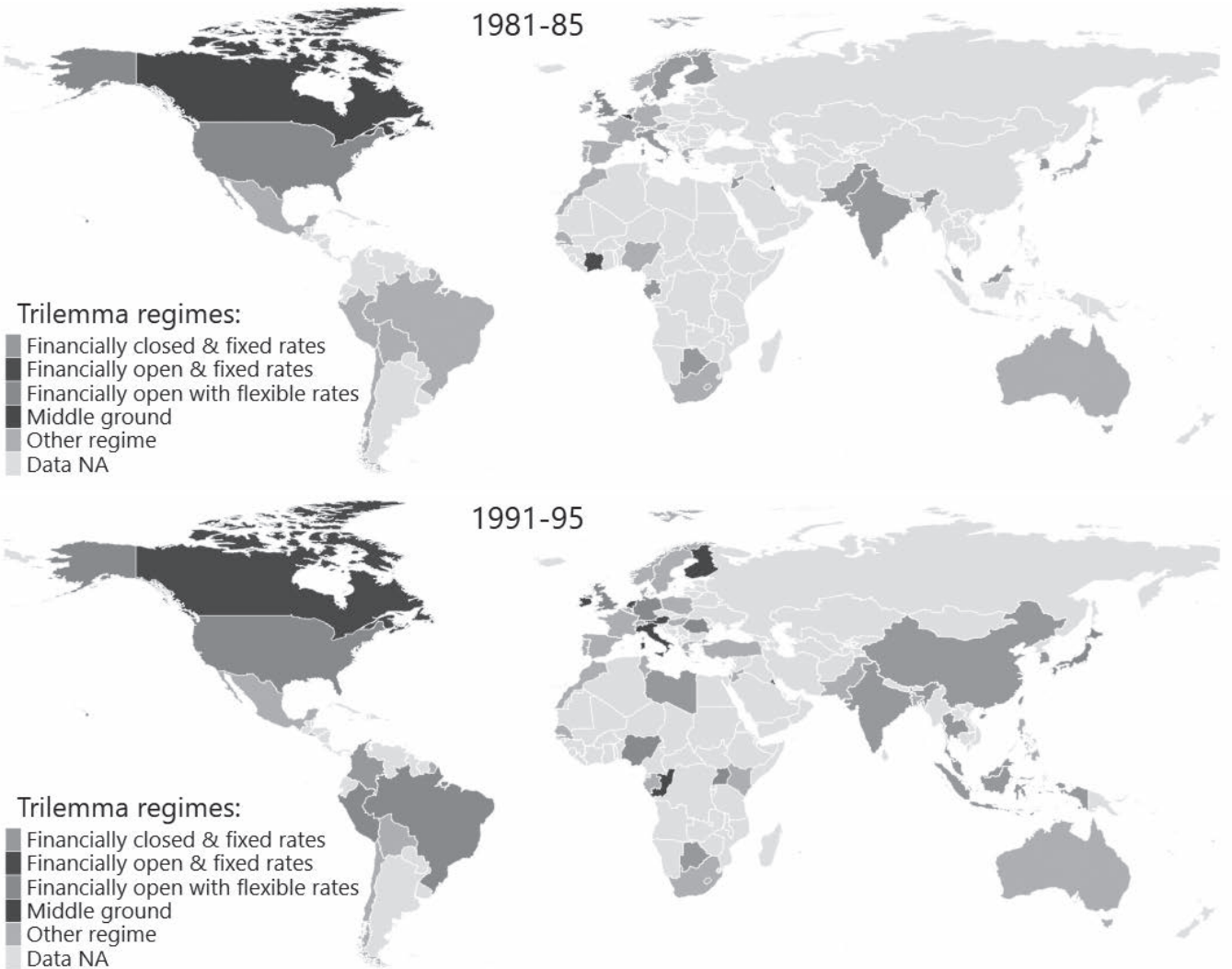
In contrast to the rising popularity of corner regimes E and I, corner regime A and middle ground regime M have not attracted much interest. Although the number of economies adopting regime M has not expanded, several economies such as Czech Rep., Israel, Singapore, and Sweden adopt this regime in the most recent period. Other non-corner regimes are shared by a large number of economies, including both advanced economies (such as Australia, Canada, the ROK, and Taiwan) and emerging & developing economies (such as China, Egypt, India, Indonesia, Malaysia, Mongolia, Pakistan, Peru, Poland, and Thailand).

Figure 5: Definition of ten trilemma regimes



Note: A color version of Figure 5 is available at the following web link: https://www.mof.go.jp/english/pri/publication/pp_review/ppr20_2_2_figures-and-tables.pdf
Source: Compiled by authors.

Figure 6: Trilemma regimes in the world, 1981-1985, 1991-1995, 2001-2005, and 2016-2020



Source: Compiled by authors from their estimations.

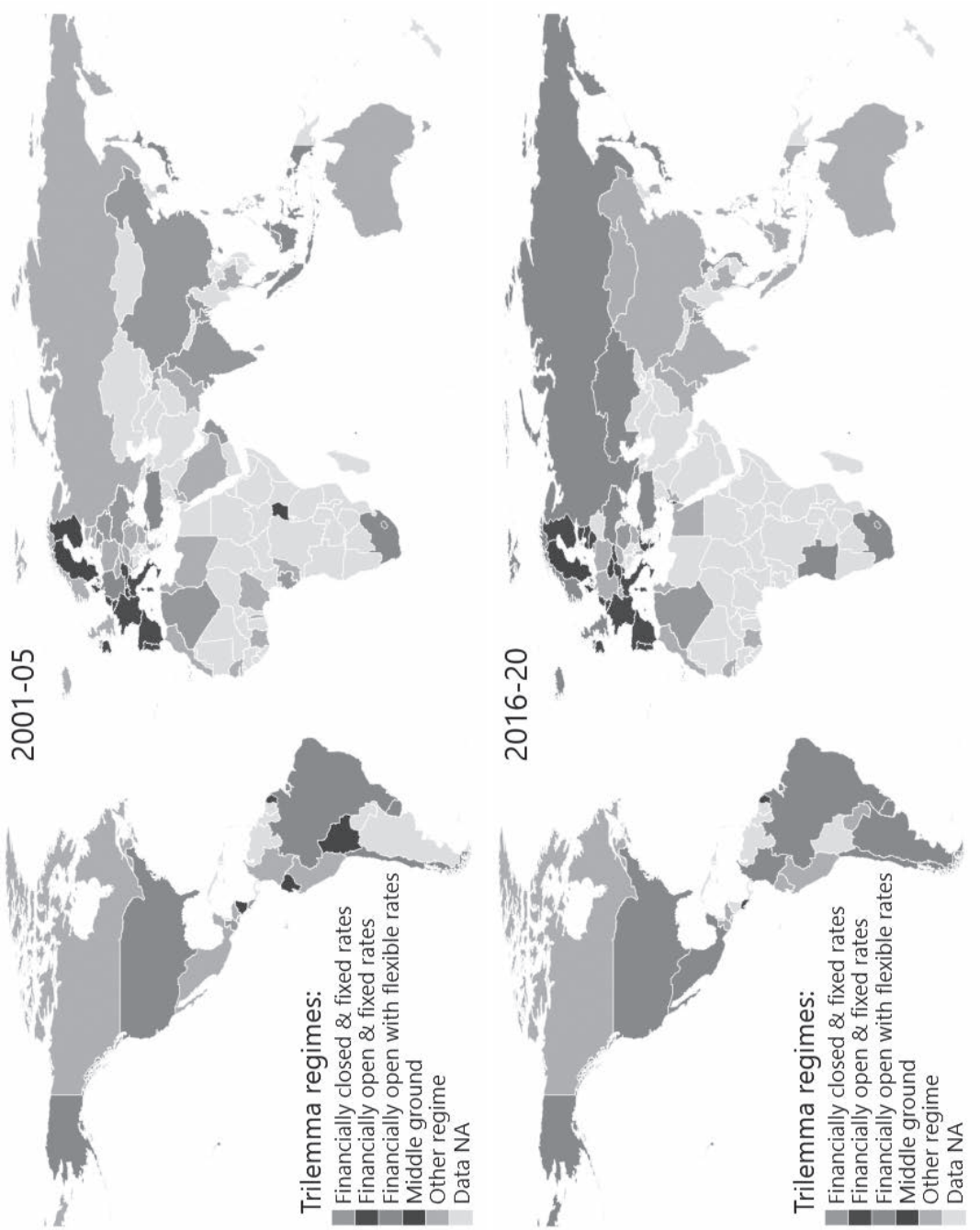


Figure 6: Trilemma regimes in the world, 1981-1985, 1991-1995, 2001-2005, and 2016-2020 (continued)

Source: Compiled by authors from their estimations.

VI. Macroeconomic Performance under Alternative Trilemma Regimes

This section assesses and compares macroeconomic performance across different trilemma regimes, i.e., three corner regimes and seven non-corner regimes including the middle ground, for advanced and emerging & developing economies. Macroeconomic performance is given by the real GDP growth rate, the consumer price index (CPI) inflation rate, and their volatilities.

VI-1. Macroeconomic performance variables

Macroeconomic performance of individual economies adopting different trilemma regimes can be assessed by considering real GDP growth rates and CPI inflation rates.[20] In this analysis, first, the median values of the growth rate and inflation rate, rather than their mean values, are obtained because data often contains some outliers which tend to dominate the mean value, and the median value captures the most central value of data, thus representing the reality in a more appropriate way than the mean value. Second, the volatility measures of the growth rate and the inflation rate are obtained from their standard deviations.

Figure 7 depicts the median real GDP growth rate and the median CPI inflation rate for advanced economies and emerging & developing economies. Generally speaking, both the growth rate and the inflation rate are higher for emerging & developing economies than for advanced economies, which suggests that it would be more appropriate to assess macroeconomic performance separately for advanced and emerging & developing economies than combining them into one large sample. In addition, the inflation rate has a downward trend over time for both groups of economies, so it would be important to capture this downward trend in assessing inflation performance.

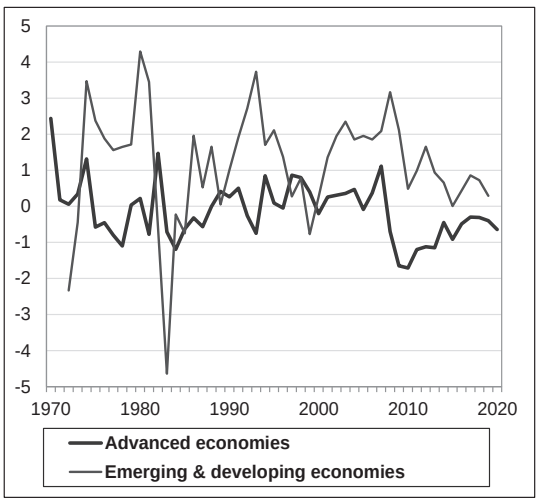
To construct variables for the GDP growth and CPI inflation rates used for assessing macroeconomic performance across different trilemma regimes for the groups of advanced economies and emerging & developing economies, several additional steps have been taken. First, for each group, the difference between the observed growth rate (which varies by country and year within the group) and its annual median (which varies by year) is calculated. Next, the median value and standard deviation of this difference in growth rates are calculated for each of the 10 trilemma regimes for the group. The same calculation is performed for the inflation rate. That is, for each group, the difference between the observed inflation rate (which varies by country and year within the group) and the annual median inflation rate (which varies by year) is obtained, and then the median value and standard deviation of the inflation rate difference are calculated for each trilemma regime.

The reason why the difference between the observed growth (or inflation) rate and the median growth (or inflation) rate for each year is used here is that it is assumed that the mon-

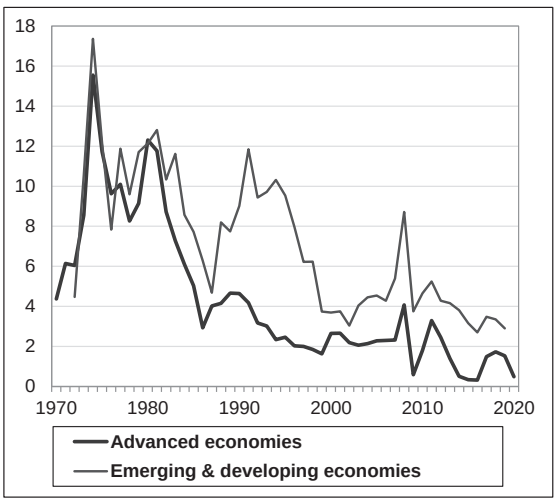
[20] Data for these macroeconomic variables are collected from the World Bank's *World Development Indicators* database. The number of sample economies is 102 in total (34 advanced economies and 68 emerging & developing economies) and varies across trilemma regimes. The sample period is 1970-2021 for economies with full data available and is shorter for economies with limited data availability (see Appendix II for details).

Figure 7: Median real GDP growth and inflation rates, 1970-2020

7A: Median real growth rate (%)



7B: Median inflation rate



Source: Authors' computation and compilation, using data from World Bank, *World Development Indicators* database.

etary authorities attempt to achieve growth above the target growth rate and inflation at the target rate as much as possible. In practice, it is difficult to know exactly at what level the monetary policy authorities set their annual growth and inflation targets for each economy. So, for convenience, the median values of the growth and inflation rates within each economic group are considered to be the authorities' policy targets.

VI-2. Comparison of macroeconomic performance across trilemma regimes

Macroeconomic performance variables are constructed for each trilemma regime. As explained in Figure 5, a trilemma regime is defined by a combination of the three different levels—high, middle, and low—of ERS, FMO, and MPI. The analysis here considers ten trilemma regimes, i.e., three corner regimes and seven non-corner regimes including the middle ground.

Table 4 summarizes macroeconomic performance variables for each of the ten trilemma regimes, by dividing the sample into advanced economies and emerging & developing economies. Macroeconomic performance is represented by: median(y), i.e., the median value of the difference between the observed economic growth rate and the median growth rate of the sample group (either advanced or emerging & developing economies) for each year; SD(y), i.e., the volatility of the growth rate difference defined by its standard deviation; median(π), i.e., the median value of the difference of the observed inflation rate from the median inflation rate of the sample group for each year; and SD(π), i.e., the volatility of the inflation rate difference measured by its standard

Table 4: Summary of macroeconomic performance by trilemma regime

4A. Advanced economies

	Trilemma regime			No.	Median(y)		SD(y)		Median(π)		SD(π)		Average
	ERS	FMO	MPI	obs.	Value	Rank	Value	Rank	Value	Rank	Value	Rank	rank
A	High	Low	High	198	0.52	2	3.12	9	1.04	9	4.39	9	7.25
B	High	Middle	High	94	0.27	4	3.16	10	0.32	8	3.38	7	7.25
C	High	Middle	Middle	66	0.71	1	3.09	8	-0.07	1	4.35	8	4.50
D	High	High	Middle	55	0.18	5	2.38	3	-0.22	5	1.86	3	4.00
E	High	High	Low	372	-0.30	8	2.70	6	-0.07	1	1.36	2	4.25
F	Middle	Middle	High	162	0.30	3	2.68	5	0.22	5	4.66	10	5.75
G	Middle	High	High	136	-0.08	7	2.48	4	-0.14	3	2.05	4	4.50
H	Middle	High	Middle	54	-0.54	10	1.77	1	12.00	10	1.33	1	5.50
I	Low	High	High	141	-0.33	9	2.35	2	-0.26	7	2.43	6	6.00
M	Middle	Middle	Middle	139	0.00	6	3.04	7	-0.18	4	2.29	5	5.50

4B. Emerging and developing economies

	Trilemma regime			No.	Median(y)		SD(y)		Median(π)		SD(π)		Average
	ERS	FMO	MPI	obs.	Value	Rank	Value	Rank	Value	Rank	Value	Rank	rank
A	High	Low	High	414	0.61	2	4.15	7	-0.53	4	6.11	3	4.00
B	High	Middle	High	215	-0.12	6	2.87	2	-1.42	6	5.73	2	4.00
C	High	Middle	Middle	128	-0.11	5	3.93	5	-0.25	2	9.00	4	4.00
D	High	High	Middle	23	-0.17	7	5.45	10	-2.46	9	4.00	1	6.75
E	High	High	Low	56	-0.05	4	4.85	9	-1.53	8	13.22	6	6.75
F	Middle	Middle	High	295	0.16	3	3.48	4	0.80	5	17.20	7	4.75
G	Middle	High	High	21	-0.27	8	2.60	1	0.44	3	36.92	9	5.25
H	Middle	High	Middle	13	0.69	1	3.01	3	-0.15	1	9.46	5	2.50
I	Low	High	High	251	-0.64	10	4.18	8	3.01	10	942.14	10	9.50
M	Middle	Middle	Middle	68	-0.63	9	4.00	6	-1.52	7	17.70	8	7.50

ERS = exchange rate stability; FMO = financial market openness; MPI = monetary policy independence; SD = standard deviation; y = real GDP growth rate (difference from the sample group median); π = CPI inflation rate (difference from the sample group median).

Note: y (or π) is the difference between the observed growth (or inflation) rate and the median growth (or inflation) rate of the sample group, i.e., either a group of advanced or emerging & developing economies, in each year. The total number of observations is the sum of those for A through I, that is, 1,278 annual observations for advanced economies and 1,416 annual observations for emerging & developing economies. The dark and light blue color cells in the average rank column indicate the best and second-best performance, respectively, and dark and light orange color cells indicate the worst and second-worst performance, respectively. For a color version of Table 4, see the following web link: https://www.mof.go.jp/english/pri/publication/pp_review/ppr20_2_2_figures-and-tables.pdf

Source: Compiled by authors from their estimations using data from World Bank, World Development Indicators database.

deviation.[21] The table also shows the number of observations for each regime and the ranking of each macroeconomic performance variable as well as average ranking. As explained below, the ranking is provided to facilitate the assessment of overall macroeconomic performance.

The first observation made in the table is that corner regimes (A, E, and I) are relatively popular among both advanced and emerging & developing economies. In the case of advanced economies, the two most favored regimes are E and A, which are corner regimes,

[21] More concretely, the values of median (y) and SD (y) for trilemma regime A in the case of advanced economies (the first row of Table 4A) are calculated in the following way. First, the difference between the observed economic growth rate of advanced economy j in year t (y_{jt}) and the median growth rate of all 1,278 advanced economies in year t (y_{at}) is constructed. Second median (y) and SD (y) are obtained as the median and standard deviation of the growth rate difference ($y_{jt} - y_{at}$), respectively, for the sample of 198 advanced economies in regime A. Median (π) and SD (π) for regime A are similarly calculated. The same calculation procedure is applied to other regimes and to emerging market & developing economies whose total number of observations is 1,416.

followed by F (one of the six non-corner regimes), I (the remaining corner regime), and M (the middle ground). The three corner regimes account for 56% of the total sample of 1,278. In the case of emerging & developing economies, the two most popular regimes are A (a corner regime) and F (a non-corner regime), followed by I (another corner regime) and B (a non-corner regime). Together with E, the three corner regimes account for 51% of the total sample of 1,416. The middle ground is not well received by emerging & developing economies, accounting for only 5% of the total.

Another observation is that there usually is some trade-off among the macroeconomic performance variables. In evaluating macroeconomic performance, it would be reasonable to claim that: the higher the median value of the economic growth rate difference (y), the better; the smaller the volatility of the growth rate difference, the better; the closer the median value of the inflation rate difference (π) to zero, the better; and the smaller the volatility of the inflation rate difference, the better. A trade-off is observed, for example, in the case of regime A for advanced economies, where the median value of the economic growth rate difference is the second highest among all regimes, but the remaining variables indicate second-worst outcomes. As another example, in the case of regime H for advanced economies, the median values of the growth rate difference and the inflation rate difference show the worst outcomes among all regimes whereas their volatility measures exhibit the best results.

In order to resolve this type of trade-off, the table ranks regimes for each macroeconomic performance variable, obtains the average ranking of performances for each regime, and identifies two top regimes that deliver the best or worst outcomes. The table reveals that, in the case of advanced economies, regimes D and E deliver the best performance, and regimes A and B deliver the worst performance. One of the best performing regimes is E, which is the "financially open fixed rate" corner regime. One of the worst performing regimes is A, which is the "financially closed fixed rate" corner regime.

In the case of emerging & developing economies, regimes H delivers the best performance and regimes A, B, and C deliver second-best performance (yielding identical average rankings) while regimes I and M yield the worst and second-worst performance, respectively. One of the second-best regimes (among A, B, and C), i.e., A, is the "financially closed fixed rate" corner regime. This is in sharp contrast with the case of advanced economies where corner regime A and non-corner regime B deliver the second-worst outcome. The worst performing regimes (I and M) in the case of emerging & developing economies are the "flexible exchange rate" corner regime and the "middle ground" regime.

Essentially, corner regime A generates the worst result for advanced economies while it yields one of the best outcomes for emerging & developing economies. Corner regime I delivers neutral outcomes for advanced economies, while it provides one of the worst outcomes for emerging & developing economies. The remaining corner regime, E, tends to deliver neutral outcomes for both advanced economies and emerging & developing economies. The "middle ground" regime (M) produces neutral results for advanced economies but one of the worst outcomes for emerging & developing economies.

The analysis above reveals that there is no single, common trilemma regime that delivers

the best or worst macroeconomic outcome for both advanced and emerging & developing economies. This does not necessarily mean that an economy can be better off shifting to a regime that tends to generate better outcomes (such as regime D and E in the case of advanced economies or regime H in the case of emerging & developing economies). The reason is that rational authorities of any economy must be adopting the best regime given the various structural and other conditions that affect their trilemma choice. Thus, deviating from the chosen trilemma regime may make the economy's macroeconomic performance worse. But if the authorities do not make a rational or appropriate choice, a shift to another regime may produce a better result.

VII. Conclusion

The index of ERS has been derived from the RMSE of the Frankel-Wei and/or Kawai-Pontines regression equations, which also identify each economy's anchor currencies. The index of FMO has been measured by the ratios of the sum of each economy's external assets and liabilities to GDP and to trade. The index of MPI has been obtained from the extent to which an economy's short-term interest rates respond to foreign interest rates and/or domestic (GDP gaps and inflation rates) and external variables. As any of the trilemma indexes ranges between 0 and 1, the three indexes have been adjusted so that their sum equals 2.

Using these indexes, this paper has investigated three issues. First, it has examined various economies' exchange rate arrangements, by reviewing the degree of exchange rate stability or flexibility as well as the identified anchor currencies, and calculated the economic size of major currency zones in the world and in each region of the world. The GDP sizes of major currency areas have been calculated from the estimated weights of anchor currencies for individual economies. One of the innovations of this paper has been that when calculating the size of each major currency zone, the weights of anchor currencies are adjusted according to the value of the ERS index.

The analysis of exchange rate arrangements has demonstrated that, globally, the relative economic shares of the USD and GBP zones were large in the 1960s and 1970s, but both have declined since the 1980s, with the emergence of the EUR zone (initially the DEM zone) and the JPY zone and the recent rapid rise of the RMB zone. However, the JPY and EUR zones have been shrinking since the 2000s and 2020, respectively. Instead, the size of the RMB zone has risen in recent years, supplementing the roles played by the USD, EUR, GBP, and JPY. Nonetheless, the USD remains the most dominant anchor currency for many economies, and the USD zone remains the largest currency zone in the world. The residual portion of the world economy that is not part of any major currency zone—i.e., the portion that is judged to be under a floating exchange rate regime—has been growing in size as a trend.

There are considerable differences among emerging & developing regions in the world with respect to the degree of exchange rate stability or flexibility and the size of major currency zones. The regions have generally increased their exchange rate flexibility over time, and in recent years their exchange rate flexibility has become higher than that of advanced

economies. Still, there are regional differences as indicated by Europe and Latin America's highly flexible exchange rate arrangements and the Middle East and Central Asia's very stable exchange rate regimes. The size of the USD zone is large in the Middle East and Central Asia at 85% of regional GDP, while it is 44% in Asia, 31% in Sub-Saharan Africa, and 17% in Latin America. The size of the EUR zone is largest in Europe at 25% of the region's GDP, and relatively large in Sub-Saharan Africa at 18% and Latin America at 11%. The size of the RMB zone is 18% of the region's GDP in Asia and 12% in Sub-Sahara Africa.

Second, the paper has analyzed the global trends of trilemma regimes over the past 50 years and their differences between advanced and emerging & developing economies as well as among emerging & developing regions, by presenting regimes in trilemma triangles. The analysis has demonstrated that economies in the world, with some exceptions, have generally moved in the direction of greater FMO in addition to greater exchange rate flexibility. Advanced economies can be divided into three types. The first type includes economies such as Iceland, Japan, and Norway, which have achieved the "flexible exchange rate" corner regime of maintaining low levels of ERS and high levels of FMO and MPI. The second includes Euro Area members that pursue the "financially open fixed rate" corner regime with high levels of ERS and FMO but no MPI. The third includes such economies as Israel, Singapore, and Sweden that opt for a "middle ground" with some degrees of ERS, FMO, and MPI. Today, there is no advanced economy that adopts the "financially closed fixed rate" corner regime of maintaining high degrees of ERS and MPI and a low degree of FMO.

Emerging & developing economies have steadily increased their exchange rate flexibility and FMO. In the 1970s and 1980s, most of them adopted the traditional "financially closed fixed rate" corner regime, or a regime close to it. While many emerging & developing economies still maintained this traditional regime during the 1990s and 2000s, some economies subsequently increased their exchange rate flexibility, a trend that has intensified since 2010. In the most recent period, emerging & developing economies can be divided into three types. The first includes Algeria, Bangladesh, and Romania that still stick to the traditional corner regime. The second includes Argentina, Brazil, Russia, South Africa, and Turkey that adopt the "flexible exchange rate" corner regime. The third includes China, Egypt, India, Indonesia, Pakistan, and Thailand, which choose non-corner regimes such as the "middle ground." Interestingly, few emerging & developing countries today adopt the "financially open fixed rate" corner regime.

In Asia, diverse trilemma regimes coexist today. Japan has long achieved the "flexible exchange rate" corner regime. The ROK, Indonesia, Malaysia, and the Philippines appear to be approaching this regime over time. Singapore has attained the "middle ground." China maintained the traditional "financially closed fixed rate" corner regime for a long time, but in recent years it has been moving in the direction of the "middle ground" by allowing some degrees of exchange rate flexibility and financial market opening. Hong Kong kept the "financially open fixed rate" regime for a long time, but in recent years it also appears to be shifting toward the "middle ground."

Finally, the paper has evaluated economies' macroeconomic performance, by focusing

on GDP growth, CPI inflation, and their volatilities under ten different trilemma regimes. The analysis has revealed that there is no common trilemma regime that guarantees the best macroeconomic outcome for both advanced economies and emerging & developing economies. Some trilemma regimes work well for advanced economies but not for emerging & developing economies, and vice versa. For example, the "financially closed fixed rate" corner regime delivers good outcomes for emerging & developing economies but not for advanced economies. Another corner regime of flexible exchange rates with open financial markets yields neutral macroeconomic outcomes for advanced economies but the worst outcomes for emerging & developing economies. Interestingly, the "middle ground" regime does not produce sound outcomes for either advanced or emerging & developing economies.

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Appendix I: Construction of the New Trilemma Indexes

This appendix explains in detail how each of the trilemma indexes is constructed.

I-1. Exchange rate stability

Frankel-Wei and Kawai-Pontines methods

To construct an index that measures the degree of ERS, the methodology first introduced by Haldane and Hall (1991) and popularized by Frankel and Wei (1994) is employed.[22] Frankel and Wei (1994) investigated the extent of influence of major currencies on the exchange rate of economy *j* using the following estimation model:

$$\Delta ln\left(\frac{x}{NZD}\right)_{jt} = \beta_{0j} + \beta_{1j}\,\Delta ln\left(\frac{USD}{NZD}\right)_t + \beta_{2j}\,\Delta ln\left(\frac{EUR}{NZD}\right)_t + \beta_{3j}\,\Delta ln\left(\frac{GBP}{NZD}\right)_t + \beta_{4j}\,\Delta ln\left(\frac{JPY}{NZD}\right)_t + u_{jt} \quad (1)$$

where $\Delta ln\left(\frac{x}{NZD}\right)_t$ and $\Delta ln\left(\frac{k}{NZD}\right)_t$ are the rates of change in the exchange rates of currency x and major currency k (= USD, EUR, GBP, and JPY) against the New Zealand dollar, the numéraire currency.[23] The currencies included in the right-hand side of the estimation equation, such as the USD, the EUR (or the Deutschemark [DEM] until 1998), the GBP, and the JPY, can be thought of comprising an implicit basket of major currencies in the mind of monetary authorities in economy *j*. Therefore, $\hat{\beta}_{kj}$, the estimated coefficient on the rate of change in the exchange rate of major currency k against the numéraire, represents the weight of currency k in the implicit basket. If the currency of economy *j* is pegged to a major currency

[22] Haldane and Hall (1991) applied their technique to sterling over a period that included both Bank of England management and relatively free floating, while Frankel and Wei (1994) sought to discover weights in an informal currency basket. See also Kawai and Akiyama (1998, 2000), Bénassy-Quéré et al. (2006), Kawai and Pontines (2016), Tovar and Nor (2018), Ito and McCauley (2019, 2020), and Ito and Kawai (2021).

[23] In other studies, the Swiss franc (CHF) and Special Drawing Rights (SDR) are sometimes used as numeraire. Accordingly, this paper has also tried CHF and SDR, but the basic estimation outcomes are intact with minor quantitative differences.

or a basket of major currencies, it must be either $\hat{\beta}_{kj} = 1$ or $\sum_{k=1}^{K'} \hat{\beta}_{kj} = 1$ for the $K' (< K)$ currencies included in the implicit basket. Also, in such a case, the goodness of fit of the above estimation model must be high.[24]

The basic assumption here is that monetary authorities use an implicit basket of currencies for the purpose of exchange rate stabilization or management, and that the extent of response to the change in the value of the entire basket would vary across economies and over time. The major currencies included in the estimation equation are often held by monetary authorities as foreign exchange reserves. In the years before the introduction of the euro in 1999, the DEM is included in place of the EUR. For the former French or Belgian colony economies, the French franc and Belgian franc were the target currencies for exchange rate stabilization, respectively, but the DEM is used instead of the francs.[25]

In this paper, two modifications are made to the Frankel-Wei model. First, the estimation model is applied to each of the sample currencies by using overlapping, rolling windows of 36 months.[26] In other words, $\hat{\beta}_{kj}$'s, the weights of the major currencies in the implicit basket, become time-varying because monetary authorities are assumed to keep updating their information sets in each month.

Second, the Chinese RMB is treated as one of the major currencies for this estimation after 1999. There is not much question that the RMB has become a major anchor currency in the sense of influencing the movements of a number of economies' exchange rates together with other major currencies.[27] However, merely including the exchange rate movements of the RMB in equation (1) would be problematic. The RMB used to be pegged to the USD and is still tied to dollar movements to some extent, which means that the RMB's exchange rate movements are highly correlated with those of the dollar. This creates a serious multicollinearity problem and would make the estimated β's inaccurate. To overcome this problem, the paper adopts the Kawai and Pontines (2016) method.

The first step of the Kawai-Pontines procedure is to regress the rate of change in the RMB exchange rate on those of other major currencies, using 36-month windows, as follows:

$$\Delta ln\left(\frac{RMB}{NZD}\right)_t = \phi_0 + \phi_1 \Delta ln\left(\frac{USD}{NZD}\right)_t + \phi_2 \Delta ln\left(\frac{EUR}{NZD}\right)_t + \phi_3 \Delta ln\left(\frac{GBP}{NZD}\right)_t + \phi_4 \Delta ln\left(\frac{JPY}{NZD}\right)_t + \omega_t \quad (2)$$

The estimation of equation (2) provides the estimated residual, $\widehat{\omega}_t$, as:

$$\widehat{\omega}_t = \Delta ln\left(\frac{RMB}{NZD}\right)_t - [\,\hat{\phi}_0 + \hat{\phi}_1 \Delta ln\left(\frac{USD}{NZD}\right)_t + \hat{\phi}_2 \Delta ln\left(\frac{EUR}{NZD}\right)_t + \hat{\phi}_3 \Delta ln\left(\frac{GBP}{NZD}\right)_t + \hat{\phi}_4 \Delta ln\left(\frac{JPY}{NZD}\right)_t\,] \quad (3)$$

Thus, the estimated residual, $\widehat{\omega}_t$, removes the part of the RMB movement that is af-

[24] The constraint of $\sum_{k=1}^{K} \hat{\beta}_{kj} = 1$ is imposed in the estimation. Considering that the estimated betas represent weights in the hypothetical basket, it makes sense to impose such a constraint. However, as is explained later, from 1999 on, the Kawai-Pontines (2016) modification to the original Frankel-Wei method is adopted because the Chinese yuan is also treated as one of the major currencies.

[25] The estimation also includes a dummy variable that takes the value of one if the monthly rate of change in the exchange rate of the economy's currency is greater than 10% in absolute terms so as to minimize noise from exchange rate disruptions such as abortion of an exchange rate regime and sudden re/devaluation of the currency. Similarly, the regression includes a dummy variable that takes the value of one in the first month after the introduction of the euro.

[26] As a result, the estimation results for every 3 years would become the same as the results using non-overlapping 3-year panels.

[27] See Kawai and Pontines (2015), Ito (2017), Ito and McCauley (2019, 2020), Tovar and Nor (2018), and Ito and Kawai (2021).

fected by the movements of major currencies, particularly those of the USD. Using $\widehat{\omega}_t$, the Kawai-Pontines estimation equation that is the counterpart of equation (1) becomes:

$$\Delta ln\left(\frac{x}{NZD}\right)_{jt} = \gamma_{0j} + \gamma_{1j}\,\Delta ln\left(\frac{USD}{NZD}\right)_t + \gamma_{2j}\,\Delta ln\left(\frac{EUR}{NZD}\right)_t + \gamma_{3j}\,\Delta ln\left(\frac{GBP}{NZD}\right)_t + \gamma_{4j}\,\Delta ln\left(\frac{JPY}{NZD}\right)_t + \gamma_{5j}\,\widehat{\omega}_t + v_{jt} \quad (4)$$

One may consider estimating equation (4), but doing so does not necessarily yield good results, so Kawai and Pontines (2016) propose to estimate the following equation by subtracting $\widehat{\omega}_t$ from both sides of equation (4):

$$\Delta ln\left(\frac{x}{NZD}\right)_{jt} - \widehat{\omega}_t = \gamma_{0j} + \gamma_{1j}\left[\Delta ln\left(\frac{USD}{NZD}\right)_t - \widehat{\omega}_t\right] + \gamma_{2j}\left[\Delta ln\left(\frac{EUR}{NZD}\right)_t - \widehat{\omega}_t\right] + \gamma_{3j}\left[\Delta ln\left(\frac{GBP}{NZD}\right)_t - \widehat{\omega}_t\right] + \gamma_{4j}\left[\Delta ln\left(\frac{JPY}{NZD}\right)_t - \widehat{\omega}_t\right] + v_{jt} \quad (5)$$

This estimation yields results that are more robust, stable and accurate (Kawai and Pontines, 2016). Here, it is assumed that the weights of the major currencies in the currency basket in equation (4) sum up to one, i.e., $\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4 + \gamma_5 = 1$. Hence, from equation (5), the estimate of the RMB weight is obtained as: $\hat{\gamma}_5 = 1 - \hat{\gamma}_1 - \hat{\gamma}_2 - \hat{\gamma}_3 - \hat{\gamma}_4$. The Kawai-Pontines method is applied to the rolling regressions from January 1999.

The RMSE for the ERS index

The RMSE is chosen as a measure of ERS, because the RMSE reflects how tightly an economy's exchange rate follows those of a basket of major currencies. The RMSE has been proposed by Bleaney and Tian (2020) as a measure of exchange rate stability or flexibility. Given that the estimates from equation (1) or (5) are time-varying (with 36-month windows), so is the RMSE.[28] The annual average of the time-varying RMSE is used to measure the level of *ERS*.[29]

This paper also constructs indexes for ERS for major currencies other than the USD. For the EUR, GBP, and JPY, the RMSEs are obtained by regressing each exchange rate only on the USD rate. Therefore, the ERS for Euro Area member countries is a common value. For the Chinese RMB, the RMSE is obtained from equation (2), which regresses the RMB rate on the USD, EUR, GBP, and JPY rates. In all cases, the Frankel-Wei regression equation is used. For the U.S. dollar, which is treated as the world's most important anchor currency, the degree of ERS is not measured.

A high level for RMSE means that the estimation model does not have a good fit, which suggests that the economy of concern tends to have exchange rate *flexibility*. To construct an index for ERS, the RMSE is converted as follows:

$$ERS_{jt} = \frac{\left(RMSE(p(90)) - RMSE_{jt}\right)}{\max\left(RMSE(p(90)) - RMSE_{jt}\right)} \quad (6)$$

[28] In a similar context, Kawai and Akiyama (1998) chose the standard error of a regression similar to equation (1) and Ito and Kawai (2014a, 2014b, 2021) used the adjusted R^2.

[29] Because of the unique distribution of RMSE, which is skewed to the left with fat tail on the right-hand side, the RMSE values are winsorized at and above the 90th percentile.

where $RMSE(p(90))$ is the 90th percentile of RMSE. In this way, the *ERS* index ranges between 0 and 1, where 0 means no ERS (i.e., the highest degree of exchange rate flexibility), and 1 means rigid ERS.

I-2. Financial Market Openness

The index of FMO constructed in this paper is based on the *de facto* measure of financial openness developed by Lane and Milesi-Ferretti (2001, 2007, 2017). Lane and Milesi-Ferretti compile data for international investment positions for about 180 countries between 1970 and 2020.

Lane and Milesi-Ferretti normalize the sum of "total external assets" and "total external liabilities" as ratios of GDP and total trade volume (that is, exports plus imports) and use these ratios as measures of financial openness. In this paper, several modifications are made. First, normalizing external assets and liabilities as ratios of GDP and trade has both merits and demerits, so this paper uses the average of both ratios.[30]

Second, including foreign exchange reserves as part of total external assets for the purpose of creating a measure of financial openness can be problematic because monetary authorities' reserve investment should not be treated in the same way as private investment. One can think of China and several other East Asian economies, which may appear as "financially open" if their massive foreign exchange reserves are included as part of their total external assets, when in fact they have tight controls on private cross-border capital movements.

Third, the measure of financial openness based on total external assets and liabilities tends to have an explosive path, which needs to be addressed. Indeed, Quinn et al. (2011) show that the measure is nonstationary. Therefore, it is necessary not only to normalize the sum of total external assets and liabilities in a rational way, but also to define an index of FMO that falls between 0 and 1.

Given these observations, the index of FMO is constructed in the following way. First, two measures of financial openness are calculated in a way similar to Lane and Milesi-Ferretti's procedure by normalizing the sum of external assets and liabilities, less official foreign exchange reserve assets, as ratios of GDP and total trade. Next, the average of the two is obtained:

$$FMO\_1_{jt} = \frac{1}{2}\left\{\frac{\text{Total Assets}_{jt} + \text{Total Liabilities}_{jt} - \text{Official Reserve Assets}_{jt}}{GDP_{jt}} + \frac{\text{Total Assets}_{jt} + \text{Total Liabilities}_{jt} - \text{Official Reserve Assets}_{jt}}{(EX+IM)_{jt}}\right\}. \quad (7)$$

[30] Normalizing the sum of total external assets and liabilities as a ratio of GDP would make the financial openness measure susceptive to business cycles. Also, it would make the measure appear unnecessarily low for large economies such as the United States and make the one for international financial centers—such as Ireland, Luxemburg, Singapore, or Hong Kong —appear extremely high, much higher than that of the United States which has presumably one of the most open financial markets in the world. Normalizing the sum of total external assets and liabilities as a ratio of total trade volume, on the other hand, would make the financial openness measure less susceptive to business cycles and the economy being a financial center. It, however, tends to penalize too harshly economies that are highly open to international trade such as Singapore.

Then, advanced economies are assumed as a group to have achieved full FMO as of the late 1990s. Using this assumption, the financial openness measure for advanced economies in the period from 1995 to 1999 is calculated as FMO_1_{ADV} and regarded as the highest level of FMO.[31] Finally, the financial openness measure, FMO_1_{jt}, obtained from (7), is normalized as a ratio of FMO_{ADV}, which defines the index for FMO as follows:[32]

$$FMO_{jt} = \frac{FMO\_1_{jt}}{FMO\_1_{ADV}} \quad \text{where } 0 \leqq FMO_{jt} \leqq 1 \tag{8}$$

Essentially, the FMO index is a *de facto* indicator rather than a *de jure* indicator as has been developed by Chinn and Ito (2008), and ranges between the value zero (lowest degree of FMO) and one (highest degree).

I-3. Monetary Policy Independence

To construct the index of MPI, the following estimation model for the short-term interest rate in economy *j* is considered:

$$\Delta i_{jt|t-12} = \varphi_{jy}\tilde{y}_{jt} + \varphi_{j\pi}\tilde{\pi}_{jt} + \varphi_{jy_{Gt}}y_{Gt} + \varphi_{joil\pi}oil\pi_{jt} + D_j{}'\ \Phi_D + \varepsilon_{jt} \tag{9}$$

$$\Delta i_{jt|t-12} = \gamma_j \Delta i^*_{jt|t-12} + D_j{}'\ \Phi_D + \upsilon_{jt} \tag{10}$$

$$\Delta i_{jt|t-12} = \gamma_j \Delta i^*_{jt|t-12} + \varphi_{jy}\tilde{y}_{jt} + \varphi_{j\pi}\tilde{\pi}_{jt} + \varphi_{jy_G}y_{Gt} + \varphi_{joil\pi}oil\pi_{jt} + D_j{}'\ \Phi_D + \nu_{jt} \tag{11}$$

$$i^*_{jt} = \hat{\gamma}_{1j}i_{USDt} + \hat{\gamma}_{2j}i_{EURt} + \hat{\gamma}_{3j}i_{GBPt} + \hat{\gamma}_{4j}i_{JPYt} + \hat{\gamma}_{5j}i_{RMBt} \tag{12}$$

where $\Delta i_{jt|t-12}$ and $\Delta i^*_{jt|t-12}$ refer to changes in the domestic and foreign short-term interest rates, respectively, over a 12-month period;[33] $\tilde{y}_{jt}$ is the year-to-year growth rate of industrial production and is a proxy of the output gap; $\tilde{\pi}_{jt}$ is the year-to-year inflation rate measured by the consumer price index (CPI) and is a proxy of the inflation gap; y_{Gt} is the year-to-year growth rate of the world economy, measured by the average rate of change in industrial production of the Group of Seven (G7) and BRIC (Brazil, Russia, India, and China) economies; $oil\pi_{jt}$ is the year-to-year rate of change in the price of crude oil; and *D* is a vector of dummies to control for high- or hyper-inflation.[34]

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[31] Luxembourg is excluded from the calculation since it is an extreme outlier due to its role as an international financial center. The *de jure* indicator of financial openness developed by Chinn and Ito (2006, 2008) also shows that the level of financial openness reached the highest level in the mid-1990s and has plateaued since then.

[32] Any FMO_{jt} taking a value above one is assumed to be one.

[33] The change in the policy rates over 12 months is used instead of month-to-month changes, because of the following reasons. First, estimation with the first-differenced policy rates would involve too much noise that affects both the estimated coefficients and the adjusted R^2. Second and more importantly, estimating the equation using month-to-month changes is essentially the same as assuming that the home economy must react to a change in the foreign interest rate *i** within one month, which may be too restrictive an assumption.

[34] More specifically, the regression includes the interest rate dummy that takes the value of one if the policy interest rate is greater than 100%; the inflation dummy that takes the value of one if the change in the rate of inflation from the same month in the previous year is greater than 50%; and the interest rate change dummy that takes the value of one if the change in the policy rate is greater than 5% points from the previous month or 50% points from the same month in the previous year.

Equation (9) assumes that the domestic short-term interest rate is determined by the domestic economic factors (output gap, $\tilde{y}_{jt}$, and inflation rate gap, $\tilde{\pi}_{jt}$) and global economic conditions (world output and oil prices). It says that monetary authorities in economy *j* would set the policy interest rate to control the domestic output and inflation gaps and react to global conditions, so the equation mimics the Taylor rule. Equation (10) assumes that the domestic short-term interest rate is determined by the foreign interest rate, which is a weighted average of the short-term interest rates of the major currency countries with the weights being the estimated coefficients on the major currencies obtained from the Frankel-Wei or Kawai-Pontines equations as indicated by (12). The specification is based on the approaches adopted by Shambaugh (2004) and Obstfeld, Shambaugh, and Taylor (2005), with dummies D also included. Equation (11) is an integrated version of equations (9) and (10) to allow for the possibility that the domestic short-term interest rate is set according to the (synthetic) foreign short-term interest rate, domestic economic factors, and global economic conditions.

To construct the index of MPI, the explanatory powers, represented by the R^2's, of equations (9), (10) and (11) are used. That is, if the domestic monetary authorities set the short-term interest rate in a way to closely respond to developments of domestic and foreign economic conditions, then the goodness of fit of equation (9) must be high and the authorities are judged to have MPI. On the other hand, if the domestic monetary authorities closely follow the monetary policy of the major currency countries, the goodness of fit of equation (10) must be high, which means that the domestic interest rate is determined by the weighted average interest rates of the major countries and, thus, the domestic authorities do not have MPI.

Using these estimation models and focusing on their R^2's, the following two types of measures for the level of MPI are defined:

$$MPI\_1 = \frac{R^2 \text{ of Eq. (9)}}{R^2 \text{ of Eq. (11)}} \tag{13}$$

$$MPI\_2 = 1 - \frac{R^2 \text{ of Eq. (10)}}{R^2 \text{ of Eq. (11)}} \tag{14}$$

Here, *MPI*_1 indicates that the higher this ratio is, the more explanatory power the domestic economic factors (and global economic conditions) have in explaining the domestic short-term interest rate in comparison to the explanatory power of the foreign short-term interest rate. Hence, the higher this ratio is, the higher the level of MPI. On the other hand, *MPI*_2 indicates that the more explanatory power the foreign interest rate has in explaining the variation of the domestic short-term interest rate, the higher the second term of the right-hand side of equation (14) and, hense, the lower the value of *MPI*_2 is. This means that the higher the value of *MPI*_2 is, the higher the level of MPI.

To decide which measure to choose between (13) and (14), the following approach is adopted for each sample economy. First, if the adjusted R^2 of equation (9) is sufficiently greater than that of equation (10), then *MPI*_1 is chosen as the index of MPI because the vector of domestic and global economic variables better explains the domestic interest rate than does the foreign interest rate. Second, if the adjusted R^2 of equation (10) is sufficiently greater than that of equation (9), then *MPI*_2 is chosen as the MPI index. Finally, if the adjusted R^2's of

equations (9) and (10) are sufficiently close to each other, the average of *MPI*_1 and *MPI*_2 is chosen as the MPI index.[35]

Appendix II: Country List and Trilemma Index Data Availability

	Country Name	cn	AE	EMMIE	LIE	ERS		FMO		MPI	
1	Albania	914	0	1	0	1995	2021	1993	2020	2007	2019
2	Algeria	612	0	1	0	1970	2021	1970	2020	2003	2018
3	Angola	614	0	1	0	1970	2021	2000	2020	2008	2017
4	Argentina	213	0	1	0	1970	2021	1970	2020	2007	2017
5	Armenia	911	0	1	0	1995	2021	1996	2020	1997	2010
6	Australia	193	1	0	0	1970	2021	1970	2020	1971	2019
7	Austria	122	1	0	0	1970	2021	1970	2020	1970	2020
8	Bahrain	419	0	1	0	1970	2021	1980	2019	1979	2011
9	Bangladesh	513	0	0	1	1974	2021	1973	2020	1995	2018
10	Barbados	316	0	1	0	1970	2021	1975	2019	1974	2014
11	Belarus	913	0	1	0	1995	2021	1994	2020	2003	2010
12	Belgium	124	1	0	0	1970	2021	1970	2020	1970	2020
13	Bolivia	218	0	1	0	1970	2021	1970	2020	1973	2009
14	Botswana	616	0	1	0	1970	2021	1976	2020	1978	1996
15	Brazil	223	0	1	0	1970	2021	1970	2020	1981	2020
16	Bulgaria	918	0	1	0	1970	2021	1991	2020	2001	2020
17	Cote d'Ivoire	662	0	0	1	1970	2021	1970	2020	1971	2017
18	Canada	156	1	0	0	1970	2021	1970	2020	1970	2020
19	Chile	228	0	1	0	1970	2021	1970	2020	1978	2019
20	China	924	0	1	0	1970	2021	1981	2020	1992	2019
21	Colombia	233	0	1	0	1970	2021	1970	2020	1992	2019
22	Congo, Rep.	634	0	0	1	1970	2021	1970	2019	1992	2006
23	Costa Rica	238	0	1	0	1970	2021	1970	2020	2001	2020
24	Croatia	960	0	1	0	1995	2021	1996	2020	1998	2014
25	Cyprus	423	1	0	0	1970	2021	1975	2020	1973	2018
26	Czech Rep.	935	1	0	0	1996	2021	1993	2020	1999	2020
27	Denmark	128	1	0	0	1970	2021	1970	2020	1975	2020
28	Ecuador	248	0	1	0	1970	2021	1970	2020	2001	2020
29	Egypt	469	0	1	0	1970	2021	1970	2020	2011	2017
30	El Salvador	253	0	1	0	1970	2021	1970	2020	1992	2019
31	Estonia	939	1	0	0	1995	2021	1995	2020	2001	2020
32	Finland	172	1	0	0	1970	2021	1970	2020	1970	2020
33	France	132	1	0	0	1970	2021	1970	2020	1970	2020
34	Gabon	646	0	1	0	1970	2021	1970	2019	1979	2010
35	Georgia	915	0	1	0	1998	2021	1995	2020	2010	2016
36	Germany	134	1	0	0	1970	2021	1970	2020	1970	2020
37	Greece	174	1	0	0	1970	2021	1970	2020	1970	2020
38	Guatemala	258	0	1	0	1970	2021	1970	2020	2002	2017
39	Honduras	268	0	0	1	1970	2021	1970	2020	2001	2018
40	Hong Kong	532	1	0	0	1970	2021	1990	2020	1983	2019
41	Hungary	944	0	1	0	1971	2021	1991	2020	1982	2020
42	Iceland	176	1	0	0	1970	2021	1970	2020	1999	2018
43	India	534	0	1	0	1970	2021	1970	2020	1972	2020
44	Indonesia	536	0	1	0	1970	2021	1970	2020	1988	2017
45	Iran	429	0	1	0	1970	2021	1970	1982	1970	2010

[35] More precisely, the following procedure is adopted: If the adjusted R^2 of equation (9) is greater than the sum of the adjusted R^2 of equation (10) and the standard error of the difference between the two adjusted R^2's, then *MPI*_1 is chosen as the MPI index. If the adjusted R^2 of equation (10) is greater than the sum of the adjusted R^2 of equation (9) and the standard error of the difference between the two adjusted R^2's, then *MPI*_2 is chosen as the MPI index. If the difference between the two adjusted R^2's is within its standard error, then the average of *MPI*_1 and *MPI*_2 is chosen as the MPI index.

46	Ireland	178	1	0	0	1970	2021	1970	2020	1980	2020
47	Israel	436	1	0	0	1970	2021	1995	2020	1985	2020
48	Italy	136	1	0	0	1970	2021	1970	2020	1970	2020
49	Japan	158	1	0	0	1970	2021	1970	2019	1970	2020
50	Jordan	439	0	1	0	1970	2021	1976	2016	1977	2019
51	Kazakhstan	916	0	1	0	1996	2021	1994	2020	2007	2017
52	Kenya	664	0	0	1	1970	2021	1970	2020	1989	1996
53	Korea, Rep.	542	1	0	0	1970	2021	1971	2020	1970	2020
54	Kuwait	443	0	1	0	1970	2021	1974	2019	1978	2010
55	Latvia	941	1	0	0	1995	2021	1995	2020	1997	2020
56	Libya	672	0	1	0	1970	2021	1990	2019	1970	2010
57	Lithuania	946	1	0	0	1995	2021	1995	2020	1998	2020
58	Luxembourg	137	1	0	0	1970	2021	1990	2020	1987	2020
59	Malaysia	548	0	1	0	1970	2021	1970	2020	1972	2019
60	Malta	181	1	0	0	1970	2021	1970	2020	2001	2020
61	Mexico	273	0	1	0	1970	2021	1970	2020	1977	2020
62	Moldova	921	0	0	1	1994	2021	1995	2020	2005	2010
63	Mongolia	948	0	1	0	1993	2021	1992	2020	2008	2020
64	Morocco	686	0	1	0	1970	2021	1970	2020	1972	2018
65	Netherlands	138	1	0	0	1970	2021	1970	2020	1970	2020
66	Nicaragua	278	0	0	1	1970	2021	1970	2020	2000	2014
67	Nigeria	694	0	0	1	1970	2021	1970	2020	1972	2008
68	Norway	142	1	0	0	1970	2021	1970	2020	1983	2020
69	Oman	449	0	1	0	1970	2021	1973	2019	2005	2010
70	Pakistan	564	0	1	0	1970	2021	1970	2020	1972	2019
71	Paraguay	288	0	1	0	1970	2021	1970	2020	2006	2017
72	Peru	293	0	1	0	1970	2021	1970	2020	1980	2018
73	Philippines	566	0	1	0	1970	2021	1970	2020	1994	2019
74	Poland	964	0	1	0	1970	2021	1995	2020	1992	2020
75	Portugal	182	1	0	0	1970	2021	1972	2020	1970	2020
76	Qatar	453	0	1	0	1970	2021	1994	2020	2010	2010
77	Romania	968	0	1	0	1970	2021	1990	2020	1995	2020
78	Russia	922	0	1	0	1995	2021	1993	2020	1997	2020
79	Saudi Arabia	456	0	1	0	1970	2021	1970	2020	1998	2010
80	Senegal	722	0	0	1	1970	2021	1970	2020	1978	2017
81	Serbia, Rep.	942	0	1	0	2003	2021	1999	2020	2009	2020
82	Singapore	576	1	0	0	1970	2021	1970	2020	1975	2020
83	Slovak Rep.	936	1	0	0	1996	2021	1993	2020	2000	2020
84	Slovenia	961	1	0	0	1994	2021	1995	2020	1996	2020
85	Solomon Is.	813	0	0	1	1970	2021	1980	2020	2012	2019
86	South Africa	199	0	1	0	1970	2021	1970	2020	1970	2018
87	Spain	184	1	0	0	1970	2021	1970	2020	1970	2020
88	Sri Lanka	524	0	1	0	1970	2021	1970	2020	1999	2010
89	Sweden	144	1	0	0	1970	2021	1970	2020	1970	2020
90	Switzerland	146	1	0	0	1970	2021	1980	2020	1970	2020
91	Taiwan	528	1	0	0	1970	2021	1989	2020	1982	2020
92	Tajikistan	923	0	0	1	1995	2021	1997	2019	2001	2009
93	Thailand	578	0	1	0	1970	2021	1970	2020	1988	2019
94	Togo	742	0	0	1	1970	2021	1970	2020	2005	2009
95	Tunisia	744	0	1	0	1970	2021	1970	2019	1989	2018
96	Turkey	186	0	1	0	1970	2021	1970	2020	1986	2020
97	Uganda	746	0	0	1	1970	2021	1970	2018	1994	2003
98	Ukraine	926	0	1	0	1995	2021	1994	2020	2003	2020
99	U.K.	112	1	0	0	1970	2021	1970	2020	1970	2020
100	Uruguay	298	0	1	0	1970	2021	1970	2020	2003	2019
101	Venezuela	299	0	1	0	1970	2018	1970	2014	2009	2016
102	Vietnam	582	0	0	1	1970	2021	1995	2020	2014	2019

AE = advanced economy; EMMIE = emerging market and middle-income economy; ERS = exchange rate stability; FMO = financial market openness; LIE= low-income economy; and MPI = monetary policy independence.